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CHALLENGES OF SCIENCE

Materials of International Practical Internet Conference

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PREFACE

This book presents the conference proceedings of the International Practical Internet Conference "Challenges of Science" held by the Institute of Metallurgy and Ore Beneficiation, Satbayev University in Almaty, the Republic of Kazakhstan, on 22 November 2021 for the fourth time.

The conference contributes a wide exchange of scientific achievements, and views on the challenges of the development of sciences, both from academia and from the industry. Its success is reflected in the papers published here, allowing a real scientific exchange of ideas. Conference materials are indexed by CrossRef (USA), e-libray.ru (Russia), and a directory of open access to scholarly resources via ISSN 2707-9481 (ROAD, France). ROAD, with support from the UNESCO Communications and Information Sector, provides free access licensed under Creative Commons to all conference materials worldwide.

This conference can only succeed as a team effort, so the editors want to thank the international scientific committees and the reviewers for their valuable advice. We would like to take this opportunity to thank all of our authors who provided feedback, too. We are sure that publications in this book will stimulate both basic and applied research, and will greatly advance our knowledge and capability in future scientific projects.

We hope for further fruitful cooperation. On behalf of the organizing committees, I extend my warmest welcome to all of you to take part in the next issue in 2022. This conference is planned to be held annually and it has an open call proposal for the development of this scientific project. Short proposals should be sent to conference@kims-imio.kz for more information.

Prof., Dr. **Bagdaulet Kenzhaliyev**
Chief-in editor
On behalf of the organizing Committees
Almaty, the Republic of Kazakhstan
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Processing the results of space observation of the processed areas of Karaganda

Abstract: The article is devoted to the development of a method for tracking deformation in the underworked territories of Karaganda based on the data processed by radar images from the ENVISAT satellite. The article provides an overview of the use of modern radar satellite systems. The step-by-step search of archival data on the territory of Karaganda in the Eoli-sa program is described. The processing of radar images from the ENVISAT satellite for the period from 2003 to 2010 in the SARscape module of the ENVI software package is described in detail. Based on the processed data, graphs of dynamic processes were compiled. The analysis of the results of interferometric processing of radar data is performed. Traditional and modern methods of tracking the deformation of underworked territories are also analyzed.
Keywords: satellite radar interferometry, landscape changes, observation of geodynamic processes, radar data, processing of space images, motion interferomogram.

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Introduction

Today Kazakhstan ranks eighth in the world in terms of coal reserves. Coal mining creates voids in mountain ranges, which in turn causes movement of the earth's surface. The classical method of preventing the movement of the earth's surface, that is, filling voids with material, is rarely used in Kazakhstan due to its economic inefficiency, therefore, collapse of the earth's surface is common. In 2014 alone, similar disasters occurred in several cities of Kazakhstan: Ridder, Karaganda and Kokshetau. In the city of Karaganda, where the mines of the Karaganda region are located close to each other and, therefore, in the midst of large-scale mining operations, very dangerous subsidence processes occur.

Monitoring such topographic changes and geodynamic processes using traditional measurement methods such as leveling and total station is a laborious process. In addition, traditional control methods do not provide a complete picture of the processes occurring outside the profile lines or in hard-to-reach places. Satellite radar interferometry technology for observing such phenomena shortens the acquisition time between periods and allows an image of the rapid movement of the earth's surface at that moment. Its coverage area is 30 * 30 km. Currently, foreign companies are engaged in radar interferometric survey in the Republic of Kazakhstan (Kainz Wolfgang, 2019; Kharchenko, 2017).

Satellite radar interferometry is a measurement technique that exploits the interference effect of electromagnetic waves. The essence of the method is the creation of an interferogram. An interferogram is a composition of two images of the same area, made by one satellite, and provides information about the phase and amplitude of the signal.

Among the areas of application of satellite radar interferometry data are the following:

– creation of a digital terrain model, including a high-precision one (samples with a spatial increase of about one meter and an accuracy of determining the height of 1-2 meters);

– measurement of deformations to the nearest part of the radar wavelength;

– Determining the speed of a vehicle, such as a fast moving object.

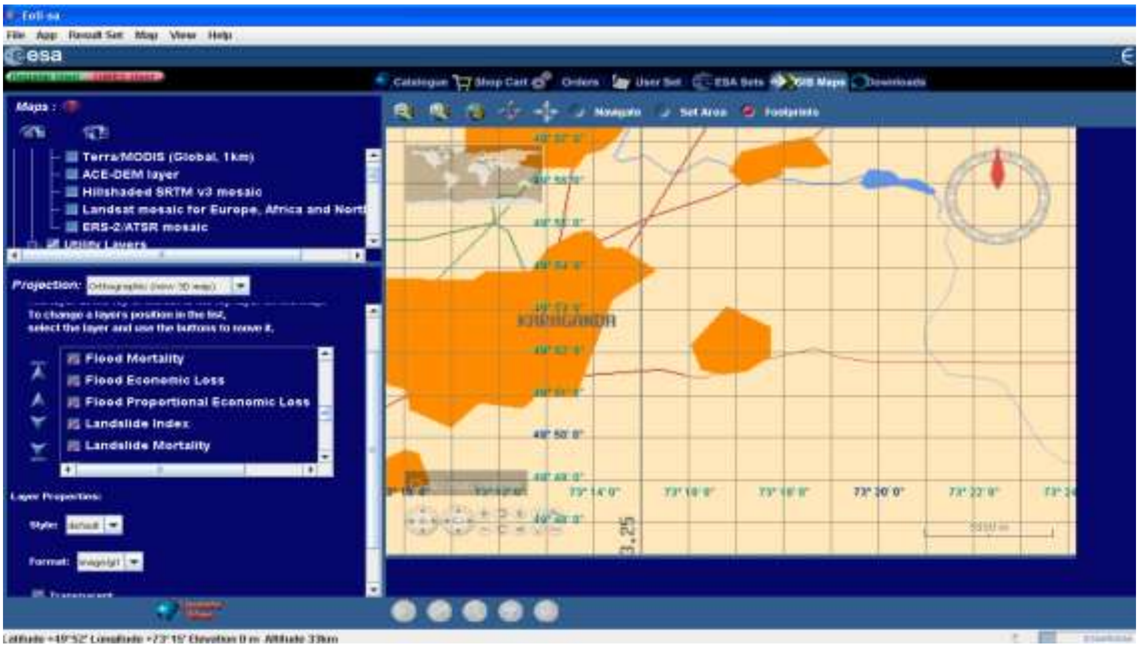
In terms of price and quality, low magnification radar data (10-30 m - ENVISAT, ERS-2, etc.) are in great demand, while medium magnification radar data (4-8 m) have very good prospects. Such radar surveys are used to create digital terrain forms, mapping, monitoring the ecological state of the area, assessing seismic hazard, monitoring floodplains and areas with constant fog, as well as for solving many other problems in various fields of activity.

Unique tasks can be solved using high-resolution radar data (1-3 m). However, due to their relatively high cost, they are mainly in demand only when solving local problems. For example, high-resolution radar images can detect movement of the earth's surface, especially buildings and industrial structures, with very high accuracy. In this regard, the ability of high-resolution radar data to recognize objects and group them is significantly improved with the help of specialized software products such as SARscape (Morev & Nezamov, 2018).

Experimental part

The Eoli-sa program was used to obtain data from the archives of the European Space Agency, i.e. for the selection of satellite images (Picture 1) [3].

Picture 1. Eoli - sa program interface



Eoli-SA is a free multi-platform interactive program. It allows users to access, order, and ultimately track their status in the Terrestrial Product Catalog. It also allows GSP, SCI and SPR operators to retrieve product data and metadata online. Product content is integrated into collections that can be easily queried and viewed (Tarasova, 2019).

Based on the analysis of the data in the archive, the ENVISAT satellite system was selected.
As a result of the search for information in the archives by the ASAR sensor in the Eoli-sa program, 29 images from 4 different tracks were found. To view and order satellite images, it is necessary to identify the ASAR Image Mode sensor and select the observation time. When choosing the time of observations, the period from 2003 to 2010 was taken into account. (Picture 2).

You can view the images identified in the search results by clicking the outline of an image on the map, clicking the image thumbnail to the right of the map, or selecting a row in the table. An example of an archived image is shown in Picture 3.

Satellite images were processed in the SARScape module of the ENVI software package. This program was also acquired under the aforementioned grant project funded by the Ministry of Education and Science of the Republic of Kazakhstan.

Picture 2. Complete result of each image, taking into account the trajectory and track

Picture 3. done on December 18, 2006 Archival photo of Karaganda

The discussion of the results

At the first stage of processing, ENVISAT satellite images were imported from the raw * .N1 extension to the * .cls extension and the baselines were processed. According to the research, i.e. satellite images of ENVISAT track 363, a graph of the dependence of the time factor on the critical base was built (Picture 4) (Kharchenko, 2017).

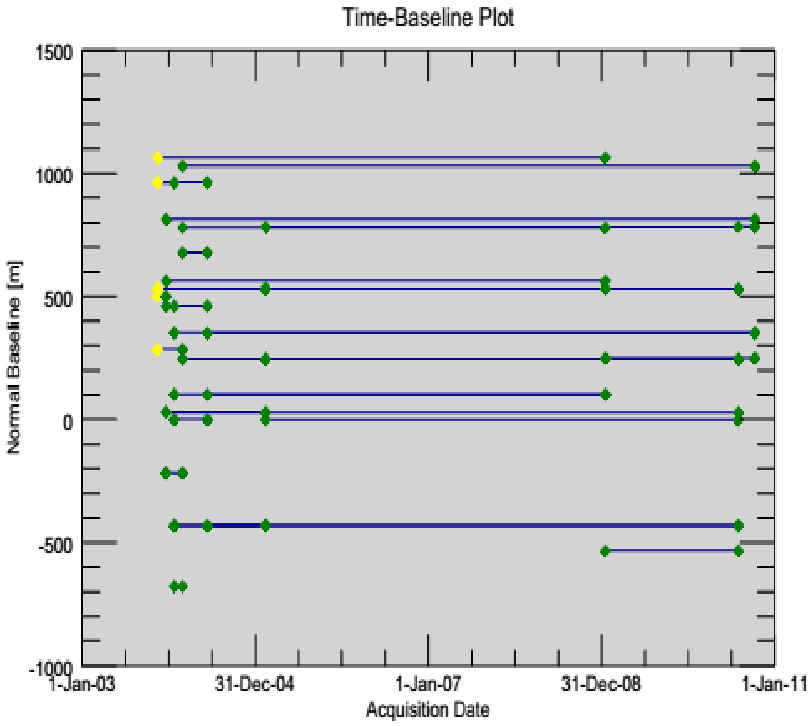
Save your file in WORD format, Calibri font, size 11, 1 spacing.

The second stage of processing is the selection of pairs for interferometric processing. Pairs were selected according to several criteria, i.e. of the total number of possible pairs. The time base is the interval between images of the interferometric pair (Kharchenko, 2017).

At the third stage of development, a quantitative terrain model was created. SRTM data in Kazakhstan has been increased by about 90 meters. Creation of the Karaganda SES on July 31, 2010 and 10/09/2010. ENVISAT - satellite imagery used.

General data processing was carried out under the temporary license of the SarScape module. The licensor is the Sovzond company, the official distributor of the ENVI program in Russia. SarScape software is an additional module of the ENVI program for pre- and thematic processing of radar images. The interferometry module allows you to perform interferometric processing of radar data and, finally, to obtain a digital terrain model or earth displacement map.

Picture 4. Graph of dependence of the time factor of the satellite image ENVISAT track 363 on the critical base



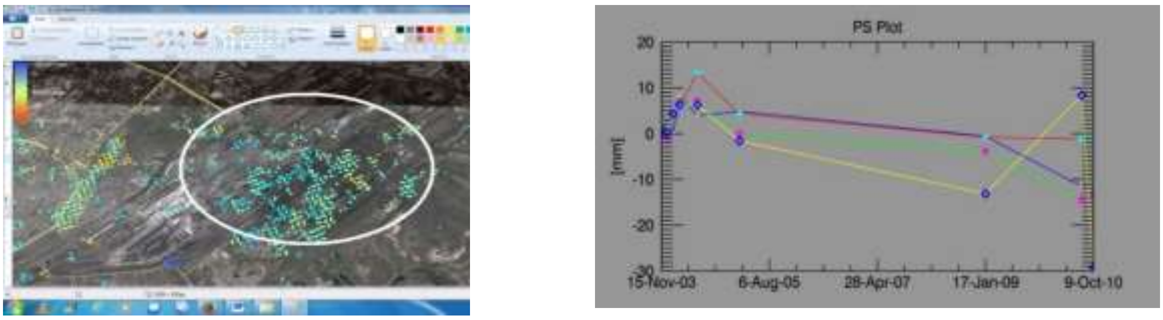
The main result of this work is a differential interferogram in the form of obtaining a synthesized phase of the terrain from a complex interferomogram (Morev & Nezamov, 2018).

Based on the processing of pairs of radar images from the ENVISAT satellite, a map of the subsidence of the surface of civil and industrial objects, as well as areas of the location of mines in the Karaganda region and the Oktyabrsky district, was obtained.

Geocoding and calibration were carried out in relation to the digital terrain model of Karaganda, previously developed by the author. According to the results of processing and calculations, in urban areas there are both stable areas with small displacements, and areas with a real acceleration of the subsidence process.

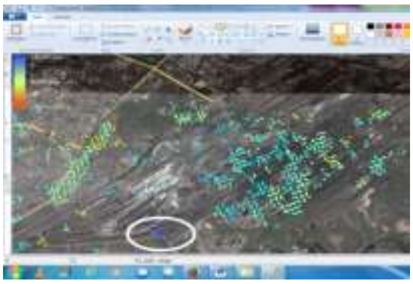
The subsidence value is obtained from the drawings, and the subsidence graph is plotted at the points shown in the figure (Picture 5).

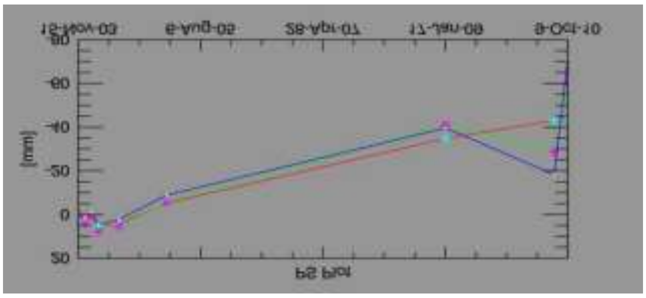
Picture 5. Territory



In 2013, a surface subsidence of 40 mm for the reporting period was recorded in the area of the chimneys of the chemical production of coke HU-1 (Picture 6).

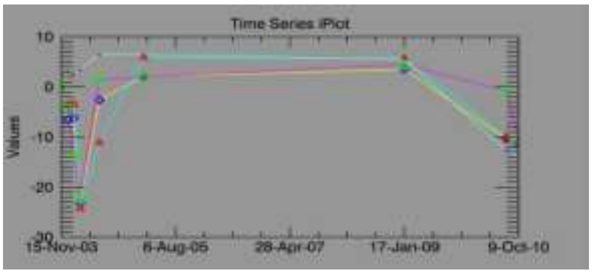
Picture 6. Landslide in the area of pipelines





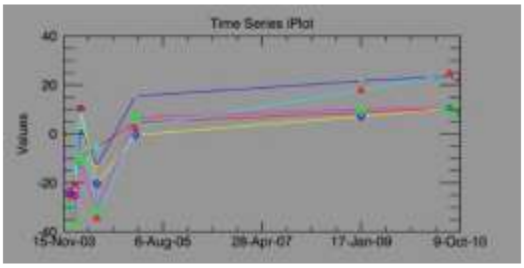
Due to the lack of mines and insufficient processing, the Maikuduk and Abai areas are in good condition (Picture 7.8).

Picture 7. Study of the subsidence process in the Abai area



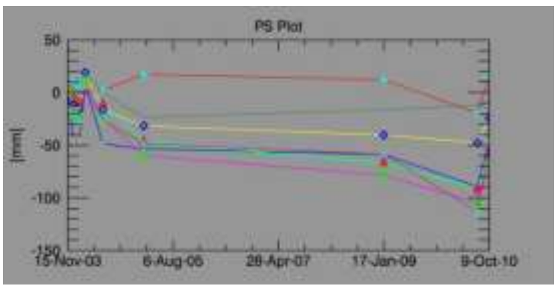
From 2003 to 2010, a slight subsidence of about 10 mm was observed in the Oktyabrsky district (Picture 8).

Picture 8. Oktyabrsky district - Maikuduk



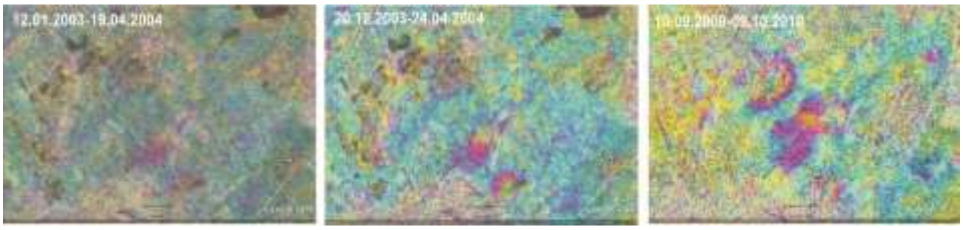
Photos taken in 2009-2010 made it possible to analyze events and accidents associated with the deformation and collapse of buildings and structures in the Karaganda region in 2011-2013 (Susan Smith, 2020).

Picture 9. Dams in Botakara settlement dynamics of the deformation process



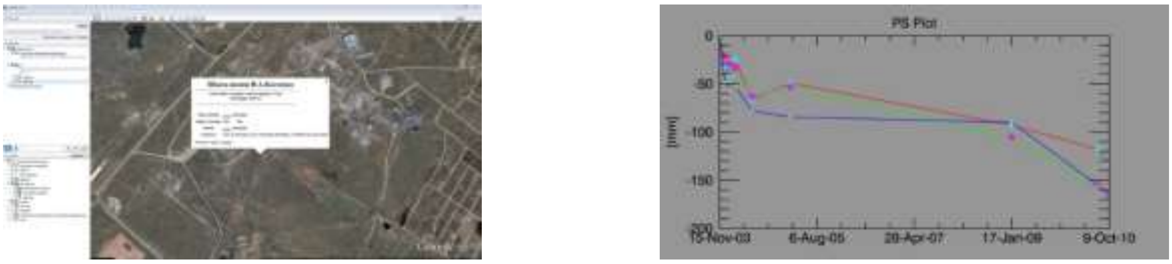
The results of the analysis of the plain in the area of the Kostenko mine show that since 2004 two sedimentary forms have appeared in the area of the Kostenko mine. In 2010, the amount of precipitation spreading increased (Picture 10). During the specified period, work was carried out at the Kostenko mine K1 on the seam and 45 K1-z on the longwall. The thickness of the exposed layer was 2.8 m (Kharchenko, 2017).

Picture 10. Creation of differentiated interferograms of Karaganda on different pairs of images



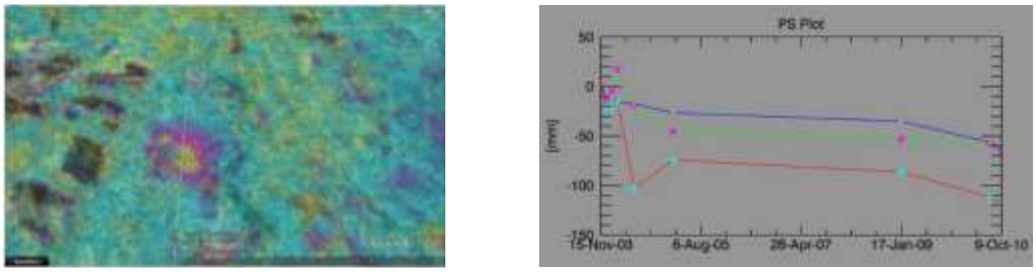
In addition, from 2003 to 2010, annual subsidence was observed in some areas of the Kostensky mine (Picture 11).

Picture 11. The territory of the mine Kostenko



Analysis of the surface of the city of Shakhtinsk, where the operating Kazakhstanskaya mine is located, showed that accelerated subsidence occurred in 2009-2010 (Picture 12).

Picture 12. Mine territory Shakhtinskaya



The data from the space probe coincided with the development plan of the Shakhtinskaya mine, which makes it possible to use the data from the space probe to monitor the development of the deposit, as well as to prevent dangerous deformations. Prediction of dangerous deformations is very important for this region, since the settlement of Severny is located not far from the mine (Susan Smith, 2020).

Conclusions

The results of the study showed that the method of satellite radar interferometry has a number of advantages over traditional methods of surveying and calculating when monitoring the movement of the surface of the treated areas. The results of the data on subsidence of the earth's surface showed good correlation and high measurement accuracy. Among the advantages of this method, it is worth noting the possibility of monitoring large areas by area and the clarity of the results obtained. All this allows us to propose the method of satellite radar interferometer for observing the movement of rock massifs as a reliable method for controlling subsidence and deformation.

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Constructivist approach in pedagogical science

Abstract: The article examines the problems of constructivist understanding of education, the innovations, opportunities and limitations that the constructivist model of the pedagogical process offers. The aim of the work was to analyze the constructivist model of education and those innovations and prospects for understanding the modern educational process that the constructivist approach brings. Constructivism changes the view of teachers and other scientists and practitioners in their view of what is happening in the relations of people in education. Due to its controversial nature, the development of the ideas of constructivism in the context of the development of educational ideologies and technologies leads to the reconceptualization of the traditional model of education, and the constructionist model of education itself can and should become the object of systematic methodological, theoretical, empirical and applied research. Any of the educational approaches available now can be disclosed as an example of a constructivist model of education, the leading features of which are the dialogic nature of education, the focus on understanding the inner and outer world in dialogue with significant other people, the consideration of such a dialogue as a process of building a person's own life world and himself, as a creative "rediscovery" of the basic truths of human existence, as the adoption of socially and personally significant decisions in a situation of educational, professional, life choice.
Keywords: education, pedagogical process, constructivist approach, intersubjectivity, reflexivity, consensus.

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Introduction

Postmodernity, the era of the late XX and early XXI centuries, leaving, leaves a lot of interesting and productive developments, which undoubtedly includes constructivism. Challenging the existence of reality as such, constructivism proposed several options for solving the problem of a person's comprehension of himself and the world, united by a common idea of production of internal and external reality in social dialogue, in the interaction of people and groups (actors and co-actors) interested in solving problems, united in situational, substantive, active collaborations (associations, groups) to develop an optimal and satisfying consensus solution to the problem for all participants as stakeholders. Constructivism has changed the way people look at relationships in a number of areas, including management and education. Today, abroad, and, to a lesser extent, in Russia, the constructivist approach is among the most influential approaches, within the framework of which explanatory schemes are proposed for analyzing the realities of educational practice of teaching [1; 2; 3; 4].

The purpose of the research problem

The purpose of our work was to analyze innovations and the prospects for understanding the modern educational process in the context of a constructivist approach.

Research methodology and technique

The paper uses a systematic approach to the analysis of the problems of didactic communication in the context of the constructivist model, and comprehends the prospects for understanding the modern educational process in the context of the constructivist approach.

Research results

Constructivism as an ideology, methodology and technology has brought many interesting and important points to the understanding of educational interaction, didactic communication and directions of its development [5; 6; 7; 8]. Unfortunately, in the practice of education, constructivism is partly implemented abroad, but not in Russia. This is somewhat paradoxical, since foreign researchers, inspirers and developers of constructivist ideas in education, the cultural-historical theory of L.S. Vygotsky, along with the works of J. Dewey, J. Piaget, is interpreted as an example of social constructivism [9; 10; 11; 12]. Didactic communication appears in the constructivist model not as a concomitant phenomenon of interaction between the teacher and the student regarding the educational content, but as a certain self-valuable reality, constructed by the student himself with the active participation of the teacher. This very important "innovation" favorable for the development of the education system contains a response to the claims of modern "e-learning", education using ICT or "digital education", postulating that in the world of educational "E-Text" the role of the teacher will be reduced to a guide or dispatcher, directing the search for information necessary for learning at a particular stage of "continuous education". In constructivism, a teacher is not only a necessary "detail", but is a center of "power" (and even "power") that structures the educational interaction of subjects. The assimilated information is considered as a source material for joint creative (re- or de-) construction, therefore it cannot be considered in isolation from its carriers, as an extra-personal and extra-temporal standard. As a result, the course of work on the detection and awareness, processing and comprehension, acceptance and rejection, taught in dialogue with the teacher / teacher and other schoolchildren / students of one or another didactic content, is built in the logic of a detailed search, open discourse, encouraging critical judgments ("critical thinking") Trainees and its structuring, reflexive activity of schoolchildren and students in relation to the surrounding reality. To what extent the educational content lends itself precisely to this style of presentation and interpretation, the question remains controversial, open and until now solved only partly at the level of individual programs and methodological developments. A general convincing theory of the message of educational content by the supporters of the constructivist approach, in our opinion, has not yet been created.

It is important that "According to the methodological principle of constructivism in philosophy, psychology, sociology (J. Kelly, J. Piaget, A. Schutz, K. Gergen, P. Berger, T. Lukman, V. S. Stepin, U. Maturana, F. Varela, R. Vatslavik, I. Glaserfeld), knowledge is not contained directly in the object (in "objective reality") and is not extracted from it in the course of "movement from relative to absolute truth", but is built (constructed) by the knowing subject in the form of various kinds of models, which can be both alternative and mutually "[13, p. 129]. The plurality of truth gives rise to its pluralization and patchwork, its "correspondence" as relativity to specific people and groups of people, situations and relationships.

This is noted in many works, including the relativism of antiquity, the Middle Ages, modern times, etc. (Heraclitus, F. Aquinas, O. Spengler, M. Blok, L. Fevr, A. Ya. Gurevich and others), but especially in postmodernism (M.P. Foucault, J. Derrida, J. Lacan, J. Baudrillard, K. J. Gergen, R. Barth, J.-F. Lyotard, F. Guattari, A. Vezhbitskaya, F. Capra, K. Knorr-Cetina, P. Vaclavik, E. von Glazersfeld, H. von Foerster, U. Maturana, F. Varela and G. Roth), etc., - where the concept of deconstruction of culture develops, the result of which is multiplicity, uncertainty, fluidity / emergence of reality [14; 15; 16]. There are many ideas and theories of a constructivist sense in psychology, including educational psychology (J. Kelly, J. Piaget, J. Grinder, R. Bandler, etc.). P. Watzlavik substantiated the very concept of constructivism as a "science of reality", which recognizes reality as a construction of the one who observes it, that is, the construction of the observer himself [17, p. 7]. A subject means any participant in didactic interaction: teacher, student, psychologist, manager, parent, etc. There is a close connection between the pedagogy of constructivism and philosophical constructivist concepts (P. Watzlavik, U. Maturana, F. Varela). Constructivism in pedagogy is an important part of research and applied development: "From the point of view of a constructionist, socio-psychological research is capable of participating in the creation of new forms of cultural life. By developing new theoretical languages, research practices, forms of expression and methods of intervention, psychology creates favorable conditions for cultural transformation" [18, p. 43].

So, in the studies of J. Piaget, it is illustrated that in a person's understanding of himself and the world, his "logic", the specificity of the cognitive and other activities of the subject is reflected, that different cultures can have specific, different from each other logics and "psycho-logic", which is sharply different from the realistic representation given, for example, in the works of P. Ya. Halperin, who believed that logic is hidden in the very objects of knowledge and their relationships. Objectivity is an important part of dialogue in cognition and other spheres insofar as the world "dictates" how it can and should be understood. According to R. Tagore, the truth should be considered as a dialogue that strives not for an independent reality, but for consistency between human understanding as a whole and "individual" understanding, reflecting a particular point of view [19, p. 43-44].

However, many scientists and educators do not share optimism about constructivist research in pedagogy and psychology. For example, M. Matthews, T. Duffy, D. Johansen, J. Canselaar, believe that the popularity of constructivist pedagogy is associated with the methodological crisis of pedagogy in recent decades, including the lack of discourses that can explain the changeable, unstable nature of educational phenomena [20, c. 303], as well as the needs of developing new educational techniques, not theories [21, p. 2]. K. Gerzhen, S. Rowlands, R. Carson think differently: for them constructivism is one of the leading models and theoretical concepts of education of our time [22]: constructivism changes the understanding of the goals and values of education as an active interaction between a teacher and a student, the understanding of didactic interaction as intersubjective dialogue between the student and the teacher. At the same time, "the emphasis on the procedural nature of teaching means highlighting the importance of a method, a path in search of an answer, and not finding an "objectively correct solution", therefore, the "mistakes" of schoolchildren and students are considered in the context of how they "allow a glimpse into the organization of their empirical experience" [23, p. 15]. Education as a socio-cultural process makes it possible to check the constructions of reality of each student and teacher for "viability", to correct them if necessary:education is an intersubjective space and time for constructing meaning, including the meaning of learning and upbringing in themselves, in education, interindividual constructions of reality arise and develop collective "models of interpretation": a person understands that his reality is always "socially constructed" [24, p. 5]. The teacher helps students understand themselves and the world, but does not insist that the student must accept other people's understandings or build his own world. In the works of D. Dewey, for example, there is the term "active learning", which implies the understanding of the world as active co-creation [25, p. 84; 26].

Domestic researchers, psychologists and educators, sociologists and cybernetics, philosophers and culturologists are beginning to slowly develop constructivist models and offer their specific technologies in education (S.A. Tsokolov, E.G. Vinogradov, O.E. Baksanskiy and E.N. Coachman). In our opinion, special attention should be paid to studies of educational innovations (N.N. Pluzhnikova, P.V. Menshikov, V.M. Petrovichev and V.I. Ivanova, N. Babich, etc.). V.M. Petrovichev and V.I. Ivanova note that the culture of pedagogical research, as well as the culture of education in general, presuppose the methodological literacy of teachers, including an understanding of the constructivist aspects of knowledge and skills to be "mastered" [27]. N. Babich believes that constructivism helps to understand "social interaction as a starting point on the path to understanding the relationship between learning and teaching in different in the "school" - institutional contexts of the development of children, students, students, teachers from the point of view of their personal, social and professional formation and development" [23, p. 7-8]. It rests on the understanding of constructivism as "a theory about the limits of human knowledge, the belief that all knowledge is necessarily the product of our own cognitive actions" [20, p. 304], understanding oneself and the world is the construction of reality, and not a reflection of some internal or external reality existing outside the one who understands, which is revealed at the moment of understanding [28; 29; 30], it "is an active process of constructing the subject's environment ... knowledge has an adaptive meaning and is focused on adaptation (adjustment) and survival ... knowledge serves to organize the subject's inner world and does not serve the tasks of describing objective ontological reality ... scientific knowledge ultimately should serve practical purposes "[31, p. 12-13]," knowledge is not what is in people's heads, but what people do together "[32, p. 270].

In general, researchers from different countries rely on the understanding that the "constructivist orientation" in its aspect sets "the main goal of education ... is the development of more and more complex and complex forms of thinking and problem solving within the essence or work space" and time [33, p. 32]. Learning is a process of enrichment, organization, reorganization and improvement of knowledge and skills, characteristics of a person and his abilities, "the development of the ability to use scientific concepts and ways of thinking, when necessary" [34, p. 312]. Learning is described as a process of transformation through participation in sociocultural activities [35; 36]. The teacher is engaged in "creating a platform" (the metaphor was proposed in the works of D. Wood, J. Bruner, and G. Ross [37] - applying methods of guiding students' understanding in the "zone of proximal development" [37; 38; 39; 40; 41], including intensive interaction in "Active group", personalized additional guidance from a teacher or a lecturer, non-delayed and meaningful feedback, confirmation as approval or disapproval, projection, and problematization, clarification and suggestions, reflection and confrontation, etc. [41, p 351]. Project-Based Learning, Critical and creative thinking skills are vital in pedagogical sciences as well. These skills are advised to be integrated into all subjects in school in Malaysia [42; 43]. According to K. Stone [40], a schoolchild or student as an active participant - an actor, a subject - of didactic interaction as an interpersonal interaction builds and develops mutual understanding, they achieve and maintain intersubjectivity through exchanges in which the student learns in interaction with more competent and those who have achieved more in one area or another than he, the participants [37, p., 272]. The platform and its creation as a process of support for learning computer etent mentor ("leadership of others", as well as guiding, teaching strategies, initiated by the teacher) are "an ongoing interpersonal process in which communicative exchanges of participants serve to create a constantly evolving mutual point of view on how to comprehend a particular situation" [40, p .180]. J. Van de Paul, M. Wolman and J. Beishuisen, R. Tharp and R. Gallimore, D. Wood, J. Bruner and G. Ross identify a number of support methods: modeling, situational management, feedback, training, polling and cognitive structuring [37].

Conclusions

In our opinion, the essence of constructivism, including in the field of teaching and pedagogical reality, comprehensively reflects the basic postulates, such as:

1) The process of teaching and upbringing in modern schools and universities is based on information about the reality surrounding students, obtained not only from teachers and parents as mentors, but also from the student's or student's own experience, If a new idea does not fit into the existing one of the subject of education value, semantic, behavioral, etc. the framework, the learner with the support of the mentor and the "educational platform" created by him as a system of strategies for the development of the individual and his understanding of himself and the world, should try to reconstruct it. To do this, he can use the resources of training and education on the part of a professional teacher / mentor / tutor, resources of self-study and self-education, as well as resources of group training and education (network, organizational, etc.) as mutual training and mutual education.

2) In understanding the phenomena of the surrounding reality, it is necessary to distinguish between personal and social aspects, meanings and so on. The social aspect is associated with the generalization of the experience of one's own and others' interaction with nature and with the world of physical objects and with the community, its separate groups and subgroups, including ethnic, clan, family, marital and friendly relations, considered in the context of their social significance, social values. The personal aspect encompasses the experience of interactions of the subject himself and his relatives with other individuals and groups, correlated with the formation of the individual as a person, partner and professional, in the context of personal meanings and the significance of these processes. Naturally, the social and personal contexts closely intersect, the harmony between them ensures the well-being of society and the individual at all levels of their existence and development, and differences and contradictions act as the driving forces of development.

3) Knowledge and skills transmitted to the learner or learner are constructed, deconstructed and reconstructed in the course of researching a problem situation in order to achieve a "consensus" within groups of (self-, inter-) teaching and (self-, inter-) learners (as heterogeneous actors - participants in the "activity group / situational association / educational collaboration", etc.). Knowledge and skill correlates with the norms and values of this group, its idea of the meaning of human existence, its goals. The knowledge and skills of a person, like a person himself / herself, are tele-oriented: living in the present, remembering the past, a person is able and seeks to change him / her and the world, striving for the future that he constructs consciously or unconsciously, voluntarily or involuntarily, independently or jointly.

4) The question of the "truth" of the knowledge, skills, traits and abilities transmitted and cultivated in the learner, according to the pluralistic model of reality (as constructed and reconstructed), cannot be resolved unambiguously. The teacher can and should talk about different understandings of the surrounding person and the reality inside a person, about the boundaries, possibilities and limitations of the application of this knowledge and skills, about the pros and cons of certain traits and competencies.

Constructivism changes the view of teachers and other scientists and practitioners in their view of what is happening in the relations of people in education. Due to its controversial nature, the development of the ideas of constructivism in the context of the development of educational ideologies and technologies leads to the reconceptualization of the traditional model of education, and the constructionist model of education itself can and should become the object of systematic methodological, theoretical, empirical and applied research. Any of the educational approaches available now can be disclosed as an example of a constructivist model of education, the leading features of which are the dialogic nature of education, the focus on understanding the inner and outer world in dialogue with significant other people, the consideration of such a dialogue as a process of building a person's own life world and himself, as a creative "rediscovery" of the basic truths of human existence, as the adoption of socially and personally significant decisions in a situation of educational, professional, and life choice.

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How to Integrate STEM Education in The Indonesian Curriculum? A Systematic Review

Abstract: STEM education has received a lot of attention, including in Indonesia, because it is considered capable of preparing competitive students in the 21st century. However, the implementation of STEM learning is constrained because there are no standard guidelines according to the curriculum 2013 (education curriculum in Indonesia). Therefore, the aim of this study is to find an integration formula for STEM learning and the curriculum 2013 based on the synthesis of various literature to find a formula for implementing STEM learning in accordance with the curriculum 2013. This study is a systematic review. The data sources in this research are 46 selected literatures and relevant to the research objectives published between 1996 and 2020. The data sources are literature published in ISBN books, government documents, and journals. The data collected from the literature were analyzed with a thematic model starting with data introduction, initial coding, compiling code within a theme, analyzing themes, naming themes, and relating findings to research questions. The research resulted in a learning step that combines EDP in STEM, the scientific approach in the 2013 curriculum, and project learning steps. The merger produces a guideline for implementing STEM learning in the 2013 curriculum starting from problem identification, making problem-solving designs, design realization, testing and studying product deficiencies, improving products, drawing conclusions, and communicating the findings of the learning process.
Keywords: STEM Education, Indonesia, Curriculum, Teaching Activity.

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Introduction

The development of technology in this century is going very fast (Arlinwibowo, Retnawati, Hadi, Kartowagiran, & Kassymova, 2021; Marsigit et al., 2020). This makes a significant difference from the previous era (Arlinwibowo, Retnawati, Kartowagiran, & Kassymova, 2020). This condition has been responded to by many experts that formulating the skills needed in this century. By elaborating many expert opinions and observing the social condition of the country, the Ministry of Education and Culture of the Republic of Indonesia made a standard guideline for the implementation of 21st century education which was formulated as the Indonesian Partnership for 21 Century Skill Standard (IP-21CSS). The standard directs the implementation of education to be oriented to 21st century skills (creativity and innovation, critical thinking and problem solving, communication, and collaboration) coupled with the use of ICT, character education development, and emphasis on spiritual values (Ariyana, Pudjiastuti, Bestary, & Zamroni, 2018).

Education is required to make transformations in order to be able to develop students' abilities in accordance with the formulation of abilities that must be mastered at this time (Arlinwibowo, Retnawati, & Kartowagiran, 2020). The educational approach for students in Science, Technology, Engineering, and Mathematics (STEM) has received increasing attention over the past decade (Honey, Pearson, & Schweingruber, 2014). STEM is considered to be able to align the education process with the demands of the times. In this era the problems faced are increasingly complex and integrative learning STEM is felt to be very suitable with these conditions (Roehrig, Wang, Moore, & Park, 2012) because the real problem is indeed not fragmented in the barriers of scientific discipline (Beane, 1995; Czerniak, Weber, Sandmann, & Ahern, 1999). With integrative learning, student experiences become more relevant to real life (Furner & Kumar, 2007).

The STEM approach began to develop in Indonesia (Arlinwibowo, Retnawati, & Badrun, 2020). In the academic environment, several studies have been conducted to try to search for the effects of STEM implementation in learning. Some research results show that there is a positive correlation between STEM implementation and the quality of student learning outcomes (Khaeroningtyas, Permanasari, & Hamidah, 2016; Putra, 2017; Wisudawati, 2018). In the environment of policy makers and education providers, STEM-based learning training has often begun through the Ministry of Education and Culture, the Center for Development and Empowerment of Educators and Personnel (PPPPTK), SEAMEO QITEP, and universities.

However, education institutions must not implement the concept of learning in a hurry. Learning must still adjust to the applicable curriculum. The 2013 curriculum has the characteristics of scientific learning (Ariyana et al., 2018) and STEM has an engineering design process identity (Kelley & Knowles, 2016). Both of them have specific learning steps. On the other hand, there are similarities, STEM is identical to the project (Chesky & Wolfmeyer, 2015) while the 2013 curriculum mandates project-based learning to be one of the learning models (Ariyana et al., 2018). At present, there is no reference that clearly shows the mixing of the two. Thus, this study aims to synthesize a variety of literature in order to find a formula for STEM student delivery in accordance with the 2013 curriculum.

Research Methodology

This research is a systematic review carried out to conduct a basic study of STEM education implementation in accordance with the curriculum in Indonesia. Researchers compile research results from various journals, theories, and expert opinions contained in a variety of relevant books, handbooks issued by the Indonesian government, and legislation in force in Indonesia. Researchers focus on collecting various literature related to STEM, integrative education, thematic education, project-based learning, and the curriculum 2013 as a curriculum that currently applies in Indonesia. There are 46 selected pieces of literature which will then be used as basic analysis.

The process of screening literature is carried out by taking into account several criteria, namely (1) published between 1996 and 2019, (2) articles are published in a journal, books have ISBNs, and government documents have been authorized by authorized officials or downloaded from official government pages, (4) the substance in the literature accordingly can assist researchers in solving research questions.

Analysis of the results uses thematic analysis for identifying, analyzing, and reporting themes on a data set. According to Braun & Clarke (2006), to carry out thematic analysis, the six phases in thematic analytics are recognizing data, making initial code on data, compiling code to look for themes, examining themes, defining and naming themes, and ending the report of themes by linking them back it to the research question.

STEM Education

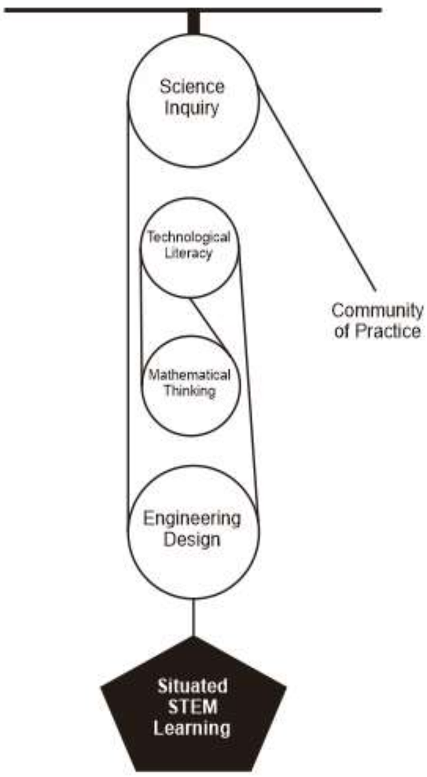
The most common implementation of learning is subject fragmentation. Subjects are taught separately without any focus on the relationship between subjects (Green, 2014), this phenomenon also occurs in Indonesia. The STEM approach emphasizes that fragmentation of subjects must be minimized, especially in disciplines related to science, technology, engineering, and mathematics. The four STEM fields are inherently related so that it will benefit students to learn through contextual projects according to the demands of the times (Chesky & Wolfmeyer, 2015).

The STEM approach is formulated in education with the aim of improving the quality of graduates in global competition. STEM education is a method of learning techniques in teaching the STEM discipline (Ntemngwa & Oliver, 2018). Integrated STEM learning is classroom management (Wisudawati, 2018) and a pedagogical approach of integrating two or more STEM disciplines in a project (Ntemngwa & Oliver, 2018) in authentic contexts to enhance student learning quality (Kelley & Knowles, 2016). Roehrig et al., (2012) said that STEM integration is an approach that builds natural relationships between STEM domains to enhance student understanding in each discipline, make learning more interesting, and expand understanding through relevant contexts. Kanematsu & Barry (2016) state that STEM learning combines STEM disciplines with creativity at all levels of education, formal and informal. Rosicka (2016) believes that STEM education is the umbrella of the STEM domain that is taught collectively with an interdisciplinary approach so as to improve critical thinking skills and problem solving.

STEM education aims to prepare students to be able to compete in the 21st century. Through STEM education, 21st century skills that are critical thinking, creativity, communication skills, collaboration, and independence can be developed through integrated project-based learning (Bybee, 2010). In terms of substance, STEM education aims to find connections between STEM subjects and provide relevant context for learning content (Kelley & Knowles, 2016). In terms of students, STEM education implementation aims to (a) deepen students' understanding of concepts; (b) broadening student understanding through exposure to STEM contexts that are relevant to society and culture; and (c) increasing interest in the STEM discipline and expanding the path for students to enter the STEM field (Roehrig et al., 2012).

