INTRODUCTION

In order to achieve better results in quality and quantity of the products of ferro-nickel, the article has an experimental and scientific analysis of parameters which deal with the rotational roasting furnace. Also, the paper deals with the melting process of the electrical furnace. The implications are based on the several months of experimental work on the possibility of merging the ore from Kosovo with the lateritic ore from Albania. In order to have a better look of the roasting process and to direct the process toward acquisition of qualitative load with positive technical and economical effects of the process we should comprehend the behavior of each component during the process. Calcium carbonate (CaCO₃) is one of the important components for roasting which has an important role during the process development, it absorbs the heat which is released from the oxidation of the charge and by heating itself it lowers the temperature of the charge and keeps it in porous-friable condition. Quartz (SiO₂) has the role of thermal regulator in the process of oxidation of the charge, it impacts the composition and viscosity of slag. Paper has the analytic, graphical, and experimental analysis of the production of charge aiming the increase in the quality and production in the electrical furnace. Paper has the positive findings in the increase of the quality and production with economical and environmental stability in the smelter of Drenas.

Literature Review

The smelter of iron-nickel in Drenas is projected for processing 1 374 000 t of ore in a year and the production of 52 000 t of metals iron-nickel with 23-25 % Ni+CO composition. The main projector of technology is Gipronickel institute of former Soviet Union. The producers of the technological equipment are: Smidth Denmark company for rotational furnaces and Elken Norway company for electrical furnaces. The granulometric composition of the ore of Kosovo which is processed is 70 % with 5 mm diameter and 20 % humidity composition. The chemical composition is 1,32 % Ni, 0.07 % Co, 24 % Fe₂O₃, 46 % SiO₂, 8 % MgO, 2,2 % Al₂O₃, 1,2 % Cr₂O₃, 0,2 % CaO.

The maximum temperature of roasting in rotational furnace is 900-950 °C. The minimum time of material staying in furnace is 60min. The optimal parameters of particles in the charge are 20-28 mm.

The maximum content of oxygen in gasses of furnace is 5 % then the process builds up according to reactions:
1 450-1 500 °C which depends on the composition of 80 % Fe. The temperature of the melting process is about this chemical composition: 14 % Ni, 0.7 % CO, electrical furnaces in Drenas produce iron-nickel with als and the lowering of the quality of iron-nickel. The chrome and the overfeed of iron-nickel with these met-

pools in the furnace causes the uncontrolled growth of distance around 400 mm beyond the limit of liquid stage cal furnace develops with the slipping of the charge in cooling and the removal of dusts. The process of electri-

coke and gasses formed which enable the continu-
sous movement of melting material, heat and reactions in the process. The liquid products of melting precipitate in the floor of the furnace respective to their specific weight. The gasses are withdrawn with filter and sent to cooling and the removal of dusts. The process of electrical furnace develops with the slipping of the charge in distance around 400 mm beyond the limit of liquid stage in temperature around 850-1 050 °C. The concentration of CO in gasses is about 80-90 % and then we have intensive development of silicate reduction and metals of oxides according to these reactions

FeO + C = FeO + CO / Qkj

FeO + C = FeO + CO / Qkj

NiO + C = NiO + 3CO / Qkj

NiO + C = NiO + CO / Qkj

We have these technological effects:

Reduction of 70-80 % of the quantity of FeO3 in FeO,

Reduction of 2-5 % of the quantity of FeO in Fe,

Reduction of 30-50 % of the quantity of NiO in Ni and,

Thermal dispersion of 50-60 % of the quantity of CaCO3

The composition of gasses on exiting the rotational furnace is 9 % CO2, 0.1 % CO, 30 % N2, 5 % O2, 0.1 % SO2 and dusts of 50 gr/m3. The removal of dusts from rotational furnace gasses is done with cyclones (rooms for precipitation), the charge is sent directly in electrical furnace or is kept in special blockhouse which are sealed from inside with fire-resisting material in order to keep the charge temperature at 800 or 850 °C [1,2].

The Melting Process of Electrical Furnace

The melting process of electrical furnace is suffi-
ciently sensitive and at well seen parameters depends on the physical-chemical characteristics of the charge and the material which are put into the furnace. The conditions of the full dispersion of electrical energy in thermal energy. The usage-loading of electrical furnace in the heated charge in temperature 700-800 °C is done with the help of blockhouses and pipes places on ceiling of the furnace. The furnace is heated with electrodes sank is melted slag. The heating of the charge close to electrode and gasses formed which enable the continu-

oxides according to these reactions

NiO + CO = NiO + CO2

NiO + SiO2 + 2CO = 2Ni + SiO2 + 2CO2

CO + CO + CO2 = CO + CO + CO2

CO + SiO2 + 2CO = 2CO + SiO2 + 2CO2

The presence of reductive matter in the surface of the pool in the furnace causes the uncontrolled growth of temperature and the formation of zones with high temperatures. These zones impact the reduction of silica and chrome and the overfeed of iron-nickel with these met-

