neutralized by a solution of ammonia NH₄OH with obtaining complex salt Zn(OH)₂ZnSO₄ at 40 °C during 30 minutes; then the filtration and washing of a sediment by cat-ion-polymerized water in the ratio L:S=7:1 and drying of a sediment at temperature 150 °C during 120 minutes are carried out. At 2nd stage carbonization of dry sediment Zn(OH)₂ZnSO₄ by ammonium carbonate (NH₄)₂CO₃ solution was conducted with obtaining complex salt Zn(OH)₂ZnCO₃ at 40 °C during 30 minutes. At 3rd stage zinc oxide (ZnO) was obtained by thermal decomposition of the dried sediment of complex salt Zn(OH)₂ZnCO₃ at 220 °C during 20 minutes. The developed technology allows to obtain zinc oxide of brand “Pure” from low-grade sulphide concentrate.

Key words: neutralization, carbonation, thermic decomposition, zinc oxide, X-ray analysis, atomic absorption analysis


UDC 669.181.4:669.046.4


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COMPARATIVE ANALYSIS of TECHNOLOGY PARAMETERS of CHARGE PREPARATION for DIRECT IRON RECOVERY from SSOMDE IRON CONCENTRATE with VARIOUS REDUCTANTS

Abstract: The paper describes results of experimental determination of basic technology parameters of charge preparation for direct iron recovery. The charge consists of Sokolovsko-Sarbajsk Ore Mining and Dressing Enterprise (SSOMDE) iron concentrate and carbon reductants: blast-furnace coke, charcoal and carbonizate recsil. SSOMDE concentrate consists mainly of magnetite and contains, %: Fe – 66.51; FeO - 22.63; Fe₂O₃ - 69.90; SiO₂ - 5.05; Al₂O₃ - 1.70; CaO - 3.47; MgO - 0.78; S - 0.32; P - 0.05. Reductant chemical composition is as follows, %: blast-furnace coke: Fe₄O₃ - 0.76; FeO - 0.05; Fe₂O₃ - 1.04; SiO₂ - 0.05; Al₂O₃ - 2.62; CaO - 0.41; MgO - 0.46; S - 0.82; P - 0.01; Csolid - 88.02; charcoal: Fe₄O₃ - 0.58; FeO - absent; Fe₂O₃ - 0.83; SiO₂ - 0.10; Al₂O₃ - 0.05; CaO - 0.73; MgO - 0.29; S - 0.02; P - 0.09; Csolid - 79.85; and carbonizate recsil: Fe - 0.28; FeO - absent; Fe₂O₃ - 0.40; SiO₂ - 1.56; Al₂O₃ - 1.04; CaO - 0.27; MgO - 0.32; S - 0.34; P - 0.02; Csolid - 94.84. Calculation of initial charge composition was made by the method of Yu. Yusfin and N. Pashkov. It was found that the charge for ore-carbon pellets should contain 83.78 % of SSOMDE concentrate and 16.22 % of blast-furnace coke; 82.39 % of SSOMDE concentrate and 17.61 % of charcoal; 84.78 % of SSOMDE concentrate and 15.22 % of carbonizate recsil. Differential-thermal analysis was used to find the temperature of initial interaction of SSOMDE magnetite concentrate with carbon reductants. It was found that active recovery of iron begins at the following temperatures: blast furnace coke 930 °C, charcoal 780 °C, carbonizate recsil 840 °C. Ore-carbon pellets metallization experiments in Tamman resistance furnace (as binder – liquid glass, ρ = 1.20 g/sm³) show that recsil allows getting highest degree of metallization about 83 – 90 %. Metallized with recsil pellets contained 55 – 60 % of metal iron.

Keywords: SSOMDE concentrate, carbon reductants, blast-furnace coke, charcoal, carbonizate recsil, ore-carbon pellets

Introduction. Throughout its history, the industrial coke-free metallurgy is continuously increasing the production of direct recovery iron (DRI) due to growing demand for high-quality scrap iron for steel-making needs. Shortage of scrap metal makes steel producers to use metallized pellets and sponge iron containing 85-95 % Fe; 0.5-2.0 % carbon and minimal levels of non-ferrous metals, phosphorus and sulfur. Midrex Technologies company forecasts DRI production to reach 120 million tons annually by 2020, which is 70 % higher than in 2010 [1].