Thus it can be concluded that integrated STEM education is a methodical approach to integrating two or more STEM disciplines in one contextual project to mastery 21st century competencies such as problem solving skills, critical thinking, innovation ability, creative thinking, communication, and collaboration.

Picture 1. Illustration of STEM Learning (Kelley & Knowles, 2016)



According to Bryan, Moore, Johnson, & Roehrig one of the characteristics of integrated STEM learning is the practice of engineering and design of technological engineering as a planned process that involves the use of scientific and mathematical concepts through the justification of the design (Shahali, Halim, Rasul, Osman, & Zulkifeli, 2017). STEM integration can occur in various ways in combining STEM disciplines such as emphasizing one discipline more than another, serving informal, non-formal, or informal settings, and involving various pedagogical strategies (Honey et al., 2014). The integrated STEM approach uses real-world contexts to investigate authentic problems using active learning (Hernandez et al., 2014) which leads to increased motivation, and increased achievement in science and mathematics (Furner & Kumar, 2007). The application of the STEM approach to learning also requires a student-centered learning model (Corlu, 2013). Thus it is logical if Herschbach states that an integrated curriculum can improve the quality of learning and make science more relevant to the real world (Green, 2014). (Kelley & Knowles, 2016) describe STEM in a series of pulleys as in picture 1.

The picture shows that the learning process is something that must be raised. The technique of converting natural resources (science and mathematics) so that it can be utilized by humans (Barak, 2012). Engineering design can provide an ideal STEM content integrator (Katehi, Pearson, & Feder, 2009). In addition, engineering design combines engineering practices so as to bring all four disciplines into harmony. The nature of engineering design uses a systematic approach to solving problems in all areas of STEM (Kelley & Knowles, 2016). Technical design in learning is carried out by asking questions, imagine, design (plan), create, and improvements (Lachapelle & Cunningham, 2007; Syukri, Halim, & Mohtar, 2017). But Susan & Delaney (2011) adds an experimental step between the process of testing and improving.

Science is based on certain principles, including empirical evidence and understanding that science is in a context. Science is in-depth and extensive content knowledge (NBPTS, 2016). Science has the ability to transfer scientific knowledge to an authentic situation so that it can be understood. Science learning requires teachers who are able to encourage the development of scientific inquiry skills, curiosity, and openness to new ideas. Scientific inquiry trains students to think and act like scientists, formulate questions, draw hypotheses, and conduct investigations with practice (Kelley & Knowles, 2016).

Technology has a close relationship with engineering. Technology is the home of engineering, where engineering is the process of producing technological products. Practically, technology can increase productivity and effectiveness through the manipulation of knowledge (Barak, 2012). Technology is a process that includes designing, making, and using technology to overcome various problems (Kelley & Knowles, 2016; Kenzhaliyev et al., 2014; Kenzhaliyev et al., 2017; Kassymova, 2018). Technology literacy is the ability to use, manage, assess, and understand technology (Zinn, 2014). STEM educators must provide opportunities for students to think through technology as tools for change with positive impacts on culture, society, politics, economics, and the environment (Kelley & Knowles, 2016). Only by learning technology, students can utilize technology.

The last pulley is mathematical thinking. Burghardt and Hackers state that mathematics is a tool to evaluate patterns and solutions rationally (Kelley & Knowles, 2016). NCTM (2000) provides the formulation of the importance of mathematics, namely (1) Mathematics for life, that is, life is increasingly closely linked to a mathematical pattern. (2) Mathematics as a part of cultural heritage is the result of culture. Many historical relics are documented with mathematical patterns. (3) Mathematics for the workplace that is the world of work really needs a mathematician in modeling various problems. (4) Mathematics for the scientific and technical community that is all fields of science require mathematics in processing information and drawing conclusions.

Thus, in each discipline STEM has its own role in a real problem. The key problem profile at this time is (1) the cause and effect can be explained by science, (2) the patterns of events can be concluded by mathematics, (3) designing a solution to the problem can be done by the engineering, and (4) technology becomes a product as a tool or the result of a problem solving project. To guarantee the implementation of STEM learning, a learning step formula is needed. EDP is a step in the learning process that can guide the STEM learning process so that learning objectives can be achieved.

Integrated Education

The integration is used to describe the nature of the relationship between two or more disciplines included in an interdisciplinary unit. The point to note is that the learning process is carried out based on careful planning and runs on a certain theme by keeping in mind the graduation standards set in each discipline. The focus of learning is to provide a correlation between knowledge and context in an idea (Gehrke, 1998; Lonning, Defranco, & Weinland, 1998). Drake & Burns (2004) states that integrated education is a concept where connections between disciplines (skills and knowledge). The keyword of an integrated curriculum is a collective effort for each form of curriculum that deliberately connects various sciences from various disciplines of study into a unity of knowledge (Fu & Sibert, 2017).

Drake & Burns (2004) divides integration education into three types of approaches namely multidisciplinary, interdisciplinary, and transdisciplinary. The multidisciplinary curriculum has the same theme or the same ability in various disciplines, but each subject is still different and separate. For example, the theme of "identity" can be explored in geography (mapping), history (nationality), literature (characterization), science (classification), and so on (Drake & Reid, 2018). In an interdisciplinary approach, the curriculum governs general learning across disciplines. The curriculum divides general learning that is embedded in scientific disciplines to emphasize interdisciplinary skills and concepts. Each other can be identified, but not considered as urgent as in a multidisciplinary approach (Drake & Burns, 2004). The transdisciplinary curriculum goes beyond scientific disciplines. Learning focuses on pressing questions, problems, or problems so the subject is mixed holistically. There may be focused attention on developing relevant capabilities (Drake & Reid, 2018).

Real-world problems are not fragmented and thus require skills that cross disciplines (Beane, 1995; Czerniak et al., 1999). Thus, various policies throughout the world lead to discipline integration in the curriculum. Based on various research results, the integrated curriculum has a positive correlation with student learning achievement when compared to traditional models (Yoon, Dyehouse, Lucietto, Diefes-dux, & Capobianco, 2014). The benefits of an integrated curriculum can be seen internationally; countries that are at the top of the PISA scale all have policy provisions for integrated education (Drake & Savage, 2016).

Indonesian Curriculum

Indonesia made a curriculum change from KTSP to curriculum 2013 (Retnawati, Munadi, Arlinwibowo, Wulandari, & Sulistyaningsih, 2017; Zurqoni, Retnawati, Arlinwibowo, & Apino, 2018). In its implementation, the curriculum 2013 had the same curriculum and textbook standards for all schools (Sigid & Setiawan, 2018). The purpose of applying the curriculum 2013 is to improve the quality of learning and balance the development of students' attitudes, knowledge, and skills (Kartowagiran, Retnawati, Sutopo, & Musyadad, 2017).

The first character of the curriculum 2013 is the use of a scientific approach in the learning process. The method of inquiry must be based on evidence from observable, empirical, and measurable objects (Ariyana et al., 2018). According to De Vito states that science is learning that adopts the steps of researchers to build knowledge through scientific methods. The learning model needed is a model that develops science thinking ability (Retnawati, 2015).

Teaching steps in the curriculum 2013 include: (a) introduction (greetings, summoning one by one, aperceptions, and motivating), (b) main parts (classics, groups, and individual learning), (c) evaluation (written tests, exercises, improvement and enrichment activities), and (d) Reflections (Sigid & Setiawan, 2018). Scientific learning is carried out with the stages of asking, trying, associating, and communicating (Edelson, Gordin, & Pea, 2011). To strengthen the scientific approach, according to Minister of Education and Culture Regulation No. 22 of 2016 concerning the standards of basic and secondary education processes, school is necessary to apply discovery/inquiry learning. To encourage the ability of students to produce contextual work, both individually and in groups, it is strongly recommended to use a learning approach that produces work based on problem solving (project based learning).

STEM Integration in Curriculum 2013

The first thing that will be solved is to adjust the implementation of STEM education with the Curriculum 2013. Various core components must be synchronized so that it becomes a mutually supportive entity. Learning in the Curriculum 2013 with a scientific approach through observing, questioning, gathering information, processing information, and communicating (Ariyana et al., 2018; Edelson et al., 2011). Whereas STEM education has two special characteristics namely the existence of engineering design (EDP) processes and project-based learning. EDP in learning includes steps starting with asking, imagining, planning, making, testing, and revising for product improvement (Lachapelle & Cunningham, 2007; Susan & Delaney, 2011; Syukri et al., 2017). Project-based learning must be filled with steps starting from asking questions, designing products, arranging schedules, making products, conducting trials, and evaluating learning experiences (Ariyana et al., 2018; Zancul, Sousa-zomer, & Cauchick-miguel, 2017).

Table 1. Core of STEM Education Steps

	Scientific (Curriculum 2013)		EDP (STEM)
1	Observe	1	Ask
2	Ask	2	Imagine
3	Collect the information	3	Plan
4	Process information	4	Create
5	Communicate	5	Experiment
		6	Improvement

The steps for implementing STEM education that is adjusted to the Curriculum 2013 is (1) Identify the problem is the initial stage of implementing STEM-based learning in the Curriculum 2013 is to identify problems. At this stage, students are directed to look at phenomena or events related to themes determined by the teacher. Through these observations, students are expected to be able to identify various problems that occur. Problems are questions that will be used as project directions in learning. (2) Planning a design to answer the problem. The design phase is done after the student is able to identify the problem and can focus on the particular problem to be studied. Thus, students are directed to gather various relevant information as a basis for making project designs. The design includes product design and scheduling design in implementing projects. The design began by making a product design based on student knowledge, then students make an estimate of the product manufacturing schedule. (3) Making products. Students realize the design that refers to the planning that has been prepared in the previous stage. (4) Trial of the product and evaluations. Products will be tested to know their quality. The results of the trial will produce various data that can be analyzed. That analysis result can be used as a material to conclude whether there is a need for improvement or not. (5) Revising the product based on the conclusion of the trial results so students focus on several sections to be revised. These improvements aim to make the product function better. (6) Summarizing and communicating findings. After the final product is declared final, students are directed to make conclusions based on the process that has been passed, including why revisions must be made. The teacher conditions students to be able to deduce the results of the project in the domain of science that is being targeted (Science, Technology, Engineering, and Mathematics). The findings were presented in front of other friends and carried out a discussion with each other.

In points 4 to 5, it can be repeated steps to be able to produce the best product (if the revision is still not optimal). Next, the thing that must be considered is the STEM integration approach in the learning process in accordance with the curriculum. At present, the curriculum that applies in Indonesia is the Curriculum 2013 where the concept of learning in thematic elementary schools (for some thematic subjects) while junior and senior high schools use the concept of fragmentation between subjects. Thus the transdisciplinary approach is not suitable because it does not pay attention to every discipline. A suitable approach is multidisciplinary and interdisciplinary. They can still identify each discipline so that the final report on student learning outcomes for each subject can still be administered.

Conclusions

The literature review produces a learning syntax that aligns between EDP Steps in STEM, Scientific Method in Curriculum 2013, and project-based learning steps. The syntax of implementation STEM in Curriculum 2013 is identifying problems, designing designs to answer problems, making products, conducting product trials and evaluations, revising products, concluding and communicating findings.

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Upgrading Quality of Learning with E-Learning System

Abstract: This article studies different ways of learning. Behavioral, cognitive, constructivist learning, multiple learning styles, e-learning, and brain-based learning are interrelated with each other and teachers should ensure that all students should be involved in all types of learning styles to get learning outcomes. The Covid-19 pandemic has forced governments around the world implement policies to limit face-to-face meetings with community activities. This makes community activities carried out virtually. It also happens in education system, teaching and learning activities which are usually carried out in classes face to face, this time have to use the internet as a learning medium. E-learning environments create lessons interactive. Knowledge is integrated from many different sources when students are learning something. The result of this study by analyzed ways of learning is five *learning approaches*. The stages of learning approaches are student to be active, engaged in the learning process, increase previous knowledge, explore the situation, and to be motivated. Nevertheless, use of the internet for learning or e-learning also cannot be separated from various deficiency and emerging issues within the higher education context.
Keywords: education, e-learning, students, approach, and teachers.

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Introduction

As Skinner (1958) stated that education must be efficient for every student. Till to date, Skinner's observation of school education has not lost his relevance yet (Flindt, 2005, p. 61). The curriculum must be revised and learning materials must be improved for efficient learning.

Student-centered learning strategies, models and methods will encourage the development of knowledge and burnish students' skills. According to Wagner in Suartama (2014), knowing the global development, know information and remember facts are not enough for students, but they must be able to think critically, solve problems, and have skills in communicating and working together. In addition, students must also be able to adapt, have the initiative, and be able to access and analyze information.

The Covid-19 pandemic has forced governments around the world implement policies to limit face-to-face meetings with community activities. This makes community activities carried out virtually. It also happens in education system, teaching and learning activities which are usually carried out in classes face to face, this time have to use the internet as a learning medium.

The use of the internet as a learning medium requires schools, teachers and students to be able to use modern information and communication technology in order to achieve the purpose of learning. Schools need to make policies in determining the right media or e-learning to be used in learning activities. E-learning is learning that utilizes the support of internet technology. In e-learning, teachers do not just upload learning materials that can be accessed online by students, but teachers also evaluate, establish communication, collaborate, and manage other learning aspects (Suartama, 2014). Teachers and students must be able to understand the concept and use of e-learning to create active, innovative, creative, effective, and fun learning. Through e-learning, learning materials can be accessed anytime and from anywhere. In addition, the material can be enriched with various learning resources including multimedia and quickly updated or edited by the teacher.

E-Learning provides a flexible learning environment, it requires more than just transforming learning material into web-based environments and learning online. Successful implementations of e-learning environments require an understanding of the technology and pedagogy integration for learning to take place effectively (Kahiigi, Ekenberg, Hansson, Tsubira, Danielson, 2008). An effective e-learning strategy needs to focus on effectiveness as well as efficiency, and it needs to integrate all the available technologies for ensuring a capable organization. Strategies that focus on one-for-one substitution of e-learning for platform training are ultimately doomed to failure (Rosenberg, 2002. According to Ally in Suartama (2014), the development of learning materials in e-learning needs to consider three well-known learning theories, namely: behaviorism, cognitivism, and constructivism. These three theories can be used as a taxonomy of learning, for example behaviorism theory to teach facts (what), cognitivism theory to teach processes and principles (how), and constructivism theory to teach higher intellectual activity (why).

Research methodology

*Behavioral learning. L*earning is the acquisition of new behavior. John B. Watson used this term in the realm of educational psychology for the first time in the USA. This method of learning is called conditioning. There are two types of conditioned learning. The first one is called *classical conditioning*. Experiment on classical conditioning was initially conducted by a Russian psychologist, Ivan Pavlov with means of a bell to make dogs salivate before feeding them. Pavlov identified 4 stages of the process of conditioning: *acquisition, extinction, generalization* and *discrimination*. Another type of behavioral learning is called *operant conditioning*. B. F. Skinner is the most famous psychologist for this type of learning. He used a lever device which was a reward system for animals; as a result of pressing a lever in the box, animals got a pellet of food. This way of learning is more powerful and flexible because of its positive and negative *reinforcement, reward* and *shaping* processes. Skinner states that immediate feedback has great importance for reinforcement of programmed learning (Alan Pritchard, 2009, p. 5-13). For instance, nowadays e-learning materials enable such conditions to indicate whether a student is successful with the question reply or not, by active flashing on the computer display; self-paced e-learning has a potential to be powerful because a student studies materials in bite-sized pieces on his own pace.

Constructivist learning. Cognition is a high level of behavior. It is about to think and understand a situation and accordingly act. *Cognitive learning* is related to the mental construction (Arpentieva et al., 2021). Cognitive learning is a mental process such as learning, perceiving, remembering, speaking, solving problems, critical thinking, analyzing and so on (Shanty et al., 2018; Mustapha et al., 2019). Constructivist learning takes place when new information is built and added to the current knowledge, understanding and both mental and physical skills. Prior knowledge plays a key role in learning. Learners are able to learn something when they are active in the learning process. Constructivist learning was initially developed by Jean Piaget. He studied 4 stages of child cognitive development; this formed the basis of the constructivist movement. He concluded that students should actively construct their knowledge. Learning is an active mental process (Woolfolk, 1993). *A socially constructive approach* takes place in pair conversation. Learning occurs by anyone who is more knowledgeable in different environments, not only in the classroom. Any social interaction may lead to the learning process. Vygotsky's work offered proximal development, which means that a learner accumulates more theoretical knowledge by a more knowledgeable person and may act more effectively (Alan Pritchard, 2009, p. 17-29).

So, constructivism is a thought or view of the formation of knowledge with the active participation of learners (Candra, & Retnawati, 2020). Thus, constructivism is considered as the process of acquiring knowledge through the active adaptation of individuals to the environment (Piaget, 1936). Moreover, constructivism is part of the process of social interaction outcomes as knowledge construction (Vigotsky, 1978). In the e-learning environment, students should be independent learners, which means that they will be active learners and interact with the virtual environment. Researchers state that online materials are widely accepted as a useful and effective tool, especially, in the field of language acquisition. In addition, digital technology increases the interest and motivation of students in the social sciences (Lai & Lin, 2020). Prior knowledge and social interaction are a crucial part of learning.

Learning styles. To open students' full potential, it is also essential to rely on Howard Gardner's *multiple intelligence theory* (Gardner, 1993). Students should be taught by the different ways of learning to get learning outcomes. Nowadays, e-learning may enable such learning multiple environments by means of Internet resources. For instance, there was a case study about the successful learning outcomes of online language proficiency in the EF English Live online platform for adult education (Kenzhaliyev et al., 2020; Kassymova et al., 2020). This study concluded that it is important to have a piece of prior knowledge and intrapersonal motivation in order to learn online. Online education is useful for personal self-development as well as cognitive development (Kassymova et al., 2020). Once students become actively engaged in e-learning environments, they develop a sense of control and motivation to self-development. There are many learning styles for individuals and different models depending on the learners' personalities. For instance, the Honey-Mumford Model which includes 4 stages such as activist, reflectors, theorists and pragmatists. Table 1 gives a brief pictorial explanation of different ways of learning. Problems can arise for teachers when they convey knowledge in one way that they consider every student will understand; there is also a drawback if a learner gets used to accumulate a piece of knowledge in his learning style, he will refuse other teaching approaches when he studies in a group of students (Alan Pritchard, 2009, p. 55). That is why it is essential for teachers to implement all the possible learning styles in the classroom.

Table 1 Ways of learning

Behaviorism	
Classical conditioning by I. Pavlov	Operant conditioning by B. F. Skinner
Constructivism	
Cognitive constructivism by J. Piaget	Social constructivism by L. Vygotsky
Learning styles	
Teaching approaches for various temperaments: *Extroverts, introverts, sensors, intuitors, thinkers, feelers, judgers, perceivers by Briggs & Myers*	Multiple intelligence theory by Gardner: *Linguistic, logical, visual, bodily/kinaesthetic, musical, interpersonal, intrapersonal, naturalistic learners*
Brain-based learning	
Memory and stress-free learning	Left and right hemispheres

Brain-based learning. Learning takes place in the brain. It is apparent that the brain is divided into two *hemispheres: left and right*. The brain divides learning between visual and verbal tasks. Reading and learning from the context take place in the left hemisphere whereby the right one enables learning via visual means (Döring, K./Ritter-Mamczek, p. 161, 1997). Successful teachers engage students in both learning tasks in order to generate both sides of the brain. They should also pay attention to the memory activities which should be meaningful in the learning context. O'Keefe and Nadel's (1978) model describes *taxon/locale and spatial/autobiographical types of memory*. The first type is motivated by rewards and punishments; the second one is related to associations, especially when a person experiences some events.

To organize a stress-free environment is very important for both teachers and students. From the historical perspective, it is obvious that teachers were strict with their learners and used some kind of punishment. Stress is a kind of emotion that slows down the learning process. Reavis (1999) tried to explain in his book called ‘The Animal School’ that teachers should pay attention to each student's ability and not force students to do what they are not capable of. Each student is an individual and unique. The learning process should be focused on the student's learning style and create an atmosphere where students can develop their strengths by using their abilities. Learning is a social process, it should be organized in the way of interaction; the content of learning materials should be meaningful for students and related to their previous knowledge to get good learning outcomes. Table 2 indicates philosophical assumptions in different learning ways with implications for practice by John W. Creswell (2013).

Table 2 Philosophical Assumptions with Implications for Practice by John W. Creswell (2013)

Assumption	***Questions***	***Characteristics***	***Implication for Practice***
Ontological	Are behavioral learning methods widely used in e-learning environments?	Behavioral learning is a change in knowledge and skills in a positive way. As a result, a student will learn something new in order to achieve his own goal. The learning process is conditioned by reinforcement and habit.	Immediate feedback given after reading a text plays a key role in computer-based education system; a student answers several questions online and gets the learning outcomes at once without waiting for a teacher next time in the classroom.
Epistemological	What is a teacher’s role in cognitive development while students are studying?	Learning is a mental process. It should be always developed by a learner. Learners should be engaged in the learning process by being active and interested or motivated to learn something new and accumulate new information to the current one. Additionally, more knowledgeable teachers or trainers play a key role in cognitive development in order to encourage students in the right way of learning.	Blended learning style might be an excellent example of cognitive development of students. In the classroom, they will be engaged in the proximal development by their teachers and out of the classroom, students will explore for more information to solve the assigned academic task; here the information technology is of great importance if used properly.
Axiological	What is a role of the brain in learning?	The brain controls all the process which takes place in our body. It is believed that the brain is divided into left and right hemispheres and each of them is responsible to learn specific academic tasks.	Since each part of the brain works differently, teachers should include all the academic tasks in their curriculum which operate students' brains for beneficial learning.
Methodological	What is the value of multiple teaching approaches?	A sensitive teacher will convey knowledge to students in the way of the comfort zone. Students will be able to demonstrate and develop their strengths in the learning process.	Nowadays, e-learning environments may be a good example of learning in the comfort zone. Students may study at their pace at any time.

E-learning environments. The XX-th century changed learning ways from traditional campus-based education to e-learning (electronic learning). It is obvious that the e-learning system has become functional because of the current global pandemic COVID 19 which has been influencing the Kazakhstani education system as well since March 2020. All education systems switched from class-based learning to distance education without educational institutional preparation (Arlinwibowo et al., 2020). Flindt (2005) indicated *three stages of e-learning*: stage 1 is related *to learning context* in different online forms such as HTML or PDF; stage 2 refers to *communication elements* such as *synchronous* (video, telephone, or web conference) and *asynchronous* (emails); stage 3 is *supported by teachers via information communication technology*. For instance, EF English Live platform is considered to be the world's most advanced cloud based school (Figure 1). Digital education has been available to a large number of students in comparison with traditional education for affordable prices or even for free charge. In addition, e-learning materials have been advanced from simple to complex academic tasks. *The most valuable feature of e-learning is that students will experience different social-cultural communication*. As can be seen from Figure 1, students from the world have access to this platform and participate in virtual learning, and a teacher manages the e-learning environment. Students have an opportunity to choose their own methods of learning. In the virtual classroom, the learning atmosphere is almost the same as at face-to-face lessons. There are multiple functional buttons for raising hands if there is a question or to listen if a student does not want to speak. There is also an instant chat display which can replace the traditional blackboard.

Figure 1 E-learning environment in EF English Live

E-learning related to behaviorism. Programmed instruction, introduced by behaviorist B.F. Skinner, is a system whereby a student learns on his own via specially prepared books or equipment without a teacher. The goal of this program was to free teachers from burdensome drills and repetitive problem-solving inherent in teaching basic academic subjects like spelling, arithmetic, and reading.

Skinner focused his programmed instruction on the principle of operant conditioning, which theorized that learning takes place when a reinforcing stimulus is presented to reward a correct response (Bower & Hilgard, 1981). One of the advantages of e-learning is that a student gets immediate feedback on the tasks. It was Pressey who first emphasized the importance of immediate feedback in education and proposed a system that enables students to learn at his own pace. Pressey also pointed out that teaching machines increase effective learning outcomes (Skinner, 1958, p. 969). There are two types of learners: fast and slow. They were not taught equally enough at traditional lessons, and e-learning environments permit each student to learn at his rate which is another upside of digital education. E-learning advantages are outweighed by these or other considerations in the way of individual learning.

Online games in the classroom. Recent research by Ellison et al. (2016) has shown that online games develop collaborative learning, critical thinking, and problem-solving skills among youth. Applying online games such as in schools is significant in the digital era. For instance, students benefit from Minecraft to enhance learning activities in science, technology, architecture, physics, engineering, math and as well as linguistic skills such as writing, speaking, listening and reading. Additionally, teachers benefit from using Minecraft as a teaching tool in the classroom to increase academic engagement with students. Online games have the potential to push a player to think cognitively and to interact socially with others. Players creatively build their new virtual world; they participate in complicated problem-solving tasks. This study recommends online games to be implemented in the classroom as a teaching and learning tool for motivation and to improve academic activities. As Piaget (1951) stated that play is a significant mediator for learning and socialization.

“My hypothesis is that in the future the gaming industry will blow up the whole world. For example, with VR glasses, you can immerse yourself in the virtual world, and feel the essence of the game. For instance, Figure 2 was built by me and I got experience in how to work on

architecture. In the future, you will be able to enter the game, and feel the meaning of the game, feel and sense different things. For example, how it rains or you feel cold and warm, you can get injured in shooters or feel the emotions of characters. Adults say that games do not develop thinking, that games take time and disturb functions of the brain, but I think that if you create a game that would develop children with cerebral palsy, then the world would already open up the future. I got this conclusion from my experience in video games, for 6 years I have played different games. At first, I played Minecraft, and after nine years I started playing shooters like Critical ops created by the Finnish developers of Critical Forse, after that, I switched to CSGO. This is how I got my 6 years of experience in the field of video games. A lot of new things should be created that people like and develop their thinking skills and abilities like in Minecraft or discover leadership skills like in CSGO", shares a pupil, Farid Vafazov, with his experience on online games from I.V. Panfilov Kazakh-Russian Specialized School-Lyceum №54 in Almaty, Kazakhstan.

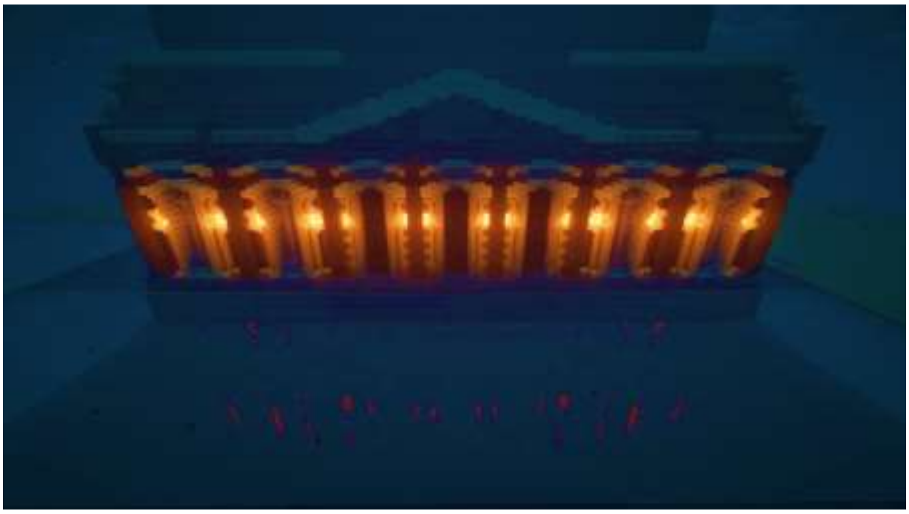

Figure 2 A house built by a gamer in Minecraft online games

E-learning related to cognition and brain. The latest cognitive theories confirm that the brain is identical to the computer. The cognitive theories are divided into three streams such as *thinking psychology, action theory approach,* and *neuroscience learning research*. The thinking psychology emphasizes that there is not only language, logic, perception, memory, and problem analysis in this theory but also meaning and comprehension play a key role (Flindt, p. 66, 2005). The action theory approach is related to psychological internal and external actions. According to Leontjew (1977), internal action is a reflection of external action. These actions require a cognitive analysis and exact realization notes, action strategies, and knowledge about what, how, why, etc. this action will be processed (Rosemann, 1974). It is apparent that according to the current neuroscience learning research, the brain is a central organ for learning something new. Nerv cells are specialized on the information process and its storage in the brain. Regardless of our needs, we always learn something new (Spitzer, p.18, 2003). Younger students learn faster than the elder students who will learn everything based on their life experience.

E-learning materials are widely used in education fields such as linguistics, psychics, aviation, psychology, medicine or business, etc. For instance, there are different chatbots that are beneficial to use for people who feel stressed or depressed. Chatbots can support communication with people. A "chatbot" or "bot" is an artificially intelligent software program that uses natural language processing to simulate an intelligent conversation with end-users via auditory or textual methods. Many bots are programmed to act like humans so that when a person interacts with them it feels like asking another person for help in communication (Patent, US10025567B2, 2018-2037). E-learning materials are very beneficial in the learning process. For example, educational simulations enable students to conduct an experiment in the virtual environments that they learned from the theory.

"Simulations are a great way to teach students to make decisions with ambiguity because they've taken all kinds of courses over the years, they've been tested, sometimes with cases, sometimes using regular tests; but this allows them to use the full range and make decisions," says John Kraft, Susan Cameron Chair of International Business, Warrington College of Business,

University of Florida / Visiting faculty, Aalto Mikkeli (https://www.cesim.com/).

E-learning environments create lessons interactive. Knowledge is integrated from many different sources when students are learning something. Regular subject-based courses are narrower and they may focus on the textbook or lecture. But in e-learning, students will try to pull together rather uncertain information from different sources via the internet.

E-learning environments might be implemented in the technical engineering industries as a simulator. Developed research technologies obtained by professional researchers in real time can be applied in digital environments for the purpose to avoid the danger of chemical reactions (Kenzhaliev et al., 2014; Kenzhaliev et al., 2017). Such an approach not only protects human beings from dangerous metal reactions and also increases future young engineer researchers' competency (Kassymova, 2018). Students can master their skills in the online simulators before starting working in the laboratories (Kenzhaliev et al., 2017).

Research findings

Having analyzed ways of learning, the authors offer five *learning approaches* as a result of this study. This requires students to be active, engaged in the learning process, to increase previous knowledge, to have needs and intrapersonal motivation for self-development; learning takes place in the brain and teachers should ensure that the curriculum should include different academic tasks for the left and right hemispheres operations. ….

Learning appchoach includes the following stages for students:

- To be active
- To be engaged in the learning process
- To increase previous knowledge
- To explore the situation
- To be motivated

The trend topic of e-learning has undergone an enormous change in recent years. If you look from the beginnings of e-learning to the present, from a technical point of view there is a change from simple behaviorist-oriented learning programs to today's complex learning platforms with online learning communities such as web classes, database connections, and interactive learning content. Researchers predicted in 2005 that the concept of e-learning would evidently embark on a new campaign of conquest in the next few years in Europe. However, success only seems possible if one knows the mistakes of the past and does not repeat them. The problems of the previous e-learning included technical problems, lack of involvement and relevance for everyday work, lack of social contacts, problems with on-the-job learning, badly designed and pedagogically and didactically immature e-learning courses and inadequate self-learning skills of the participants (Flindt, 2005, p. 354-355). In this study, it is obvious that e-learning environments are dramatically improved and benefit learners with the convenience of learning.

Another study (2018) conducted an experiment on cognitive development in e-learning and concluded that Bloom's taxonomy is an incredibly powerful tool at all levels of the education system in terms of e-learning environments to develop students' behavior and get a better learning outcome. The basic goal of the e-learning industry is to make the teaching and learning process easy, active, and enjoyable. Such an approach enables students to become problem solvers and critical thinkers which is the top aim of the Blooms' taxonomy concept (Ratniece, 2018).

Nevertheless, use of the internet for learning or e-learning also cannot be separated from various deficiency. First, lack of interaction between teachers and students or even between students themselves. This lack of interaction can be detaining for achieve the learning objection. Second, students who do not have high motivation will be left behind, even can be fail. Third, not all places have internet facilities. According to (Kahiigi, Ekenberg, Hansson, Tsubira, Danielson, 2008), There is emerging issues within the higher education context: (1) identifying pedagogies underlying online courses. (2) improving ICT (Information and Communication Technology) skills for both teacher and student. (3) Technology use mostly for teacher that being too traditional in their teaching strategy and unwillingness to adopt change. (4) Management support, because e-Learning initiatives require full commitment and support from management for their operationalization and sustainability.

Conclusions

Learning is a cognitive process and it cannot be seen or touched. Learning outcomes are measured by an education assessment system. Telling is not teaching, students should be actively and socially engaged in the learning process. It is obvious that without active social engagement and motivation, effective learning for students is far less likely to be good learning outcomes regardless of the form of education, age, or sex of students whether it is an online or traditional lesson or self-study. In addition, there are prospects in online games, they should be studied properly in order to discover a lot of new things in the online education industry. Learning should take place in stress-free environments since learning is a social brain-based process; it should be also flexible and offer multiple opportunities for students to work alone or in the team.

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Processing and production of pellets from poor-grade manganese-containing raw materials

Abstract: there is a review of current researches in the processing of poor-grade manganese raw materials. The variety of manganese minerals caused by the valent state of metal in compounds is demonstrated. Different processing methods for manganese-containing mineral and technogenic raw materials are considered. The process of extraction of manganese from ferruginous manganese ore using reduction roasting and magnetic separation, beneficiation technology of poor-grade manganese ore to improve the ratio of Mn/Fe; processes of beneficiation and sintering of fine ferruginous manganese ore with low manganese content; production of agglomerate from the concentrate of manganese poor-grade ore to produce ferrosilicon manganese are described. Results of the authors researches intended to obtain concentrate from manganese-containing sludge and to produce hardened pellets suitable for melting into ferromanganese on its basis using a new component of the binder are presented.

Keywords: poor quality manganese raw materials, beneficiation methods, manganese concentrate, agglomeration, manganese pellets

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Increased demand for manganese alloys and compounds for various industries drives the need to develop and improve manganese beneficiation technologies, including poor-grade manganese ores

World manganese resources are divided into three main categories: oxide, siliceous, and carbonate ores under beneficiation characteristics [1]. The choice of the appropriate beneficiation process depends on the gangue minerals and their association. The gravity separation techniques are applied to siliceous ores and are used industrially in India and Brazil. Iron minerals are always present as impurities in all types of manganese ores; however, they are successfully removed via various magnetic separation processes. Carbonate ores are mainly found in Ukraine, China, and South Africa, and these ores are enriched mainly by gravity and magnetic separation. The type of ore also plays an important role in the alloying process.

Due to the decreasing resources of rich manganese ores [2], the use of poor-grade ores and technogenic raw materials in industrial processes is of great importance nowadays. Fine-grained raw materials with low manganese content and manganese-containing tailings result from mining, crushing, and beneficiation of ores with high manganese content.

Manganese is an important alloying element in the production of special alloys and is also used for sulphur fixing and as a deoxidant in the traditional production of carbon steel [3].

Manganese oxide, silicate, and carbonate ores are mainly mined as raw materials for steel production where Mn is mainly added as ferroalloys (approximately 90 %) but they are also used for the production of batteries and to a lesser extent for the production of fertilizers and pigments. Increased consumption of manganese and its compounds has led to increased production of manganese.

The raw material mined as a raw material for blast furnaces or arc furnaces and sometimes for sintering or pelletizing is often manganese oxide, but manganese silicate and manganese carbonate minerals are also present in significant concentrations. The mineral and chemical compositions of manganese ore are complex in composition and texture as manganese can be present in a divalent, trivalent, or quadrivalent state. In addition, manganese minerals include other elements (e.g. K, Na, Fe, Mg, Al, Si, and Ba) (Table 1).

Table 1. List of common Mn minerals and their composition (formed by the predominant valent state of Mn)

Mineral	Formula
Pyrolusite	β-MnO_2
Ramsdellite	γ-MnO_2
Nsutite	$(Mn^{4+})_{(1-x)}$ (Mn^{2+}) $O_{(2-2x)}$ $(OH_{2x}$
Hollandite	$Ba(Mn^{4+}{}_6, Mn^{3+}{}_2)O_{16}$
Coronadite	$Pb(Mn^{4+}{}_6, Mn^{3+}{}_2)O_{16}$
Cryptomelane	$K(Mn^{4+}{}_7, Mn^{3+})O_{16}$
Manjiroite	$Na(Mn^{4+}{}_7, Mn^{3+})O_{16}$
Romanecite	$(Ba, H_2O)_2(Mn^{4+}, Mn^{3+})_5O_{10}$
Vernadite	$(Mn^{4+}, Fe^{3+}, Ca, Na)$ $(O,OH)_2{\cdot}n(H_2O)$
Byrnessite	(Na, Ca) 0,5 $(Mn^{4+}, Mn^{3+})_2O_4{\cdot}1{,}5(H_2O)$
Hydrohetaerolite	$(Zn, Fe\ 2^+, Mn^{2+})$ $(Mn^{4+})_3O_7{\cdot}3H_2O$
Lithiophorite	(Li, Al) $Mn^{4+}O_2(OH)_2$
Manganite	γ-$Mn^{3+}OOH$
Brownite-I	$(Mn^{2+}, Mn^{3+})_6(SiO_4)O_8$
Brownite- II	$Ca\ (Mn^{3+}, Fe^{3+})_6\ (SiO_4)O_8$
Bixbyite	$(Mn^{3+}, Fe^{3+})_2O_3$
Marokite	$CaMn^{3+}{}_2O_4$
Hausmannite	$Mn^{2+}(Mn^{3+})_2O_4$
Iacobsite	$(Mn^{2+}, Fe^{2+}, Mg)(Fe^{3+}, Mn^{3+})_2O_4$

The degree to which impurities of other elements in manganese ore minerals influence their microhardness is difficult to assess because microhardness data for common manganese ore minerals usually do not include relevant information on their chemical composition.

The physical, mineralogical, and textural properties of manganese ore minerals are known to influence their thermal properties and hence their high-temperature behavior during agglomeration or alloy production.

Manganese minerals are often interchanged or closely intergrown on a micron-scale (e.g. nsutite and cryptomelane), therefore knowledge of the chemical composition of minerals, the texture of minerals, and the nature of intergrowth of small minerals is necessary to determine the processing of manganese raw materials.

As a rule, ores with a manganese content of more than 30% and a manganese/iron ratio of more than 5 are required for the production of manganese alloys. Ores with low manganese content (≈12 % and less) can be used in the production of manganese cast irons.

Due to the decrease of rich manganese ores (> 30 % Mn), attempts have been made to use poor-grade siliceous manganese ores to produce SiMn alloys. In addition, many countries such as China, India, and Russia do not have ores with high manganese content.

In the production of SiMn alloy, silica manganese ores are first reduced with carbon in a blast furnace with an operating temperature range of 1250-1350 °C to remove the iron component due to the melting difference between the manganese silicate slag and the iron slurry.

Roasting followed by magnetic separation is used to increase the Mn/Fe ratio in poor-grade manganese ores. The magnetic separation process requires more advanced and expensive equipment, but has advantages such as ease of use, environmental compatibility, and low further operating costs.

In the roasting process, the manganese oxide and iron oxide are reduced in stages to MnO and Fe respectively. When magnetic separation is used, products can be enriched to produce magnetic concentrate and non-magnetic residue, respectively.

Research on manganese ores has mainly focused on the recovery of manganese by metallurgical methods. In developing methods of complex utilization of ferruginous manganese ores it has been found that crystalline substitution of Fe and Mn can easily occur between manganese and iron oxides, forming spinel-type manganese ferrite with strong magnetism.

The influence of mineralogy on the magnetic separation of manganese minerals has been described, while data on manganese beneficiation using dry magnetic separation from ferrous manganese ore (poor-grade high iron-manganese ores) is limited.

Numerous studies have been conducted on the use of electrolytic manganese residues (EMR) [4]. The effective use of electrolytic manganese residue (EMR) resources can not only bring environmental and social benefits but also economic benefits from the operation of electrolytic manganese residue (EMR) facilities.

In terms of catalytic activity, the most promising mineral manganese oxide is cryptomelane, which has been the subject of some fundamental research in recent years. The versatility of cryptomelane-based materials is due to their high porosity, acidity, hydrophobicity, electronic and ionic conductivity, as well as easy removal of lattice oxygen and reduction ability.

Thus, low Fe and Mn iron-manganese ores can be concentrated using mineral separation techniques such as physical separation, including gravity, washing, magnetism, flotation and leaching, smelting, and carbothermal reduction roasting followed by magnetic separation or acid leaching. In addition to the carbothermal reduction firing that has been used in recent decades, the reduction behavior of Fe and Mn oxides exposed to reducing agents such as solid and gaseous reductants (CO, H_2, CH_4, graphite, coke, biomass, coal).

A study [5] presented the results of microhardness tests on manganese ore minerals from several different types of manganese ores with different mineralogical properties and textures. The data obtained show that there is a clear relationship between mineral microhardness and porosity, microcrystallinity from micro- to nanometres, resulting in large variations in microhardness for some common manganese ore minerals. For example, cryptomelane with lower reflectivity and higher nano- and microporosity has a significantly lower microhardness (average 267 kg/mm^2) than cryptomelane with higher quality reflectivity (average 629 kg/mm^2).

This study showed that microhardness of important and common manganese ore minerals is not only a factor determining mineral properties such as mineral type and crystal structure but also properties that vary within a mineral - crystallinity, crystal size, and micro- and nanoporosity of an individual mineral crystal. Furthermore, micro-hardness affects the extent to which certain phases can affect the behavior at high temperatures and the tolerable moisture limit during bulk transport of fine-grained ore due to differences in the water-holding capacity of different minerals and different forms of the same mineral.

The microhardness of manganese ore phases can be used in combination with physical testing methods to better determine the relationship between mineral and ore particle texture types and porosity, the permeability of the bulk sample. An integrated approach to determine the relationship between mineral (particle) texture, microhardness, and process characteristics such as CO reduction reactivity in an electric furnace has been proposed.

In [6] beneficiation of two different Indonesian low-grade manganese ores was carried out by gravity separation and reduction roasting followed by magnetic separation to improve their Mn/Fe ratio. The effect of particle size and reductive roasting temperature in the beneficiation process was determined. X-ray fluorescence and X-ray phase analysis methods were used to characterize poor-grade manganese ores and beneficiation products. It was found that manganese oxide in the form of pyrolusite (MnO_2) is easier to enrich with increasing Mn/Fe ratio than in the form of pyroxmangite ($MnSiO_3$) and grossular manganese ($Ca_{1,3}Mg_{0,1}Mn_{0,8}Fe_{0,8}Al_2(SiO_4)_3$. At optimal conditions of beneficiation of poor-grade manganese ore – reduction roasting at 700 °C followed by magnetic separation process - an increase of Mn/Fe ratio from 1.39 to 4.0 was achieved.

Poor-grade iron-containing manganese ore is a potential source of solid waste. In a study [7], a reductive slurry roasting and magnetic separation (SRMS) technique was used to treat iron-bearing manganese ore for complex extraction of iron and manganese. The phase transformation of minerals during roasting was investigated using an X-ray diffraction analyzer (XRD) and a high-resolution transmission electron microscope (HRTEM). At optimal conditions – reduction temperature 680 °C, reduction time 30 min, CO concentration 20 %, particle size 0.9 mm obtained iron concentrate with the iron content of 67.38 % and recovery rate of 87.14 % and manganese concentrate with a manganese content of 30.51 % and recovery rate of 87.02 %. Magnetite converted from hematite was enriched into magnetic separation concentrate and manganosite converted from pyrolusite and brownite into magnetic separation tailings. SRMS allows full use of the iron-bearing manganese without residue.

Studies on characteristics of beneficiation and agglomeration have been carried out to develop a strategy to use the typical Indian fine-grained manganese ore [8-10]. The main mineral phases detected are pyrolusite, hematite, goethite, clay, feldspar, and quartz. QEMSCAN and Sink-Float studies have shown that 40 % of the manganese minerals are in liberated form, while 30 % are associated with iron minerals. Classification followed by a two-stage high-intensity magnetic separation process (1.7 and 1.1 Tesla) resulted in 35-40 % ferromanganese material with 47-49 % Mn recovery. The material was briquetted with molasses (7 %), cement (3 %), and bentonite (1 %). The resulting sinter is suitable for use in smelting furnaces in metallurgy. An economically efficient technological scheme has been developed.

The paper [11] discusses the production of agglomerate from poor manganese ore concentrate for the production of ferrosilicon manganese. It was discovered that the chemical composition of Jezda concentrate used in ferrosilicon manganese production was 30-32 % Mn and 28-30 % Si. The optimum rate of coke fines during sintering was 9 %.

We studied the beneficiation of technogenic manganese-containing raw materials with coarseness less than 5 mm. It was found that the main valuable minerals of the feedstock are psilomelane, pyrolusite, bementite; among the rock-forming minerals, quartz and kaolinite, often saturated with fine iron compounds, predominate.

Beneficiation of manganese sludge of particle size class - 0,071 + 0 mm on a laboratory concentrator table was carried out. The possibility of obtaining fine manganese concentrate with a manganese content of 28.57 % and iron content of 10.69 % with recovery 68,5 % and 72,37 %, accordingly. Manganese pellets were produced from the obtained manganese concentrate with grain size less than 2.5 mm using a new binder component - natural material.

The results of X-ray phase analysis of manganese-containing pellets fired at 1150 °C showed that when kaolin is used as a binder, phases of jacobsite, ulvöespinel, ferrian, and ferrous bustamite are formed in the charge during firing. The ulvöespinel, ferrian is a complex spinel phase. Appending a new binder natural material into the charge somewhat changes the phase composition of the firing product and contributes to the formation of the following phases: jacobsite, bustomite, instead of spinel phase appears hedenbergite – pyroxene of complex composition. The combined appending of a high-iron binding agent and lime increases the content of jacobsite to 84.4 %, whereby only two phases are formed: an oxidized form of manganese-iron compound (jacobsite) and complex hedenbergite. The pellets produced are suitable for further metallurgical processing - smelting into ferromanganese.

To sum up, the results of studies by foreign and Kazakh authors have shown the possibility of processing low-quality manganese-containing raw materials using new technological solutions.

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On the possibility of flotation processing of technogenic gold-containing waste from enrichment plants

Abstract: The aim of the work is the flotation processing of gold-containing tailings using composite flotation (CF) agents. According to the results of chemical analysis, the studied tailings sample contains 0.39 g/t gold. The main part of the initial tailings sample is represented by rock-forming minerals such as quartz, clinochlore, microcline, tremolite, albite, calcite, and muscovite. According to the results of the rational analysis, 39.50% of gold is in the hard-to-recover form with quartz; 28.87% is in the form of fine-grained gold; 31.63% is in intergrowths with sulfides and rocks. The optimum reagent scheme of flotation processing of tailings was chosen: degree of regrinding of 95% of grade -0,074 mm, consumption of sodium butyl xanthate of 100 g/t, consumption of foaming agent T-92 of 30 g/t. Under the chosen reagent scheme the gold-containing concentrate containing 6,4 g/t gold at the recovery of 49,68% was obtained. Preliminary regrinding of tailings allows to increase the gold recovery in the blanks concentrates by 27.96%. The reagent scheme of flotation of gold-containing tailings with the application of composite flotation (CF) agent was tested. A composition of sodium butyl xanthate and reaeflot was used as a composite flotation reagent for the improvement of gold extraction from flotation tailings. Application of composite flotation (CF) agent pre-treated on the dispersant increases gold recovery into gold-containing concentrate by 4.65%, in comparison with the basic collector sodium butyl xanthogenate. Consumption of flotation agent CF is reduced by 20%.
Keywords: anthropogenic waste, flotation, composite reagent, concentrate.

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Introduction

Over the many years of mining enterprises' operation, billions of tons of ore mining and concentration wastes have accumulated in dumps and tailings. The maintenance of these facilities requires significant capital and material costs, and the stockpiled crushed enrichment waste pollutes the soil and the atmosphere through water and wind erosion. The issue of improving environmental safety can be solved both by creating technologies for the processing of stockpiled enrichment waste and by maximizing the recovery of all useful components.

In this regard, the use of modern approaches, new flotation reagents, and modernized equipment for enrichment of mineral and technogenic raw materials is a priority when creating innovative technologies (Chanturiya V.A. et al. (2016), Magomedov D.R. et al. (2018), Abdykirova G.Zh. et al. (2020) [1-3].

The problem of finding effective reagents for flotation of non-ferrous and noble metals from man-made wastes is relevant (Matveyeva T.N. et al. (2017), Kianinia Y. et al. (2019), Erdenova M.B. et al. (2018), Semushkina L.V. et al. (2018) [4-7].

Thus, in the flotation of sulfide minerals application of such reagent as dithiopyrilmethane was tested. In flotation of gold-bearing ores, dithiopyrilmethane feeding into the pulp showed that it increases the extraction of gold-bearing arsenopyrite by 6% in the presence of basic sodium butyl xanthogenatecompared to the use of sodium butyl xanthogenate alone (Ivanova T.A. et al. (2018) [8].

Due to the increased processing of low-grade technogenic waste, the development of new innovative solutions for the extraction of base and noble metals with low production costs is required (Algebraistova N.K. et al. (2018), Fatahi M.R. et al. (2017), Xiao J. et al. (2017), GusevV.Yu. et al. (2018) [9-12].

Wastes of the gold extraction plant operating by gravitation and flotation scheme were investigated. Gold is in its native form and the form of intergrowths with pyrite. The main mass of the tailings is represented as quartz, muscovite, chlorite, albite, calcite, and dolomite. The possibility to enrichthe gold-containing tailings without regrinding by gravitation and flotation methods was studied. It was determined that the use of reagents combinations provides higher gold extraction in comparison with the application of butyl xanthate alone. The developed combined gravity-flotation beneficiation scheme allows to obtain gravity and flotation concentrates with a content of about 60 g/t gold at a total metal recovery of about 63.6% (Algebraistova N.K. et al. (2018) [13].

An increase of technical indicators of flotation can be achieved by using a combination of different collectors. Thus, during flotation of copper-zinc ore of Gaisky deposit butyl potassium xanthogenate; sodium butyl dithiophosphate; a mixture of thionocarbamate and dithiophosphate; as well as mixtures of these collectors in different ratios were used as collector reagents. The highest selectivity was obtained when using the composition of thionocarbamate and dithiophosphate as a collector reagent (Nikolayyev A.A. et al. (2016) [14].

Scientists are conducting research on creation of different dialkyldithiophosphates. The properties of dialkyldithiophosphates and the reagents containing them are greatly influenced by the strong surface-active properties of dialkyldithiophosphates. The surface-active properties in the series of dialkyldithiophosphates with the C4-C12 hydrocarbon chain length have been studied. It was found that the maximum sulfide recovery corresponds to dialkyldithiophosphate C10 (Riaboy V.I. et al. (2015) [15].

Thus, based on analysis of scientific and technical literature it is concluded that combination of different collectors, dispersion, and optimization of the composition of such reagents (increase or decrease of length of a hydrocarbon radical and its branching, introduction of additional component) leads to improvement of foaming, gathering and other properties.

Research methods

Modern research and analytical equipment were used for the studies: Optima 2000 DV atomic emission spectrometer; D8 ADVANCE X-ray diffractometer; Thermo Nicolet Avatar 370 FTIR spectrometer; Venus 200 PANalyical B.V. X-ray fluorescence spectrometer; JEOL JXA-8230 electron raster microscope, JEOL JXA-8230 electron scanning microscope. The technological equipment was used: a jaw crusher DMD160/100; ball mill 40ML-000PS; flotation machine FML; photometric sedimentometer FSH-6K; dispersant T18 digital ULTRA-TURRAX; laser particle analyzer Winner2000E; mechanical eraser MM-1.

The objects of the research were technogenic gold-containing tailings of Kazakhstani deposit and composite flotation (CF) agent. A composition of sodium butyl xanthogenate and reaflot was used as a flotation agent for the flotation of gold-containing tailings.

Results and discussion

The material composition and reagent regime of flotation of gold-containing tailings with the use of basic reagents were studied.

X-ray phase, X-ray fluorescence, and chemical analyses were performed. X-ray phase analysis was performedon diffractometer D8 Advance (BRUKER), Cu-Kα radiation. Processing of the obtained data of diffractograms and calculation of interplanar distances were performed using EVA software. The results of the X-ray phase analysis are presented in Table 1.

The main part of the initial sample of flotation tailings, according to the X-ray phase analysis results, is represented by rock-forming minerals such as quartz (41.2%), clinochlore (20.1%), microcline (14.3%), tremolite (13.1%), albite (5.2%), calcite (3.5%), muscovite (2.6%). According to the results of chemical analysis, the studied sample of tailings contains 0.49 g/t gold, 3.8% iron.

Table 1. Results of X-ray phase analysis of initial gold-containing flotation tailings

Compound Name	Formula	S-Q
Quartz, syn	SiO_2	41.2
Clinochlore (IIb-4)	Mg4.882Fe0.22Al1.881Si2.96O10(OH)8	20.1
Microcline, intermediate	KAlSi3O8	14.3
Tremolite	(Ca1.97Na0.016Fe0.014)Mg5Si8O22(OH)2	13.1
Albite, low	Na(AlSi3O8)	5.2
Calcite	Ca(CO3)	3.5
Muscovite-1M, syn	KAl2Si3AlO10(OH)2	2.6

X-ray fluorescence analysis of the original tails was performed on a Venus 200 PANalytical B.V. X-ray fluorescence spectrometer with wave dispersion. (PANalytycal B.V., Holland). According to the results of X-ray fluorescent analysis, the main mass in the primary sample of flotation tailings of the Bestobe ore deposit is silicon - 24.573%, oxygen - 43.701%, aluminum - 6.734%, iron - 3.256%, calcium - 3.115%.

According to the results of rational analysis, 39.50% of gold is in the hard-to-recover form with quartz; 28.87% is in the form of fine gold; 31.63% is in intergrowths with sulfides and rocks.

Granulometric analysis of initial tailings sample with the distribution of gold by size classes by sieve method was performed. The results are shown in Table 2. The results of the granulometric analysis showed that 71.76% of gold is in the class of less than 40 microns.

Table 2. Results of particle size analysis of initial gold-containing flotation tailings

Size class, mm	Yield %	Au content, g/t	γxβ Au	Distribution %
+0.1	1.18	1.69	1.99	5.63
-0.1+0.071	20.08	0.30	6.02	17.02
-0.071+0.040	15.22	0.13	1.98	5.59
-0.040+0	63.52	0.40	25.41	71.76
Total:	100.00	0.35	35.40	100.00

Dispersive analysis of initial tailings was performed on a photometric sedimentometer FSH-6K, which is designed to measure the particle size distribution of powders and suspensions with a particle size less than 300 microns. The instrument operates based on the Stokes sedimentation law and the Lambert-Beer law of radiation attenuation in turbid media. The sedimentation process is performed in the evenly mixed diluted suspension of a solid phase (ore) in the dispersion liquid (water) and is fixed by a change of intensity of light, passing through suspension, in which particles are sedimented. The apparatus determines the Stokes diameter of the particles. The Stokes diameter is the diameter of such spherical particle, the sedimentation rate of which is equal to the sedimentation rate of the non-spherical particles being examined. The instrument makes measurements of the optical density of the suspension at the level of optical slits at the time moments, calculated in advance according to Stokes law, corresponding to sedimentation of particles of the given size. Results of dispersion analysis are shown in Fig. 1.

The results of the analysis of variance indicate that in the initial sample of tailings the largest of the initial sample of tailings the largest part is the size classes of 15-20 microns and 70-80 microns.

LabNauchPribor LLC
Photosedimentometer FSKh-6

Initial values:

Particle size range	1.00 - 300.0 µm
Powder material density	2.89 g/cm³
Particle shape factor	1.00
Liquid phase density	1.00 g/cm³
Viscosity of the liquid phase	1.00 mPa*s

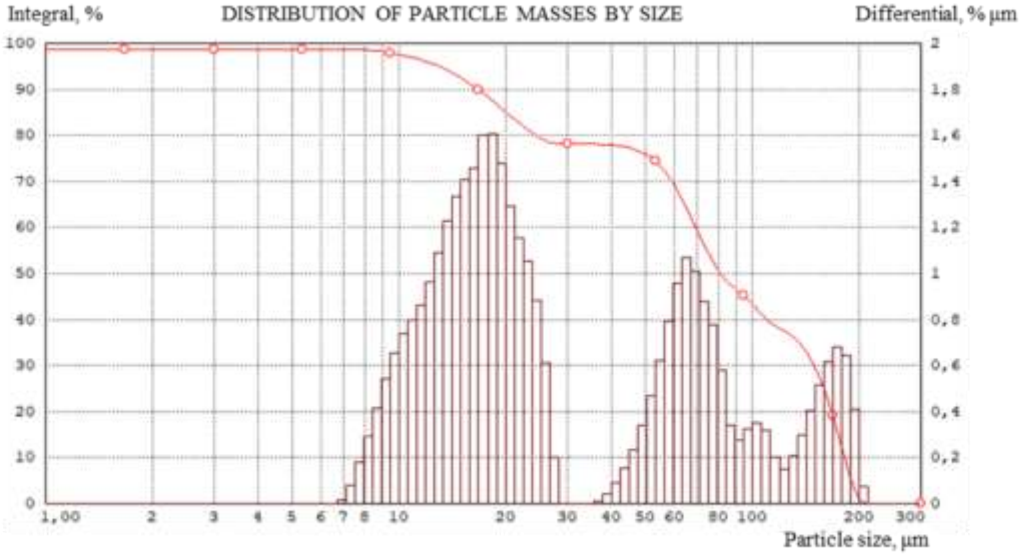
Measured: 14.04.2021 at 13:24

Result file: fsh.dat

DISTRIBUTION STATISTICS

Mean values:	
Median diameter	81.7 µm
Root Mean Square diameter	115.0 µm
Mean Harmonic diameter	21.8 µm
Deviations:	
Standard:	61.4 µm
Root Mean Square	63.9 %
Asymmetry coefficient	0.7
Dispersion	9449.1 µm²
Specific surface area (mass)	951 cm²/g

Modes of distribution:
17.8 67.1 178.6 µm



Last measurement

Larger, µm	%	In the interval, µm	%	Larger, µm	%	In the interval, µm	%
1	98,7	0 - 1	1,3	45	77,3	40 - 45	0,6
2	98,7	1 - 2	0,0	50	75,9	45 - 50	1,4
3	98,7	2 - 3	0,0	56	72,7	50 - 56	3,2
5	98,7	3 - 5	0,0	63	66,7	56 - 63	6,0
7	98,7	5 - 7	0,0	70	59,4	63 - 70	7,3
10	97,6	7 - 10	1,1	80	51,0	70 - 80	8,4
12	96,0	10 - 12	1,6	90	46,5	80 - 90	4,4
14	93,8	12 - 14	2,2	100	43,5	90 - 100	3,0
20	84,9	14 - 20	8,9	125	37,1	100 - 125	6,4
25	79,5	20 - 25	5,5	140	33,5	125 - 140	3,6
28	78,1	25 - 28	1,3	160	24,5	140 - 160	9,0
32	78,1	28 - 32	0,1	180	11,4	160 - 180	13,1
36	78,1	32 - 36	0,0	250	0,0	180 - 250	11,4
40	77,9	36 - 40	0,1	300	0,0	250 - 300	0,0

Fig. 1. Dispersive analysis of initial gold-containing flotation tailings at FSH-6K

The reagent mode of flotation of tailings enrichment with the use of basic reagents was tested. For the research, the initial tailings were reground in the laboratory ball mill 40ML-000PS up to 95% of the class -0.074 mm. Flotation experiments were performed on laboratory flotation machines with the volume of chambers 1,5; 0,75; 0,5 liters. Experiments were performed in the closed cycle. The scheme of flotation included regrinding, the main flotation, control, and two retreatment operations of the gold-containing concentrate. In the experiment 8 pieces of tailings, 0.5 kg each were used. In the process of regrinding, they used soda to create a pH of the environment equal to 8.0-8.5. The time of flotation operations was: basic flotation was 15 minutes, control flotation was 10 minutes, the first retreatment was 8 minutes, the second retreatment was 6 minutes. The following reagents were used: as a collector was sodium butyl xanthate and composite flotation (CF) reagent; as a foaming agent was T-92. The ratio of solid to liquid in flotation was 1:3. The flotation pulp after regrinding was stirred with the collector (2 min) and foaming agent (1.5 min) without air supply at a rotor speed of 1300 rpm. After atmospheric air supply flotation treatment of pulp was performed according to the applied scheme of enrichment.

The optimum reagent conditions of flotation tailings processing were selected: the degree of regrinding of 95% of grade -0,074 mm, the consumption of sodium butyl xanthate of 100 g/t, the consumption of foaming agent T-92 of 30 g/t. Under the chosen reagent mode the gold-containing concentrate containing 6,4 g/t gold at the recovery of 49,68% was obtained. Preliminary tailings regrinding increases the recovery of gold in the rough concentrate by 27,96%. The results of the research are presented in Table 3.

Table 3. Results of flotation of gold-containing tailings using regrind

Product name	Yield, %	Au content, g/t	Au extraction,%	Note
Concentrate	2.23	5.409	21.72	Basic mode without regrinding. Initial tailings fineness 88.0% of 74 µm class
Industrial product 2	5.02	1.096	9.91	
Industrial products 1	1.85	0.77	2.56	
Foam composite flotation agent	4.91	0.44	3.89	
Tailings	85.99	0.40	61.92	
Initial tailings	100.00	0.56	100.00	
Concentrate	4.93	6.4	49.68	Grinding 95.0%of 74 µm class
Industrial products 2	2.79	0.92	4.04	
Industrial products 1	3.91	0.62	3.82	
Foam composite flotation agent	4.18	0.41	2.70	
Tailings	84.19	0.3	39.77	
Initial tailings	100.00	0.64	100.00	

In the process of regrinding of gold-containing technogenic raw materials for a more complete opening of mineral aggregates, ultra- and micro-dispersed gold particles, covered with oxide films of iron and quartz, are formed. They are practically not captured by ordinary sulfide flotation. The applied microheterogeneous emulsion of composite flotation agent possesses simultaneously aggregation and flotation ability in relation to ultrafine gold minerals to carriers, covered with oxide films of iron and quartz.

At use in flotation of the composition of collectors, the mechanism of their interaction with a surface of minerals is defined by features of a surface of minerals and the activity of each component of the collector. At dispersion besides microbubbles the microemulsion is formed, which at collision with slurry particles of minerals spreads and hydrophobized their surface, improving the process of their flotation. Microbubbles in turn are much easier to fix on such hydrophobic surfaces of slam particles.

The reagent mode of flotation of gold-containing tailings using composite flotation (CF) agent, which is a mixture of sodium butyl xanthogenate and Realflot was tested. The composite flotation (CF) agent was used in the form of an emulsion obtained in a T18 digital ULTRA-TURRAX dispersant. The particle sizes of a microemulsion of composite flotation (CF) agent were measured on the laser particle analyzer

Winner2000E. The optimum ratio of sodium butyl xanthate to the reagent in the composite reagent was defined, which was 85:15 and the optimum reagent consumption in the main flotation was 80 g/t. The content of particles smaller than 20.8 microns in the composite reagent with a ratio of sodium butyl xanthogenate and Reaflot 85:15 percent is 26% (Figure 2).

Laser Particle Sizer Testing Report
Winner2000E

Jinan Winner

Jinan Winner

Measuring range:0.1-300um **Printing Time:01.06.2021 12:45:55**

Sample Information

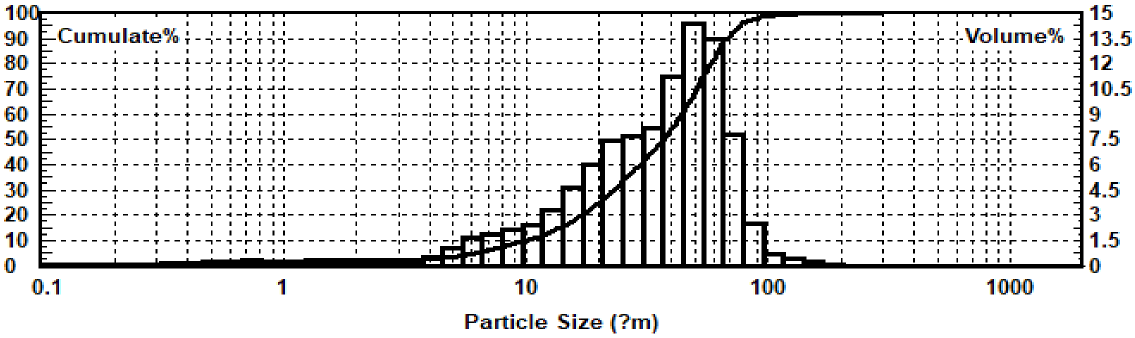
Sample Name:Test Sample source: Delivery Date:01.06.2021
Sample refractive index:1.51-i*0.100 Sample density: 1g/cm^3

Testing Information

UltraSonic Time:120s Testing enterprise:
Disperse medium:1 Measured by:
Dispersant:1 Measuring Time:01.06.2021 12:40:42

Analyse Result(Analysis mode:Free distribution Statistics-Mode: By Volume distribution)

D10=10.031 um Dav=38.661 um D[3,2]=12.019 um
D50=37.327 um S/V=4992.158 cm^2/cm^3 D[4,3]=38.661 um
D90=68.231 um S/g=4992.158 cm^2/g Fitting deviation:0.005
Optics Concentration:33.5



Size(?m)	Volume%	Cumulate%	Size(?m)	Volume%	Cumulate%	Size(?m)	Volume%	Cumulate%
0.121	0.029	0.029	1.745	0.111	2.139	25.169	7.435	33.452
0.146	0.033	0.062	2.112	0.025	2.164	30.455	7.688	41.140
0.177	0.040	0.102	2.555	0.013	2.178	36.851	8.165	49.305
0.214	0.049	0.151	3.092	0.036	2.213	44.590	11.186	60.492
0.259	0.061	0.212	3.741	0.171	2.385	53.954	14.340	74.831
0.314	0.074	0.286	4.527	0.528	2.912	65.285	13.493	88.325
0.380	0.104	0.390	5.477	1.062	3.974	78.995	7.797	96.121
0.460	0.160	0.551	6.627	1.643	5.617	95.585	2.498	98.620
0.556	0.237	0.788	8.019	1.898	7.515	115.659	0.703	99.323
0.673	0.270	1.058	9.703	2.101	9.616	139.948	0.436	99.759
0.814	0.285	1.343	11.741	2.387	12.003	169.338	0.207	99.965
0.985	0.254	1.597	14.207	3.328	15.331	204.901	0.034	99.999
1.192	0.258	1.855	17.191	4.676	20.007	247.932	0.001	100.000
1.442	0.173	2.028	20.801	6.010	26.016	300.000	0.000	100.000

Contact us

Name:Jinan Winner Particle Instruments Stock Co.,Ltd URL http://www.jnwinner.com
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Fig. 2. Distribution of composite reagent particles with the ratio butyl xanthogenate : Reaflot = 85:15

The results of flotation of gold-containing tailings using the composite reagent are presented in Table 4.

Table 4. Results of flotation tailings using composite reagent

Product name	Yield,%	Au content, g/t	Au extraction,%	Note
Concentrate	4.01	9.1	54.33	Total consumption of composite reagent 80 g/t
Industrial products 2	2.46	1.0	3.66	
Industrial products 1	3.65	1.1	5.98	
Foam composite flotation agent	3.98	0.9	5.33	
Tailings	85.9	0.24	30.7	
Initial tailings	100.0	0.672	100.0	

At an optimum consumption of the composite reagent of 80 g/t, a gold-containing concentrate containing 9.1 g/t gold was obtained with a recovery of 54.33%. Application of composite reagent increases gold recovery into concentrate, in comparison with the basic mode, by 4.65% with a reduction of its consumption by 20%.

Conclusions

The paper presents the results of laboratory research on flotation processing of gold-containing tailings using the composite flotation (CF) agent. The composite flotation (CF) agent is a microemulsion of sodium butyl xanthogenate and Realflot composition. The gold concentrate with a gold content of 6.4 g/t and recovery of 49.68% was obtained in the basic mode. The use of the composite flotation (CF) agent increases the recovery of gold in the gold concentrate by 4.65%, compared with the basic collector sodium butyl xanthate. The consumption of the composite flotation (CF) agent is reduced by 20%.

Acknowledgments

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Research and development of a comprehensive technology for processing kaolinite clays in Kazakhstan

Abstract: In the Republic of Kazakhstan, the most promising are kaolinite clays of the Alekseevsky deposit. For effective processing of clays, it is necessary to develop special methods of processing, since satisfactory results were not achieved when using standard methods of gravity processing. The article provides the results of studies of the effect of preliminary chemical activation on the yield of the kaolinite fraction during gravitational processing. Previously, the method of preliminary chemical activation of raw materials in a solution of sodium bicarbonate has proven itself well in the processing of various mineral raw materials. It is determined that as a result of preliminary chemical activation, changes in the phase composition occurred. The dependence of the yield of the kaolinite fraction on the temperature of chemical activation, duration, and the ratio of W:T and the concentration of the sodium bicarbonate solution. Based on the results obtained, a technology for the complex processing of kaolinite clays has been developed, which provides for the preliminary chemical activation of the feedstock at the beginning of the process, which will effectively isolate high-quality kaolinite and quartz products, which will significantly reduce the flow of materials entering for sintering. As a result of activation, the phase composition of the kaolinite fraction has changed: the percentage of the kaolinite fraction has decreased; new phases of muscovite and sodium aluminosilicate appeared; the amount of quartz increased.
Keywords: kaolinite, quartz, silicon module, chemical activation, chemical processing, technology.

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Introduction

The Pavlodar Aluminum Smelter (PAZ), the only alumina producer in the Republic of Kazakhstan, uses low-quality bauxites from the Krasnooktyabrsk deposit located in the Kostanay region, with a low flint modulus and high iron and carbonate contents [1, 2]. Existing bauxite reserves can be enough to operate PAZ at existing capacities for not more than 15 years, therefore, it is relevant to the search for alternative raw materials sources of alumina, one of which can be kaolinite ores; the world reserves are estimated at 16 billion tons [3]. Modern mining and processing of kaolinite raw materials have an established infrastructure, are provided with raw materials and in the future can be adapted to the production of alumina and by-products [4].

The characteristics of the raw materials are of paramount importance when selecting the optimal technological process for processing kaolinite clays, which determine the theoretical yield of alumina, the consumption of reagents in key technological operations and the amount of sludge to be further processed, which should maximally meet the capabilities and interests of the respective region [5].

By now, a significant number of methods for processing kaolins and kaolinite clays are known and continue to be improved, among which acid technologies are historically significant. Their disadvantages are the formation of hard-to-filter finely dispersed sediments and the use of expensive acid-resistant materials and equipment [6-9].

The technology of autoclave opening in the medium of high-modulus aluminate solutions with the precipitation of silica in the form of ferrous hydro-garnets or sodium-calcium hydrosilicate ($Na_2O{\cdot}2CaO{\cdot}2SiO_2{\cdot}H_2O$) is of considerable interest for the processing of kaolinite clays [5]. The undoubted advantage of this method is its versatility and the possibility of using the hydrometallurgical process for processing high-silicon raw materials of various nature. Additionally, it is distinguished by the significant complexity of the technological scheme and its hardware design, which has ruled out the industrial implementation of this method until now.

The most industrially developed method is the technology of sintering kaolin raw materials with soda and limestone added in a ratio based on the following stoichiometry [10]:

$$Al_2O_3{\cdot}2SiO_2{\cdot}2H_2O+4CaCO_3+Na_2CO_3=2NaAlO_2+2(2CaO{\cdot}SiO_2)+2H_2O+5CO_2 \qquad (1)$$

This stoichiometry makes it possible to determine the mass of the charge, as well as to estimate the consumption of reagents and the yield of sludge, which corresponds to the composition of calcium orthosilicate with high accuracy.

Methods

X-ray fluorescence analysis was performed on a wave dispersion spectrometer Venus 200 (PANalyical B.V., Holland).

Chemical analysis of the samples was carried out on an optical emission spectrometer with inductively coupled plasma Optima 2000 DV (Perkin Elmer, USA).

Semi-quantitative X-ray phase analysis was performed on a D8 Advance (BRUKER) diffractometer using copper Cu – Kα radiation at an accelerating voltage of 36 kV and a current of 25 mA.

Thermal analysis of the provided sample was carried out using a simultaneous thermal analysis instrument STA 449 F3 Jupiter.

Chemical activation of kaolinite clays was carried out in a solution containing from 40 to 120 g/dm^3 $NaHCO_3$ at the ratio L:T = 2 - 10.0 and temperatures of 90 - 230 °C using a thermostated installation with 6 autoclaves rotating through the head with a working volume of 250 cm^3, duration of activation ranged from 30 to 300 minutes. The maximum content of sodium hydrocarbonate in the solution was 120 g/dm^3, taking into account its solubility limit.

Results and discussion

The raw product was a representative sample of kaolinite clay from the Alekseevskiy deposit provided by company Arai pro LLP.

The chemical composition of the clay sample, wt. %: Al_2O_3 - 26.9; SiO_2 - 56.6; Fe_2O_3 - 0.537; Na_2O - 0.07; SO_3 - 0.028; K_2O - 1.31; LOI 14.555, silicon module (μ_{si}) - 0.47. Appearance: free-flowing whitish sand, density 2.06 g/cm^3, bulk density 1.36 kg/cm^3, average grain size 2 mm.

X-ray phase analysis of a clay sample is presented as, %: kaolinite 31.4, muscovite 1.1, and quartz 67.5.

According to thermal analysis, the kaolinite phase appears with endothermic effects (-) 167.8 °C, (-) 566.6 °C, and exothermic effects (+) 993.8 °C. The endothermic effect with an extremum at 575 °C on the DTA curve, as well as endothermic effects with extrema at 539.8 °C, 555.9 °C on the dDTA curve, are associated with the manifestation of dehydration of aluminum hydroxides - boehmite, diaspora with varying degrees of grinding. The combination of the endothermic effect with an extremum at 167.8 °C and an exothermic effect with a peak at 993.8 °C on the DTA curve is associated with the manifestation of the clay mineral allophan - $mAl_2O_3nSiO_2pH_2O$. The combination of an endothermic effect with an extremum at 167.8 °C and an exothermic effect with a peak at 647.2 °C is a manifestation of the SiO_2nH_2O opal phase.

A finely dispersed kaolinite fraction was isolated with the composition by washing with running water for further research, wt%: Al_2O_3 - 31.2; SiO_2 - 51.6; Fe_2O_3 - 0.53; CaO - 0.43; Na_2O - 0.095; MgO - 0.2;

SO_3 - 0.02; K_2O - 1.5; TiO_2 1.05; Cl - 0.02; LOI 13,355; μ_{si} - 0.6. The phase composition of the kaolinite fraction: kaolinite - 63.2%, quartz - 21.6%, muscovite - 15.3%. The fraction yield was 41.4%.

The chemical composition of the separated coarse quartz fraction, wt%: Al_2O_3 - 7.65; SiO_2 - 65.5; Fe_2O_3 - 0.68; CaO - 0.29; Na_2O - 0.031; MgO - 0.08; SO_3 - 0.05; K_2O - 0.39; TiO_2 - 0.9; Cl - 0.016; LOI 24.413; μ_{si} - 0.12.

The optimal conditions for carrying out the preliminary chemical activation of kaolinite clay were determined for studies of the dependence of the yield of the kaolinite fraction on temperature, duration, S:L ratio, and concentration of sodium hydro carbonate solution.

When studying the dependence of the yield of the kaolinite fraction on the temperature of chemical activation, the maximum yield of 79.36% was obtained at a temperature of 150 °C (Figure 1).

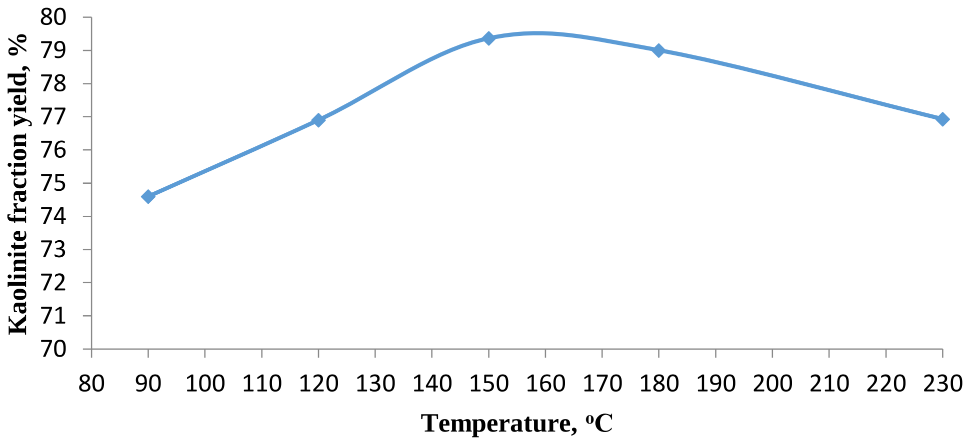

Figure 1. Dependence of the kaolinite fraction yield on the temperature of chemical activation

During chemical activation, changes in the phase composition took place, the content of muscovite decreased almost twofold, and a sodium aluminosilicate phase was formed.

The phase composition of the kaolinite fraction samples depending on the temperature of chemical activation is presented in Table 1.

Table 1. The phase composition of kaolinite fraction samples depending on the temperature of chemical activation

Name	**Content, %**					
	Activation temperature, °C					
	Ref.	**90**	**120**	**150**	**180**	**230**
Kaolinite-1A $Al_2Si_2O_5(OH)_4$	63.2	52.9	52.1	57.0	56.3	54.8
Quartz SiO_2	21.6	29.9	31.0	25.4	26.7	28.0
Muscovite – 1M $KMgAlSi_4O_{10}(OH)_2$	15.3	8.0	8.0	8.9	8.1	8.0
Sodium aluminosilicate $Na_2Al_{1.1}Si_{94.9}O_{192}$	-	5.8	5.2	4.9	5.2	5.5
Magnetite $Fe((Fe_{1.538}Ti_{0.462})O_4)$	-	3.5	3.7	3.7	3.6	3.7

When the dependence of the yield of kaolinite fraction on the duration of chemical activation is studied, it was found that the optimal duration is 120 minutes (Figure 2). A further increase in the duration of activation causes a slight increase in the yield of the kaolinite fraction.

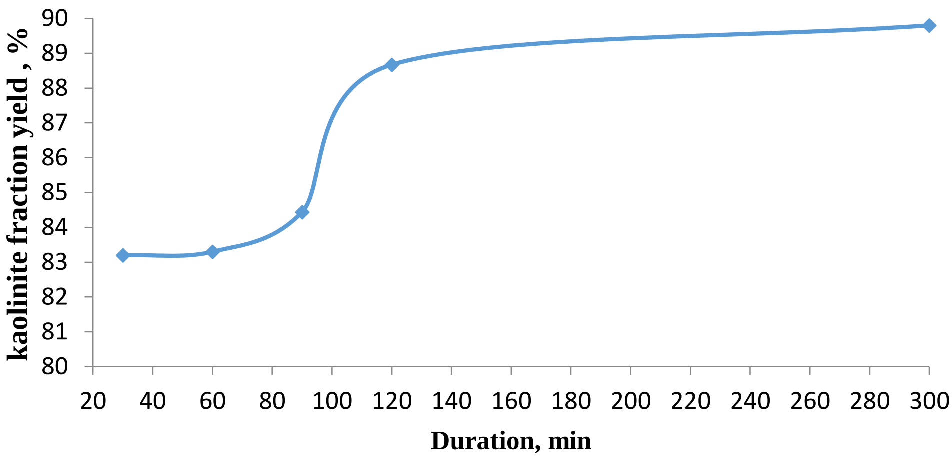

Figure 2. Dependence of the kaolinite fraction yield on the duration of chemical activation

The phase composition of the kaolinite fraction samples depending on the duration of chemical activation is presented in Table 2.

Table 2. The phase composition of kaolinite fraction samples depending on the duration of chemical activation

Name	Content, %					
	Duration, min					
	Ref.	30	60	90	120	300
Kaolinite-1A $AL_2Si_2O_5(OH)_4$	63.2	62.8	62.1	61.3	63.0	64.9
Quartz SiO_2	21.6	24.3	28.5	28.3	28.0	26.3
Muscovite – 1M $KMgAlSi_4O_{10}(OH)_2$	15.3	5.5	5.1	4.4	3.8	3.7
Sodium aluminosilicate $Na_2Al_{1.1}Si_{94.9}O_{192}$	-	4.2	4.0	3.8	3.3	3.1
Magnetite $Fe((Fe_{1.538}Ti_{0.462})O_4)$	-	3.1	2.4	2.2	1.9	2.0

In the studies, it was determined that the yield of the kaolinite fraction practically does not depend on the S:L ratio during chemical activation, therefore, it must be selected taking into account the performance of the equipment (Figure 3).

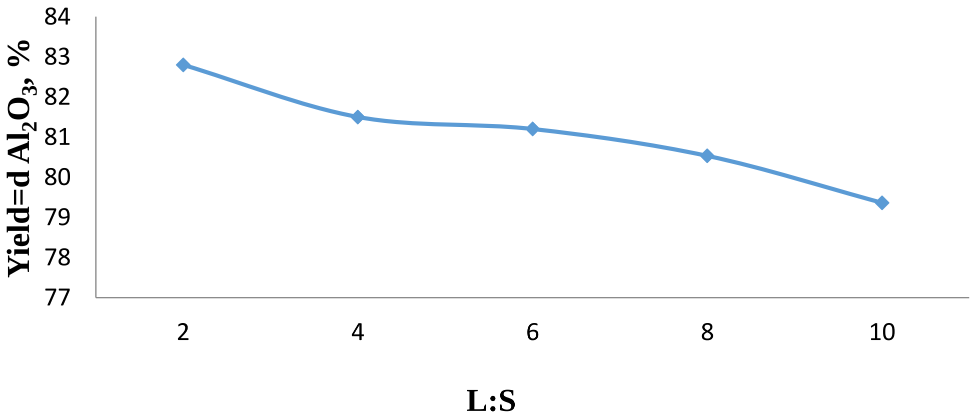

Figure 3. Dependence of the Al_2O_3 yield in the kaolinite fraction on the S:L ratio of chemical activation

The phase composition of the kaolinite fraction samples depending on the S:L ratio of chemical activation is presented in Table 3.

Table 3. The phase composition of kaolinite fraction samples depending on the S:L ratio of chemical activation

Name	**Content, %**					
	S:L ratio					
	No ref.	**2:1**	**4:1**	**6:1**	**8:1**	**10:1**
Kaolinite-1A $AL_2Si_2O_5(OH)_4$	63.2	63.1	62.6	62.5	60.4	60.1
Quartz SiO_2	21.6	29.5	27.3	25.7	27.2	26.9
Muscovite – 1M $KMgAlSi_4O_{10}(OH)_2$	15.3	3.8	4.2	5.6	5.5	5.4
Sodium aluminosilicate $Na_2Al_{1.1}Si_{94.9}O_{192}$	-	2.3	3.7	3.8	4.3	4.9
Magnetite $Fe((Fe_{1.538}Ti_{0.462})O_4)$	-	1.3	2.3	2.5	2.6	2.7

Studies of the dependence of the yield of the kaolinite fraction of clay on the concentration of sodium hydro carbonate solution during chemical activation were carried out at a temperature of 150 °C at a duration of 120 minutes and a S:L ratio = 10:1 (Figure 4).

As a result of research, it was found that the yield of the kaolinite fraction increases with an increase in the concentration of sodium hydro carbonate solution.

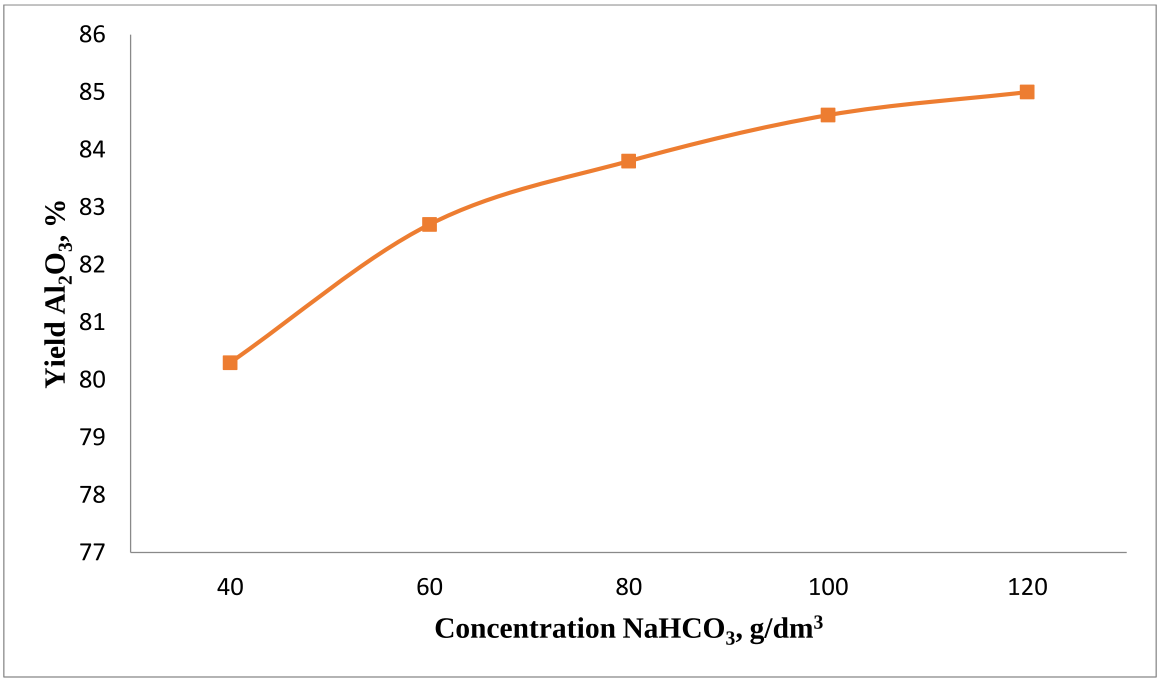

Figure 4. Dependence of the Al_2O_3 yield into the kaolinite fraction on the concentration of sodium hydro carbonate solution during chemical activation

The phase composition of the kaolinite fraction samples depending on the concentration of sodium hydro carbonate solution during chemical activation is presented in Table 4.

Table 4. The phase composition of kaolinite fraction samples depending on the concentration of sodium hydro carbonate solution during chemical activation

Name	Content, %					
	$NaHCO_3$, g/dm^3					
	No ref.	40	60	80	100	120
Kaolinite-1A $AL_2Si_2O_5(OH)_4$	63.2	62.2	63.6	62.1	65.7	65.0
Quartz SiO_2	21.6	28.9	26.1	26.2	24.8	24.6
Muscovite – 1M $KMgAlSi_4O_{10}(OH)_2$	15.3	3.8	4.1	5.4	4.1	4.0
Sodium aluminosilicate $Na_2Al_{1.1}Si_{94.9}O_{192}$	-	3.2	3.7	3.9	3.4	3.5
Magnetite $Fe((Fe_{1.538}Ti_{0.462})O_4)$	-	2.0	2.2	2.5	2.0	2.2

Based on the results obtained, a technology for the complex processing of kaolinite clays has been developed, which provides for the preliminary chemical activation of the feedstock at the beginning of the process, which will effectively isolate high-quality kaolinite and quartz products, which will significantly reduce the flow of materials entering for sintering (Figure 5).