Major conventional technologies of metallized products are Midrex, HYL-III and Finnet. These methods use gas from reformers as a reductant. Metallization is carried out in shaft furnaces. Metallization degree averages to 90-94 %, carbon level in the product is 0,5-3,0 %. ITMK3 process uses coal, coke and coal wastes as reductants and the final product is pig iron regulus containing 2,5-3,5 % carbon. Recovery of ore-coal pellets is carried out in rotating bed furnaces. Metallization of ore and ore-coal pellets can be made in conveyor, annular and revolving furnaces [1, 2].

Conventional methods of deep metallization have a number of substantial disadvantages: high carbon level in the product (up to 4 %), complex and bulky equipment, high energy consumption, low reliability of certain units and parts, necessity of reductant gas reforming. Combined with shortage of scrap metal and depletion of iron ore reserves this situation calls for new technologies of high-iron metallized product, suitable for substitution of scrap iron for steelmaking industry [2].
Magnetite concentrate of SSOMDE, produced from Sokolovsky-Sarbaiskiy iron ore deposit, contains over 66 % Fe and is used in conventional steelmaking. However, this concentrate can be used for metallized product making.

Charcoal and blast-furnace coke are widely used in metallurgy as reductants [3].

Low impurities and well-developed porous structure provide high chemical activity of charcoal, which ensures intensive flow of recovery reactions. Disadvantages of charcoal are anisotropy of structure, low level of fixed carbon, low strength and high cost.

Compared to charcoal, blast-furnace coke has higher ash level, lower porosity and reactivity.

A substitute for charcoal is created in Kazakhstan carbonizate recsil is produced by high-speed thermal-oxidizing carbonization of Shubarkol gas coal. Advantages of carbonizate recsil are higher structural strength, high fixed carbon level, structure isotropy, developed porous structure and low cost. In terms of harmful admixtures content carbonizate recsil is comparable to charcoal. Such benefits show carbonizate recsil potential as a substitute for charcoal and blast-furnace coke [3, 4].

Fine concentrates after ore-dressing cannot be used directly in roasting and smelting due to low gas permeability of charge. Required grain size is usually 5-10 mm which is achieved by sintering or pelletizing. Each method begins with charge preparation — averaging, sieving, batching, mixing and the agglomeration itself.

The charge is a mixture of materials taken in mass or volume ratio, required to produce certain product (iron, steel, metallized product, etc.). Ratio of charge components is calculated through equations of material balance of elements or compounds contained in the initial materials. Number of equations is equal to the number of materials composing the charge. There are various charge calculation methods [2, 5, 6].

Method of F.Bazanov and I. Malkin [5] is usually used for sintering of hematite and magnetite ore. Ore and limestone ratio is calculated according to materials chemistry resulting in equation of sintering material balance. Coke fines ratio is selected using experimental data or actual fuel consumption for certain sintering plant. Next stage is the equation of charge basicity. The charge composed by the calculation results is subject to mixing, moisturizing, re-mixing, pelletizing and sintering.

Most complete method of sintering charge calculation is an integrated method of Ramm that, along with charge composition, includes basic and additional equations of material balance as well as equations of heat balance of blast-furnace smelting [6].

Charge calculation for metallized pellets covers calculation of ore-reductant ratio and consists of two equations of material balance of reductant and iron with two unknown. Charge components are dry-mixed with further pelletizing using liquid binder. Pellets roasting can be made in various furnaces — shaft furnaces, fluidized bed reactors, conveyor furnaces, annular furnaces, etc. [2].

Technology of direct iron recovery with new reductant — carbonizate recsil is being developed in Abishev Chemical-Metallurgical Institute. Processes of heat generation for recovery and iron oxides reduction are combined in one reactor and take place simultaneously.

The objective of the present work is research on determination of basic technological parameters of charge preparation that consists of SSOMDE iron concentrate and different reductants: blast-furnace coke, charcoal and carbonizate recsil and evaluation of recovery potential of recsil reductant.

**Experimental Part and Results Discussion.** Research subjects are SSOMDE concentrate, blast-furnace coke, charcoal and carbonizate recsil.

**Analysis methods and equipment.** SSOMDE concentrate composition was determined by chemical analysis; reductants composition — by proximate analysis; differential-thermal analysis was made in Q-1500 derivatograph in air at 18-1000 °C and heating rate of 10 °C per minute.