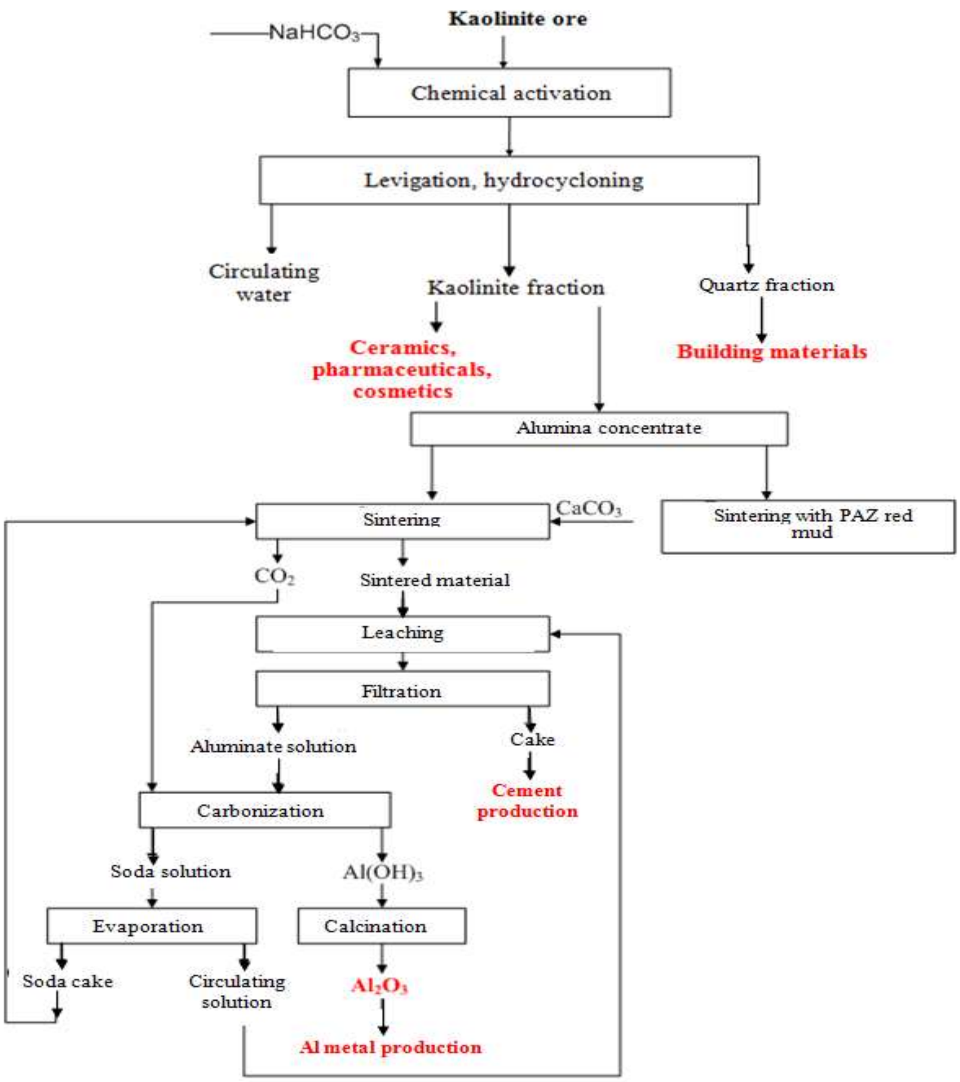

Figure 5. Process flow scheme of complex processing of kaolinite ore

Conclusions. Research has been carried out on the effect of preliminary chemical activation of kaolinite clays of the Alekseevskiy deposit in a sodium hydro carbonate solution on the separation of kaolinite and quartz fractions. The optimal mode of activation should be considered a temperature of 150 °C, a duration of 120 minutes, and a concentration of sodium hydro carbonate solution of 120 g/dm^3.

As a result of activation, the phase composition of the kaolinite fraction has changed: the percentage of the kaolinite fraction has decreased; new phases of muscovite and sodium aluminosilicate appeared; the amount of quartz increased.

The process flow scheme of the complex processing of kaolinite ore has been developed.

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Disposal of copper electrofining solutions

Abstract: The paper presents studies of the processing of spent copper electrolyte from the processing of non-ferrous metal scrap at a copper smelter in Kazakhstan. For the processing of the spent electrolyte, a stage-by-stage neutralization was carried out using zinc sublimates and potash. As a result of the first stage of neutralization with zinc sublimations to pH 4.7, a precipitate with a content of PbO 44.69 %; PO_2 16.36 % was obtained. After processing the sediment with an alkaline solution, carbonization and melting at a temperature of 900 ^oC, metallic lead and tin-containing slag with a content of SnO2 of 16.36 % were obtained. As a result of the second stage of neutralization with potash to pH 7.1, a precipitate was obtained-with a CuO content of 76.45 %. After the third stage of neutralization with potash to pH 9.5, a precipitate with a content of NiO 27.63 % and ZnO 55.75 % was obtained. After treatment of the precipitate with a solution containing 100 g / dm^3 KOH, a zinc-containing solution with a ZnO content of 225.0 g/dm^3 and a precipitate were obtained, after calcination of which nickel oxide with a NiO content of 89.14 % was obtained.

Keywords: copper electrolyte, zinc-containing product, potash, copper-containing precipitate, metallic lead, slag.

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Introduction

The processing of non-ferrous metal scrap is followed by an accumulation of foreign impurities of nickel, zinc, and others in the reversible electrolyte at the stage of obtaining electro refined copper; these impurities degrade the quality of cathode copper. Part of the electrolyte from commercial baths is periodically removed from the electrolysis cycle and processed. Enterprise productivity depends on solution processing therefore the development of effective technology is urgent.

When refined copper is received from mineral raw materials, the reversible electrolyte is regenerated. The following methods have been proposed to purify the electrolyte from impurities, i.e. extraction, sorption, membrane, and combined sorption-electrochemical ones [3, 5, 6, 10, 11].

Most non-ferrous metal scrap processing plants use a two-stage scheme of spent electrolyte processing that includes evaporation and crystallization to obtain copper sulfate and extraction of residual copper from the evaporated solution by electroextraction [4, 11]. As soon as copper has been extracted from the solution, evaporation, crystallization, and subsequent refining are applied to extract nickel in the form of a sulfuric acid salt. The method does not make it possible to selectively isolate the non-ferrous metals present in the solution.

There is a method of processing the spent electrolyte whereby copper is first extracted through electroextraction. After electroextraction, the solution is neutralized with lime white to obtain a gypsum nickel-containing cake or evaporated to release a cake containing metal sulfates (Cu, Ni, Zn, Fe) that are sold as a marketable product [1, 2, 4, 11]. Obtaining selectively separated non-ferrous metals by this method is also impossible.

The research designed to utilize solutions and selectively separate non-ferrous metal concentrates by stage neutralization using a zinc-containing industrial product took place to solve the problem of developing an effective technology for processing spent copper electrolyte.

A zinc-containing industrial product, namely, zinc sublimation, is formed during the processing of non-ferrous metal scrap in the course of fire refining of copper and is captured during the purification of exhaust gases in bag filters. Such sublimations are mixed with sulfur-containing flux, granulated, and distilled with lead and tin in a rotary furnace [7, 8, 12].

Research methods and techniques

A Venus 200 wave dispersion spectrometer (PANalyical B.V., the Netherlands) was used to perform an X-ray fluorescence analysis.

The samples were subjected to chemical analysis with the help of an optical emission spectrometer with an inductively coupled plasma Optima 2000 DV (USA, Perkin Elmer).

The semi-quantitative X-ray phase analysis was based on a D8 Advance diffractometer (BRUKER) with copper Cu–Kα radiation at an accelerating voltage of 36 kV and a current of 25 mA.

A low-vacuum electron microscope with a thermoemission cathode (LaB_6) JSM-6610LV from JEOL was applied to take microphotographs.

Research results

The study was based on the spent electrolyte of copper and zinc sublimation from the copper smelting plant of Casting LLP in Kazakhstan.

Chemical composition of the spent copper electrolyte, wt. g/dm^3: Cu 67.14; Ni 36.41; Fe 11.43; Zn 10.96; SO_4 125.9; N 4.1; As; 0.03; Bi 0.002; At 2.6; Pb 0.014; Sb 0.05; Si 0.047; Sn 0.0.

Chemical composition of the zinc sublimation wt. %: F 0.97, Al_2O_3 0.15, P_2O_5 0.82, SO_3 4.0, Cl 11.64, K_2O 0.93, CaO 0.36, Fe_2O_3 0.29, NiO 0.05, CuO 7.86, ZnO 39.46, Br 0.19, MoO_3 0.1, CdO 0.23, SnO_2 7.16, WO_3 0.36, PbO 19.4, Bi_2O_3 0.04, p.p. 0.04.

Figure 1 illustrates the electron microscopic analysis of zinc sublimation.

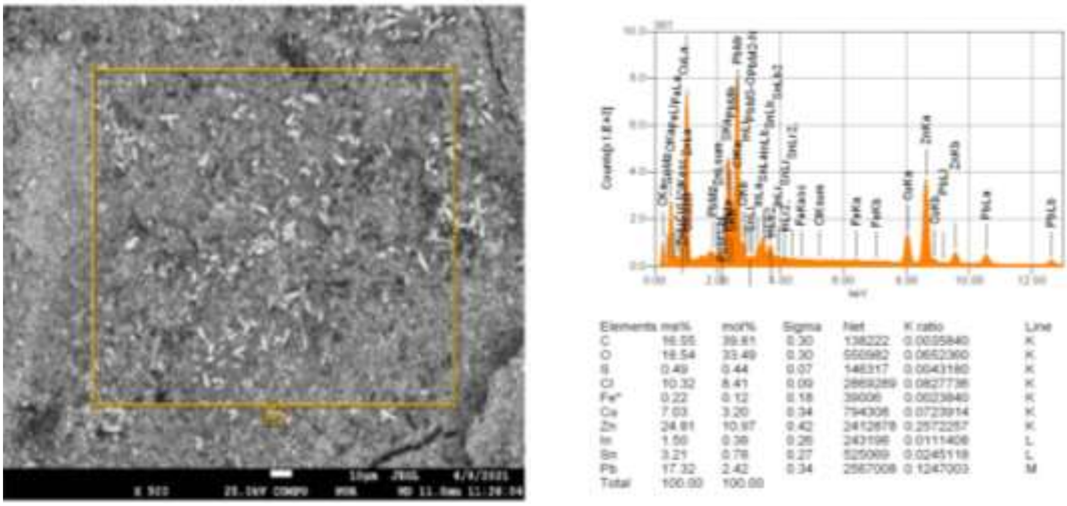

Figure 1. Microphotograph of zinc sublimation x 500

According to the X-ray phase analysis presented in Figure 2, the zinc sublimation composition is as follows, wt. %: matlokite (PbClF) – 43.1; copper sulfate ($Cu_5(SO_4)_2(OH)_6{\cdot}5H_2O$) – 20.0; copper chlorate ($Cu(ClO_4)_2$) – 10.3; zinc stonate ($Zn_2(SnO_4)$) – 9.8; moolooit ($C_2CuO_4{\cdot}xH_2O$) – 4.4; lead acetate hydroxide hydrate ($C_4H_8Pb_2O_6{\cdot}H_2O$) – 3.8; zinc oxalate (C_2O_4Zn) – 3.2; fedotovite ($K_2Cu_3+2O(SO_4)_3$) – 2.8, and zinc chloride ($ZnCl_2$) – 2.6.

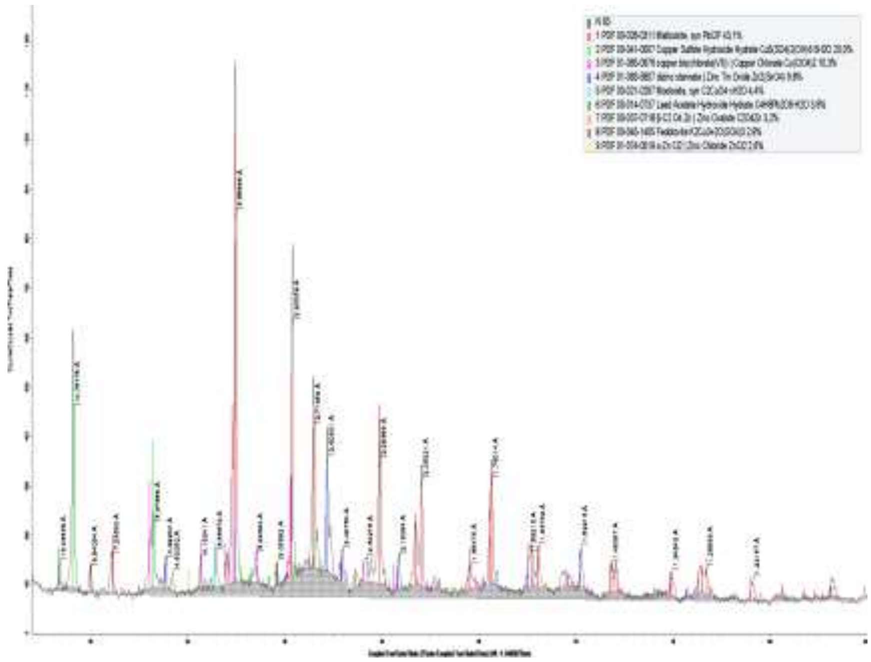

Figure 2. Radiograph of the zinc sublimation

To utilize industrial products resulting from the processing of non-ferrous metal scrap and selective separation of non-ferrous metals, stage neutralization of the spent copper electrolyte with the use of zinc sublimations was applied.

The first stage of electrolyte neutralization included zinc sublimation to pH 4.7 at S:L=5:1, temperature – 20°C, stirring time – 3 hours. Neutralization provided a black lead-tin-containing sludge, the composition of which is shown in Table 1.

The second and third stages of neutralization included potash. Potash was chosen instead of the cheaper reagent Na_2CO_3 due to the possible obtaining of a commercial, highly liquid product – potassium sulfate K_2SO_4, instead of Na_2SO_4, after purification of the solution and its evaporation.

After the second stage of the electrolyte neutralization to pH 7.1, a copper-containing sludge with a low content of impurities is obtained and it may be returned to the copper electrorefining solution.

Table 1. Chemical composition of the neutralization sludges

Name	Content, %		
	pH		
	4.7	7.1	9.5
F	0.44	0.26	0.3
Na_2O	0.71	-	-
MgO	-	-	0.11
Al_2O_3	1.56	0.34	1.3
SiO_2	4.08	0.24	0.54
P_2O_5	0.41	0.01	0.009
SO_3	11.12	5.56	3.42
Cl	0.72	4.7	0.19
K_2O	0.19	-	0.05
CaO	0.85	0.03	0.38
Fe_2O_3	5.48	0.31	0.14
NiO	0.15	1.1	27.63
CuO	2.97	76.45	0.68

ZnO	4.79	2.8	55.75
Br	0.09	0.01	-
MoO_3	0.23	-	-
CdO	0.08	0.01	-
SnO_2	16.36	-	-
WO_3	0.29	-	-
PbO	44.69	0.06	-
Bi_2O_3	0.09	-	-
p.p.	4.7	5.12	8.131
Total	100	100	100

The sludge obtained from the first stage of neutralization was treated with a solution of spent electrolyte at a ratio of S:L=10:1. This resulted in a filtrate with a pH of 2.2 and a lead-tin-containing product of the following composition, wt. %: Na_2O 0.16; Al_2O_3 0.34; SiO_2 1.83; P_2O_5 0.17; SO_3 20.53; Cl 0.51; K_2O 0.29; CaO 0.23; Fe_2O_3 0.95; NiO 0.05; CuO 1.33; ZnO 0.57; As_2O_3 0.07; Br 0.07; MoO_3 0.1; CdO 0.1; SnO_2 9.5; WO_3 0.18; PbO 62.24; BiO_3 0.11; p.p. 0.67.

To process the obtained product, a method of processing lead-containing production waste was used [9]. The method is suitable for processing lead-containing production wastes containing compounds of tin, antimony, copper, iron, zinc, bismuth, arsenic, silver, calcium, sodium, and potassium.

In accordance with [9], the obtained lead-tin product was carbonized in a solution containing 135 g/dm^3 of K_2CO_3, at S:L=4:1, and a temperature of 20^{o}C. After filtration, a sludge of the following composition was obtained, wt. %: Al_2O_3 0.42; SiO_2 2.29; P_2O_5 0.21; SO_3 2.9; Cl 0.1; K_2O 0.29; CaO 0.23; Fe_2O_3 0.95; NiO 0.06; CuO 1.66; ZnO 0.71; As_2O_3 0.1; Br 0.01; MoO_3 0.12; SnO_2 11.8; WO_3 0.22; PbO 77.8; BiO_3 0.13.

The phase composition of the carbonization sludge is as follows, wt. %: cerussite ($PbCO_3$) – 91.4; ferrous tin oxide (($Sn_{0.9}Fe_{0.1}$)O_2) – 3.0; cassiterite (SnO_2) – 2.8; ferrosilite ($Fe_3Si_{0.93}$) – 1.5, and zinc oxide (ZnO) – 1.3 (Figure 3).

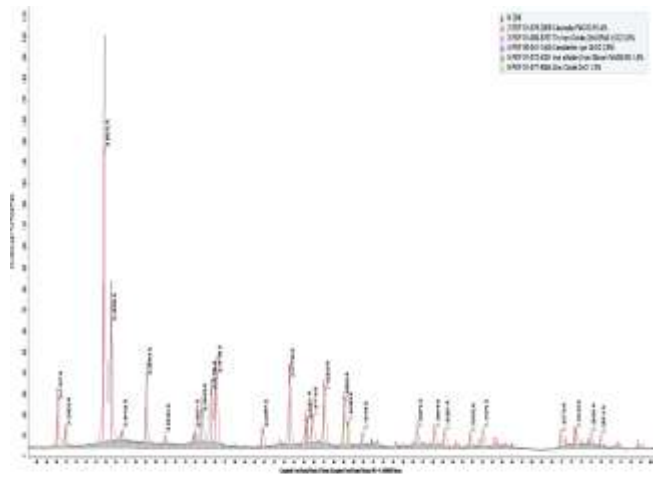

Figure 3. Radiograph of the sludge after carbonization

The carbonization sludge in a mixture of 10% charcoal and 5% K_2CO_3 was melted at a temperature of 900^{o}C for 30 minutes. A metallic lead-tin-containing slag of the following composition was obtained, wt. %: PbO 3.36; SnO_2 47.84; Al_2O_3 1.08; SiO_2 9.2; P_2O_5 1.96; SO_3 0.54; K_2O 15.1; CaO 2.7; Fe_2O_3 4.8; NiO 0.64; CuO 5.5; ZnO 0.3; As_2O_3 0.6; WO_3 3.0; p.p. 3.38.

The third stage of the spent electrolyte neutralization to pH 9.5 provided nickel-zinc-containing sludge (Table 1). The sludge was treated with a solution containing 100 g/dm^3 of KOH at S:L=3:1 and a temperature of 90^{o}C for 30 minutes. An alkaline zinc-containing solution with a ZnO content of 225.0 g/dm^3 and a nickel-containing sludge of the following composition was obtained, wt. %: NiO 76.2; MgO 3.2; Al_2O_3 0.32; SiO_2 0.35; SO_3 0.31; CaO 1.4; Fe_2O_3 0.11; CuO 0.2; ZnO 0.5; p.p. 17.41.

After the sludge calcination at a temperature of 350°C for 30 minutes, a nickel oxide sludge of the following composition was obtained, wt. %: MgO 5.44; Al_2O_3 0.54; SiO_2 0.59; SO_3 0.53; CaO 2.38; Fe_2O_3 0.19; NiO 89.14; CuO 0.34; ZnO 0.85.

The conducted researches resulted in developing the technological processing scheme for the spent copper electrolyte with the use of zinc sublimations for neutralization (Figure 4).

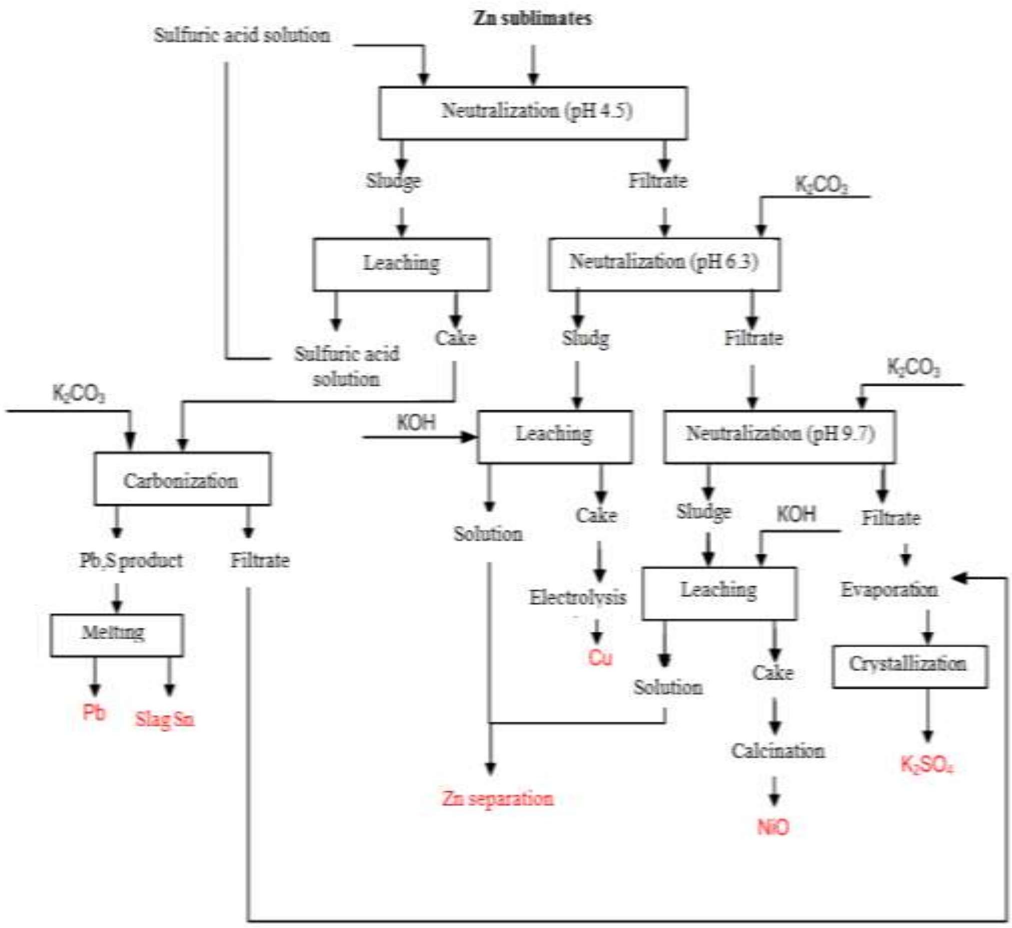

Figure 4. Technological processing scheme for the spent copper electrolyte obtained from the production of non-ferrous metal scrap

Conclusions

A staged neutralization of the spent electrolyte obtained from the electrorefined copper of processing of non-ferrous metal scrap by zinc sublimations and potash provided a copper-containing sludge of nickel oxide, alkaline zinc-containing solution, and metallic lead-tin-containing slag.

The technological scheme intended for use of industrial products resulting from the processing of non-ferrous metal scrap – the spent electrolyte and zinc sublimations – has been developed.

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The role of teaching practicum in the future biology teachers' professional training

Abstract: Currently, education is moving towards a modern quality standard, which implies the improvement of the training of students of pedagogical universities for their future professional activity. Accordingly, the priority is given to the problem of training future teachers in the period of teaching practicum, the potential of which is crucial as a "vital foundation" for personal experience in determining professional interests and needs, in mastering the methods of educational activities. In this regard, the scientific problem of training students for self-realization in the context of teaching practicum within a certain pedagogical system will contribute to the expansion and enrichment of the research area of pedagogical science and practice.
Keywords: teaching practicum, professional activities, competency, biology teacher, student, education.

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Introduction

Social demand is expressed in the requirements for the training of a new generation of teachers capable of innovative professional activities, possessing the necessary level of methodological culture and readiness for a continuous education throughout life.

Modern teachers will have to meet new challenges. The place and role of teachers in modern society will change. We can say with certainty that the socio-professional status of teachers in society becomes more important, and the social self-esteem of teachers and their assessment by society have become higher.

As a result, the requirements for future teachers' training are constantly increasing. In general, the structure and the content of training should be aimed at the personal development of teachers and the formation of the professional mentality of young specialists in the context of the realization of the modern requirements of society for the training of educational specialists. Educational specialists have to be capable of carrying out an expanded and systematic cultural reproduction including social attitudes and value orientations.

The purpose of the research is a theoretical and methodological substantiation, development and testing of the effectiveness of the system for training students in the context of teaching practicum.

The above issues caused interest and predetermined the need to solve the following tasks:

1. To supplement and clarify the concepts of "students' teaching practicum" and "future biology teachers' professional training" presented in modern pedagogical literature.

2. To develop questionnaires for 3rd and 4th year biology students.

3. To analyze the obtained results and to give their interpretation in view of the implementation of the updated biology curriculum for general education secondary schools.

The formation of new teaching culture expressed in competency-based approach makes it possible to bridge the gap between the knowledge, skills and abilities obtained in the course of education. Bridging the gap between training and practice increases the competitiveness of a specialist in the labor market. A competitive specialist with an education of any level must meet all the requirements and global trends in the development of the labor market, be able to quickly adapt to the ever-changing living conditions, have a set of necessary competencies in different areas of human activity (Kirillova, 2003).

The issues of teacher training have always been the focus of attention of leading methodologists, educators, and psychologists (Arlinwibowo et al., 2021). A.Y. Terentyev is one of the first scientists involved in the issues of pedagogical training for teaching special disciplines. He revealed the importance of the above issues, pointed out the need to bring artistic, psychological and pedagogical disciplines closer together, so that students' training will become even more in line with the pedagogical specialization of specialists graduated from a faculty. In her studies, N.S. Davlyatshina solves the problem of improving the level of professional and pedagogical training of visual arts teachers in primary schools. In the study of I.V. Solodukhin, the qualitative improvement in the visual arts teachers' training is associated with the enhancement of its practical and pedagogical orientation (Abdullina, 1990).

The purpose of teaching practicum for students is to be prepared for the main types of professional activities, the implementation of acquired professional knowledge, skills, abilities and professional adaptation, i.e. entering the profession, mastering the social role, professional self-determination, formation of positions, integration of personal and professional qualities.

It is well known that one of the methodological approaches to learning, including professional learning, is the activity approach, which proclaims that the development of any skills and psychological properties occurs when carrying out practical activities.

The analysis shows that in many universities, a continuous teaching practicum accompanies students from the first to the third year of studies, and there is a "school day" in the schedule, during which students are exempted from classes at the university and are in school. Whereas in some universities, "school days" are replaced by "school hours" when students visit a school before or after university classes. Finally, in all pedagogical universities in Kazakhstan, students come to school for state teaching practicum in the eighth semester at the graduation year, often being insufficiently prepared for teaching. What is the reason for such an unpreparedness?

Many Kazakh scientists studying such issues have studied foreign experience (Kulikova, 1997; Isayeva, 2012). Let us consider a comparative analysis of the experience of domestic and foreign higher pedagogical schools. The commission of the U.S. National Association for Education engaged in the issues of teacher education and professional standards defines teaching practicum as the "crucial" aspect of teacher education. This coincides with the vision of such issues in Kazakhstan. Like in Kazakhstan, in many U.S. universities, teaching practicum is focused on the last year of studies; however, it is held during the whole academic year. Practicum has two forms: 1) students are permanent employees of a school and receive about a third of the salary; 2) students work for free under the guidance of a senior teacher, and sometimes replace him/her. Obviously, the first form provides a fundamentally different motivation, responsibility and quality. Currently, the tendency to conduct practicum during all years of study is becoming more and more popular.

The students of Kazakh institutions of higher education are trained for teaching at school by studying the curriculum of psychological and pedagogical disciplines such as "Introduction to the teaching profession", "Age physiology and school hygiene", "Pedagogy", etc. However, it is no secret that they provide theoretical training. In the USA, great importance is attached to observation as the preparatory and initial stage of the practicum. For this, numerous schemes have been developed for analyzing teachers' activities in classroom, and school television is used to enable observing and analyzing a lesson without interfering with its natural course. In addition, the most remarkable is that in the American system of teacher education, the responsibility for organizing and conducting practical training of students lies with schools and school teachers (Hwopek, 1975; Coker & Schrader, 2004; Stimpson, Lopez-Real, Bunton, Chan, Sivan et al., 2000).

In German universities, there is a similar tradition to Kazakhstan when, during a teaching practicum, student teachers attend school lessons on a weekly basis and then discuss them under the guidance of a university teacher. The teaching practicum can last up to 3 years. Nevertheless, the peculiarity is that this practice is organized in such a way that future teachers get a full-time job at the school. Their teaching activities are supervised by experienced teachers and methodologists. After completing the practical training cycle, a future teacher passes the state exam (a second one), which contains a test of the theory, skills and abilities to conduct academic work at school (Schulz, 2005; Wankat & Oreovicz, 2001).

The time limits of teaching practicum for future teachers in the UK are on average 25% of the total amount of study time (from 18 to 32 weeks). The names of the teaching practicums of British students echoes Kazakh ones: they are observational practice, internship, and work placement. However, the fundamental difference is that practicum takes place in schools before students begin to study the theoretical disciplines of the psychological and pedagogical curriculum. Experienced schoolteachers (mentors) and teachers of colleges and universities (tutors) supervise the work of students during teaching practicum. In this case, the tutors do not directly supervise the student teaching practicum but receive information from the mentors about the results of the work of student teachers.

In the UK, there are two main forms of teaching practicum at school: traditional (long-term practicum without attending university classes) and serial (short-term practicum conducted together with university classes, which can last half a day, a day, or a week). Teaching practicum includes attending school in order to study the peculiarities of the educational process, review and analysis of demonstration lessons, micro-teaching, and independent conducting of classes (Lawson, Çakmak, Gündüz, & Busher, 2015; Sprague & Percy, 2014; Farrell, 2007).

When summarizing the main differences in the organization of practicum in Kazakh and other systems of teacher education, two conclusions can be drawn: 1) the ratio of theoretical and practical training of students varies significantly; 2) outside Kazakhstan, the responsibility for the management (including grading) of the student teaching practicum lies, to a greater extent, with schools.

These differences would be understandable if there were not a paradox: the first difference fully corresponds to the activity approach, which is proclaimed fundamental for the Kazakh educational system.

Materials and Methods

Teaching practicum is a complex process in which students perform activities defined by their specialization.

The objectives and scope of a practicum are determined by the relevant state educational standards for the levels of higher professional education.

Teaching practicum tasks can be formulated as follows:

– enhancement and consolidation of theoretical knowledge, its application in solving specific socio-pedagogical tasks;

– formation of analytical thinking, the ability to predict and model professional activities in a changing society;

– formation of a motivational-value attitude to future biology teacher activities, an orientation towards communication and interaction with the student team during studies, the need for self-realization;

– mastering the content and various forms and methods of organizing individual, group, and collective activities of children of different ages, techniques of carrying out the work with a student team;

– acquisition of the ability to conduct individual educational work with students who have learning, interpersonal communication problems etc.;

– creation of conditions for the improvement of diagnostic, communication, organizational, analytical skills and professionally significant personal qualities of biology teachers;

– formation of skills to establish professional and ethical relationships with colleagues.

In combination with academic disciplines, the practical activity of students contributes to defining orientations and prospects for professional growth in the future, strengthening the adequate professional self-esteem, and shaping the future teachers' personalities (Bailey, Scantlebury, & Johnson, 1999; Ryan, Toohey, & Hughes, 1996; Head, 1992).

In practice, the pedagogical activity of students is improved on the basis of substantial factual material, the learning and effective mastering of which is possible only with the use of live impressions and observations ("The Teaching of Style," 1972; Pfeiffer & Reighard, 1971; Belliveau, 2007; Taylor & Miller, 1985).

Important factors in students' teaching practicum are:

- students' ability to change their social and professional activities understood as the most important personal quality, which expresses a creative attitude to various aspects of life including self-attitude. Teaching practicum determines what is the focus of these activities in the professional sphere;

- versatile orientation of future teachers to all spheres of pedagogical activities: the discipline-based and educational activities of students and their methodological equipment, the educational interaction, its organization and mastering the research work methodology;

- formation, in the context of the natural pedagogical process, of a reflexive culture, when for a teacher the means and methods of his/her own pedagogical activity, the processes of developing and making practical decisions become the subject of reflection. An analysis of one's own activities helps a practice teacher to become aware of the difficulties encountered in his/her work, and to find competent ways to overcome them.

These factors of the teaching practicum are determined by the following targets:

- development of professional competency of a teacher, personal and humanistic orientation, systemic vision of pedagogical reality;

- formation of content area and reflexive culture;

- mastering pedagogical techniques and the ability to integrate with pedagogical experience.

Organizational and pedagogical conditions of teaching practicum include:

– diagnostic conditions (live and online discussion of contradictions and difficulties in the lasr year students' professional pedagogical activities; highlighting the relevant types and their characteristics);

– projective conditions (development of goals and tasks of teaching practicum focused on the formation of the core teacher competencies, their scientific substantiation, preparation of the basis for teaching practicum, development of criteria for project effectiveness and conditions for implementation);

– conditions of professional self-education (ensuring real professional growth of students through the development of individualized methods, techniques and means of self-education as a form of teacher self-improvement, participation in student scientific and practical conferences, etc.);

– conditions of value and notional attitude to the future profession (interaction with mentors and students; participation in assignments, solving pedagogical tasks etc.) (Zhirkova, 2012; Monakhov, Vlasov, & Veresova, 2004; Ivanischev, 1989; Black, 1976).

The content of teaching practicum may include the invariant system of tasks aimed at shaping the students' readiness for independent projecting and the implementation of the educational process at school, and the variable part focused on the students' expectations and their creative and scientific interests, tasks that a particular school solves in the process of implementing innovative activities' projects etc. The list of tasks of the variable part can be unlimited. These can be tasks related to participation in management activities, diagnostic studies, building an educational system, organizing exhibition activities, etc.

In the course of teaching practicum, students develop the basis for analyzing and evaluating their own pedagogical activities. Pedagogical reflection develops not only in the work with a teaching practicum log book but in every lesson, in every communication with children. During a practicum, students have to be prepared for real pedagogical activities, where they will have to perform all teacher functions. Indicators of the level of knowledge, skills, personal development and creative activity of students are closely related to the quality of the educational process and are more important for determining the effectiveness of the quality of the educational process.

One of the main tasks of teaching practicum is to study the current state of educational work in educational institutions, that is, monitoring as a constant observation of any process in order to identify its compliance with the desired result.

Results and Discussion

Teaching practicum is complex and includes the following stages: preparatory, main and final ones.

At the preparatory stage, students are trained to solve the problems of teaching practicum. They get acquainted with the practicum's content and form as well as with parameters for evaluating the success of each stage. Initial conference and seminars can be distinguished among the forms of work.

At the main stage of the practicum, the following tasks can be offered to student teachers:

- to get acquainted with the educational institution where the practicum is held (to determine the type of school, analyze the main areas of work and the pedagogical process);

- to study the class, to get acquainted with the work of teachers and the class teacher; to study individual students;

- to conduct a non-standard lesson, take part in the discussion and analysis of non-standard lessons;

- to analyze extracurricular activities plans;

- to study the class using basic psychological methods, to make a psychological and pedagogical characteristics and diagnostic card of the class;

- take part in school-wide educational activities.

The implementation of this stage can be carried out in the following forms:

- meeting with the administration and teaching staff of the school,

- work with regulatory documents,

- visiting lessons, group discussion of lessons, general pedagogical and psychological-pedagogical analysis of lessons,

- questioning the relationship and the situation of students in the class, filling in a diagnostic card, drawing up the psychological and pedagogical characteristics of students' personalities,

- conducting a non-standard lesson,

- filling in the teaching practicum log book,

- consultations with mentor teachers, group leaders, etc.

At the final stage, the results of the teaching practicum and the preparation of reporting documentation are carried out; prospects for further professional growth are determined. Summing up takes place at the final conference (Kirillova, 2003).

Conclusion

Thus, it can be concluded that modern pedagogical education meets the needs of a dynamically developing society and is actively seeking new alternative forms of professional training for students. The modern professional training should create the most favorable conditions for the development of student personality, meet the increased requirements for modern teachers, their professional and personal qualities, as well as ensure a high level of competency and mobility of students.

There is a problem of students' professional readiness and insufficiently formed professional pedagogical values. The difficulties encountered by students during the teaching practicum, show the inability to integrate knowledge from discipline-based, psychological and cultural areas (Milrud, 1997; Falileyeva, 1989; Dorofeyev, 1989). The ability to apply this knowledge in practice is also a challenge. The questionnary survey showed that student teachers are dissatisfied with their knowledge of pedagogy, psychology, and methods of teaching their discipline. This is alarming since these facts once again prove that the traditional training of teaching staff must change by acquiring new forms.

Thus, after analyzing the current state of the Kazakh education system including the latest innovative approaches and the features of organizing teaching practicum in other countries, the authors highlight areas for the further development of practicum at school:

• undergoing teaching practicum during all years of studies;

• a gradual increase in the duration of teaching practicum from year to year of studies in order to adapt students to the reality of school life;

• a gradual increase in the responsibility of schools for teaching practicum;

• enhancing the collaborative interaction of school and university teachers to improve teaching practicum programs;

• stimulation of this type of work for school teachers (for example, material incentives, advantages in certification, etc.).

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Change in the phase composition of low-quality bauxites as a result of chemical activation

Abstract: As a result of separation of a fine fraction of gibbsite-kaolinite low-quality bauxite from the Krasnogorsky deposit, it is possible to increase its silicon module. When bauxite is chemically activated in a solution of sodium bicarbonate, the fine fraction is effectively separated from the large one and the phase composition changes – the calcium silicate phase disappears and the calcite phase is formed. With an increase in the activation temperature, the content of kaolinite and siderite decreases, the content of quartz and hematite increases. Studies have shown that at chemical activation temperatures of 120 ^oC, lasting more than 120 minutes and 200 ^oC, lasting more than 40 minutes, a dawsonite phase is formed in bauxite, which compacts the mineral structure. When determining the mode of chemical activation, it is necessary to take into account the negative possibility of the formation of dawsonite.

Keywords: gibbsite-kaolinite bauxite, chemical activation, sodium bicarbonate, phase composition, conditioning, technology.

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Introduction

Gibbsite-kaolinite bauxites of the Krasnogorsk deposit are characterized by a low silicon modulus and high content of harmful components: siderite, chamosite, hematite, pyrite, organic, and other impurities, and their quality keeps declining, which leads to a sharp deterioration in the composition of solutions, industrial products and a decrease in technical and economic indicators [1]. This circumstance forms the basis for a set of theoretical and technological research to develop effective technology.

It appears practicable to process low-quality bauxites by separate leaching of clay and stony bauxite fractions, but the existing methods of bauxite fraction separation in an alkaline environment do not provide the required degree of separation of the clay part [2, 4].

However, the known processing methods applied to low-quality bauxites have many disadvantages that make it difficult or impossible to use them.

To involve most of the bauxite deposits in Kazakhstan in the processing field, a technology for processing low-quality gibbisite-kaolinite bauxites with preliminary chemical activation has been proposed [3, 5, 6].

Methods and techniques

The samples were subjected to a chemical analysis with the help of an optical emission spectrometer with an inductively coupled plasma Optima 2000 DV (USA, Perkin Elmer).

To perform an X-ray fluorescence analysis, a Venus 200 wave dispersion spectrometer (PANalyical B.V., the Netherlands) was used.

The X-ray experimental data were obtained by applying a BRUKERD8 ADVANCE device with copper radiation at an accelerating voltage of 36 kW and a current of 25 mA.

The X-ray analysis was based on an IR-Fourier spectrometer Avatar 370 in the spectral range of 4000-400 cm^{-1} from preparations including 200 mg of KBr and 2 mg of the sample.

A STA 449 F3 Jupiter synchronous thermal analysis instrument was used for the thermal analysis.

A low-vacuum electron microscope with a thermoemission cathode (LaB6) JSM-6610LV from JEOL was applied to take microphotographs.

The chemical activation of bauxite took place in a solution containing 120 g/dm^3 of $NaHCO_3$ at a ratio of S:L=10.0, temperatures of 90–200°C with the help of a thermostated unit with 6 autoclaves rotating through the head, and a working volume of 250 cm^3. The required sodium hydrocarbonate content of 120 g/dm^3 in the solution was selected taking into account its solubility limit.

The silicon modulus of the samples was determined based on the Al_2O_3/SiO_2 ratio.

Results and discussion

The study relied on a representative sample of gibbsite-kaolinite bauxite of Krasnogorsk composition, wt. %: Al_2O_3 42.0; SiO_2 11.5; Fe_2O_3 19.5; CaO 1.08; Na_2O 0.22; MgO 0.18; K_2O 0.03; TiO_2 2.05; SO_3 0.24; Cl – 0.04; p.p. 23.16; µSi 3.65.

Table 1 illustrates the X-ray phase composition of the bauxite sample.

Table 1. The phase composition of the bauxite sample

Name	Formula	%
Gibbsite	$Al(OH)_3$	54.95
Kaolinite-1A	$Al_2Si_2O_5(OH)_4$	10.02
Siderite	$FeCO_3$	6.09
Hydroaluminosilicate	$Al_2Si_2O_5(OH)_4$	5.17
Quartz	SiO_2	5.10
Calcium silicate	Ca_5Si_3	5.07
Hematite	Fe_2O_3	4.89
Titanium oxide	TiO_2	4.88
Ferrotitanium oxide	Fe_2TiO_5	3.83

The infrared spectrum of the bauxite sample is shown in Figure 1.

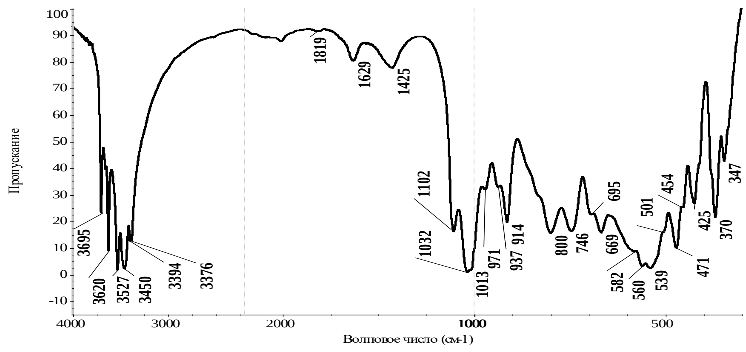


Figure 1. The infrared spectrum of the bauxite sample

The infrared spectroscopy determined the presence of the following phases: gibbsite γ-$Al(OH)_3$; kaolinite $Al_4[(OH)_8 \mid Si_4O_{10}]$; goethite α- FeOOH; siderite $FeCO_3$. Among those found, there are hematite Fe_2O_3; anatase TiO_2; diaspore α-AlOOH –[1].

The study of the bauxite sample by the thermal method of analysis (Figure 2) showed the following findings: intense endothermic effects with maximum development at 334.5°C, 557°C on the DTA curve; additional exothermic effects with peaks at 897.8°C and 989.9°C on the dDTA curve; minima were recorded at 287.9°C, 319.4°C, and 532.8°C on the DTG curve.