**Content, %**

<table>
<thead>
<tr>
<th>Material</th>
<th>FeO</th>
<th>Fe₂O₃</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>S</th>
<th>P</th>
<th>Csolid</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSOMDE concentrate</td>
<td>66.61</td>
<td>22.63</td>
<td>69.90</td>
<td>5.05</td>
<td>1.70</td>
<td>3.47</td>
<td>0.78</td>
<td>0.32</td>
<td>0.05</td>
</tr>
<tr>
<td>carbonizate recsil</td>
<td>0.28</td>
<td>-</td>
<td>0.40</td>
<td>1.56</td>
<td>1.04</td>
<td>0.27</td>
<td>0.32</td>
<td>0.34</td>
<td>0.02</td>
</tr>
<tr>
<td>blast-furnace coke</td>
<td>0.76</td>
<td>0.05</td>
<td>1.04</td>
<td>6.05</td>
<td>2.62</td>
<td>0.41</td>
<td>0.46</td>
<td>0.82</td>
<td>0.01</td>
</tr>
<tr>
<td>charcoal</td>
<td>0.58</td>
<td>-</td>
<td>0.83</td>
<td>0.10</td>
<td>0.05</td>
<td>0.73</td>
<td>0.29</td>
<td>0.02</td>
<td>0.09</td>
</tr>
</tbody>
</table>

It is known that moisture level of disperse material is a critical factor for its clumping speed and properties of raw pellets. Increase of moisture level to its optimum allows higher speed of nucleus formation and their growth to final pellets. Optimal moisture is specific for each kind of material and is determined experimentally in laboratory. Table 1 shows charge components chemistry.
According to X-ray phase analysis SSOMDE concentrate is represented by magnetite. Theoretical composition of magnetite is 31% of FeO and 69% of Fe₂O₃. Excessive Fe₂O₃ level (19.53%) indicates the presence of maggemite γ-Fe₂O₃. Unlike other iron oxides maggemite and magnetite have very close interplanar spacing which greatly complicates their identification in the X-ray diagrams. Concentrate humidity is 0.88%. Proximate analysis of reductants is shown in the table 2.

### Table 2 – Proximate analysis of reductants

<table>
<thead>
<tr>
<th>Material</th>
<th>Content, %</th>
<th>A²</th>
<th>W¹</th>
<th>Vᵐet</th>
</tr>
</thead>
<tbody>
<tr>
<td>blast-furnace coke</td>
<td>11.74</td>
<td>0.41</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>charcoal</td>
<td>2.15</td>
<td>8.10</td>
<td>18.00</td>
<td></td>
</tr>
<tr>
<td>carbonizate recsil</td>
<td>3.85</td>
<td>1.91</td>
<td>1.31</td>
<td></td>
</tr>
</tbody>
</table>

Charge composition was calculated using the method of Yu. Yusfin and N. Pashkov [2].

For CO/CO₂ ratio equal to 4 the process of iron oxides recovery with carbon can be written as follows:

\[
\begin{align*}
\text{Fe}_2\text{O}_3 + 5\text{C} & = 12\text{FeO} + 4\text{CO} + \text{CO}_2; \\
12\text{FeO} + 10\text{C} & = 12\text{Fe} + 8\text{CO} + 2\text{CO}_2; \\
6\text{Fe}_2\text{O}_3 + 15\text{C} & = 12\text{Fe} + 12\text{CO} + 3\text{CO}_2.
\end{align*}
\]

Balance of fixed carbon in the charge:

\[
\begin{align*}
Y*\text{C}_{\text{fixed}} & = X\{b_1[\text{Fe}_2\text{O}_3]_X + \eta_{\text{met}}b_2[0.9(\text{Fe}_2\text{O}_3)_X + (\text{FeO})_X]\} + \\
& + Y\{b_1[\text{Fe}_2\text{O}_3]_Y + \eta_{\text{met}}b_2[0.9(\text{Fe}_2\text{O}_3)_Y + (\text{FeO})_Y]\} + \\
& + Z\{b_1[\text{Fe}_2\text{O}_3]_Z + \eta_{\text{met}}b_2[0.9(\text{Fe}_2\text{O}_3)_Z + (\text{FeO})_Z]\} + \\
& + D\{b_1[\text{Fe}_2\text{O}_3]_D + \eta_{\text{met}}b_2[0.9(\text{Fe}_2\text{O}_3)_D + (\text{FeO})_D]\}\}
\end{align*}
\]

where 0,9 – mass ratio of FeO and Fe₂O₃; X – iron ore consumption, kg/100 kg of metallized product; Y – reductant consumption, kg/100 kg of metallized product; Z – flux consumption, kg/100 kg of metallized product; D – additives consumption, kg/100 kg of metallized product; Fe₂O₃, FeO, etc. – content of respective compounds and elements in the charge, unit part; C_{RES} – residual level of carbon in metallized product, kg/100 kg of metallized product; C_{fixed} – fixed carbon level in reductant, unit part; b₁ = 0.0625; b₂ = 0.139.