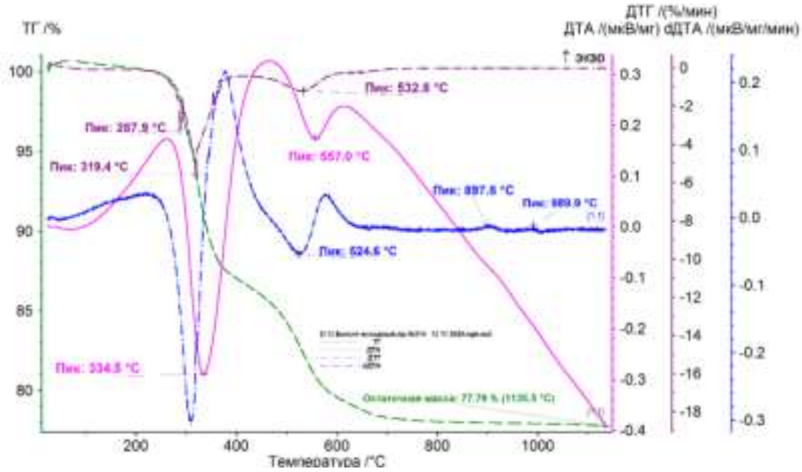
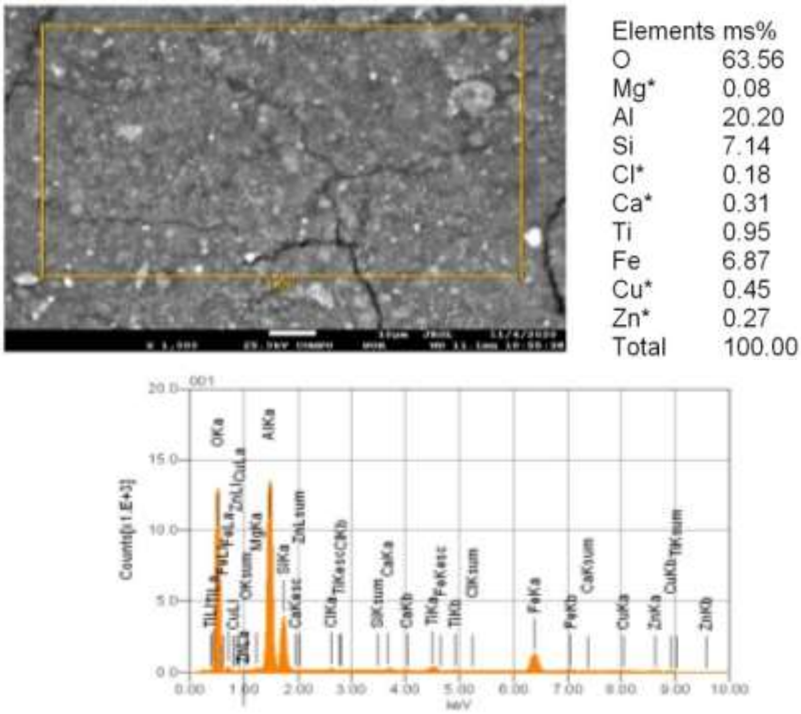


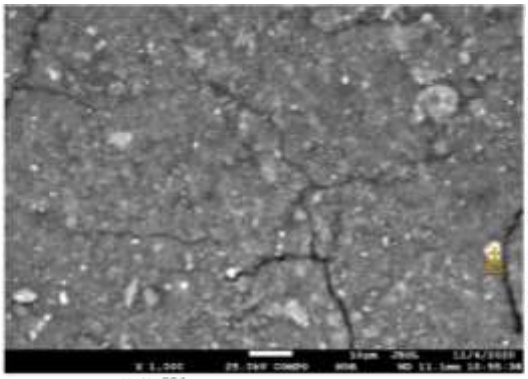
Figure 2. Thermogram of the initial bauxite sample

The deep endothermic effect with maximum development at 334.5°C, in the development area of which two minima appeared on the DTG curve (287.9°C, 319.4°C), reflects the dehydration of gibbsite and iron hydroxide. The combination of the endothermic effect with the extremum at 557°C on the DTA curve and the weak exothermic effect with the peak at 989.9°C on the dDTA curve m.b. the kaolinite manifestation. In superimposition, the combination of the same endothermic effect with the exothermic effect with a peak at 897.8°C on the dDTA curve reflects the presence of coarse-grained siderite.

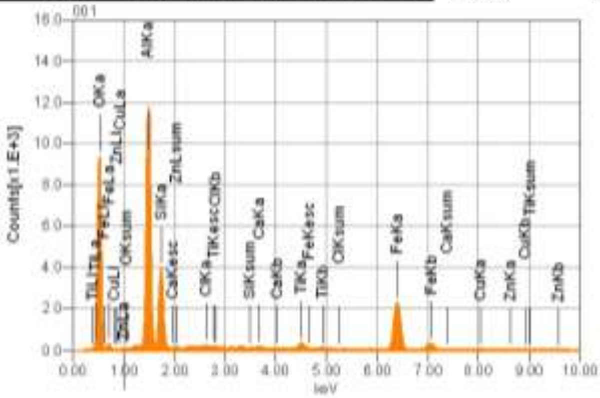
The microphotographs and electron microscopic analysis of the bauxite sample are shown in Figure 3 (a, b, c).



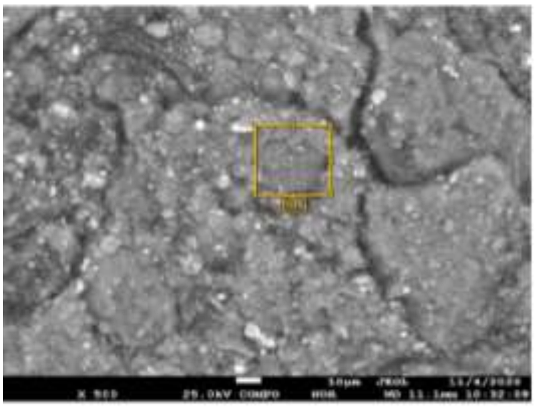
a



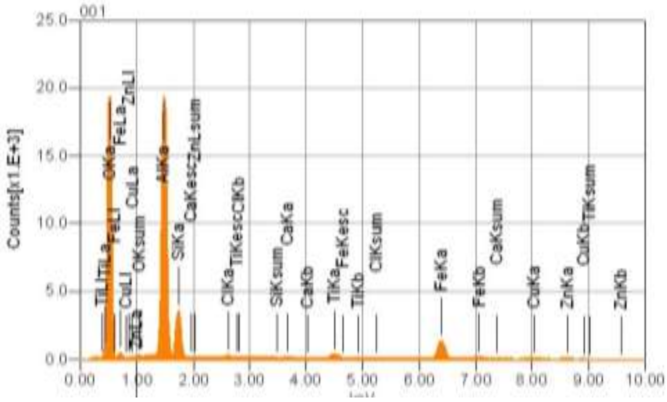
Elements	ms%
O	54.64
Al	20.75
Si	8.35
Cl*	0.21
Ca*	0.14
Ti	0.90
Fe	13.97
Cu*	0.57
Zn*	0.47
Total	100.00



b



Elements	ms%
O	66.07
Al	21.49
Si	4.87
Cl*	0.15
Ca*	0.14
Ti	0.75
Fe	5.36
Cu*	0.65
Zn*	0.50
Total	100.00



c

a – general composition; b – coarse fraction; c – a fine fraction

Figure 3. Microphotographs and electron microscopic analyzes of a bauxite sample

The microphotographs show that the coarse-grained bauxite fraction is tightly pressed by the fine fraction. The total silicon modulus of the sample section (Figure 3-a) is 3.45. The silicon modulus of the coarse fraction (Figure 3-b) is 4.41, and that of the fine fraction (Figure 3-c) is 2.19.

To increase the silicon modulus of bauxite by separating the fine fraction, the initial sample was chemically activated in sodium hydrocarbonate solution.

Determining the optimal conditions for the chemical activation of bauxite included the studies of the effect of temperature and process duration.

The effect of the chemical activation temperature on the change in the material composition of bauxite was studied at temperatures of 90–200°C for 60 minutes.

Table 2 illustrates the chemical composition of the bauxite sample depending on the activation temperature.

Table 2. Chemical composition of the bauxite sample depending on the activation temperature

Name	Activation temperature, °C					
	Init.	90	120	150	180	200
	Content, %					
Al_2O_3	42.0	42.4	42.0	42.2	42.6	42.8
SiO_2	11.5	11.4	11.3	11.3	11.4	11.5
Fe_2O_3	19.5	19.7	19.9	19.7	19.9	19.9
CaO	1.08	1.1	1.1	1.2	1.1	1.2
Na_2O	0.22	0.7	1.06	1.18	1.5	6.4
MgO	0.18	0.18	0.19	0.17	0.19	0.18
SO_3	0.24	0.17	0.18	0.18	0.19	0.16
K_2O	0.03	0.03	0.02	0.03	0.05	0.05
TiO_2	2.05	2.25	2.3	2.2	2.1	2.2
Cl^-	0.04	0.02	0.02	0.016	0.017	0.03
p.p.	23.16	22.05	21.93	21.824	20.953	15.58

The chemical activation demonstrated that the element content in the samples remained at the same level, except for sodium oxide. At an activation temperature of 200°C, a thick pulp was obtained.

Table 3 illustrates the phase composition of the bauxite sample depending on the chemical activation temperature.

Table 3. The phase composition of the bauxite sample depending on the chemical activation temperature

Name	Activation temperature, °C					
	Init.	90	120	150	180	200
	Content, %					
Gibbsite $Al(OH)_3$	54.95	55.59	56.45	55.7	52.38	55.34
Kaolinite-1A	15.19	12.11	12.43	12.44	10.79	10.86
Siderite $FeCO_3$	6.09	11.52	9.77	7.69	6.82	7.29
Quartz SiO_2	5.11	4.8	4.91	6.37	7.63	8.04
Calcium silicate	5.07	-	-	-	-	-
Hematite Fe_2O_3	4.89	5.09	5.89	6.23	6.99	7.22
Titanium oxide Ti_6O_{11}	4.88	4.69	4.59	4.57	4.51	4.64
Ferrotitanium oxide	3.82	3.67	3.70	3.80	3.76	3.41
Calcite $CaCO_3$	-	2.53	2.26	3.20	3.21	3.20

As follows from Table 3, with increasing chemical activation temperature in the phase composition of bauxite, the content of kaolinite and siderite decreases, the content of quartz and hematite increases, the phase of calcium silicate disappears, and the phase of calcite is formed.

The effect of the chemical activation duration on the change in the material composition of the bauxite sample at temperatures of 120 and 200°C was studied (Table 4).

Table 4. Chemical composition of the bauxite sample depending on the duration of activation at a temperature of 120°C

Name	**Duration, min.**						
	20	**40**	**60**	**90**	**120**	**180**	**240**
	Content, %						
Al_2O_3	42.2	42.25	42.24	42.4	42.4	38.8	36.3
SiO_2	11.2	11.1	11.3	11.3	11.1	10.9	10.6
Fe_2O_3	20.3	20.3	19.8	19.6	20.0	18.6	17.1
CaO	1.3	1.14	1.1	1.1	1.17	1.06	0.9
Na_2O	0.413	0.45	1.16	1.3	1.43	4.35	6.8
MgO	0.13	0.18	0.19	0.16	0.18	0.2	0.16
SO_3	0.19	0.16	0.18	0.17	0.17	0.04	0.19
K_2O	0.07	0.06	0.02	0.04	0.03	0.04	0.06
TiO_2	2.5	2.4	2.6	2.2	2.5	2.2	2.06
Cl^-	0.02	0.02	0.02	0.02	0.02	0.02	0.04
p.p.	21.677	21.94	21.39	21.71	21.0	23.79	25.79

The increased duration of activation to 180 minutes at a temperature of 120°C increases the Na_2O content in bauxite, while the content of other elements remains at the same level. With an activation duration of 180 minutes or more, a thick pulp is obtained; its mass is greater than the initial mass of bauxite, so the percentage of elements decreases.

Table 5 illustrates the phase composition of the bauxite sample depending on the duration of chemical activation at a temperature of 120°C.

Table 5. The phase composition of the bauxite sample depending on the duration of chemical activation at a temperature of 120°C

Name	Activation temperature, °C						
	20	40	60	90	120	180	240
	Content, %						
Gibbsite $Al(OH)_3$	51.43	51.42	51.45	51.91	50.69	45.62	43.76
Kaolinite-1A $AL_2Si_2O_5(OH)_4$	11.67	11.98	10.94	10.22	10.37	9.06	9.3
Siderite $FeCO_3$	4.89	4.58	4.77	5.00	6.56	6.02	-
Quartz SiO_2	5.28	5.18	5.61	5.94	6.02	6.55	6.05
Calcium silicate Ca_5Si_3	10.02	10.25	10.23	10.1	9.81	9.35	8.09
Hematite Fe_2O_3	6.99	7.0	7.09	6.94	6.99	7.11	7.1
Titanium oxide Ti_6O_{11}	6.32	6.2	6.25	6.6	6.54	6.23	6.71
Ferrotitanium oxide Fe_2TiO_5	3.4	3.39	3.66	3.29	3.02	4.4	4.5
Calcite $CaCO_3$	-	2.53	2.26	3.20	3.21	3.20	
Dawsonite $NaAlCO_3(OH)_2$	-	-	-	-	-	5.66	14.49

As a result of the chemical activation, the gibbsite phase content remains at the same level for up to 120 minutes, whereafter its amount decreases, and a new aluminum-containing phase – dawsonite – is formed.

Table 6 shows the chemical composition of the bauxite sample depending on the activation duration at a temperature of 200°C.

Table 6. Chemical composition of the bauxite sample depending on the activation duration at a temperature of 200°C

Name	**Duration, min.**			
	20	**40**	**60**	**90**
	Content, %			
Al_2O_3	44.1	44.38	44.83	44.8
SiO_2	11.0	11.1	10.9	10.7
Fe_2O_3	20.1	19.4	19.9	11.08
CaO	1.14	1.1	1.2	0.6
Na_2O	0.2	0.9	6.4	23.1
MgO	0.18	0.18	0.18	0.12
SO_3	0.17	0.17	0.16	0.2
K_2O	0.04	0.05	0.05	0.01
TiO_2	2.6	2.53	2.5	1.64
Cl^-	0.02	0.02	0.02	0.01
p.p.	20.45	20.17	13.86	7.74

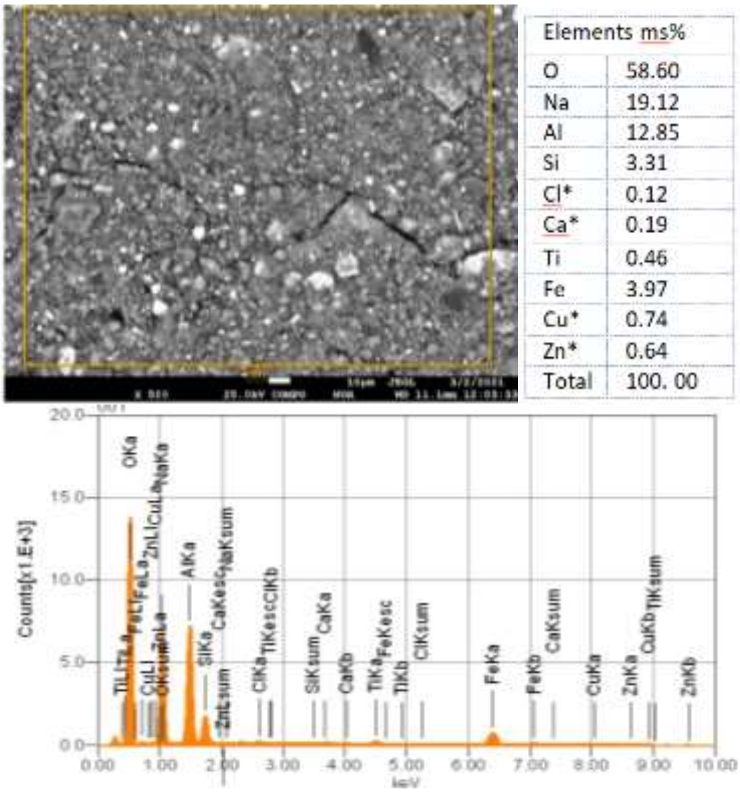
With an activation duration of 60 minutes, a thick pulp was obtained. At 90 minutes, a solid phase was obtained; it filled the entire volume of the autoclave.

The increase in the final weight of bauxite after activation at a temperature of 200°C and duration of 60 minutes or more resulted in a decrease in the element percentage, while the sodium oxide content increased sharply due to the formation of a new phase, namely, dawsonite (Table 7).

Table 7. The phase composition of the bauxite sample depending on the duration of chemical activation at a temperature of 200°C

Name	**Activation temperature, °C**			
	20	**40**	**60**	**90**
	Content, %			
Gibbsite $Al(OH)_3$	54.59	54.38	50.34	15.3
Kaolinite-1A $AL_2Si_2O_5(OH)_4$	9.58	8.85	9.8	6.34
Siderite $FeCO_3$	8.8	8.86	-	-
Quartz SiO_2	4.05	4.36	4.8	3.2
Calcium silicate Ca_5Si_3	5.45	6.28	6.22	5.45
Hematite Fe_2O_3	2.69	2.83	2.4	1.2
Titanium oxide Ti_6O_{11}	8.49	8.19	8.41	2.8
Ferrotitanium oxide Fe_2TiO_5	6.35	6.25	3.26	2.82
Calcite $CaCO_3$	-	-	14.77	62.89
Dawsonite $NaAlCO_3(OH)_2$	-	-	-	-

The microphotographs and electron microscopic analysis of a bauxite sample after chemical activation are shown in Figure 4.



Elements	ms%
O	58.60
Na	19.12
Al	12.85
Si	3.31
Cl*	0.12
Ca*	0.19
Ti	0.46
Fe	3.97
Cu*	0.74
Zn*	0.64
Total	100. 00

Figure 4. Microphotography and electron microscopic analysis of a bauxite sample after chemical activation at a temperature of 200°C and a duration of 40 minutes

The microphotograph shows that after the chemical activation of bauxite, the fine fraction separates from the coarse one, which will increase the efficiency of gravitational and chemical enrichment of the low-quality gibbsite-kaolinite bauxite from the Krasnogorsk deposit for further processing into alumina.

Conclusions

The phase composition of the gibbsite-kaolinite bauxite from the Krasnogorsk deposit is represented by gibbsite, kaolinite, siderite, hydroaluminosilicate, quartz, calcium silicate, hematite, titanium oxide, and ferrotitanium oxide.

The electron microscopic analysis of the initial bauxite showed that the coarse-grained bauxite fraction was tightly pressed by the fine one. The total silicon modulus of the sample is 3.45. The silicon modulus of the fine fraction is 2.19, and the silicon modulus of the coarse fraction is 4.41.

As a result of the chemical activation of bauxite in the sodium hydrocarbonate solution, the fine fraction is effectively separated from the coarse fraction, and the phase composition changes, namely, the calcium silicate phase disappears, and the calcite phase is formed.

As the activation temperature increases, the content of kaolinite and siderite decreases, and the content of quartz and hematite increases.

A dawsonite phase is formed in bauxite at chemical activation temperatures of 120°C, duration of more than 120 minutes, and 200°C, duration of more than 40 minutes; it compacts the mineral structure and makes further enrichment by gravity methods impossible, therefore, when choosing the activation conditions, it is necessary to exclude the formation of this phase.

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Production of non-ferrous metal concentrate in the processing of pyrite slags

Abstract: The method of preliminary chemical activation of mineral raw materials was used in the conducted studies for the complex processing of pyritic slags. The influence of preliminary chemical activation of kaolinite clays of Alexeevsky deposit in the solution of sodium hydrogen carbonate on the separation of kaolinite and quartz fractions was studied. The temperature of 150 ^{o}C, the duration of 120 minutes, and the concentration of sodium bicarbonate solution of 120 g/dm^3 should be considered the optimum mode of activation. As a result of activation, the phase composition of the kaolinite fraction changed: the percentage of kaolinite fraction decreased; new phases of muscovite and sodium aluminosilicate appeared; the amount of quartz increased.
Keywords: pyritic slags, chemical activation, leaching, phase composition, non-ferrous metals, neutralization, concentrate.

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Introduction

One of the ways to produce sulfuric acid is roasting pyrite concentrate to produce sulfurous gas [12]. The resulting pyrite slag is stored, which creates a real threat of pollution of the water and air environment, while at the same time they are a valuable source of ferrous, non-ferrous, and noble metals, not used to date due to the lack of economically viable technologies. In this regard, the development of effective, integrated technology intended to process pyrite slag is ***relevant.***

Pyritic pellets are equal to good iron ores in terms of iron content (50-60%), but their use for smelting pig iron is prevented by the presence of base metals and sulfur in them. Therefore, the technological scheme of processing should provide a sufficiently complete extraction of non-ferrous metals and obtain a product suitable for blast-furnace smelting.

The main method of processing pyritic slags introduced in some countries is chlorination roasting followed by leaching of nonferrous metal compounds [2, 6, 12, 13]. However, the high-energy consumption and the need to leach excessively large volumes is a disadvantage of the method, which reduces its practical significance.

Based on the available information [3, 7-10], the predominant direction of research is hydrometallurgical methods, which require improvement for complete utilization with the extraction of useful components - non-ferrous, precious metals, and iron.

The method of preliminary chemical activation of mineral raw materials was used in the conducted studies for the complex processing of pyritic slags. It promotes disintegration and phase changes [1, 4, 5, 11]. The method consists of thermal treatment with a solution of sodium bicarbonate. Due to the conditions of chemical activation, the hard-to-recover phases are modified and the mineral structure is disclosed by separating the non-metallic materials.

The optimal conditions for the preliminary chemical activation corresponding to the peculiarities of the mineral structure of pyritic slags were determined. The positive effect of activation is confirmed by the results of the leaching of non-ferrous metals from pyritic slags in sulfuric acid solution.

Methods

X-ray fluorescence analysis was performed with a Venus 200 wave dispersion spectrometer (PANalyical B.V., The Netherlands).

Chemical analysis of the samples was performed on an optical emission spectrometer with inductively coupled plasma Optima 2000 DV (USA, Perkin Elmer).

Semi-quantitative X-ray phase analysis was performed on a D8 Advance diffractometer (BRUKER) using copper Cu-Kα radiation at an accelerating voltage of 36 kV, current 25 mA.

Chemical activation of pyritic slags was carried out in a solution containing 40 - 120 g/dm^3 $NaHCO_3$ at S:L=2-10.0 and a temperature of 90 - 230^o using a thermostatic unit with 6 autoclaves rotating through the head, with a working volume of 250 cm^3. The duration of activation ranged from 30 to 300 minutes. The maximum content of sodium hydrogen carbonate 120 g/dm^3 in the solution is chosen to take into account its solubility limit

Results, discussion

A representative sample of pyrite slag from the sulfuric acid production of the **Tselinnyy Mining and Chemical Combine** of Kazakhstan was used in this work**.**

According to the results of sieve analysis, it was found that in the class +2.5 mm content of useful components - noble, nonferrous metals, and iron is much lower (Table 1).

Table 1. Chemical composition of classes of pyritic slags

Content, %	**Size class, mm**					
	+2.5	-2.5+1.0	-1.0+0.25	-0.25+0.1	-0.1+0.056	-0.056
Na_2O	2.44	1.43	1.19	0.959	0.75	0.71
MgO	3.29	0.65	0.67	0.483	0.41	0.39
Al_2O_3	10.96	6.92	6.37	4.163	3.11	3.03
SiO_2	39.73	27.09	25.18	16.13	11.89	11.44
P_2O_5	0.26	1.26	1.1	0.956	0.84	0.82
SO_3	0.51	7.33	8.1	7.725	6.35	6.1
CaO	9.72	2.84	2.62	1.949	1.41	1.2
TiO_2	1.26	0.42	0.37	0.25	0.178	0.16
Fe_2O_3	7.63	41.63	45.63	60.94	70.187	71.16
CuO	0.02	0.2	0.22	0.26	0.261	0.28
ZnO	0.04	0.4	0.4	0.61	0.604	0.66
As_2O_3	0.06	0.19	0.25	0.26	0.258	0.26
SeO_2	0.003	0.51	1.01	0.57	0.23	0.19
BaO	0.186	2.07	2.33	2.81	2.866	3.01
HgO	-	0.09	0.19	0.14	0.055	0.04
PbO	0.005	0.15	0.17	0.2	0.185	0.21
No	22.266	6.29	3.61	1.237	0.146	0.08
Au, g/t	0.021	1.58	2.68	2.69	2.24	2.88
Ag, g/t	0.1	11.2	16.2	19.3	21.4	22.3
Output, %	**31.0**	**6.2**	**5.5**	**20.8**	**34.3**	**2.2**

Magnetic separation determined that the + 2.5 mm class is the non-magnetic fraction and the - 2.5 mm + 0 class is the strongly magnetic fraction; it was separated at a magnetic field strength of 200 - 400 oersted.

Chemical composition of the magnetic fraction of pyritic slags of size class - 2.5 mm + 0 wt.%: Na_2O 1.4; MgO 0.74; Al_2O_3 5.69; SiO_2 23.22; P_2O_5 1.1; SO_3 6.24; Cl 0.01; K_2O 0.44; CaO 2.52; TiO_2 0.32; Fe_2O_3 52.84; CuO 0.25; ZnO 0.53; As_2O_3 0.24; SeO_2 0.3; BaO 2.4; HgO 0.08; PbO 0.16; p.p. 1.82; precious metal content, g/t: Au 2,69; Ag 19,3.

The phase composition of the magnetic fraction of pyritic slags is represented, wt. %: magemite 24.1, hematite 18.1, quartz 17.2, albite 10.2, trisodium phosphate zinc oxide hydrate 9.5, sodium aluminosilicate 6.7, barium ferrite 4.7, nitrozarosite 4.2, sodium thiorphosphate 2.8 and dolomite 2.5 (Figure 1).

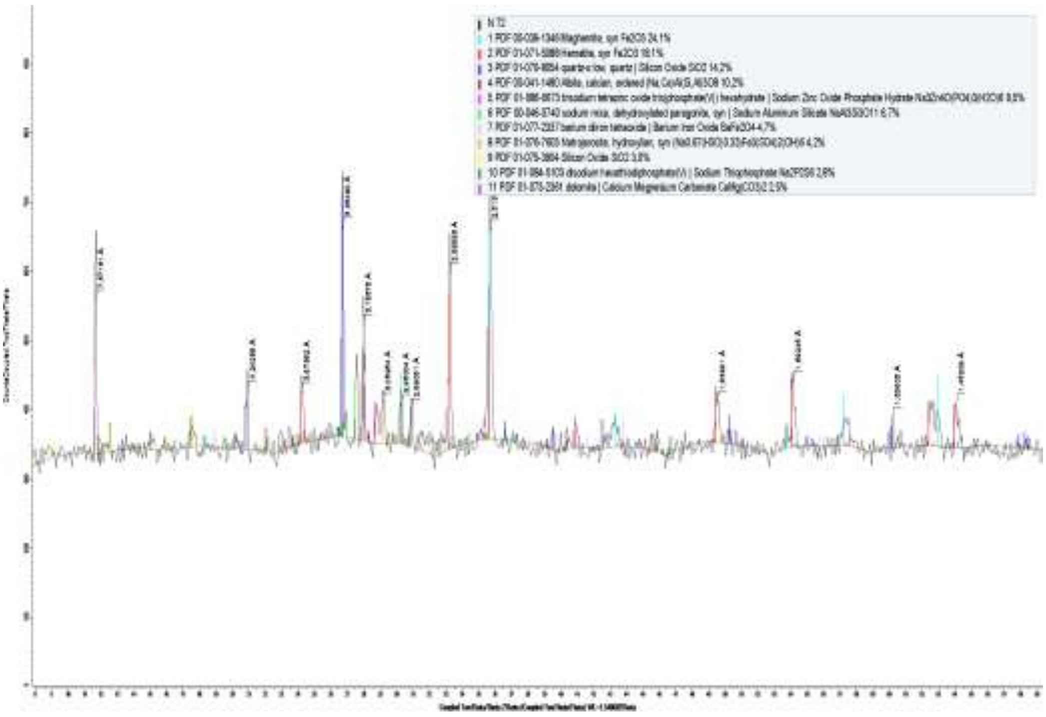

Figure 1. X-ray phase analysis of pyrite slag after chemical activation under optimal conditions

Chemical composition of the magnetic fraction of pyritic slags of size class –- + 2.5 мм wt.%: Na_2O 2.44; MgO 29; Al_2O_3 10.96; SiO_2 39.73; P_2O_5 0.26; SO_3 0.51; Cl 0.01; K_2O 0.8; CaO 2.72; TiO_2 1.26; Fe_2O_3 7.63; CuO 0.02; ZnO 0.04; As_2O_3 0.06; SeO_2 0.003; BaO 0.186; HgO 0.08; PbO 0.005; p.p. 23.076; noble metal content, g/t: Au 0,021; Ag 0,1.

The phase composition of the non-magnetic fraction of pyritic slags is represented, wt. %: magemite 2.1; hematite 1.4; quartz 29.9; albite 18.2; dolomite 18.2; calcite 17.3; clinochlore 7.7; muscovite 3.5 and gibbsite 1.4.

The poor fraction of size +2.5 mm, the amount of which is more than 30%, was not used in further studies.

To determine the main technological parameters of the preliminary chemical activation, the pellets of class - 2.5 mm + 0 were crushed in a ball mill to a coarseness of - 0.056 mm.

The dependence of the chemical activation of pyritic slags in sodium bicarbonate solution on temperature, duration, S:L ratio, and $NaHCO_3$ concentration was investigated. It has been determined that the optimum conditions of chemical activation are temperature 120 ^oC, duration 30 - 60 min, the S:L ratio = 4:1, and the concentration of $NaHCO_3$ solution 60 g/dm^3 at which the maximum changes in the phase and chemical composition are obtained.

Chemical composition of pyritic slags after activation under optimal conditions, weight %: Na_2O 1.59; MgO 0.73; Al_2O_3 5.63; SiO_2 22.3; P_2O_5 0.59; SO_3 3.45; Cl 0.01; K_2O 0.43; CaO 2.64; TiO_2 0.31; Fe_2O_3 51.89; CuO 0.24; ZnO 0.52; As_2O_3 0.16; SeO_2 0.25; BaO 2.32; HgO 0.09; PbO 0.16; p.p 6.69.

Analysis of the chemical composition showed that after activation the content of P_2O_5, SO_3, and As_2O_3 in pyrite slag decreased by 46.36 %, 44.31 %, and 33.3 % respectively.

The phase composition of pyritic slags after chemical activation under optimal conditions is represented by wt%: maghemite, 28.4; hematite, 21.8; quartz, 14.7; albite, 8.7; sodium aluminosilicate, 6.0; barium ferrite, 6.2; natrojarosite, 4.3; sodium thiophosphate, 5.7; magnesium aluminosilicate, 2.5 and calcium silicate, 1.7. (Figure 2).

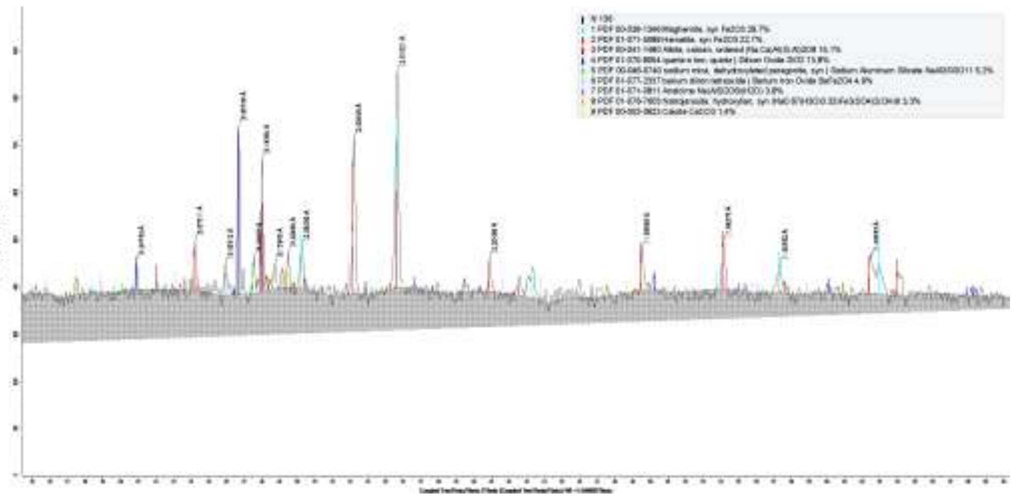

Figure 2 X-ray phase analysis of pyritic slag after chemical activation under optimal conditions

As a result of chemical activation of pyritic slags in optimal conditions, the phases of zinc phosphate trinatrium hydrate oxide $Na_3Zn_4O(PO_4)3(H_2O)_6$ and dolomite $CaMg(CO_3)_2$ disappeared; the amount of sodium thiophosphate phase $Na_2P_2S_6$ increased from 2.8% to 5.7%; the amount of albite phase $Na(AlSi_3O_8)$ decreased from 10.2% to 8.7% and that of natrojarosite $(Na_{0.67}(H_3O)_{0.33})Fe_3(SO_4)2(OH)_6$ $(Na_{0.67}(H_3O)_{0.33})Fe_3(SO_4)_2(OH)_6$ 4.2% to 3.4%; the magnesium aluminosilicate phase $(MgAl_2Si_3O_{10})_{0.6}$, calcium silicate $CaSiO_3$ appeared.

Changes in the phase composition of pyritic slags as a result of chemical activation can be associated with the course of reactions of the interaction of sodium hydrogen carbonate with trisodium phosphate zinc oxide hydrate and natrojarosite with the formation of sodium thiophosphate and an increase in the content of iron-bearing phases, and also with dolomite with the formation of calcium silicate and magnesium aluminosilicate.

Studies were carried out to determine the effect of the chemical activation of pyritic slags on the extraction of non-ferrous metals and iron during leaching in sulfuric acid solutions.

Leaching of pyritic slags after preliminary chemical activation was carried out in H_2SO_4 solutions containing 5-20% at a temperature of 60 °C and a duration of 30 minutes.

The results of the leaching of pyritic slags in sulfuric acid solutions are shown in Figure 3.

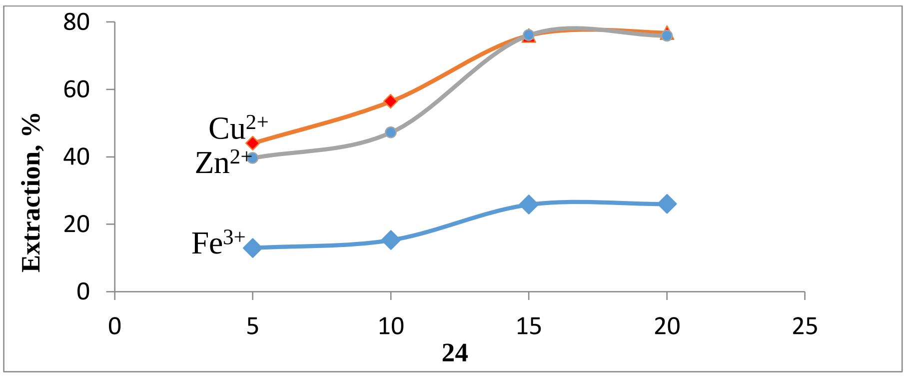

Figure 3. Dependence of non-ferrous metal and iron extraction from pyritic slags after activation in solution on the concentration of H_2SO_4

According to the data obtained, it is optimal to use a sulfuric acid solution with a concentration of 15% H_2SO_4 for leaching pyritic slags after chemical activation. Under these conditions, the recovery into sulfuric acid solution was, %: Cu^{2+} 76.8; Zn^{2+} 75.9, and Fe^{3+} 26.0.

The sulfuric acid leaching solution was neutralized with potash in several stages to obtain a non-ferrous metal concentrate (Table 2)

Table 2. Chemical composition of neutralization precipitation depending on solution pH

Content, %	pH		
	3.7	**5.46**	**9.7**
K_2O	0.11	0.08	13.8
MgO	-	-	1.2
Al_2O_3	0.12	3.0	7.5
SiO_2	0.12	1.2	2.9
P_2O_5	25.27	3.5	0.02
SO_3	8.3	11.08	15.9
Fe_2O_3	53.37	19.3	3.8
CuO	-	0.04	6.4
ZnO	-	0.01	12.54
As_2O_3	3.08	0.39	-
SeO_2	0.1	0.01	-

Neutralization to pH 3.7 was performed to precipitate trivalent iron from the solution. Under these conditions, phosphorus, arsenic, and selenium partially precipitated from the solution together with iron.

At pH 5.46, iron, phosphorus, and arsenic residues were released into the neutralization precipitate from the solution.

Neutralization to pH 9.7 was carried out taking into account the pH of complete precipitation of zinc and copper. As a result, the non-ferrous metal concentrate was obtained with the content, weight. %: CuO 6.4; ZnO 12.55. The concentrate yield was 8.5 % of the total amount of neutralization sludge or 1.5 % of the initial mass of pyrite sludge. The yield of neutralization precipitation at pH 5.46 was 2.1 %, at pH 9.7 - 14.2 %.

The obtained results indicate that neutralization for impurity extraction of Fe_2O_3, P_2O_5, and As_2O_3 and obtaining concentrate of non-ferrous metals should be carried out in two stages to pH 5.46 and 9.7.

Conclusions

The influence of preliminary chemical activation of kaolinite clays of Alexeevsky deposit in the solution of sodium hydrogen carbonate on the separation of kaolinite and quartz fractions was studied. The temperature of 150 ^oC, the duration of 120 minutes, and the concentration of sodium bicarbonate solution of 120 g/dm^3 should be considered the optimum mode of activation.

As a result of activation, the phase composition of the kaolinite fraction changed: the percentage of kaolinite fraction decreased; new phases of muscovite and sodium aluminosilicate appeared; the amount of quartz increased.

The main technological scheme of the complex processing of kaolinite ore was developed.

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Silica removal from waste of ilmenite concentrate pyrometallurgical processing

Abstract: The article presents the study results for alkaline leaching of fine ilmenite concentrate dusts from electric smelting. The physical and chemical properties of the dusts were studied using chemical and instrumental analysis methods. The dust composition was determined, X-ray phase analysis showed that the dust sample substance is in the X-ray amorphous state, iron is present in the trivalent state, and silicon is bound to magnesium. The dust sample study using a scanning electron microscope showed that part of the titanium is bound in a hard-to-disclose anasovite encapsulated in amorphous silicon oxide. The leaching study of electric smelting dust with sodium hydroxide solutions included the study of the effect of sodium hydroxide concentration, process duration, temperature, S: L ratio. The optimal conditions for dust leaching from electric smelting of ilmenite concentrate have been established: temperature 80-90 °C, duration 90-120 min, ratio S: L = 1: 5, the concentration of sodium hydroxide solution 110-115 g/dm^3. The silicon extraction degree into the solution under these conditions was 77.7%. The behavior of accompanying components of chromium, zinc, iron, and manganese during dust leaching was also studied. X-ray phase analysis of the cake after leaching shows almost complete amorphization of the leached product, the main phase is a solid solution of $Fe_2O_3 \cdot TiO_2$.

Keywords: fine dust, ilmenite concentrate, leaching, sodium hydroxide, silicon

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Introduction

The largest producers of titanium sponge are China, Japan, Russia, Kazakhstan, the USA, and Ukraine [1-4], while one of the leading suppliers - the Kazakh enterprise Ust-Kamenogorsk Titanium and Magnesium Plant JSC (UKTMP JSC) accounts for about 18% of the world production of titanium sponge. Titanium concentrate is used as a raw material for titanium production; electric reduction smelting produces titanium slag and substandard cast iron. UKTMP JSC uses one-stage electric smelting of ilmenite concentrates to produce titanium slag and cast iron, the charge for smelting is supplied in a loose state, accompanied by high dust emissions. The silicon contained in the charge is sublimed in the smelting process of ilmenite concentrates at 1600-1700 °C, and together with gases is taken into the gas duct system, it condenses in the form of amorphous silica SiO_2 in scrubbers and enters thin bag filters. Dusts cannot be returned to the electrofusion process or fed to chlorinators due to the high silica content. High silica content in the first case will provoke boiling of the melt; in the second case, the presence of silica will adversely affect the quality of titanium tetrachloride produced during slag chlorination, because later the silicon will pass into titanium tetrachloride and worsen the grade of titanium sponge. The captured dust cannot be recycled back into the process, so it is stored together with other solid waste in designated areas, landfills. UKTMP JSC generates up to 76,000 tons of chloride waste annually at maximum capacity utilization, including about 600 tons of fine sleeve filter dust. Waste is eroded and dispersed by natural precipitation and wind, contaminating water and soil basins [5]. The company has to pay huge fines for the accumulated waste maintenance.

Method (Participants, Instruments and Procedure)

Methods of analysis: X-ray experimental data were obtained on BRUKERD8 ADVANCE apparatus using copper radiation at accelerating voltage 36 kV, current 25 mA. X-ray fluorescence analysis was performed on Venus 200 PANalytical B.V. (PANalytycal B.V., Holland) spectrometer with wave dispersion. Chemical analysis of the samples was performed on an Optima 2000 DV inductively coupled plasma optical emission spectrometer (PerkinElmer, USA). The elemental and phase composition of the samples was mapped on a JXA-8230 electron probe micro analyzer (JEOL, Japan).

Experimental procedure: leaching experiments were performed in thermostatic reactors of 0.5 dm^3 volume. Slurry stirring was performed by a mechanical stirrer with an adjustable number of rotations. A certain amount of sodium hydroxide solution was poured into the reactor and heated to a predetermined temperature, upon reaching which a sample of dust was introduced and, while maintaining constant stirring of the pulp, leaching was performed. The pulp was filtered at the end of the process and the cake was washed with distilled water. The content of uncontrolled components in the washed cake was determined.

Results and discussion

The silicate base of electro smelting dust of ilmenite concentrates can be destructed by the method called alkaline desiliconization that consists in leaching the dust in sodium hydroxide solutions. The silicates should dissolve in this approach, with silicon going into the alkaline solution as a soluble sodium silicate, Na_2SiO_3, while titanium should remain in an insoluble residue.

Materials: sodium hydroxide grade "chemically pure" ("Kaustik" JSC, RF). Dust of fine cleaning of electric smelting of ilmenite concentrate, presented by Ust-Kamenogorsk Titanium and Magnesium Plant JSC, the content of the main components is given in Table 1.

Physical and chemical properties of electric smelting of ilmenite concentrate dust: the results of X-ray phase analysis of the dust are shown in Figure 1 and Table 2. The data of X-ray phase analysis indicate that the substance of the dust sample is in the X-ray amorphous state and the background of the diffractogram is high. It should be noted that iron in the dust is present in the trivalent state, and the harmful impurity silicon is associated with magnesium.

Table 1. Content of the main components of electro smelting of ilmenite concentrate dust, wt. %

Content, wt. %						
TiO_2	Fe_2O_3	SiO_2	ZnO	MgO	Cr_2O_3	MnO_2
46.37	26.90	10.04	3.18	1.55	0.45	2.90

The content of small impurities and the forms of incorporation into the dust phases of electrofusion of ilmenite concentrate were determined by electron microscopy (Figures 2-4). The presence of particles of solid solution nFe_2O_3-$mTiO_2$ was established (Figure 3).

Anosovitis can be attributed to the phase, radiographically characterized as the system Fe = Mn - TiO [6] (Figure 2). It is noted that part of the anosovite particles is in a shell of silicon and zinc oxides (Figure 3), and part is in a shell of silicon, zinc, and lead oxides. In addition, rare-earth metal phosphates and

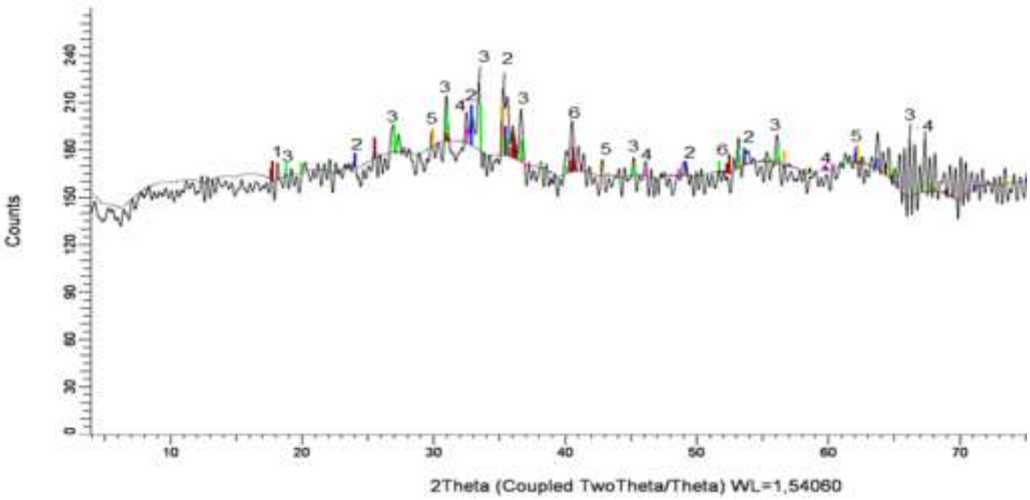

Figure 1. Diffractogram of electric smelting of ilmenite concentrate dust

Table 2 - Results of X-ray phase analysis of electric smelting of ilmenite concentrate dust (Fig. 1)

Phase number in Figure 1	**Component**	**Formula**	**Content, rel. %**
1	Iron Titanium Oxide	Fe_2TiO_5	35.78
2	Iron Titanium Oxide	$Fe_{1.5}Ti_{0.5}O_3$	16.74
3	Franklinite, syn	$ZnFe_2O_4$	16.38
4	Magnesium Titanium Oxide	$MgTi_2O_5$	13.08
5	Magnesium Silicate	Mg_2SiO_4	10.27
6	Titanium Oxide	TiO_2	7.76

particles of lead and zinc oxides are present in the electric smelting of ilmenite concentrate dust. The image obtained in secondary electrons showed the fine-dispersedness of the object.

The results of the physical and chemical studies of the dust of electro smelting of ilmenite concentrate showed that part of the titanium is bound in hard-to-open anosovite that can be enclosed in a shell of amorphous silicon oxide. The finely dispersed state of the dust should contribute to the efficiency of the leaching of a harmful impurity - silicon.

The effect of the concentration of sodium hydroxide solution. The study of the effect of the concentration of sodium hydroxide solution on the extraction of silicon, chromium, manganese, zinc, and iron in the solution was performed in the concentration range 50-130 g/dm3. The duration of the experiments was 2 h, S:L = 1:5. The stirrer rotation speed was 600 rpm.

Figure 4 shows the effect curves of the leaching degree of the controlled elements into the solution, the course of the curves shows that the most fully transferred silicon into the solution is 77.7 %. It is explained by the good solubility of sodium silicate in alkaline solutions.

The chromium leaching degree is significantly lower - 44.4%. Franklinite decomposes to form the hydroxo complex Zn (OH)-3 [7]. Silicon and iron, when present together in alkaline solution, can form various iron-silicon-containing complexes. This fact increases the solubility of iron in alkaline solution [8, 9].

The curves of metal oxides solubility dependence on alkali concentration have ascending and descending branches with a distinct maximum. The maximum is reached at sodium hydroxide concentration of 110-115 g/dm^3 under the conditions of the studies performed.

Thus, it has been experimentally established that the optimal concentration of sodium hydroxide for leaching dust from electric smelting of ilmenite concentrate is 110-115 g/dm^3.

An increase in the concentration of sodium hydroxide during the leaching of dust from the electric smelting of ilmenite concentrate resulted in a decrease in the output of the cake (Figure 5).

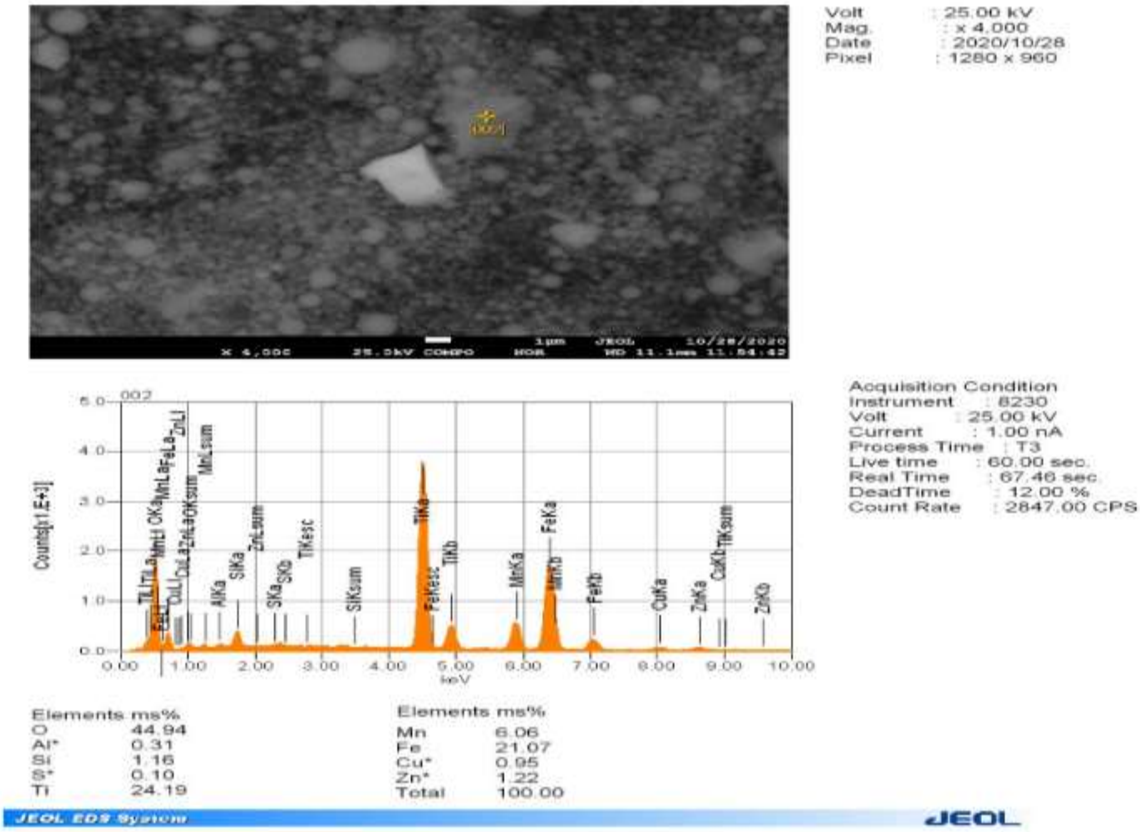

Figure 2 - Image and spectrum of anosovite particles [$MnO\ 2TiO_2$]·[$Fe_2O_3\cdot TiO_2$]

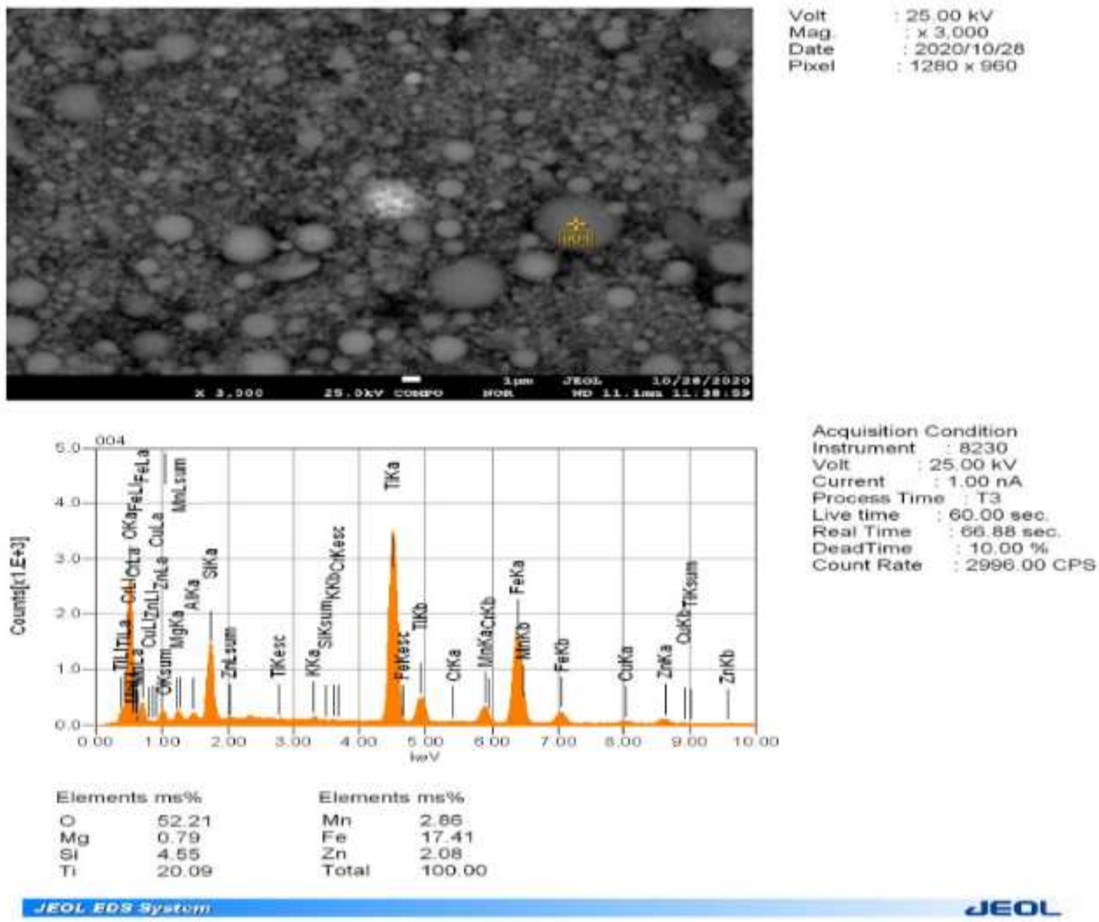

Figure 3 - Image and spectrum of anosovite particles [$MnO\ 2TiO_2$]·[$Fe_2O_3\cdot TiO_2$] in a shell SiO_2 and ZnO

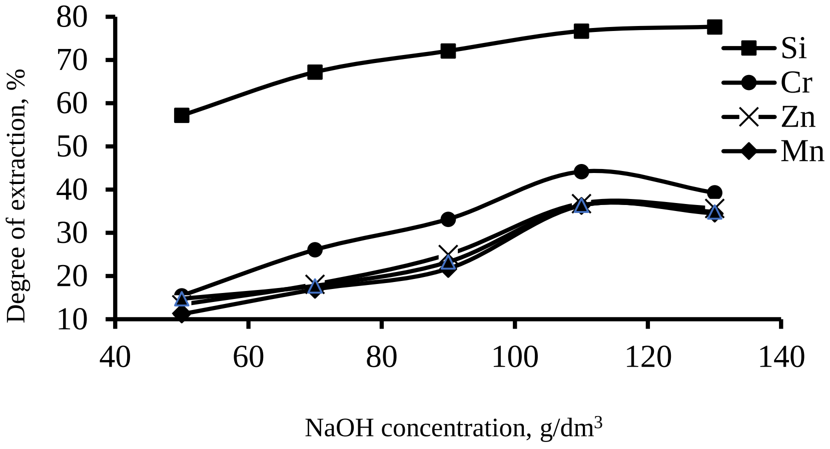

Figure 4. Dependences of the leaching degree of the controlled elements into the solution on the concentration of sodium hydroxide

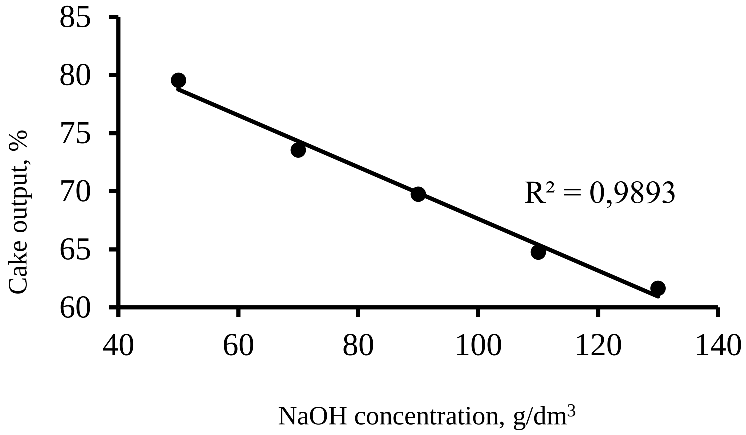

Figure 5. Dependence of cake output on sodium hydroxide concentration

Figure 6 shows a diffractogram of the cake obtained by the effect of a solution with a concentration of 110 g/dm^3 NaOH on the dust.

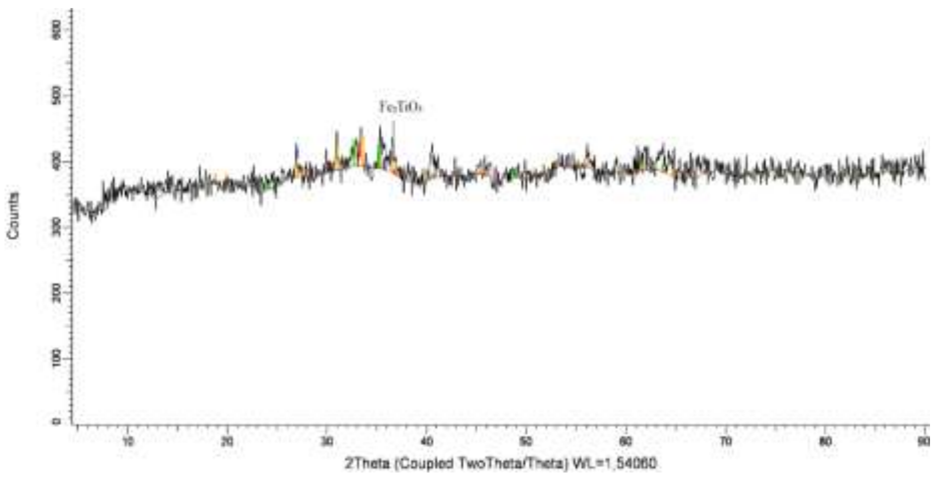

Figure 6. A diffractogram of the leaching product of electrowinning ilmenite concentrate dust (110 g/dm^{3}NaOH, S:L = 1:5, 80 °C, 2 h)

The diffractogram type shows almost complete amorphization of the leaching product. The main phase - solid solution Fe_2O_3-TiO_2 - was reliably determined. Presumably, it is titanium dioxide TiO_2 and iron oxide Fe_2O_3.

Effect of the leaching process duration. The effect of the duration of silicon, chromium, zinc, manganese, and iron leaching from electric smelting of ilmenite concentrate dust was studied in the interval 15-120 minutes, at 80 °C, S:L = 1:5, sodium hydroxide concentration 130 g/dm^3. The stirrer rotation speed was 600 rpm.

Figure 7 shows that the degree of silicon transfer into the alkaline solution already in the first 15 minutes of leaching reaches a significant value of 57.7 %. At the same time, the extraction of other controlled impurities does not exceed 13-18 %.

Increasing the duration of alkaline dust treatment beyond 90 minutes has no significant effect.

X-ray phase analysis in the initial period of the leaching process (15-30 minutes) showed the manifestation of the formed secondary components in the sludge. For example, iron hydroxide and oxides, pseudorutile (Figure 8, Table 3).

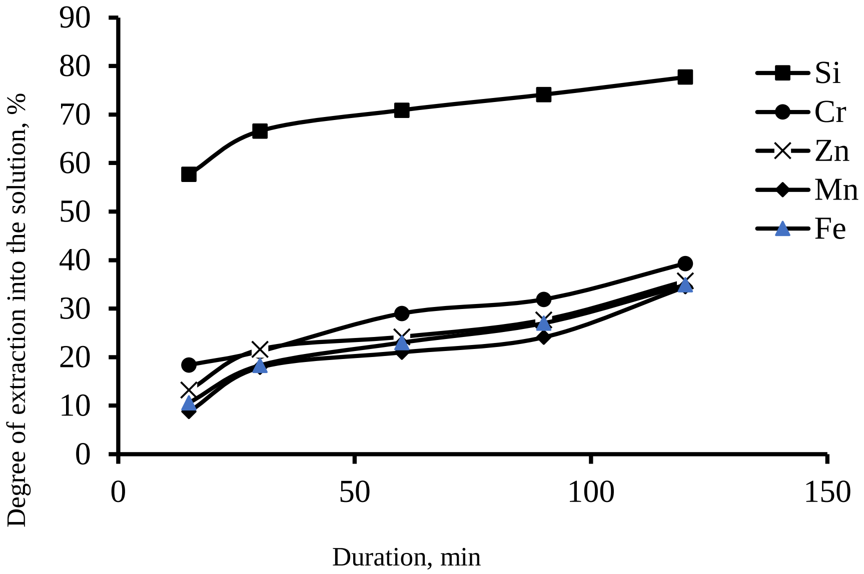

Figure 7. Effect of leaching duration on the extraction of silicon, chromium, zinc, manganese, and iron in the alkaline solution from the electric smelting of ilmenite concentrate dust

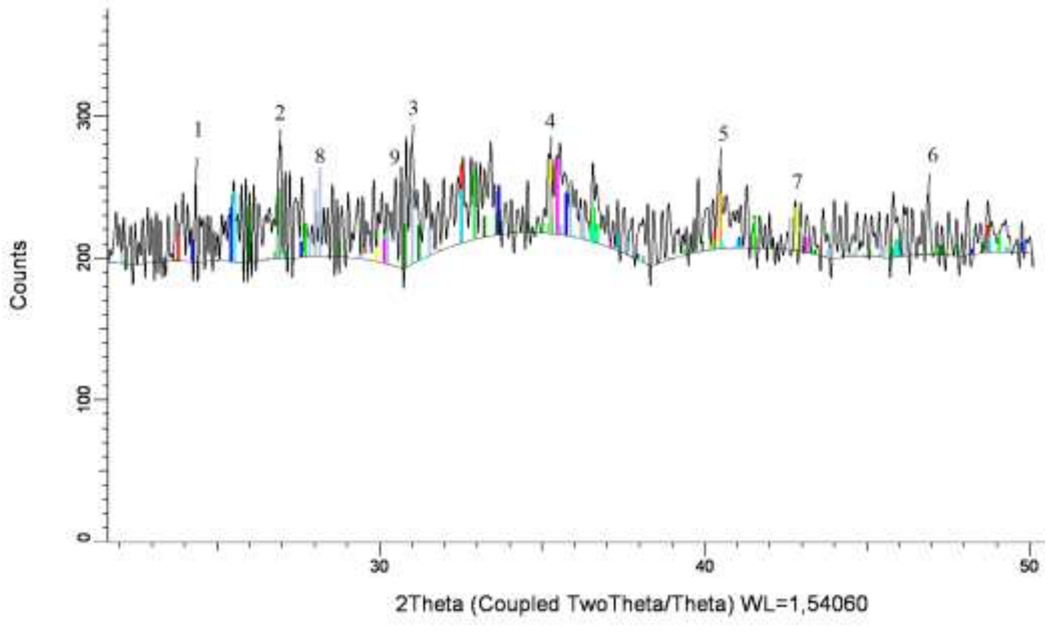

Figure 8. A diffractogram of the leaching product of electrowinning of ilmenite concentrate (duration 30 min, 80 °C, S:L = 1:5, NaOH concentration 130 g/dm^3)

Table 3. Results of X-ray phase analysis of the leaching electrofusion dust product of ilmenite concentrate (Figure 8)

Phase number in Figure 14	**Component**	**Formula**	**Content, %**
1	Ilmenite	$Fe_{1.04}Ti_{0.96}O_3$	17.79
2	Pseudobrookite	Fe_2TiO_5	15.89
3	Iron Oxide	Fe_2O_3	14.65
4	Iron Oxide Hydroxide	FeO(OH)	12.52
5	Pseudorutile	$Fe_2Ti_3O_9$	12.16
6	Iron Oxide	Fe_3O_4	10.59
7	Qandilite, syn	Mg_2TiO_4	7.69
8	Enstatite, ferroan	$(Mg_{1.561}Fe_{0.439})Si_2O_6$	6.59
9	Lead Oxide	Pb_3O_4	2.12

Soluble compounds pass into the solution and the cake output decreases with an increase in the duration of the interaction of the electro smelting dust of the ilmenite concentrate with alkali (Figure 9).

Thus, the optimum leaching duration of electric smelting of ilmenite concentrate dust with sodium hydroxide solution is 1.5-2 hours.

Effect of temperature on the leaching process. The leaching temperature effect on the extraction of chromium, silicon, zinc, manganese, and iron in the solution was studied in the range of 40-95 °C. The duration of the experiment was 2 h, S:L = 1:5, the concentration of sodium hydroxide solution was 130 g/dm^3. The stirrer rotation speed was 600 rpm.

It follows from the data in Table 4 that increase in temperature from 40 to 60 °C increases the silicon extraction degree by 23 %, further leaching temperature increase from 60 to 80 °C result in less significant silicon extraction increase - by 13 %. Leaching of dust at 95 °C enables to leach 82.8 % of silicon into a solution, that is only 5 % more than at 80 °C.

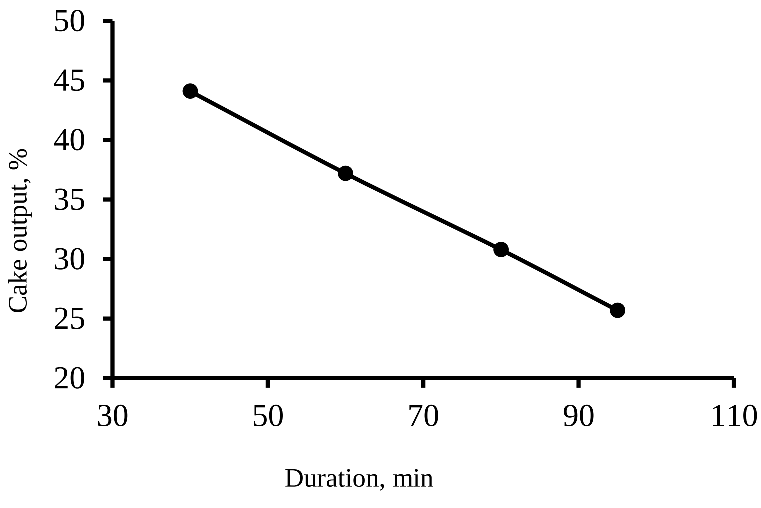

Figure 9. Cake output dependence on the leaching duration of electro-smelting dust of ilmenite concentrate (80 °C, S:L = 1:5, NaOH concentration 130 g/dm^3)

The behavior of other controlled impurities with changes in the temperature regime of the leaching process is similar to that of silicon. Thus, the optimal temperature for leaching electric smelting of ilmenite concentrate dust is 80-90 °C.

Effect of S:L ratio on the leaching process. The effect of the ratio of electric smelting of ilmenite concentrate dust to sodium hydroxide solution was studied in the range 1:4÷10 at 80 °C, duration 120 min, stirring speed 600 rpm, the concentration of sodium hydroxide solution 130 g/dm^3.

Table 4. Effect of the temperature of the electro-smelting dust leaching process of ilmenite concentrate on the degree of extraction of the controlled components in the solution, rel %

Temperature, °C	**Cake output, %**	**SiO_2**	**Cr_2O_3**	**ZnO**	**MnO**	**Fe_2O_3**
40	88.2	41.8	3.8	6.5	1.0	3.4
60	74.4	64.7	32.8	19.4	16.5	17.8
80	61.6	77.7	39.3	36.8	36.3	36.4
95	51.4	82.8	42.0	43.8	43.5	41.1

Analysis of the data in Table 5 showed that changing the ratio of solid to liquid 1:5 or more has little effect on the extraction of chromium, zinc, manganese, and iron in the solution.

The increase in the volume of alkaline solution per unit mass of dust from 1:3 to 1:8 results in an increase in the silicon extraction degree into the solution. Further increase in the sodium hydroxide flow rate has almost no effect on the transfer of silicon into the solution.

Thus, studies of the effect of the ratio of the solid phase to the liquid phase on the efficiency of the dust leaching process of electric smelting of ilmenite concentrate showed that the ratio of 1: 5 is optimal.

Table 5. Effect of the S: L ratio on the extraction of silicon, chromium, zinc, manganese, and iron into solution

S:L	Cake output, %	Extraction rate, rel %.				
		SiO_2	Cr_2O_3	ZnO	MnO	Fe_2O_3
1:3	80.0	65.4	22.8	16.7	13.0	13.5
1:5	61.66	77.7	31.3	35.7	34.5	34.9
1:8	56.3	81.1	41.0	37.0	35.3	35.7
1:10	54.7	82.1	42.4	37.7	35.1	35.4

Thus, the optimum conditions to leach electric smelting of ilmenite concentrate dust were established experimentally: temperature 80-90 °C, duration 90-120 minutes, the ratio S:L = 1:5, the concentration of sodium hydroxide solution was 110-115 g/dm^3.

Conclusions

Physical and chemical studies of electric smelting of ilmenite concentrate dust showed that part of titanium is bound in hard-to-recover anosovite that can be enclosed in a shell of amorphous silicon oxide. The fine-dispersed state of the dust should contribute to the efficiency of harmful impurity - silicon leaching.

The optimum parameters of electric smelting dust leaching of ilmenite concentrate with sodium alkali were determined: NaOH concentration - 110-115 g/dm3; S:L - 1:5; temperature - 80-90 °C; duration - 90-120 min. The silicon extraction degree into the solution was 77.7 %.

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Beneficiation of fine chromite slurry at Donskoy Mining and Beneficiation Plant JSC on concentration tables to produce hard chromite pellets

Abstract: Processing industrial products and technogenic waste is an important task in the mining and metallurgical industry. In Kazakhstan, the processing of chrome ore from the Kempirsay group of deposits has produced more than 15 million tonnes of slurry tailings containing up to 30 wt% chrome oxide. The best results in the world for the processing of fine chromium raw materials are shown by Turkish enterprises with the use of the separation of slurries by size classes and beneficiation on concentration tables. The authors conducted researches for beneficiation of chrome slurry from Dubersay tailings pond (Kazakhstan) with the use of similar technological methods that enabled to obtain concentrates with chrome oxide content of 51 wt% and increasing the yield of beneficiated fine-graded chrome concentrates by 14% as compared with the existing beneficiation process. Strong chromium pellets with a crushing resistance of over 5000 N/pellet were produced from the rich chromium concentrates with the use of the ferrofluxing iron-calcium-silica binder technology by roasting the composition consisting of rich chromium concentrate, ferrous diatomite, and intermediate products and wastes of the chromium industry.

Keywords: chrome production slurry, environmental impact, chrome slurry beneficiation, concentration table, rich chrome concentrate.

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Introduction

Mining, ore beneficiation, and smelting of ores and concentrates are accompanied by the formation of rock dumps and off-balance ores, tailings ponds, and slag dumps. The long-term development of ore deposits associated with mining, concentration, and metallurgical smelting leads to the accumulation of large amounts of waste in the form of stockpiled tailings and metallurgical slags, dumps of substandard ores and host rocks, industrial effluents, forming large-scale dumps and water settling tanks - technogenic mineral formations (TMF) [1-2].

The stored reserves of valuable components in the tailings are comparable with the natural deposits in terms of accumulation amount and content of valuable components that determine the reasonability of their categorization as technogenic deposits.

The beneficiation processes of chromite ores are accompanied by a considerable yield of finely dispersed chrome concentrates obtained by gravitational, flotation, as well as magnetic methods. These concentrates cannot be effectively processed by smelting due to low gas permeability and high dust loadings in the furnaces. Fine chromite slurries containing up to 30 % chrome oxide from different technological beneficiation lines of two concentration plants of DMBP JSC are sent to the Dubersay slurry storage facility. The total amount of slurry stockpiles at Dubersay exceeds 12 million tonnes. In small quantities, slurry from the slurry pond is processed by gravity concentration methods at the beneficiation facilities of Akzhar-

Chrome LLP, with rich concentrate going to the Aktobe Chromium Compounds Plant JSC. During this processing, the slurry with 25% Cr_2O_3 content is returned to the Dubersay slurry pond [3].

In this connection, the enterprises of TNC "Kazchrome" JSC perform works on improvement of processes directed on the decision of existing industrial problems. In the beginning, the simplest technology of gravitational enrichment of finely dispersed material on screw separators and briquetting of chrome material was applied. However, the hardness of the briquettes was low and did not allow them to be transported over long distances. Then the technologies of roasting "raw" pellets on a flexible belt of roasting machines and producing sinter on a sintering machine were implemented. However, technological solutions for roasting of fine chrome concentrate proved to be inefficient due to inappropriate choice of charge composition, frequent failures of technological equipment due to high roasting temperature - 1350 ^oC that resulted in low crushing resistance of roasted pellets and sinter with a high yield of defective pellets of sintered product. For example, in flexible belt roasting machines, due to non-compliance with the technological firing regime, with the planned yield of rejected pellets up to 3% of the total quantity, the reject rate was higher than 10% [4].

The positive experience of the Republic of Turkey on beneficiation of fine chrome raw materials (slurry) by a separate division of chrome raw materials by size classes and their beneficiation on concentration tables are known in the chrome industry. This beneficiation technology enables to receive rich chrome concentrates and tailings with the content of Cr_2O_3 not more than 3-5% [6-7]. However, it is important to obtain not only rich (not less than 50% by weight Cr_2O_3) but also agglomerated chrome raw material for further reduction electrofusion [5-8].

Russian scientists have proposed and tested the technology for iron-ore mineral sintering where cheaper Callovian clays are used as sintering material.

The theoretical justification for the synthesis of ferrosilicate-calcite fluxes, so-called FCF, was proposed in [9, 10] for iron ore pellet production technologies with the use of Callovian clays as binders, the main component of which is mixed formation mineral-like illite-smectite - 58%, mass fraction of montmorillonite component - 12%, kaolinite - 6%, quartz - 14%, calcite - 10%. The authors propose to use a charge composed of industrial waste as an analog of the Callovian clays - slags of refined ferrochrome production, and available natural raw materials - ferruginous diatomite. The composition of the charge was calculated, and studies were performed to produce hardened pellets with the use of the new binder.

The idea of use of sodium bicarbonate in chemical beneficiation of chromium slurry is described in [11]. The technology of chemical chromium slurry beneficiation enables to separate the major part of magnesium oxide from chromium spinelide, thus removing it from the system and beneficiating the chromium raw material in terms of chromium oxide.

Kazakhstan scientists have also proposed the production of ferrofluxing binders to produce hard chrome pellets [12-14].

They have a unique strength (up to 5 325 N/pellet), do not absorb moisture, and therefore do not lose mechanical resistance when they become wet due to the formation of a binding vitreous phase. There is no need for a component breakdown of 0.07 mm; 0.25-0.1 mm is sufficient; as high strength is achieved through the formation of a fluxed ferrosilicate-calcium glass phase.

The technology being developed for the production of hard pellets enables to produce hard chrome oxide pellets with extra hardness and to use inexpensive natural raw materials such as iron-iron diatomite, as well as intermediate products and wastes from chrome production (special coke, mineral parts refined ferrochrome slag and melting in limestone roasting furnace) as fluxes.

At present, the beneficiation technologies of fine chromium raw materials, used at the enterprises of the chrome industry are not effective enough, therefore improvement of technological schemes with the use of advanced technological methods is required.

The main methods used to process chromite ores are gravity beneficiation processes. DMBP uses gravity separation and heavy medium separation processes for beneficiation to produce lumpy concentrate and fine-grade beneficiation on screw separators which concentrate is fed to pelletisers to produce pellets.

Currently, poor chromite ores from different parts of the deposit and technogenic waste dumps are involved in processing that can serve as additional sources of raw materials. The processing of the Dubersay tailings slurry is inefficient, since the processing scheme includes a sequential classification scheme and beneficiation on screw separators, with slurry concentration tables and flotation machines used at the end of the scheme. The existing tailings beneficiation process is complicated and does not take into account the main gravity beneficiation principles, with the result that the beneficiation apparatus receives a stream with a particle size of 0.038 mm to 1.000 mm so that large waste rock grains go into the concentrate, and fine chromite grains go into the tailings.

Research methods and techniques

In this connection, there was a necessity to perform researches to study gravitational beneficiation of slurry tailings from the Donskoy MBP.

We have obtained new data on the process of chromite tailings beneficiation with the use of modern technological equipment that enables separation into narrow fractions of material size with their subsequent gravitational beneficiation on concentration tables.

Laboratory tests were performed on gravitational beneficiation on a concentrating table on the class -0.5 mm to perform laboratory tests on gravitational beneficiation of tailings chrome production selected a sample of Dubersay tailings slurry.

The test pattern includes the following operations: flocculant washing; classification into +0.5 mm and -0.5 mm classes; regrinding of +0.5 mm class; beneficiation on concentration table of -0.5 mm class; beneficiation of industrial product on concentration table; control operation on concentration table of industrial product beneficiation tails; regrinding on concentration table of industrial product beneficiation; classification of slurry (first concentration tails on a concentration table).

Research results

Quality concentrate with 50 % Cr_2O_3 and recovery at the level of 75 % can be achieved as a result of the beneficiation process on the concentrating table of each product separately by size and the subsequent classification of slurry with +0,5 mm class grinding, turnover of classification sands to the beginning of the process.

The resulting fine chrome concentrate was pelletized on a laboratory pelletizer.

The following components were used as a source for the synthesis of a new type of binder: obtained finely dispersed rich chromium concentrate, mineral part of refined ferrochrome slag (source CaO and SiO_2), ferrous forms of diatomite (source SiO_2 and FeO), finely dispersed. special coke (source SiO_2, regulator of pellet heating temperature), liquid glass.

Solid components of the charge were crushed in a laboratory mixer and sifted on a laboratory sieve with a mesh size of -0.25 mm.

The component composition of the mixture was, wt.%: chromium concentrate-88.0; mineral part of slag RFCH-3.0; ferruginous diatomite-4.0; chalky coke-3.0; liquid glass-1.0.

The granules were produced on a laboratory granulator. The size of crude granules is 6 to 10 mm. Untreated granules were kept at room temperature for 24 hours. The hardness of the uncooked temperate granules was 124.6 N/pellet.

The batches of "raw" pellets were roasted at temperatures of 1050-1200° C for 60 minutes in a laboratory muffle furnace.

Obtained roasted pellets (7 pieces in each batch) were tested for crushing resistance on a laboratory press MIP-25R and the average hardness was determined. Average hardness at the temperature of burning on pellet: at 1050 °C -2 854; at 1100 °C - 3980 at 1150 °C - 4 500; at 1 200 °C - 5 330.

The obtained pellets will be used for further laboratory studies with determination of their electrical melting parameters in the furnace.

Conclusions

-The researches have confirmed the possibility to separate individual fractions of chrome slurries by size and their further gravitational beneficiation by size classes to produce a rich chrome concentrate suitable for further production of roasted chrome pellets.

- Roasted hard chrome pellets with a crushing resistance of over 5000 N/pellet are obtained.

- The technology under development improves the economic efficiency of fine chrome slurry processing and increases the extraction of chrome oxide from chrome raw materials in Kazakhstan.

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The main approaches to the organization of research activities in primary education in the Republic of Kazakhstan

Abstract: This article discusses the main approaches to organizing research activities, forms and methods of organizing research activities in the course of the study of "Natural Science" in the elementary school, allowing the formation of the pedagogical process on the basis of developmental learning. Authors consider that introducing elementary school students to research activities should be focused on their own activities.
Keywords: research activities, elementary education, updated content of education, science education, elementary school student.

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Introduction

To date, the modernization of education in Kazakhstan is revising the technology of teaching in the modern educational process, guiding teachers to use in their work more effective forms and methods that allow building a pedagogical process based on developmental learning. One of the paramount tasks of the updated content of elementary education is to involve elementary school students in research activities.

With the transition to the updated content of education, elementary school teachers are faced with the task of developing students' research and cognitive skills. Namely, the activation of developmental and research functions of learning has become the main determinant for the implementation of the updated content of education in the Republic of Kazakhstan (RoK). Nowadays, the whole educational process must be aimed at conquering the highest level of education of elementary school graduates. To this end, the organization of the educational process in the primary grades is inextricably linked with the research activities of the junior school student.

Research results

Since 2018 all educational institutions of Kazakhstan have switched to the updated State General Standard of Primary Education, the main goal of which is the comprehensive development of the individual, capable of self-knowledge and self-development and aimed at:

- Improving the quality of teaching and learning by achieving a system of goals for primary education, presented in the form of expected learning outcomes;
- Implementation of the trilingual education policy;

- Combining the academic and practical orientation of primary education, providing for the mastery of basic theoretical knowledge and the development of abilities to apply that knowledge to solve problems of a practical nature;
- Gradual increase in subject knowledge and skills, ensuring the depth and complexity of the content of academic subjects, taking into account the age of students;
- Implementation of the principle of unity of education and training, based on the interconnectedness and interdependence of educational values and the system of expected learning outcomes, which determine the content of the daily educational process;
- Ensuring the protection of children's health, as well as the creation of favorable conditions for meeting the special educational needs of students and their needs for additional educational services;
- Ensuring the equivalence of primary education in the context of the diversity of types and forms of secondary education organizations
- Support and development of innovative practices in educational organizations
- organization of an objective assessment of the activities of educational organizations to ensure the quality of education [1].

Studying the Natural Science course in elementary school as a subject has great developmental potential:

- Students develop the prerequisites for a scientific worldview, their cognitive interests and abilities;

- Conditions are created for self-knowledge and self-development of the child, critical thinking, conducting research works, using information and communication technologies, application of different ways of communication, including language skills, ability to work in a group and individually.

The knowledge formed within the framework of this subject has a deep personal meaning and is closely connected with the practical life of a junior high school student

The model curriculum for the Natural Science subject for grades 1-4 at the primary level of education is based on the principle of "spirality", according to which most of the learning objectives and topics after certain academic periods of study (during the school year or in the following grades) are addressed again with a gradual deepening, complication and increase in the volume of knowledge and skills on them.

Education of elementary school students in natural sciences contributes to the development of their natural curiosity, expanding their outlook on the world, the development of scientific understanding and holistic vision of the world around them, the ability to appreciate and cherish the world around them.

Studying and mastering the Natural Science subject in elementary school will allow students to understand:

1) The diversity and complexity of the world around us, as well as the interconnectedness of natural phenomena and processes;

2) Causes of some natural phenomena and processes occurring in animate and inanimate nature;

3) The importance of natural science knowledge for many human activities;

4) Studying this subject will contribute to the accumulation of knowledge about various objects and phenomena of the surrounding world and the formation of understanding of the connection of the acquired knowledge with everyday life through a variety of practical and research activities.

The Natural Science curriculum in elementary school is aimed at forming the basics of research, thinking operations, communication skills and abilities:

1) propose hypotheses and suggest ways to test them, to draw conclusions on the basis of experimental data;

2) identify problems, formulate questions, make a research plan, observe, conduct experiments, describe and evaluate research results, make judgments, draw conclusions;

3) work with natural-science information contained in mass media reports, Internet resources, popular science literature: master search methods, distinguish semantic basis and assess reliability of information;

4) conduct simple experiments and observations revealing the nature of processes in animate and inanimate nature, interrelation of ecosystem components, impact of human activity on the environment;

5) present in various forms the results of own simple researches;

6) explain the applied significance of the most important achievements in the field of natural sciences [2].

As part of the overall goals of the renewed content of RoK primary education one of the tasks is to organize the search for new ways of action and to ensure a balance between the exploratory and the executive part of the pupils' learning activities. Preparing a child for research activities, teaching them the skills and abilities of research search becomes the most important task of education and the modern teacher.

Nowadays different approaches to the definition of research activities of students have been formed, which, for example, include search and research, experimental and research, interdisciplinary, design, technical, creative and others, carried out in the classroom and extracurricular time. At the same time, any of its types presuppose, first of all, mastering by students the technology of creativity, techniques of creative research work.

The essence of the research approach to learning consists of:

- introduction of general and private methods of scientific research into the process of academic knowledge at all its stages (from perception to application in practice);
- organization of educational and extracurricular research and creative activities;
- actualization of intrasubject and inter-subject connections;
- complication of the content and improvement of the procedural aspects of cognitive activity;
- change in the nature of the "teacher – student – student group" relationship towards cooperation.

The content basis of the exploratory approach to learning is the relationship between the content of the material studied, methods and forms of learning, organizational forms of learning. The ideas of exploratory learning are close to problem-based learning, providing for the creation of problem situations, making assumptions, finding evidence, formulating conclusions, comparing the results with the benchmark. This approach creates a natural motivation for learning, successfully develops the ability of the child to understand the meaning of the task, to plan the work, control and evaluate its results. The problem-retrieval approach makes it possible to build a flexible teaching methodology, taking into account the individual characteristics of children, their interests and aptitudes. It makes it possible to apply a wide arsenal of methods and techniques of heuristic nature, purposefully developing cognitive activity and independence of students. At the same time, the possibility of the existence of different points of view on the same question is demonstrated, tolerance and respect for the opinion of another, the culture of dialogue are fostered [3, 4].

The content of education modeled according to this strategy implies presenting educational material in such a way that children could identify a problem, find ways to solve it, and solve it. In order for the learning process to fulfill one of its main functions - educational, the problem must contain a certain cognitive charge, and this is possible only when the problem has first been worked out by the teacher. The program of learning activities is a persistent logical series, which includes a set of consistently solved learning problems. Problem-based learning assumes that students:

- ✓ identify and diagnose a problem;
- ✓ suggest possible solutions;
- ✓ draw conclusions with test results;
- ✓ apply conclusions to new data;
- ✓ make generalizations.

The content of education has a number of features when using the strategy of problem-based learning: learning problems should meet the needs and interests of this group of children. The leading role of the teacher in the learning process should be preserved, but students in any case should remain the feeling that the problem and the ways of its solution were chosen by them independently. The problem should correspond to the age peculiarities of the children. The exploratory method is not based on ready-made knowledge, but on an organized search of children in their environment. Knowledge is not given as ready-made, but is obtained as a result of children's own work on a particular material.

The result is that children develop their creative abilities, acquire new knowledge, skills of exploratory behavior and processing of materials.

Mastering the educational material in the Natural Science course of the elementary school is done through solving educational and research tasks, involving the performance of specific actions. The main unit of learning and research activity is a learning and research task, which is formulated on the basis of the learning material, presented to the student in the form of a problem task, and its solution is constructed adequately to the logic of research and involves certain actions.

The main characteristic of teaching and research task in elementary school is the feature of complexity of the problem, and the implementation of specific stages of research can proceed with a greater or lesser degree of independence for the student. This is related both to the objective complexity of the task, and the level of readiness of the student to perform operations, techniques of research activity. In addition, in the elementary school children are prepared to perform individual research activities by a system of research tasks.

From the point of view of the personal approach the enrichment of the research experience of an elementary school student is the leading reference point and the main criterion for the success of the organization of teaching and research activity. The main task of the teacher in this case will be not only to plan a common, unified and obligatory line of enrichment of research experience, but also to help each student taking into account their experience to improve their individual abilities, and develop as a person [5].

Situational approach to the organization of activities implies management of educational and research activities as an interaction of its subjects. Its essence consists in inseparability of direct and reverse impact. Student research implies not only solving the problems significant for students, but also mastering the ways of solving these problems. When organizing learning and research activities it is necessary to create learning situations, in the resolution of which the younger pupils master knowledge and ways of solving problems in the process of cognition to some extent organized by the teacher.