Balance of iron in the charge:

\[
\begin{align*}
X\{1 - [a_1(\text{Fe}_2\text{O}_3)_X]_X + \eta_{\text{met}}a_2[0.9(\text{Fe}_2\text{O}_3)_X + (\text{FeO})_X]\} + kS_X + \\
& + (\text{loss on ignition})_X + (M_{\text{Zn},\text{Mn}})_X\}} + Y\{1 - [a_1(\text{Fe}_2\text{O}_3)_Y]_Y + \\
& + \eta_{\text{met}}a_2[0.9(\text{Fe}_2\text{O}_3)_Y + (\text{FeO})_Y]\} + kS_Y + V_Y + (M_{\text{Zn},\text{Mn}})_Y\}} + \\
& + Z\{1 - [a_1(\text{Fe}_2\text{O}_3)_Z]_Z + \eta_{\text{met}}a_2[0.9(\text{Fe}_2\text{O}_3)_Z + (\text{FeO})_Z] + \\
& + kS_Z + (\text{loss on ignition})_Z + (M_{\text{Zn},\text{Mn}})_Z\}} + \\
& + D\{1 - [a_1(\text{Fe}_2\text{O}_3)_D]_D + \eta_{\text{met}}a_2[0.9(\text{Fe}_2\text{O}_3)_D + (\text{FeO})_D] + \\
& + kS_D + (\text{loss on ignition})_D + (M_{\text{Zn},\text{Mn}})_D\}\} = 100,
\end{align*}
\]

where k – desulphurization degree during metallization (usually averaging 30-50%); M_{Zn,Mn}— amount of Zn, Mn, etc. compounds removed during metallization; a₁ = 0.1625; a₂ = 0.361 [5].

Initial conditions are: metallization degree \( \eta_{\text{met}} = 1 \), desulphurization degree \( k = 0.3 \), residual level of carbon 1.0%.

Equations of fixed carbon balance and iron balance for pellets containing SSOMDE concentrate and recsil result in the following equation system:

\[
\begin{align*}
-0.1626X + 0.9469Y = 1; \\
0.5742X + 0.9248Y = 100.
\end{align*}
\]

Solution of this system shows that the charge for pellets should contain 84.78% of SSOMDE concentrate and 15.22% of carbonizate recsil.

Similar calculations were made for charge mixtures with blast-furnace coke and charcoal.

Charge compositions for above reductants are shown in the table 3.

### Table 3 – Charge composition for ore-carbon pellets

<table>
<thead>
<tr>
<th>Material</th>
<th>SSOMDE concentrate and carbonizate recsil</th>
<th>SSOMDE concentrate and blast-furnace coke</th>
<th>SSOMDE concentrate and charcoal</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSOMDE concentrate</td>
<td>84.78</td>
<td>83.78</td>
<td>82.39</td>
</tr>
<tr>
<td>carbonizate recsil</td>
<td>15.22</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>blast-furnace coke</td>
<td>-</td>
<td>16.22</td>
<td>-</td>
</tr>
<tr>
<td>charcoal</td>
<td>-</td>
<td>-</td>
<td>17.61</td>
</tr>
</tbody>
</table>

According to [7, 8], metallization degree depends more on concentrate grain size than on reductant size.
Use of 0.06 mm concentrate instead of 0.1 mm allowed to increase metallization degree from 59.1% to 76.6%. Influence of reductant fraction was insignificant for the concentrate grain size below 0.06 mm. Use of coke size of 0.075 mm instead of 0.15 mm allowed to increase metallization degree from 76.6% to 78.8%. Thus, use of finely ground materials improves recovery process. It was finally found that the charge should contain at least 85% of concentrate and reductant both ground to 0-0.074 mm.

When using reductants containing high level of volatile matter (charcoal, brown coal semi-coke, coke, etc.) it is necessary to consider volatiles contribution to the recovery process. If such volatiles are emitted at low temperatures (below 300-400 °C) their role as reductants is insignificant.

The temperature of initial interaction of magnetite concentrate with reductants was determined by differential-thermal analysis. In the figure there are represented derivatograms of pure concentrate as well as its mixtures with three mentioned reductants.