Conclusion

To sum up, introducing elementary school students to research activities should be focused on the process itself. The main thing is to involve the child in the result of the activity. Organization of learning and research activities in RoK elementary school on the basis of the integration of personal, situational and task-based approaches implies:

- Thorough and systematic study by teachers of the research experience of younger students and the differentiation of this experience;
- Creating learning situations in which students acquire knowledge and ways of solving problems;
- Creating a system of learning and research tasks (assignments) aimed at gradually enriching the research experience of children.

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Organizational and managerial conditions for creating a health-saving environment of an educational organization

Abstract: This article examines the organizational and managerial conditions for creating a health-preserving environment of an educational organization, presents a model of a health-preserving environment that contributes to increasing the levels of activity, positive cognitive motivation, interest, organization, independence of students of the educational space. Authors highlighted that it is necessary to properly organize students' individual educational and cognitive activities that correspond to individual capabilities and abilities, as well as the conditions of the educational environment.
Keywords: healthy lifestyle, health-saving environment, organizational and managerial conditions.

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Introduction

The current state of society and the pace of its development place ever higher demands on a person and his health. The wealth of any state is not only natural resources or material and cultural values, although they are undoubtedly important, but also, first of all, the people who inhabit it. In a short period of time during the pandemic, significant changes took place in society in almost all spheres of life: politics, economics, education, medicine, etc. The very perception of a person, his moral guidelines and life values have also changed.

Social problems and economic difficulties of recent years in the Republic of Kazakhstan have led to a significant decrease in the standard of living of the population, difficulties in psychological adaptation to changes in the country. All this has negatively affected the health of a significant part of the population.

Main Research part

As you know, health is not only an important indicator of social development, but also a powerful economic, labor and cultural potential. There are negative trends in the health of the younger generation, especially the increase in morbidity, changes in the indicators of physical development of children and adolescents, irrational and inadequate nutrition of children for the entire period of their education in educational institutions, the development and implementation of measures to eliminate them are constantly in the field of view of scientists.

The problem of organizing a health-preserving environment is considered in sociological, medical and pedagogical research. N.A. Amosov [1], I.I. Brekhman [2], E.P. Weiner [3], N.P. Lisitsin [4], the pedagogical and methodological basis of the health-preserving environment is covered in the works of V.V. Kolbanov, G.K. Zaitsev [5].

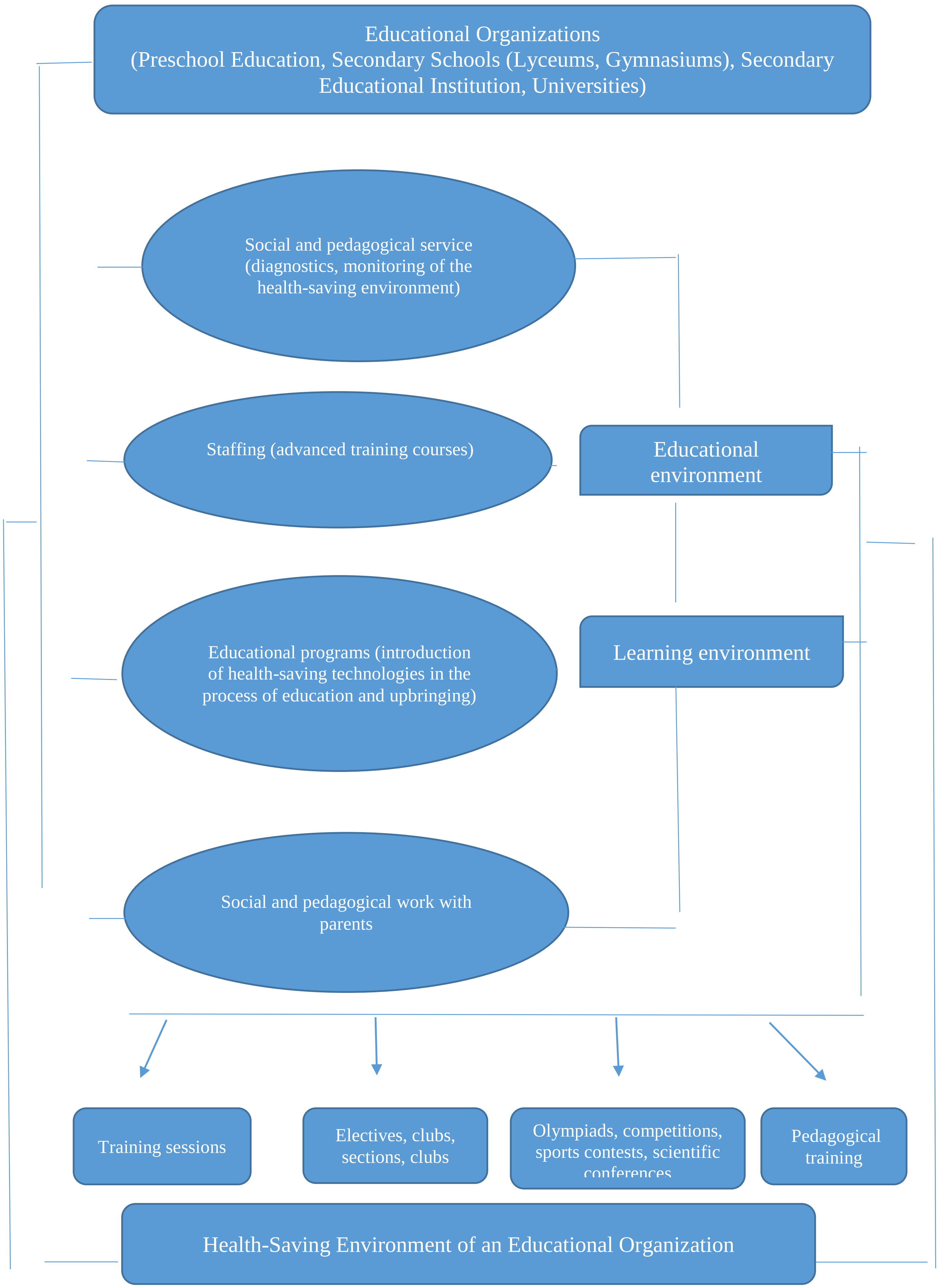

Figure 1 - Model of the health-saving environment of an educational organization

The research of the scientific foundations of the formation of a health-preserving environment in educational institutions is highlighted in the works of domestic scientists H.K. Satpayev [6], A.S. Imangaliev [7] and others.

Value orientations to a healthy lifestyle, sustainable needs for the preservation and improvement of health, the use of effective means of organizing a rational mode of education and active recreation, physical education and sports are formed with the provision of appropriate pedagogical conditions aimed at organizing a health-preserving environment of education.

An educational institution should create conditions that guarantee the protection and strengthening of the health of students and pupils.

During the analysis of the current state of the problem under study and scientific and methodological literature, we have identified organizational and managerial conditions that contribute to the creation of a health-saving environment of an educational organization:

- the integrity of the system of forming a culture of healthy and safe lifestyle of students and pupils. The systematic nature of the activity is considered on issues of health protection and promotion, the interaction of an educational institution with executive authorities, law enforcement agencies, scientific institutions;
- continuity and continuity of learning a healthy and safe lifestyle;
- an integrated approach and continuity in providing psychological, pedagogical, medical and social support to various groups of students, pupils;
- the formation of a health culture of pedagogical and scientific-pedagogical workers of an educational institution);
- rational organization of the educational process: inclusion of educational programs, projects with the use of forms, methods of teaching and upbringing, pedagogical technologies that are adequate to age-related opportunities and features for the formation of a culture of a healthy and safe lifestyle, providing favorable psychological conditions for the educational environment of students and pupils;
- organization of the work of sports sections, clubs, clubs, educational, extracurricular (extracurricular) activities of a physical culture and wellness orientation at each stage of general education and in the system of vocational education;
- organization of a system of educational and methodological work with participants of the educational process on healthy and safe lifestyle;
- professional development of pedagogical and scientific-pedagogical workers on various issues of the health-preserving environment (age psychology and physiology, human development, his health, factors that positively and negatively affect the health and safety of students, pupils);
- monitoring of the formation of a culture of healthy and safe lifestyle of students, pupils (availability of analytical data on the formation of the value of a healthy and safe lifestyle among students, pupils, contributing to the creation of a health-preserving environment.

The above organizational and managerial conditions for creating a health-saving environment of an educational organization contributed to the development of a model for the implementation of the educational space by moving from the management of educational organizations to the management of educational programs (Figure 1).

The presented model is a condition for self-development, self-education and personal training at different levels of the organization of knowledge acquisition by students, as well as continuity between different types of institutions is built.

Having studied the scientific and methodological literature on the problem under study [8, 9, 10], we took into account the principles of formation and organization of a health-saving environment in an educational organization during the implementation of the developed model in practice, namely:

- the principle of naturalness (taking into account the age and individual characteristics of students);
- the principle of consciousness and activity (the formation of value orientations for a healthy lifestyle, its conscious personal inclusion in programs for the preservation and strengthening of one's own health);
- the principle of priority of the student's personal development;

- the principle of scientific approach in the organization of scientifically based and proven health-saving technologies);
- the principle of connection of theory with practice (practice-oriented approach);
- the principle of value orientation of the educational process (ensuring the unity of the formation of a healthy and intellectually developed personality);
- the principle of subjectivity of health-saving educational process (freedom of choice in the learning process, taking into account one's own interests and the state of his physical and mental development).

Our research is a set of measures of the educational process in the educational organization system, which should ensure that students achieve high levels of activity, positive cognitive motivation, interest, organization, independence, interest in obtaining a quality result.

The diverse nature of existing developments in the content, forms and methods of educational work is explained by differences in setting specific research goals, the evolving nature of society's requirements for specialists and other factors. The creation of organizational and managerial conditions is based on the use of certain forms and methods of work, with the help of which the necessary atmosphere of the team is achieved.

As for the forms of monitoring and evaluating the effectiveness of activities in the process, in which each student individually and creatively, in accordance with their abilities and capabilities, solves the tasks set, also traditional methods of observation: survey, interviewing, programmed control, performance of written and artistic tasks, testing, analysis of products of activity, statistical data processing.

Conclusion

To meet the educational needs of participants in the educational space, it is necessary to properly organize their individual educational and cognitive activities that correspond to individual capabilities and abilities, as well as the conditions of the educational environment in which the activity is carried out. Undoubtedly, the state of success gives confidence, new strength, which forms students' higher educational needs.

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Deposition of a titanium carbonitride coating by magnetron sputtering on a substrate with a potential voltage

Abstract: Titanium carbonitride (TiCN) is of high relevance in the field of creating wear-resistant protective coatings in order to ensure maximum wear resistance and service life of parts of friction units. Titanium carbonitride coatings were obtained by magnetron sputtering at various bias substrate in the range from 0 to -130 V with a step of 10 V. The effect of the bias substrate on the deposition rate, phase and elemental composition, and the friction coefficient of the obtained coatings was investigated. As a result of the obtained dependences, the most optimal mode of deposition by the method of reactive magnetron sputtering with a negative bias voltage on the substrate was determined.
Keywords: titanium carbonitride, magnetron sputtering, bias substrate, coating, substrate.

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Introduction

Today titanium carbonitride (TiCN) is of high relevance in the field of creating wear-resistant protective coatings in order to ensure maximum wear resistance and service life of parts of friction units. Due to its high resistance to abrasion and wear, TiCN is a more suitable coating for parts operating in constant friction [1, 2]. TiCN coatings are formed by mixing C and N in an FCC structure and appear to have the best properties of the two precursors, such as the plasticity of TiC and the adhesion strength of TiN. It was found that the tribological properties of TiCN depend on the substrate, deposition method, film thickness, and structural features [3]. Therefore, the development of effective methods for obtaining coatings from TiCN in real industrial conditions is of great technological importance.

To date, various physical and chemical deposition technologies are used to obtain TiCN coatings. There are such methods as magnetron sputtering (MS) [4-6], cathode sputtering [7], plasma deposition [8], laser methods [9, 10], CVD-based methods [11, 12] and hybrid deposition [13, 14] and others. Among them, MS is one of the promising methods for the deposition of TiCN coatings with increased wear resistance. MS has a low level of impurities and makes it easy to control the deposition rate [15]. Depending on the spraying conditions, this method also allows one to obtain coatings with different morphologies and crystallographic structures. TiCN coatings exhibit a wide range of different properties depending on magnetron sputtering conditions, such as pressure and composition of the reactive gas, operating pressure, temperature, material and composition of the target, substrate, and others. Several studies of TiCN [5, 16-19] were carried out to study the effect of sputtering conditions on the properties of TiCN coatings, and the effect of bias voltage on the substrate has not been sufficiently clarified. In this regard, it is of interest to study the effect of the potential shift on the substrate on TiCN films obtained by the reactive MS method.

Methods

Titanium carbonitride (TiCN) coatings were deposited in a DC MS system using a titanium target. The target was prepared by cutting a titanium sheet of VT1-0 grade with a diameter of 99 mm and a thickness of 5 mm. The distance between the target and the substrate holder was kept constant at 30 cm. Well-polished steel plates of AISI 304, 40X and 10X18H10T grades, titanium and Al foil were used as substrates, which were acetone cleaned before being placed in the sputtering chamber. Before deposition, the chamber was evacuated to a base pressure below 5 10^{-5} Torr. The MS setup is equipped with an APEL-IS-21CELL ion source and APELMRE100 magnetrons. Before the deposition of coatings, the substrates were ionically cleaned with argon at an operating voltage of 2.5 kV, a current of 20-25 mA, a pressure of 1-2.5$\cdot 10^{-3}$ Torr, with a duration of 20 min. The testing of the modes of TiCN coating deposition was carried out under the conditions of asymmetric power supply of the magnetron sputtering system. For this, the potential voltage was applied not only to the magnetron, but also to the substrate. The substrate bias voltage (U_s) was applied using an APEL-M-5PDC power supply. In order to study the effect of U_s on the deposition rate (DP) and the composition of the displacement coating, the feed was applied from 0, -70, -90, -110, -120, -130 V. The flow of inert and reaction gas was controlled by flow meters of the RRG12 brand. The total gas flow rate of Ar / C_2H_2 + N_2 was set at up to 1.5 L/h to maintain the operating pressure in the chamber at 10^{-3} Torr. After reaching the working pressure of the Ar / C_2H_2 + N_2 gas atmosphere, the plasma was ignited. The plasma current was recorded in all experiments at 2 A, the voltage was varied in the range of 500-700 V. For this, an APEL-M-5PDC-1000A-1 power supply was used. The deposition time of all coatings is constant, 2 hours. Finally, the thickness of the TiCN films was in the range of 0.7 -1.4 μm, which was checked using field emission scanning electron microscopy (SEM).

TiCN films were analyzed for morphology, elemental and phase composition. CO was defined as the ratio of the coating thickness to the deposition time. The thickness of the coatings was measured gravimetrically using a Sartorius Cubis MSA3.6P analytical balance and verified by scanning electron microscopy (SEM).

The morphology of the coatings was analyzed using SEM on a JXA-8230 (JEOL) microscope at an accelerating voltage of 20 kV and an electron beam current of up to 7 nA. For all areas of the samples selected for SEM studies, the backscattered electrons (COMPO) mode was used. The elemental composition of the coating was determined by the method of energy dispersive X-ray analysis EDS.

The phase composition of the coating was determined using a D8 Advance (BRUKER) diffractometer with α-Cu radiation (λ ≈ 1.54 Å). X-ray photography was carried out with Bragg-Brentano focusing. Diffraction patterns were recorded in the range of angles 2θ: 20 ÷ 90 ° with a step of 0.05 °, the recording rate was 2 deg / min at a voltage of 35 kV and a current of 20 mA. For the phase analysis, the PDF 2 base was used.

The friction coefficient (CoF) of the coatings were measured in the sliding friction mode according to the "ball-on-disk" scheme on a TRB^3 tribometer. Sample rotation speed - 1 cm/s, load - 1 N, wear track radius - 4 mm, friction path - 100 m, data collection speed: 50 Hz, a Si_3N_4 ball with a diameter of 6 mm was used as a counter body.

Results and discussion

Figure 1 shows the dependence of DP and the TiCN film thickness on the negative bias voltage applied to the substrate. As can be seen from the graph, the thickness of the TiCN coating (Figure 1, black line) on the substrate without displacement is 1.45 μm, then it decreases to 0.78 μm (-130 V). The deposition rate

(Figure 1, red line) decreases starting from the sample without substrate voltage to substrate bias -130 V from 0.72 to 0.39 μm/h, respectively. The reason for this is probably the effect of re-sputtering due to ion bombardment or surface growth by incoming ions, as noted in works [6, 20-23]. The negative bias voltage applied to the substrate provides continuous ion bombardment of the substrate. This is called re-sputtering, which reduces the DR of the TiCN coatings [6].

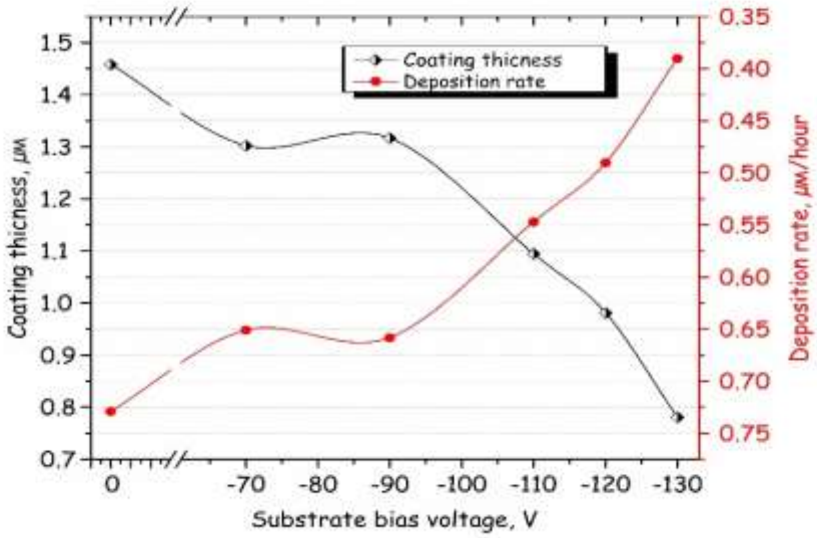

Figure 1. Dependence of the deposition rate and thickness of the TiCN coating on U_s

The effect of the applied negative bias voltage on the chemical composition of TiCN coatings deposited at different U_s is shown in Figure 2. The applied negative voltage noticeably affects the atomic composition of the coatings obtained. In the range U_s from 0 to -100 V, the elemental composition of all coatings remains approximately constant. As the bias increases from -100 V, a significant change in the chemical composition is noted, namely, a decrease in the amount of nitrogen to 34 at.% and an increase in carbon to 25.6 at.%. Also, in this region of bias substrate, titanium increases slightly to 40.5 at.%. The increase in the amount of carbon is apparently associated with the carburization of the surface of the titanium target with the prolongation of the deposition time, which creates favorable conditions in the plasma for the formation of TiC rather than TiN.

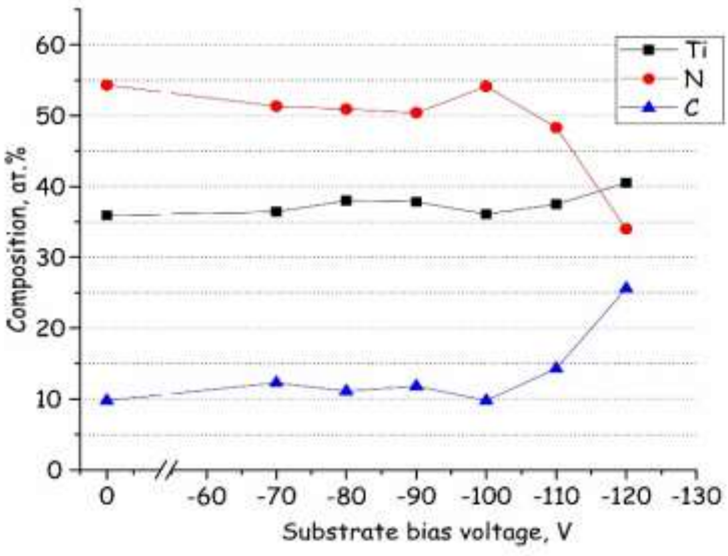

Figure 2. Dependence of the elemental composition of TiCN coatings on U_s

Substoichiometric concentration Ti/(C + N) is one of the important ratios for TiCN coatings. The Ti / (C + N) ratio for the obtained coatings with and without substrate are shown in Table 1. In the coating applied without bias substrate, the ratio Ti/(C + N) = 0.56 was observed. In the case of coatings with U_s, the substoichiometric concentration of Ti/(C + N) is in the range from 0.58 to 0.68. Among the deposited coatings, -120 V has the closest substoichiometric concentration value, which is 0.68. Although, it should be noted that in this sputtering mode of the MS coating is formed at a low deposition rate.

Table 1. The ratio of elements Ti/(C + N) for the obtained TiCN coatings

U_s, V	0	-70	-80	-90	-100	-110	-120
Ti/(C+N)	0,56	0,58	0,61	0,61	0,56	0,59	0,68

Figure 3 shows an X-ray phase analysis of TiCN coatings deposited at various negative substrate bias voltage. The diffraction patterns show that with an increase in the bias voltage of 0 V to 65 V, the intensity of the diffraction maximum also increases, the content of acetylene in the composition of the reaction gas increases the lattice period of the coatings and the width of the X-ray line, decreases the texturing parameter of the coatings, but then, with a further increase to -70 V, the diffraction intensity decreases, and over time, with an increase to -120 V, remains stable.

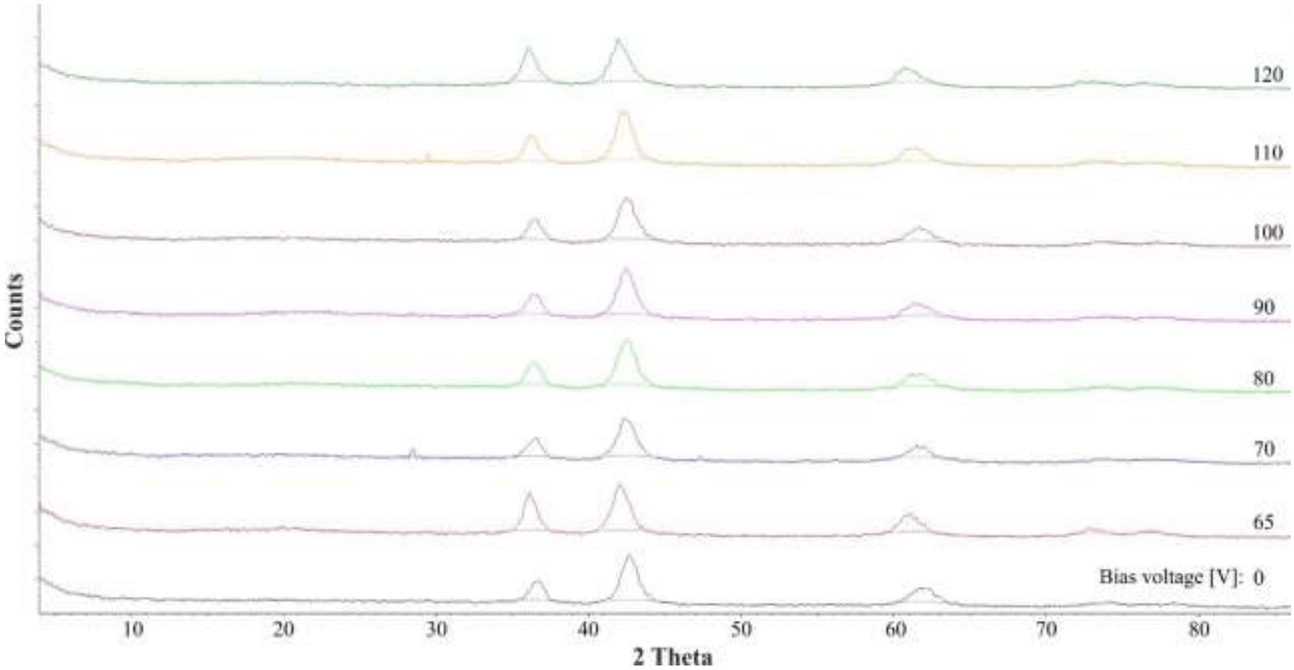

Figure 3. Influence of bias voltage during TiCN coating deposition on diffraction patterns

The wear resistance of TiCN coatings mainly depends on the microstructure, hardness and adhesion, which are usually measured in terms of the coefficient of friction and weight loss during wear [22]. Typically, TiCN coatings have a low coefficient of friction (CoF). The CoF of the deposited coatings at U_s = 0, -70, -100 V are shown in Figure 4. The resulting coatings showed an average CoF value from 0.06 to 0.188. As can be seen, the low CoF has a sample deposited on the substrate with a potential bias of -70 V. In other cases, the CoF are approximately the same, which are in the region of about 0.18. The CoF results are in good agreement with the results obtained for TiCN films by Saoula N. et al. [6, 22], however, the CoF for the -70 V sample is much lower than in these works. The results show that it should be possible to obtain high wear resistance of the film with an appropriate choice of substrate bias. Currently, for these purposes, tribological and mechanical properties are being studied depending on the applied bias of the potential to the substrate during the deposition of TiCN coatings.

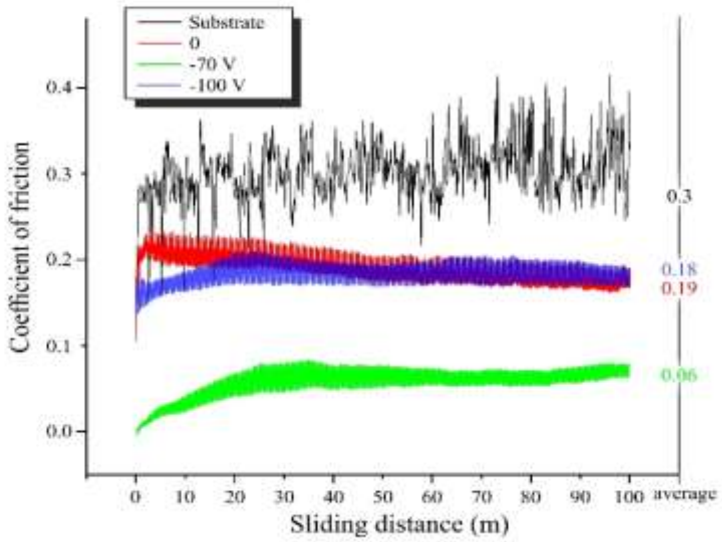

Figure 4. CoF for TiCN coatings obtained at U_s = 0, -70, -100 V

Conclusions

In modern tribology, coatings made of titanium nitride - TiN and titanium carbonitride - TiCN are in the lead, since they have a lower cost and simplicity of production technology. TiCN coatings were deposited by magnetron sputtering on a substrate with displacement. The influence of the bias of the substrate potential on the deposition rate, elemental and phase composition of the coatings was investigated, and the coefficient of friction of the coatings was also studied. The deposition rate of the TiCN film decreases with increasing voltage on the substrate. With increasing stress, the concentration of titanium and carbon increases, along with a decrease in the concentration of nitrogen. A low coefficient of friction is recorded on TiCN coatings, obtained at - 70 V. As a result, an optimal mode with a potential shift of - 70 V is determined, where TiCN coatings are formed with a low coefficient of friction and with a high deposition rate, with acceptable compositions. Further studies on tribological and mechanical tests are required to fully represent the quality of coatings for wear resistance, which will be determined at the next stage of the study.

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Formation of teachers of the initial stage of education - readiness for innovation

Abstract: This article examines the readiness and formation of teachers of primary education - innovative activity. The relevance of this topic lies in the search and application of innovative technologies in primary schools, where the main task of teachers is to quickly adapt to modern innovations and the ongoing changes in updated education. The XXI century is called the century of high or digital technologies, and therefore creative, active, fast-learning and inquisitive people are in demand in any industry. The modern system of updated education develops children's research and cognitive structure of activity. In this regard, adjustments are made to the educational program in almost every country to develop students' abilities, based on research and cognitive activity, where one of the first steps is primary school.

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Introduction

To date, the education system is in search of innovative ways of updated education. One of the most important tasks is the ability of teachers to react sensitively and quickly adapt to changes in practice. This is due to the need to make managerial decisions that ensure a number of professional changes of the teacher, which may reflect the needs of a modern school both in organizational, pedagogical and social terms.

Literature review

Given the experience and age of many teachers, we can say that they are experiencing serious difficulties in implementing innovative and digital activities, which complicates the process of their adaptation to the requirements of modern schools and reduces the effectiveness of their work. It should be emphasized that the activities of primary school teachers to develop educational programs in accordance with the current updated program and online training in connection with the pandemic are innovative. This, in turn, requires teachers to have the skills to design programs that support this process. In this regard, the question arises about the need to increase the level of readiness of teachers for innovation and the search for effective means of solving this problem on the part of the head of the educational institution. There is a huge amount of work on the subject of innovation, the development of new methods, variations and improvements of existing ones, as well as the constant, urgent interest of researchers in this task.

According to the studied problem, various directions of research of innovative activity are reflected in the scientific and pedagogical literature: general and specific features of creative activity are considered in the works of V.I. Zagvyazinsky [1], A. Aitpaeva [2], Danilov D.A.[3]; from the point of view of studying pedagogical achievements and spreading best practices, innovative activity of a teacher is studied by A.M. Bakhtyzin [4]; N.R. Yusufbekova [5]; features of innovative phenomena in the modern education system are considered: A.P. Panfilova [6]; A. P. Usoltsev [7];

For many years, the methodology of primary school teaching has been constantly searching for innovative teaching methods that contribute to the activation of educational and cognitive activity of younger schoolchildren. Innovation is the introduction of new methodologies and standards into the educational process. Obedience, repetition, imitation are replaced by new requirements: the ability to see problems, calmly accept them, and solve them independently. This applies to all spheres of life: household, social and professional. Correlating the concept of "innovation" with the pedagogical process, the term innovation means the introduction of fundamentally new goals, content, methods and forms of educational activity. In the pedagogical encyclopedia [8], the concept of "pedagogical innovation" is considered as an innovation in pedagogical activity, a change in the content and technology of teaching and upbringing aimed at increasing their effectiveness"

Innovations become possible due to the introduction into professional activity of didactic and educational programs unknown to practice, which presupposes the removal of the pedagogical crisis. The development of the ability to motivate actions, independently navigate the information received, the formation of creative unconventional thinking, the development of children through the maximum disclosure of their natural abilities, using the latest achievements of science and practice— are the main goals of innovation. Innovative activity in education, as a socially significant practice aimed at moral self-improvement of a person, is important because it is able to ensure the transformation of all existing types of practices in society. When choosing a teaching style, the teacher's beliefs have a greater influence than his knowledge, because in the learning process they influence everything he does in the classroom, beliefs to accept new ideas, so I completely revised my teaching methodology before and after. The modern requirements of society for the teacher are such that the teacher must constantly engage in self-education, expanding the boundaries of their capabilities. He should be able to change quickly and be able to apply new approaches and technologies in the classroom. In a word, the teacher must keep up with the times.

Innovative technologies are capable of modernizing the educational process as a whole and directing it to achieve learning outcomes, replacing the accustomed traditional learning system, which is primarily based on reproductive learning. It is also important to consider such a concept as "psychological readiness for innovation", which is characterized by a holistic psychological aspect, representing the unity of the cognitive component (knowledge in the field of innovation, forms, methods, modern educational technologies and pedagogical tools), emotional (positive attitude to innovations) and activity components [9].

Also, special attention should be paid to the teacher's readiness for innovative activities aimed at improving professional activity, as well as the ability to identify existing problems in the training and education of students, effectively solve them and eliminate mistakes.

That is, an innovator teacher should be focused on creating his own creative tasks, methods and set up for innovative activity. It is important to be prepared to overcome the difficulties associated with the content and organization of innovation activities. It is necessary to master the skills of mastering pedagogical innovations, to be able to develop their own innovations, using different techniques during the lesson, such as "Right, wrong statements", the game "Do you believe?", Bloom's daisy, basket of ideas, cluster, insert, thick and thin questions, cinquain, embodiment (in the role of a person, animate or inanimate being), business game, dialogue of historical or literary characters, illustrative comparison of facts, documents, events, epochs, civilizations, dramatization a real or fictional historical event, a journey, role-playing game, quizzes, etc.

Primary school teachers are called upon to teach children creativity, to educate in each child an independent personality who owns the tools of self-development and self-improvement, who is able to find effective ways to solve problems, search for the necessary information, think critically, engage in discussion, communication, but of course, the nature of the innovative activity of a teacher depends on the teacher himself and his level of personal readiness for this activity, but the conditions provided for its development are not unimportant. The main result of innovative learning is the development of the child's personality on the basis of educational activities, "it is necessary that the child learns about himself as a person, and his interests coincide with universal values" [10].

Research Results

This result, we believe, is possible through the introduction of modern educational technologies into the practice of primary school teachers, allowing them to solve the task of modern innovative education - the upbringing of a socially active personality.

Undoubtedly, traditional tools have become insufficient to achieve these goals, and teachers are not ready for innovative activities at all. The question arises, how to help teachers to be ready for innovation.

For the effectiveness of innovative activity and systematic methodological work with the teaching staff to improve their professional competence, it is necessary:

- the teachers of an educational institution have an individual development plan that mobilizes their expected abilities and capabilities;
- systematic accounting of teacher's successes in pedagogical activity and achievements in the work of teachers;
- creating a creative environment for the teacher and combining the efforts of the entire teaching staff to build an educational space where each teacher could realize their importance;
- establishing a trusting, direct relationship in which the teacher will lose the fear of being misunderstood by colleagues and management.
- properly structured work of the head of an educational institution for the expansion and implementation of innovative activities in an educational institution.
- conducting scientific and methodological seminars between teachers, round tables, exchange of new ideas, advanced training courses, etc.;
- consistency, creating a situation of success, creating a creative atmosphere, etc.

So, the formation of readiness for innovative activity among teachers of the initial stage of education will allow to activate the activity of teachers, attract them to work together, mobilize the creative potential of primary school teachers, help the teacher's personality self-actualize, select the most effective teaching methods and techniques, means that contribute to the activation of the mental activity of younger schoolchildren.

Conclusion

The use of innovative research methods in the educational process, discussions, cognitive games, integrated lessons with the use of ICT opens up the possibilities of cognitive research activity of students. Professional competence, pedagogical skills, intellectual and moral character of a teacher, are one of the main conditions for the effectiveness of the educational process. Thus, the formation of readiness for innovative activity among teachers of the initial stage of education will allow to activate the activities of teachers, attract them to work together, mobilize the creative potential of primary school teachers, help the self-realization of the teacher's personality, select the most effective teaching methods and techniques, means that contribute to the activation of the mental activity of younger schoolchildren. The use of innovative research methods, discussions, cognitive games, integrated lessons with the use of ICT in the educational process opens up opportunities for cognitive research activities of students. Professional competence, pedagogical skills, intellectual and moral character of a teacher are one of the main conditions for the effectiveness of the educational process.

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Ways of organizing the educational process in elementary school based on the project-research form of educational activity

Abstract: This article examines the ways of organizing the educational process in primary school on the basis of the project-research form of educational activity. The relevance of this topic lies in the search and application of the design and research form of educational activity in primary school, where the main task of teachers is to quickly adapt to modern projects and the ongoing changes in updated learning. The XXI century is called the century of high or digital technologies. Creative, active, fast-learning and inquisitive people are in demand in any industry. The modern system of updated education develops children's research and cognitive structure of activity. Therefore, in the educational program, in almost every country, adjustments are made for the development of students' abilities, based on research and cognitive activity, where one of the first steps is primary school.
Keywords: primary education, project, design and research work.

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Introduction

The reforms taking place in the education system in the Republic of Kazakhstan are the transition to a program of updated educational content. It was the impetus for the introduction of the updated content of education that was the activation of the learning function, the achievement of learning goals, through the organization of the educational process based on the project-research form of educational activity.

The initial stage of education contributes to the formation of the foundations of research and cognitive activity. According to the State Standard of the Republic of Kazakhstan, the goal of primary education is to create an educational space favorable for the harmonious formation and development of a student's personality with the basics of a wide range of skills:

- Functional and creative application of knowledge
- Critical thinking
- Conducting research
- Use of information and communication technologies
- Application of various communication methods, including language skills
- Ability to work in a group and individually [1].

Main Research body

The achievement of this goal is inextricably linked with the organization and construction of the educational process based on research and cognitive activity. The problem of including a younger student in educational and research activities turns out to be very relevant, but not always successfully solved. Because of this, it is necessary to actively search for favorable conditions for the organization of project and research activities of schoolchildren in the primary education system.

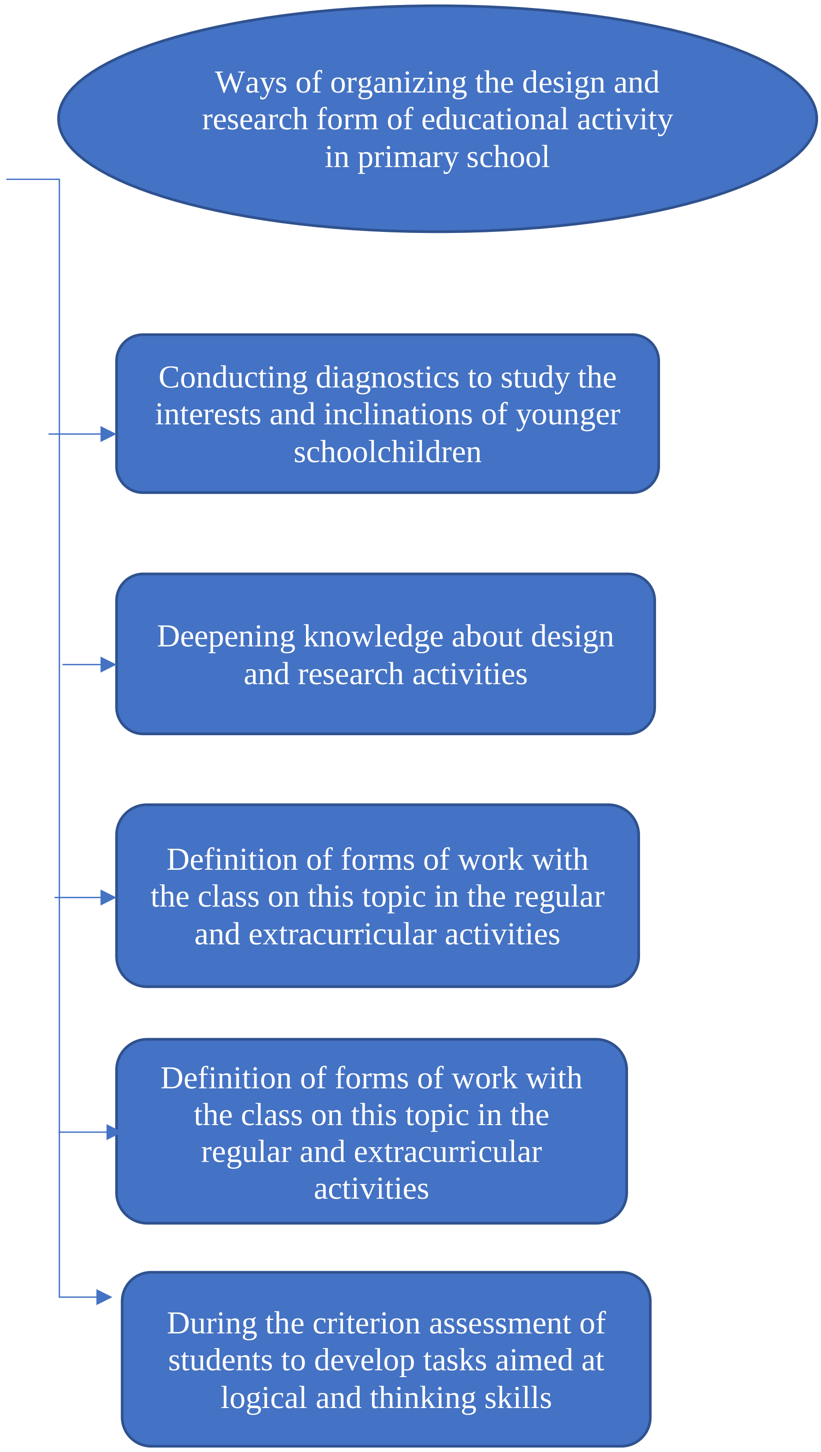

Figure 1 - Ways of organizing the design and research form of educational activity in primary school

An elementary school teacher in the organization of project and research activities is a carrier of knowledge and information, an organizer of activities, a consultant for solving a problem, obtaining the necessary knowledge and information from various sources, mastering a set of specific skills that will allow for the correct implementation of interaction with students in the process of project and research activities:

- the ability to find and set real educational and research tasks for students in a form understandable to children;
- the ability to engage students personally with a valuable educational task;
- ability to perform the function of coordinator and partner in the research search;
- the ability to offer your help, not impose it;
- the ability to be tolerant of students' mistakes and offer their help only when students begin to feel the hopelessness of their search [2, 3].

The purpose of design and research activities in primary school is to promote the involvement of younger students in an active cognitive process based on project activities for the formation of general academic competencies. In the course of the problem under study, we identified ways to organize the design and research form of educational activity in primary school (figure 1).

In the practice of primary school work, we focus on the most acceptable projects:

- short-term projects are carried out both individually and in group form in extracurricular work or at home, information selection, presentation preparation, etc.;
- mini-projects - conducted in the classroom and by the end of the lesson the finished result;
- creative projects - involves the most free, unconventional approach in the performance of work (fairy tales, drawings, crafts, etc.) and the design of the results;
- Research projects - substantiation of the relevance of the topic, the purpose and objectives of the study, mandatory hypotheses with subsequent verification and discussion of the results obtained.

When organizing the design and research form of educational activity in primary school, it is necessary to take into account the age-related psychological and physiological characteristics of students [4]. Thus, the topics of educational projects and educational research should be in the field of cognitive interests of the younger student and be in the zone of immediate development. It is advisable to limit the duration of the project or research at the level of primary general education to several weeks in the mode of scheduled extracurricular activities. In the process of working on the topic, you can conduct excursions, observation walks, social actions, work with various text sources of information, preparation of practically significant products, a wide public presentation with the invitation of students, parents, teachers and school administration.

When organizing project-research educational activities in primary school, it is necessary to take into account the use of methods and methods of activity in accordance with the class level [5, 6]. So, in the 1st grade, the following methods and methods of activity are used in class activities: collective educational dialogue, examination of subjects, creation of problem situations, reading-examination, collective modeling; in extracurricular activities - games-classes, joint determination of his own interests with the child, individual drawing up of schemes, execution of models from various materials, excursions, exhibitions of children's works, which contributes to:

- maintaining the research activity of schoolchildren on the basis of existing ideas;
- development of skills to raise questions, make assumptions, observe, make subject models;
- formation of initial ideas about the researcher's activities.

In the 2nd grade, the inclusion of younger schoolchildren in educational and research activities is carried out through the creation of a research situation through educational and research tasks and tasks and recognition of the value of joint experience and is focused on acquiring new ideas about the features of the researcher's activity, namely:

- to develop the skills to determine the topic of the study, analyze, compare, formulate conclusions, formalize the results of the study;
- to support the initiative, activity and independence of schoolchildren.

At this stage, the following methods and methods of activity are used: in scheduled activities - educational discussion, observations according to the plan, stories of children and teachers, mini-studies; in extracurricular activities - excursions, individual compilation of models and schemes, mini-reports, role-playing games, experiments.

On the basis of the accumulated research experience of schoolchildren, the third and fourth grades of primary school continue to further accumulate ideas about research activities, its means and methods, awareness of the logic of research and the development of research skills. In the process of learning, there is a complication of activities with an increase in the complexity of educational and research tasks, in the reorientation of the educational process to the formulation and solution of educational and research tasks by schoolchildren themselves, in the unfoldment and awareness of reasoning, generalizations and conclusions. Accordingly, the corresponding methods and methods of schoolchildren's activities are highlighted: mini-studies, research lessons, collective execution and protection of research papers, observation, questioning, experiment and others.

Thus, the enrichment of students' research experience based on individual achievements is ensured throughout primary school education. In addition to regular educational and research activities, it is necessary to actively use the possibilities of extracurricular forms of research organization. These can be various extracurricular activities in subjects, as well as home studies of schoolchildren. The results of the children's work must be presented and commented on by the teacher or by the children themselves (display, exhibition).

Conclusion

For the effective and correct organization of the design and research activities of younger schoolchildren, it is necessary to take into account the recommendations for a teacher at the level of primary general education:

- ✓ strive to develop in each child his individual inclinations and abilities;
- ✓ focus more on the process of research search during extracurricular activities;
- ✓ teach children to identify connections between academic subjects, events and phenomena;
- ✓ form a culture of intellectual work in children, the ability to extract information and knowledge, the ability to analyze, synthesize and classify the information they receive;
- ✓ do not do for children what they can do on their own;
- ✓ teach younger students to analyze learning situations and solve research problems.

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Development of programmable logic controller teaching aids on electrical motor installation course among vocational school students in Aceh, Indonesia

Abstract: Programmable Logic Controller (PLC) is a competency that must be mastered by third-level vocational school students in an electrical motor installation course. PLCs can be operated using programming languages such as sequence function charts, block diagrams, instruction lists, ladder diagrams, and others. This competency is important because it is often used in the industrial world. To create better and more effective conditions in the teaching and learning process, the development of teaching aids is needed to improve and enhance students' skills. This research, to design and development a useful teaching and learning tool teaching medium to help teachers teach concepts PLC-based electrical control systems, both theoretically and practically. The ADDIE model was used in developing the aids. The verification stage is carried out to ensure that the teaching aids that have been developed are suitable for use. In addition, this kit is relatively small with dimensions of 45x34x20 mm and is easy to move and can be used in various places. Confirmation involves lecturers and teachers who teach the field of electrical engineering. The results of the study found that the respondents strongly agreed that the PLC teaching aids was suitable for use in the learning process. Respondents also stated that using the tool because did not waste time and was easy to use. However, it is suggested that further research be conducted to identify the effectiveness of this teaching aid on students.
Keywords: development, teaching aids, PLC, ADDIE, vocational students.

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Introduction

Currently, the industrial fields have entered the era of automation, and the use of automated control systems has simplified the entire construction process. The machines are now operated by a computer control system commonly called Programmable Logic Controller (PLC) [1]. In the Curriculum 2013, the current range of skills has been tailored to the needs of the course, knowledge development, technology and the world of work. One of the professional fields of the vocational school is the field of electrical engineering, which is a type of interest skills. It contains PLC competency standards for form 3 students vocational school. PLC can be used in various forms of instructions developed by programmers. PLC is a single computer-based processor device that needs to be scrutinized in vocational school

*Corresponding author

institutions (Figure 1). PLC is a very widely used control system in the industry. PLC can be defined as a controller component consisting of input signals and output signals, and programs that are provided to the PLC to run or control machines organized by programmers. Programming control PLC analyzes input signals and sets the state of the output signals according to the program written by the user.

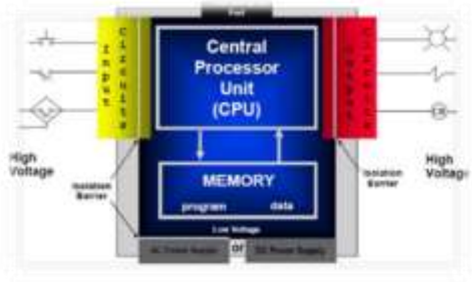

Figure 1 – The fundamental of PLC system

To train students with PLC tool application skills, in-depth knowledge and skills are of paramount importance. The mastery of vocational students on PLC programming theory is still very low. This is because it is easier for them to understand the curriculum through direct practice than to only theoretically understand it (Abdullah et al., 2010). Proficiency in PLC programming is a skill that every student must possess in electrical engineering, especially when exploring the field of automation in the field of automation in the field of industry in the future. This is especially important, especially when practical learning in PLC programming differs from traditional learning methods. It involves expensive and limited equipment, safety issues that need to be solved, and extensive and ongoing training and skills requirements (Lim, 2002). The following question of study has been discussed in this research:

1. What is the need for a tool to teach programmable logic controller (PLC) for electrical motor installation course among students of a form 3 vocational school in Aceh, Indonesia?
2. How to develop a tool to teach programmable logic controller (PLC) for electrical motor installation courses among students of form 3 vocational school in Aceh, Indonesia?

Literature Review

The use of teaching aids in the teaching and learning process is absolutely necessary to understand what teachers are delivering [9]. Learning activities in technical schools are majority practical. Teachers are required to create learning environments that involve students to be motivated and seamless by determining appropriate strategies, approaches, models, media and learning techniques in order to achieve learning goals [27].

The use of media in the form of teaching aids is everything that explains the concept of learning from abstract or obscure material can be true and clear, thus developing students' thoughts, emotions, attention and interests, thus guiding students in the teaching and learning process [28].

From the relevance of the learning of the electrical motor control system, the delivery of all aspects of knowledge related to the development of the control system should be done especially for new users so that they can master the appropriate skills, the appropriate method for teaching this control system is to use teaching aids [22]. Isa [13] argues that teaching aid is one of the teaching aids used in the teaching and learning process that can help students understand the course content more effectively. The use of appropriate teaching aids has the potential to enhance academic competency and create different perceptions of how students benefit [19].

The various teaching aids available today are easily accessible, but less practical as they require considerable space to operate. This requires simpler aids to facilitate learning and teaching experiences. It is also necessary to ensure that the design of new aids is in line with industry standards as well as assisting in the learning process of teaching. In addition, laboratories are often an important component of technical education. However, factors such as limited laboratory hours, expensive equipment, and a high student ratio of equipment often impede student learning. Teaching aids can be used to help prepare students to make the most of limited laboratory resources [10].

There are many advantages to using good teaching aids to support PLC-based programming learning. This includes the possibility for students to learn on their own, since students can check their own calculations and understanding by incorporating appropriate programming systems into computer software and can further be simulated using teaching aids so that students have the opportunity to consider more realistic examples [3].

According to Ibrahim [11] the PLC teaching aids enable students to carry out various control strategies using microprocessor aimed at assisting learning activities in the laboratory as a complement to the theory of programming systems taught to students.

Programmable Logic Controller (PLC) is widely used in the manufacturing industry for automatization and becomes one of the important courses at the secondary and higher education levels. Studying theory in class alone is not enough to gain knowledge about PLC programming. Therefore, teaching aids are needed to assist in interactive learning in classes as well as live activities in the laboratory [25].

Meanwhile, Isa [13], stated that learning practices using PLC-based teaching aid for practical training in theoretical studies can help students better understand programming concepts, and can also effectively apply students' knowledge and experience in the teaching process. Burhan, Talib, & Azman [4], in their study found that PLC teaching aids can improve direct skills aspects through circuit planning, installation and problem solving. From practical learning results in the laboratory, it was found that there was an increase in knowledge and skills directly as students used PLC teaching aids.

According to Mahadi et al. [15], in project-based learning, the use of PLC teaching aids is very important in improving the understanding and experience of students. Through this teaching aid, preliminary testing of the PLC control system can also be done in the actual laboratory. This can also save time in learning the PLC control system. In the 21st century engineering teaching and learning process, PLC-based electrical and automation courses require the use of advanced techniques and learning aids to enhance students' understanding of everyday learning activities.

From the Gavali, Patil, & Koli [8] research, the use of PLC teaching aids has found that student experience has increased to a considerable level through activities that allow students to collaborate and control PLC devices through collaboratively laboratory-oriented interactive tasks. In line with Sukir et al. [24] study which states that the effective use of PLC teaching aids in practical programming activities can effectively improve students' learning outcomes in cognitive, psychomotor, and affective aspects.

According to Ab Rahman et al. [26], the use of PLC teaching aids can form higher thinking ability to a certain extent, and can even deepen students' understanding of input and output circuit connectivity methods on motor control systems. With teaching aid suitable, teaching and activities become more effective as students gain real experience while developing PLC control systems similar to existing control systems in the industry. Hence, they also have the opportunity to work in groups to learn programming systems and improve communication skills, collaboration, idea sharing, learning ability, etc [21].

Khairudin et al. [14] in their study found differences in the competency level of students using PLC teaching aids. Students who do simulations with the help of PLC teaching aid have better interest and achievement in learning competencies compared to those who do not use the teaching aids in their learning activities. In line with study Yahaya, Mustafa, & Ahad [29], found a positive effect on students using PLC teaching aids in their learning activities compared to students using conventional methods, they can be enthusiastic and want to learn the topic of PLC. Students are more focused and pay full attention when PLC teaching aids are exposed to the learning process. The use of PLC teaching aids is one of the teaching methods that has been proven to enhance students' competency. The diversity of approaches practiced by teachers such as the use of teaching aids is encouraged to make students more interested in the topic of the programming system and ultimately remove their negative response to the topic of the programming system.

According to Fatkhurohman & Ratnanto Fitriadi [7], the use of PLC-based teaching aid is felt to be better and easier to learn especially for students who are just learning the industrial control system. Applying PLC programming with abstract and difficult staircase diagrams becomes easy to understand because it is simpler with the help of teaching aids. Furthermore, the use of teaching aid helps students to understand the correct wiring so as to avoid mistakes during operation.

Michal & Peter Ján [16], argues the priority in utilizing the PLC teaching aids is to provide the practical experience and skills required as a programmer of the PLC. This kit also contributes to the creativity of students. Meanwhile, Perdana, Permata, & Fatkhurrokhman [20] stated that the practice of using PLC teaching aids can significantly improve students' competencies. In addition, with the availability of such teaching aids, students can learn it more freely whether they are at school or at home. Therefore, it can be said that the use of PLC teaching aids has already facilitated and had a positive impact in programming learning, especially in technical and vocational schools in the field of electrical engineering. Based on the findings of past studies on the effects of using PLC teaching aids, researchers should conduct studies to develop PLC teaching aids that are easier to use at a higher cost more affordable and safe to use.

Methodology

This study was conducted to develop PLC teaching aids on electrical motor installation courses on PLC programming topics to assist teachers in providing an understanding of the concept of PLC culling. The context of this study is to provide easy-to-use teaching aids, safe to use and affordable aid construction costs to assist teachers in the implementation of the process teaching and practical learning.

The correspondents in this study are 3 expert teachers in electrical engineering at a vocational school in Aceh, Indonesia who evaluated the design and usability of the PLC teaching aids that have been developed.

Experiment Design

The study used an expansion method with the ADDIE model. This research is carried out to study the exact condition of the object, and there is no need to test any specific hypothesis. PLC teaching aids need to be developed to achieve research objectives. The PLC teaching aids developed consist of two stages, namely hardware and software development. PLC teaching aid hardware is an arrangement of several components connected through electrical wiring while software is an application used for programming that allows teaching aids to work and be used according to the needs of users. The software used is the *CX-Programmer* which contains the plc and *CX-Designer* programming languages that serve as a design application in the Human Machine *Interface* through the help of computers.

In this study, the ADDIE model was chosen as a guide for researchers to develop teaching aids systematically according to regular processes. ADDIE is an acronym for describing the main sections and steps to follow, namely analysis, design, development, implementation and evaluation. The development process of the teaching aids in this study involves five phases, namely the process of analyzing at an early stage, the process of designing teaching aids, developing teaching aids and planning activities, and finally the testing and evaluation process of the entire teaching aid. This model was chosen because it emphasizes repetition for each phase. Each phase is also connected to each other. If the phase cannot be properly implemented, the process can be repeated until it is completed.

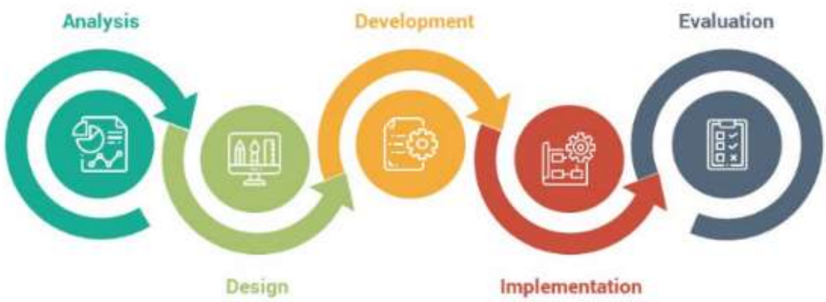

Figure 2 - ADDIE model

The ADDIE model has been absorbed in the development of logic control programming (PLC) teaching aids consisting of phases of analysis, design, development, implementation and evaluation (Figure 2). The educational philosophy that needs to be applied when the ADDIE model is used is that the learning process needs to be student-centered, innovative and inspiring for students [17]. The ADDIE model can be used to produce effective teaching aids, especially technological aids.

Results

Finding and discussion

Research Question 1: What is the need for a tool to teach programmable logic controller (PLC) for an electrical motor installation course among students of form 3 vocational school in Aceh, Indonesia?

Analysis of the need to develop a product to ensure that the product is built to meet the needs of consumers. This study was conducted to analyze the needs and specifications of the teaching aids in PLC programming on the electrical motor installation course among students of form 3 vocational school. Analysis of the development needs of PLC teaching aids based on the views of expert teachers during pilot studies, where there are various problems faced by teachers and students in the teaching and learning process on the Electrical Motor Installation course on the topic of PLC programming, specifically in form 3 students vocational school. Researchers conduct interviews on expert teachers to identify problems in learning and obtain insights for the importance of developing PLC teaching aids.

Teacher expert 1st provides insight on problems in learning hands on electrical motor installation, students only do conventional learning, i.e. simple connection of wiring motor. This causes students not to understand the methods of control of electrical motor using complex coding and software.

Teacher expert 2nd also emphasizes the problems in learning the PLC programming-based electrical motor installation course. Students do not understand the basic knowledge of PLC programming and motor control due to poor teacher learning. Unfortunately, the lack of teachers' understanding of the field has made PLC teaching aid difficult to produce. Furthermore, the cost of expensive ones makes providing PLC teaching aids difficult to do.

This was agreed by teacher expert 3rd by saying that the lack of stakeholders' attention regarding the provision of teaching aids, resulting in less effective learning activities because the existing PLC teaching aids do not correspond to the total number of students.

Based on the views of the expert teachers, the above is the basis for the development of PLC teaching aids that can be used by teachers and students to support the practical learning process. The provision of PLC teaching aids developed must be able to solve the problems that arise, namely by producing PLC teaching aids at a low cost, easy to use and stimulating student interest and improving the achievement of learning outcomes.

To overcome learning problems in the electrical motor installation course, the development of PLC teaching aids was developed based on the views of experts during the pilot study. To produce products that are suitable to the needs of consumers, a development model is used as a formwork so that the development process meets the right procedures and methods. The ADDIE model was chosen as the model in this study because it is considered the most suitable.

The ADDIE model comprises five phases of analysis phase, design phase, development phase, implementation phase and evaluation phase. This model is one of the systematic teaching design models in the production of effective and user-friendly computerized learning materials [2].

The analysis phase in the process of learning aid development is to identify problems and analyze the needs of teaching aids in learning. This is to ensure that the learning aids developed can meet the needs of real users. To identify this requirement, a pilot study was conducted on the installation of electric motor based on PLC technology and found that students had difficulty in understanding the learning due to technical complexity and principles. Students also cannot see the application of logical control programming operations on the installation system of the electrical motor itself. In this study, researchers focused more on discussing ADDIE development models as references in developing tools to teach PLC.

Research Question 2: How to develop a tool teaching programmable logic controller (PLC) for electrical motor installation courses among students of form 3 vocational school in Aceh, Indonesia?

The ADDIE model adapts inputs, processes and outputs as a way to complete all phases [6]. Inputs will respond with known variables through the receipt of data, information and knowledge [5]. The input level in this study is through the need for data, information and knowledge based on the response from the respondents during the study.

The process is seen as a way to stimulate creative thinking in using procedures, translating and explaining various approaches that can be used in the learning process [5]. In the process stages include a design process which is a systematic method of planning, developing, evaluating and managing the learning and development process that refers to the tools used to create learning materials. The purpose of this phase is to produce and verify learning resources. Once the design and development process is completed, then the next process is the implementation process. The purpose of this implementation phase is to provide a society to help teach learning lessons that can accommodate the learning process that has been developed. This phase also includes preparing students and teachers involved in the learning process.

Output sends results from process phases in appropriate action [17]. The output part is the evaluation process. The purpose of the evaluation phase is to evaluate the quality of the product and the learning process before and after the implementation process. The usual procedure in the evaluation phase is to determine the evaluation criteria, select or develop the assessment tool and subsequently perform the assessment. A common component of the evaluation phase is collecting and analyzing data related to the criteria to be evaluated. The study has three evaluation criteria namely achievement, 21^{st} century skills and motivation of students towards teaching materials. The achievement criteria are chosen by the researchers because the achievement will show the researchers the extent to which the impact of teaching aids based on PLC can impact students' understanding and achievement of students' competency courses on PLC programming topics.

The results of a study conducted by Razak & Rahman [23] show that teaching aids developed by them using the ADDIE model managed to have a positive impact as an additional learning tool. Mukhari & Naharuddin [18] also applied ADDIE design models in the development of their teaching aids. The results of testing the teaching aids found that they meet the features of interactive multimedia and meet the objectives set. The same goes for the study conducted by Zakaria & Rahman [31]. The ADDIE model used successfully attracts students to the teaching and learning process.

Analysis

According to Branch [5] there are several steps in the phase of needs analysis which are to confirm the existence of achievement gaps, determine teaching goals, ensure the needs of consumers, identify the necessary resources in the next development process and prepare a project management plan.

Need analysis was also carried out with the aim of looking at the issues and problems of learning the electrical motor installation course on the topic of PLC students of form 3 vocational school in Aceh, Indonesia area which led to the need for the development of media teaching aids PLC. The use of media and learning resources is an influential component of the learning process. Learning media in this context is a technology and/or a set of tools that carry material content messages that can be used for learning needs.

Design

Kit Design. PLC teaching aids are designed in two stages, namely hardware design and electrical design. PLC teaching aid is designed using the 2010 version of Auto cad software. The software used to draw or design 2D and 3D objects. Auto cad is a CAD (Computer Aided Drafting) based software that is widely used because it has many advantages over other products with the same functionality. Usually this is used by civil engineers, electricians, machinery and some other similar jobs. The researchers chose this software to design PLC teaching aid because it is of high quality and can be made resembling original shapes. Researchers can also adjust the size of the design results. The software is able to produce design drawings with high precision, easy and with very efficient time. Figure 3 shows the design of the hardware of the PLC teaching aids.

Electrical Design

To design electrical circuit wiring, researchers adapted to existing components and materials. The design of the electrical circuit wiring of PLC teaching aids is also designed using Auto cad software. Figure 4 is a block diagram of PLC teaching aid system.

(a) (b) (c)

Figure 3 - (a) 3D design of PLC teaching aids, (b) sketch views on PLC teaching aids, (c) sketch of the front view of the PLC teaching aids

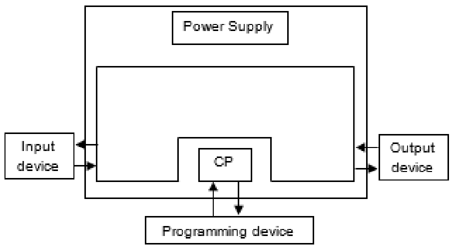

Figure 4 - PLC teaching aid block diagram

According to Figure 4 above, the PLC teaching aid block diagram consists of an input component consisting of a push button. The PLC programming device in the study used the PLC Omron CPM1A which has 20 terminals that can be used as an addressing of input and output components represented with numeric codes 00 to 11 which facilitate programmers when designing and building electrical machine programming designs. Power supply works to drain the electric current for components that require direct current (DC). The electric current that goes into the power supply of the shuttle current 220VAC is transformed into a direct current of 24VDC. While the output device consists of indicator lights, electric motors etc. The PLC teaching aids are also multiplied by the Inverter Schneider electric motor speed regulator device atV12H075M2, potentiometer and human interface device HMI Omron NS5 Series.

Development

Physical Development. The development of PLC learning aids consists of two activities, namely physical development and software development. The development of PLC teaching aids is structured from electrical components that are interconnected with each other. Wooden boxes are used as a place to place the components of teaching aids. Wood material is chosen because wood is a material that cannot transmit electric current until it is felt safer for use.

As for the planning and construction work, PLC teaching aid does not escape the use of tools and materials that facilitate researchers in completing a job. The tools and materials used consist of: 1) Jigsaw machine used for cutting acrylic material; 2) saw machine for cutting wood material; 3) drill machine sits to perforate acrylic material; 4) wood crab machine to smooth the surface of wood; 5) meters to measure the needs of wood and acrylic materials; 6) hammer used to punch objects, so that the object is firmly glued, where normally the beaten object is nails; 7) nails 1,5" for the hardening of the sides of the wood material to be stronger; 8) screwdriver useful for twisting the screws; 9) screws used to glue parts of again of wood material and components; 10) HPL adhesives to coat the surface of wood; and 11) glue wood to glue the sides of wood material and HPL adhesives on wooden surfaces. Table 1 details the requirements of the components used in the construction work of the PLC teaching aids.

Table 1 - Components of the teaching aids

No	Materials	Specifications	Total
1	Kit box	Wood 45x35x20	1 Unit
2	Acrylic	Marga Cipta, 3 mm white	1/2 Meter
3	MCB 1 phase	Visalux VS-106, 6A, 230/400 V~ 50Hz	1 Unit
4	HMI	*Omron* NS5 Series	1 Unit
5	PLC	*Omron* CPM1A, 20CDR-A-V1	1 Unit
6	Inverter Altivar Schneider	Schneider, ATV12H075M2, SYS Drive 3GJV, 0.75kW, 1HP, 200, 240V	1 Unit
7	Power Supply	DP177.101, 24V/10A DC	1 Pcs
8	Banana plug (+)	Standard	10 Pairs
9	Jack Banana Plug (-)	Red/Black/Yellow	41 Pcs
10	Push button	NO/NC	2 Pcs
11	Indicator Lamp	Red, Green, Yellow	8 Pcs
12	Potentiometer	100kΏ	1 Pcs
13	Bush bar	12 Terminal	2 Pcs
14	Port PLC Cable	*Omron* RS232	1 Set
15	PLC-HMI communication cable	*Omron* RS232	1 Set
16	Connecting cable	ITS 1.5 mm red/blue/black color	5 Meters

The stage of development of the PLC teaching aid is to make box measurements in accordance with the sketch design of the previously made product. Next, the wood material is cut in size using a machine and glues parts of wood material that have been cut using glue and nails. Figure 5 is the activity of building wooden boxes of PLC teaching aid.

Figure 5 - PLC teaching aid box development

Subsequently, after the teaching aid box was completed, researchers installed an HPL sticker to provide an attractive look at the teaching aid box and installed corner plates to provide security to users and the PLC teaching aid boxes. Figure 6 is the look of boxes before and after installing HPL stickers.

(a) (b)

Figure 6 - (a) The look of the box that has not been sticker; (b) the look of the box that has been given stickers

Further stages are by perforating the surface of acrylic materials as the placeholders of key components such as PLC, HMI and *Inverter* components, as well as *input* components such as press buttons and *output* components such as indicator lights and electrical circuit wiring points. Figure 7 shows the perforated activity of perforated acrylic materials using drill machines.

Figure 8 shows the activity of installing electrical circuit wiring. The installation of electrical circuit wire is done by connecting the cables to the component terminals as well as connecting the output from each of the components to the banana ignition plate by way of being pecked. The relationship of electrical circuit wiring between components and ignition is a reference to previously planned electrical designs.

Figure 7 - Acrylic drilling activities

Figure 8 - Soldering of electrical circuits to PLC teaching aid components

Figure 9 of the PLC teaching aids that have been developed. Once the PLC teaching aids have been developed, the next stage is to design the programming system in CX-Programmer software and face-to-face design of the electrical machine control system in the *CX-Designer* software so that it can be applied to the kit.

Figure 9 - PLC teaching aid display

Software Development. The *CX-Programmer* software is a software used to create PLC programming systems from the *Omron* brand. The software is also used for testing of the PLC programming work system before being transferred to the PLC device. The *CX-Designer* software can be used as a simulation that is featured face-to-face on HMI devices and can be combined with the *CX-Programmer* software. To be able to use both of these softwares, the user first installs into the computer system. Besides, users also need to configure the computer system with PLC and HMI devices. Figure 10 is Omron's *CX-One* software.

Figure 10 - Computer software for PLC and HMI programming

Evaluation

The development of PLC teaching aid was carried out by conducting several assessments on the delegate group. There are three stages to go through and verification on PLC teaching aid is the following:

- First stage: Pilot Study
- Second stage: Expert Evaluation
- Third stage: Use of teaching aid

Based on commented by the 1st expert, the PLC teaching aid developed has a suitable size until the compilation of neat and neat components in the box. In addition, the PLC teaching aid also has a circuit protector so that the electrical terminal is not exposed until it is safer to use.

Expert 2 gives the view that the PLC teaching aids that have been developed have relatively affordable construction costs due to the use of medium and readily available materials in the environment. The teaching aids are also sturdy and protect students against electrical shocks.

According to experts 3, PLC teaching aids are developed in a portable form thus facilitating mobility in practical learning. In addition, the PLC teaching aid has also been equipped with a manual of use and is equipped with circuit protectors and plug-in components. According to Intan [12], the effect of using teaching aids with plug and unplug systems is higher compared to using conventional wiring systems. In line with a study conducted by Zahri & Osman [30], they argue that teaching aids that use plug-in components make it easier for students to process circuits for understanding purposes. The use of teaching aids can also increase the level of understanding of students and thus improve the number of scores obtained [32]. In addition, the amount of time in practical activities can also be reduced and thus provides an opportunity for students to try practically repeatedly. This teaching aid can also make it easier for teachers to stage demonstrations and in turn spark students' interest in practical practice in the laboratory.

Conclusion

This study was conducted to develop PLC teaching aids in electrical machine assembly courses. Based on the findings, the respondents strongly agreed that PLC teaching aids are suitable and safe for students to use in the learning process. For its very simple operation, users only need to connect the electrical circuit from teaching aids to the input and output components of the block terminals that are already available. In addition, PLC teaching aids can save time in delivering learning content and make it easier for teachers to control students in the classroom. Interesting and creative teaching aids can usually attract and focus students on the learning process. The development of PLC teaching aids is one of the efforts to improve students' knowledge and understanding in learning PLC topics. Through these teaching aids, teachers can reveal the concept of automation and PLC programming either theoretically or practically become more effective. Overall, PLC teaching aids have a positive impact on learning.

This study provides a clear picture that the use of appropriate teaching aids can help students to obtain better learning outcomes in the competency of electric motor installation course on the topic of PLC programming. This study has also produced teaching aids that are cheap, easy to use, safe and can stimulate students' interest in learning. Through this study, it is hoped that teachers can pay attention to the provision of creative and innovative and affordable teaching aids to produce an effective learning. The proposed advanced study is to test the impact of these teaching aids on student achievement in electrical machine assembly courses.

Conflicts of interest. On behalf of all authors, the corresponding author states that there is no conflict of interest.

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On methods of modifying natural minerals

Abstract: Recently, more and more attention is paid to the ecological safety of the republic due to the increased threat of environmental pollution by radionuclides, particularly by uranium, while the processing of uranium-containing raw materials generates a significant amount of liquid industrial waste. The main waste disposal method is a sorption, which requires the use of inexpensive sorbents. Such sorbents can be obtained on the basis of domestic natural raw materials. The significant disadvantages of natural sorbents are a low sorption capacity, which can be increased by developing effective and relatively cheap methods for their modification. The absence of the methods of modification is a limiting factor for the widespread using of natural sorbents for environmental purposes. Variants of modification of natural aluminosilicate and coal-mineral raw materials of Kazakhstan by physical and chemical methods are considered. The chemical methods include the modification with a mixture of tributylphostat and di-2-ethylhexylphosphoric acid in kerosene to obtain "solid-phase extractants", a mixture of phosphoric acid and polyacrylamide, and the synthesis of organominerals. The possibility of using technogenic raw materials as a modifying reagent has been studied. Zeolite of the previously unexplored Kosmurun deposit and shungite of the Koksu deposit were selected for research, and slags of phosphorus production were selected as a technogenic raw materials. Their physical and chemical properties have been studied.
Keywords: natural sorbents, zeolite, shungite, modification, sorption capacity.

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Introduction

Recently, more and more attention is paid to the ecological safety of the republic, due to the increased threat of environmental pollution by radionuclides, particularly by uranium. While the processing of uranium-containing raw materials, a significant amount of liquid industrial waste is formed, the main method of the processing is sorption, which requires the use of inexpensive sorbents of complex action.

There are in Kazakhstan a significant reserves of mineral raw materials, which are of interest in natural ion-exchange materials. The availability of mineral and coal-mineral raw materials, their low cost, ease of using and existing environmental problems necessitate the production and study of new sorbents with a complex of valuable properties for the extraction of radionuclides.

Against the background of significant and diverse mineral raw materials with sorption properties, shungites and zeolites occupy a special position as the most studied. The significant disadvantages of natural sorbents include low sorption capacity, which can be increased by developing effective and inexpensive methods for their modification.

The ability of zeolites and zeolite-containing rocks to effectively absorb and retain radionuclides has been shown in many works [1-6].

Various options for obtaining sorbents with improved sorption and kinetic properties are used. For the formation of new adsorption centers, increasing the sorption capacity and selectivity of the sorbent, use inorganic materials modified with amidoxime or iminodiacetate groups, as well as salts of heteropoly acids [7, 8]. Sorbents with amidoxime groups on various carriers have shown high efficiency in the extraction of radionuclides, as well as good kinetic properties [9-12].

Main Research Part

To isolate radionuclides from complex technological solutions, sorbents with diphyryl, aminophosphinate, carbamoylmethyl-phosphinate and other phosphorus-containing functional groups have been developed, which are capable of producing stable complexes with radionuclides [13-16].

The synthesis of organopolymers takes a special place in the preparation of modified sorbents. This is how an organozeolite was synthesized based on natural zeolite-containing tuffs and a water-soluble polymer of polyhexamethylguandine, as well as epichlorohydrin as a cross-linking agent, which simultaneously exhibits cation-exchange, anion-exchange and bactericidal properties [17]. The sorbent is highly selective to oxygen-containing anions and uranium carbonate complexes.

All described methods were developed using foreign raw materials. Organopolymers for the sorption of copper (II), lead, and molybdenum ions have been synthesized on the basis of Kazakhstan [18].

At the same time, there are no real methods for obtaining modified sorbents that would have proven themselves well in the processes of uranium sorption. In this regard, the problem of obtaining modified sorbents based on natural raw materials remains relevant for the nuclear industry.

We used a previously unexplored zeolite from the Kosmurun deposit and shungite from the Koksu deposit as an initial raw material.

For research, we used chemical, X-ray phase, thermogravimetric, mineralogical methods of analysis, as well as the method of electron microscopy.

According to physicochemical studies, zeolite has the following elemental and phase composition (Tables 1 and 2).

Table 1 – Elemental composition of the original zeolite

SiO_2	Al_2O_3	Fe_2O_3	Na_2O	CaO	K_2O	MgO	P_2O_5	MnO	TiO_2	Other impurities	SiO_2 / Al_2O_3
62,2	13,4	5,9	1,6	5,3	6,5	2,2	0,4	0,2	0,5	1,8	4,6

Table 2 – Phase composition of the original zeolite

Name	**Formula**	**Zeolite**
Clinoptilolite	$(Na, K, Ca)_6(Si,Al)_{36}O_{72}.20H_2O$	21.5
Quartz	SiO_2	21.3
Albite	$Na(AlSi_3O_8)$	19.4
Diopside	$Ca(Mg,Al)(Si,Al)_2O_6$	13.9
Hematite	Fe_2O_3	9.3
Lomontitis	$Ca(H_2O)2.8(Al_2Si_4O_{12})(H_2O).5$	7.8
Erinith	$((Fe^{+2},Fe^{+3},Al)3Mg3(Ca,Na)4(Si13.5Al4.5O42)\ (OH)_6)\cdot 11.3H_2O$	6.8

Figure 1 shows the results of a thermogravimetric study of a sample of the original zeolite.

DTA analysis shows that an endothermic effect with extrema at 236 ° C, 364 ° C and an exothermic effect with a peak at 749.5 ° C were recorded, which can be interpreted as a manifestation of harmotom zeolite - $Ba[Al_2Si_6O_{16}]$. The first two effects reflect the stepwise dehydration, the exothermic effect - the destruction of the lattice, amorphization of the decay products. The combination of the endothermic effect with maximum development at 236 ° C (dDTA curve) and the exothermic effect with a peak at 822.8 ° C (dDTA curve) may reflect the presence of chabazite zeolite - $(Ca,Na_2)(Al_2Si_4O_{12})6H_2O$.. In the area of the development of the endothermic effect, the process of dehydration takes place, and in the area of the exothermic effect, the process of destruction of the crystal structure with the formation of an X-ray amorphous phase. The combination of an exothermic effect with a peak at 464.6 ° C (DTA curve) and an endothermic effect with a maximum development at 236 ° C (dDTA curve) may be a manifestation of calcium-type clinoptilolite - $Ca[Al_2Si_7O_{18}]6H_2O$.

The endothermic effect with a maximum development at 582.8 ° C (DTA curve) could manifest itself as a result of the implementation of various processes in various phases. The dDTA curve shows that this effect breaks down into two effects - with extremes at 553.5 ° C and 573.4 ° C. There are also two minima on the DTG curve - at 555.9 ^{0}C, 571.7 ^{0}C. Therefore, in the area of its development, dehydration of the analcime zeolite - $Na_2[AlSi_2O_6]\cdot 2H_2O$ is possible. Also, dehydration of impurities of some clay minerals is likely here - illite (hydromica) (Ca, Na) $Al_2[(OH)_2AlSi_3O_{10}]$ $(H_2O)_2$, afrosiderite (ferrous chlorite) - $2SiO_2Al_2O_3(FeO)\cdot H_2O$. In superimposition, the endothermic effect with a maximum development at 573.4 ° C may be a manifestation of the polymorphic transformation of quartz (SiO_2). The endothermic effect with the maximum development at 721.7 ° C can be a reflection of the dissociation of calcite, and the endothermic effect with the maximum development at 853.3 ° C (dDTA curve) is a reflection of the transition of the calisilite impurity ($K_2OAl_2O_3\cdot nSiO_2$) from the hexagonal to the rhombic modification. This same effect, in overlay, can reflect the decay of the illite lattice. The endothermic effect with an extremum at 788.1 ° C can be a manifestation of dehydration of an admixture of finely dispersed muscovite - $K_2O_3Al_2O_36SiO_2\cdot 2H_2O$. A weak exothermic effect with a peak at 995.6 ° C may reflect the crystallization of illite lattice decomposition products.

In superimposition, a combination of endothermic and exothermic effects in the temperature range of 100 - 600 ° C can be a manifestation of iron hydroxides - goethite, lepidocrocite, amorphous hydroxide.

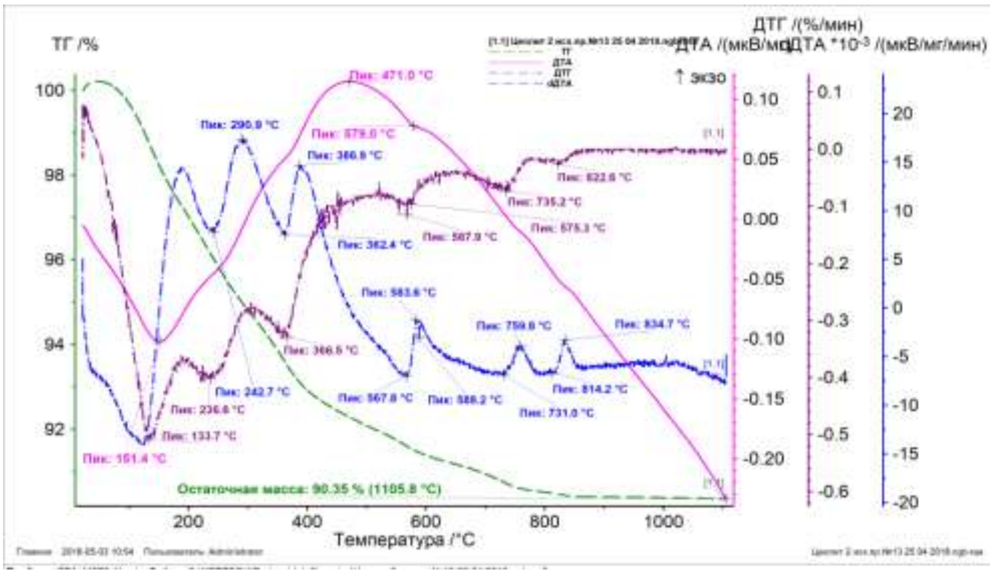

Figure 1 - Zeolite thermogram

Deep mineralogical studies, as well as data obtained with the JXA-8230 electron probe microanalyzer from JEOL, also showed a complex composition and noted the structural features of the initial raw materials. In particular, comprehensive physicochemical studies have confirmed that the mineral belongs to the calcium-type zeolite, which is not typical for the studied zeolite raw materials of Kazakhstan; it is distinguished by structural features inherent in calcium-type clinoptilolite.

Shungite is a unique natural formation, lying in the form of shungite rocks and representing a compacted mechanical mixture, the main components of which are finely dispersed phases of noncrystalline carbon and silicon dioxide, which form a single composite system. The elemental composition of shungite is presented in Table 3. According to X-ray phase analysis, the shungite of the Koksu deposit consists of quartz, siderite, muscovite, albite and clinochlore.

Table 3 - Shungite composition

C	K	Al	Si	Fe	S	Na	Mg	P	Ca	Ti	V	O	Mn
15,0	0,83	3,52	14,9	2,9	0,05	0,12	0,90	0,26	16,43	0,26	0,16	43,2	0,12

Natural shungite, like zeolite, has a low sorption capacity for uranium.

In the process of research, three options for the technology of shungite beneficiation by flotation were proposed and tested. The optimal variant was turned out to provide for froth flotation of shungite rock, preliminarily crushed to a fraction of 71 microns, with the addition of lime to create a pH of the medium equal to 8.0-9.0 and water glass for depression of gangue minerals. Kerosene was used as a collector, and T-80 was used as a blowing agent. The composition of shungite concentrate is shown in Table 4. The flotation scheme is shown in Figure 2.

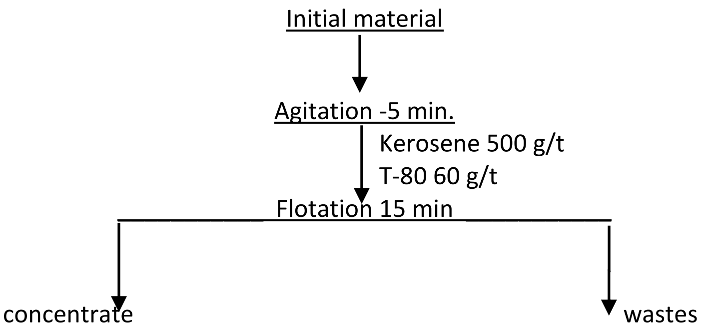

Figure 2 - Shungite flotation scheme

Table 4 - Shungite composition of the Koksu deposit after flotation

Product name	Out put, %	Content, %							recovery, %						
		C	O	Al	Si	S	K	Fe	C	O	Al	Si	S	K	Fe
Test №3															
Concentrate	43,2	**21,0**	40,9	3,29	14,8	0,05	0,77	3,1	**60,5**	40,8	40,3	42,9	47,9	39,9	46,1
Wastes	56,8	10,4	45,0	3,7	14,9	0,04	0,88	2,8	39,5	59,2	59,7	57,1	52,1	60,0	53,9
Ore	100	15,0	43,2	3,52	14,9	0,05	0,83	2,9	100	100	100	100	100	100	100

It follows from the table that in the process of flotation shungite enrichment in carbon is observed, in the resulting concentrate the carbon content increased to 21%. X-ray phase studies have shown that with the enrichment of shungite, the content of quartz decreases, dolomite is almost completely transformed, the content of siderite, microcline, albite and muscovite increases, and new phases appear, such as clinochlore and epidote.

As mentioned above, natural minerals have a low sorption capacity [19, 20, 21], which can be increased by modification.

In the course of our research, we have developed and tested physical and chemical methods for modifying natural minerals.

Ultrasonic activation is one of the modern ways to accelerate the course of various chemical processes. Analysis of literature data shows that ultrasonic treatment of sorbents in a liquid medium contributes to the emergence of cavitation, which is one of the main reasons for the acceleration of physicochemical processes, which leads to the intensification of the sorption extraction of components from a liquid medium. However, in some cases, the effect of ultrasound on the sorbent can be one of the reasons for reducing its mechanical strength, especially of natural sorbents. In this regard, it was proposed to act not on sorbents, but on a liquid medium (chemical reagents) with their subsequent activation of natural materials [22, 23].

Chemical methods of modification included the treatment of natural minerals with organic extractants, phosphoric acid in combination with polyacrylamide by the method of obtaining "solid-phase extractants", as well as the synthesis of organominerals based on natural sorbents and organic compositions. Organic compositions were formed on the basis of dimethylformamide (DMF), glycidyl methaacrylate (GMA), and a solution of oxyethylene diphosphonic (OEDP) acid in the presence of a catalyst of 0.02% benzoyl peroxide (PB). All three options have proved to be good in uranium sorption tests.

The uranium content in waste solutions, as a rule, is 5-15 mg / dm^3. In this regard, we have adjusted the productive solution in accordance with the given uranium concentration and studied the sorption process by modified zeolite and shungite. The kinetic dependences of the sorption of uranium in a static mode from the imitate showed that it is possible to extract uranium by more than 90% with modified sorbents already in the first 45 - 50 minutes.

These modified sorbents can be used for analytical purposes, as well as in low-tonnage production conditions. Their widespread use for the disposal of large volumes of liquid uranium-containing waste is unprofitable. Currently, work in this direction continues. In order to reduce the cost of modified sorbents, studies are being conducted on the possibility of using technogenic raw materials as modifiers, in particular, phosphorus slag, which is a waste of the phosphorus industry and is formed during the electrothermal production of yellow phosphorus. According to the conducted physicochemical studies, the main phase of the phosphorus slag - calcium silicate - is represented by the amorphous phase of volostanite. The slag also contains small amounts of calcite and ankerite, phosphorus is present in the form of lazulite.

Studies in the field of calcium silicate synthesis have shown that rational and environmentally friendly options include methods based on the interaction of initial components in an aqueous medium at elevated temperatures and, in some cases, pressure, i.e. hydrothermal method. The hydrothermal method allows not only the synthesis of hydrosilicates, but also affects their structure and particle morphology. Hydrothermal conditions simulate the formation of minerals in the earth's interior. As the aqueous phase, calcium salts and sodium chloride are usually used.

Conclusion

To sum up, it was found that during the hydrothermal treatment of slag in a carbonate medium, with an increase in temperature, the amorphous phase is transformed into a crystalline phase, and the morphology of particles also changes: the conglomerates existing in the initial sample gradually change their shape and turn into particles of an acicular structure. During the hydrothermal treatment of phosphorus slag with sodium chloride, its amorphous structure is retained.

Several options for modifying natural minerals have been developed. An indicator of one or another modification method is the sorption process.

Studies have shown that the sorption capacity of modified sorbents increases when natural minerals are dressed with phosphoric slag, activated in a chloride medium, and iron in a carbonate medium. This technique can be used to separate them.

Conflicts of interest. On behalf of all authors, the corresponding author states that there is no conflict of interest.

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CONTENTS