The curve of pure SSOMDE concentrate (a) shows diffused endothermic effect with maximum at 140 °C, caused by removal of adsorption moisture, corresponding to mass decrease on TG curve. Exothermic effect at 370 °C is oxidation of FeO on the magnetite surface with formation of thin film of hematite α-Fe₂O₃. Mass increase begins from this point and continues throughout the heating in the range of 580-1000 °C which is explained by oxidation of remaining magnetite to maghemite γ-Fe₂O₃. Exothermic effect at 505 °C is a transition of cubic γ-Fe₂O₃ into trigonal modification [9].

Derivatograms of charge mixtures containing concentrate and one of reductants (b, c, d) have evident endothermic effects due to adsorption moisture removal: 100-240 °C for carbonizate recsil and 130 °C for charcoal and dehydration at 230-410 °C for blast-furnace coke.

At 500 °C we can see emission of volatiles from carbonate recsil, at 612 and 525 °C – the same for blast-furnace coke and charcoal, respectively. Parallel to that, at 500–840 °C (b), 612-930 °C (c), 560-780 °C (d) we can see partial gasification of carbon with recovery of iron oxides. At 840 °C (b), 930 °C (c) and 780 °C (d) and higher there is abrupt endothermic effect caused by intensification of recovery processes, which requires greater amount of heat [8].

Evaluation of reductants quality made previously allowed to determine their reactivity at 1273 K, ml/(g·s): 0.27 for blast-furnace coke; 2.0-3.0 for carbonizate recsil and 8.1 for charcoal [10]. Derivatograms of concentrate mixtures with reductants show that higher reactivity of reductant causes lower temperature of recovery beginning. Active recovery of iron oxides in oxidative atmosphere begins at 930 °C for blast-furnace coke; 840 °C for carbonizate recsil and 780 °C for charcoal, which corresponds to the data shown in [11].

Research was made on pelleting the charge mixtures with waterglass (ρ = 1.2 g/cm³). Pellets size was -15+10 mm, moisture level 9-12%. After air drying moisture level decreased to 0.89 - 1.70%. Compression strength was 11.6-14.0 kg per pellet, impact strength for 1.5 m height was 7-8 drops.

Preliminary metallization experiments were made in Tamman resistance furnace at 1200 and 1300 °C, heating duration 3-5 min [12]. Phase composition of metallized product was determined by X-ray phase analysis. Pellets with charcoal had low strength after roasting at 1200 °C, with most pellets broken. At 1300 °C peripheral area of whole pellets was formed by sponge iron while the core remains unrecovered due to low temperature or short time of recovery. Regardless of temperature and heating duration, pellets contained Fe₄net, Fe₃O₄ and Fe₂O₃. Metallization degree was below 50%. Further increase of duration or temperature is unpractical due to high energy consumption. Besides, serious disadvantage of charcoal is its high cost.

Roasting of pellets with blast-furnace coke at 1200 and 1300 °C resulted in homogenous regulus of sponge iron of initial shape, without cracks and destruction, with oxide film covering metallized product inside. Regardless of heating duration pellets roasted at 1200 °C contained Fe₄net, Fe₃O₄ and FeO. Pellets roasted at 1300 °C contained Fe₄net, Fe₂O₄, FeO and minor amount of FeC. Compression strength was over 20 kg per pellet, impact strength over 20 drops from 1.5 m, metallization degree over 80%. Pellets are suitable for further smelting. However, shortage of coking coal and high ash level significantly reduce practical value of blast-furnace coke for this process.

Roasting of pellets with recsil at 1200 and 1300 °C also resulted in homogenous regulus of sponge iron of initial shape, without cracks and destruction. Regardless of heating duration pellets roasted at 1200 °C contained Fe₄net and that roasted at 1300 °C contained Fe₄net and minor amount of FeC. Pellets have thin oxide film covering metallized product inside. Metallization degree was 83-90%. Compression strength was over 20 kg per pellet, impact strength over 20 drops from 1.5 m.
Conclusions. Evaluation of technological parameters of charge preparation containing SSOMDE iron concentrate and different reductants: blast-furnace coke, charcoal and carbonizate recsil was made in the work.

Moisture levels and grain size of initial materials were studied. DTA analysis showed that active recovery of iron oxides begins at 930 °C for blast-furnace coke; 840 °C for carbonizate recsil and 780 °C for charcoal. According to calculations the charge for ore-carbon pellets should contain 83.78 % of SSOMDE concentrate and 16.22 % of blast-furnace coke; 82.39 % of SSOMDE concentrate and 17.61 % of charcoal; 84.78 % of SSOMDE concentrate and 15.22 % of carbonizate recsil. Preliminary experimental research show that carbonizate recsil would have the highest efficiency as a reductant for this process. After roasting at 1200 °C metallization degree was 83-90 %, compression strength was over 20 kg per pellet, impact strength over 20 drops from 1.5 m.

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Maakalada tikeiyl icallyna keltpiring temiridi alu urdiisi yushi kuryamnda kemiri bar icallyga keltpiring: jana rekosi karbonizaty, agash kemiri men domendii koks xone CSGPO koncentratyn tanurty shykaipalyr dainduuda negii teggocio technologiya parametriyren anystau boiniya tarkibebel zertte napiegeri Yusniliyagan. CSGPO koncentratyny m persistenceyay yusniliy gan jeke yusniliy: Fe – 66,51; FeO – 22,63; Fe3O4 – 69,90; SiO2 – 5,05; A12O3 – 1,70; CaO – 3,47; MgO – 0,78; S – 0,32; P – 0,05. 0,05 turdy. Domendii koks: Fe – 0,76; FeO – 0,05; Fe3O4 – 1,04; SiO2 – 6,05; A12O3 – 2,62; CaO – 0,41; MgO – 0,46; S – 0,82; P – 0,01; C – 68,02. Agash kemiri: Fe – 0,58; FeO – anhydtagaman; Fe3O4 – 0,83; SiO2 – 0,10; A12O3 – 0,05; CaO – 0,73; MgO – 0,29; S – 0,02; P – 0,09; C – 79,86. Rekosi karbonizatyny yusniliy: Fe – 0,28; FeO – anhydtagaman; Fe3O4 – 0,40; SiO2 – 1,56; A12O3 – 1,04; CaO – 0,27; MgO – 0,32; S – 0,34; P – 0,02; C – 94,84. Shykaipaly materyaldardan yusniliyyn Yus. C. Yusfiniyny yusniliy N.F. Pashkov yusniliy iclemam aste tyskiy ayiniy boiniya etkiyi. Kem-kemiri tiiashkirtynyn shykaipalyay hitapduu uchun shyka 83,78 % CSGPO koncentratyny men 16,22 % domendii koks, 82,39 % CSGPO koncentratyn men 17,61 % agash kemiri, 84,78 % CSGPO koncentratyn men 15,22 % rekosiyay turdy keretigine kerestek. DTA aidi arxiliy icallyka keltpirigternen m persistenceyay CSGPO koncentratyny arxaitasy basaayyn tyurudaay unystau. Temir oksidernin tayty kemirtemikten belsendi icallyka keltpirig: agash kemiri – 780 °C, rekosio – 840 °C, domendii koks yusniliy uchun – 930 °C temperaturada basaayyn ayiklanad. Tamamnia pesheede kem-kemiri tiiashkirtynyn dasi (bailancystyrish retinde siiyyn shynyn mettalantyrduru kuriizide icallyka keltpiring retinde rekosi karbonizatsiyyn pайдалану ангуштты тимдирек екени anystau anystau, alynkag mettalantyrdyrshyn tiiashkirt 55 – 60 % Fe, –ден turdy, ал metalantyrdyrshyn dehne 83 – 90 % kurydagi.

**ТУЙІНДЕМЕ**

Мақалада тікелей қалпына келтірілген темірді алу үрдісінің ресурстарының жаңа шығармаларын, жаңа қалыңдық қалыңдықтарға қолданылыс нормасының және кокс қалыңдықының қалыңдығының әсерін талқылатын көптеген қызметкерлерге қатысты көмек беруді талқылатын мәрказ. Қазақстандық қасиетпен қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндігін талқылатын қызметкерлерге қатысты аспаптардың қызметін жасаудың мүмкіндік
Introduction. The annual volume of world production of zinc exceeds 10 million tonnes. Half of this volume is used to protect steel against rust. Environmentally attractive fact in favor of use of zinc is that 80 % of it is used again, and it does not lose its physical and chemical properties. Protecting steel against corrosion, zinc helps to preserve natural resources, such as iron ore and energy. Extending the service life of steel, zinc increases the life cycle of goods and capital investments, i.e. buildings, bridges, power and water distribution, telecommunications, thus protecting investment and helping to reduce repair and maintenance costs [1].

It is known [2], that 85 % of the total world production of zinc is obtained from concentrates, and the rest of sub-standard and secondary raw materials and wastes of chemical and metallurgical industries.

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