FeO totl: 15.84 %, CaO 2.54 %, CO 0.04 %, Cr2O3 1.07 %, Al2O3 2.17 %, MgO 15.36 %, MnO 0.36 %, SiO2 49.78 %, Ni 1.23 %, C-fix 3.50 %.
The average monthly chemical composite-on of the charge which is produced from the rotational furnace with 10 % of the charge being from the ore of Albania:

Fe\textsubscript{totl}: 19,85 %, CaO: 5,08 %, CO: 0,05 %, Cr\textsubscript{2}O\textsubscript{3}: 1,76 %, Al\textsubscript{2}O\textsubscript{3}: 4,08 %, MgO: 12,62 %, MnO: 0,39 %, SiO\textsubscript{2}: 41,25 %, Ni: 1,11 %, C-fix\textsubscript{x}: 3,00 %, etc.

The Products of Electrical Furnace

As mentioned above that the standard products of electrical furnace are: metaline (iron-nickel), slag and composition of gasses that depends on the chemical composition of the charge and the technological melting process in electrical furnace. We have done some statistical analysis (quantitative) and chemical of industrial products of the electrical furnace which directly depend on the ratio of the mix of ores from Kosova and Albania [2-4].

Alternative I

The chemical composition of metaline (Fe-Ni) of the electrical furnace is produced from the charge with 7 % of the ore of Albania. The average daily chemical composition of metaline (Fe-Ni):

13,41 % Ni, 0,37 % S, 3,00 % Si, 0,59 % Ca.

The average monthly chemical composite-on of metaline (Fe-Ni):

0,74 % Al, 3,34 % Si, 0,35 % Cr, 0,53 % Co, 13,75 % Ni, 0,04 % Cu, 73,47 % Fe, 0,35 % S, 0,44 % Ca.

The average monthly chemical composite-on of slag:

0,09 % Ni, 18,57 % Fe, 5,25 % CaO, 57,82 % SiO\textsubscript{2}, 12,73 % MgO, 20,09 % FeO, 2,23 % Al\textsubscript{2}O\textsubscript{3}.

Alternative II

The chemical composition of metaline (Fe-Ni) of electrical furnace produced from the charge of 10 % ore from Albania.

The average daily composition of metaline (Fe-Ni): 13,32 % Ni, 0,36 % S, 2,50 % Si, 0,64 % C. The average monthly chemical composition (Fe-Ni): 0,74 % Al, 2,50 % Si, 0,35 % Cr, 0,53 % Co, 13,32 % Ni, 0,04 % Cu, 73,47 % Fe, 0,36 % S, 0,64 % C.

The average daily chemical composition of slag: 0,07 % Ni, 13,67 % Fe, 2,85 % CaO, 57,38 % SiO\textsubscript{2}, 16,59 % MgO, 17,6 % FeO.

The average monthly chemical composite-on of slag: 0,07 % Ni, 13,6 % Fe, 2,85 % CaO, 57,98 % SiO\textsubscript{2}, 16,59 % MgO, 17,6 % FeO, 2,23 % Al\textsubscript{2}O\textsubscript{3}.

The Industrial Management of the Quantity of the Electrical Furnace Products in Drenas

The management of the charge and the products of the electrical furnace with the charge is complex and like that is treated with a three month timeline in 1:10 ratio of the mix from Kosova ore and Albania ore [3].

Alternative I

The charge of electrical furnace with 7 % of ore from Albania used in the plant is:

\[ G_{\text{charge}} = 1\,356 \, (24\,h)^{-1}\]

The acquired quantity of nickel is:

\[ G_{\text{Ni}} = 13,45 \, (24\,h)^{-1}\]

\[ G_{\text{Ni}} = 403,5 \, (720\,h)^{-1}\]

\[ G_{\text{Ni}} = 403,5 \times 12 = 4\,842 \, \text{tyr}^{-1}\]

The quantity of slag is about 75-80 % of the charge and is calculated with the expression:

\[ G_{\text{slag}} = G_{\text{charge}} \times \% \text{ slag in charge} \, t/h \]

The quantity of dusts is about 1% of the charge and is calculated with the expression:

\[ G_{\text{dust}} = G_{\text{charge}} \times \% \text{ of dust in charge} \, t/h \]

The quantity (Fe-Ni) is calculated with the expression:

\[ G_{\text{metaline}} = G_{\text{charge}} - G_{\text{slag}} - G_{\text{dust}} \, t/h \]

Based on expressions (8), (9) and (10) in table 1 are presented the quantities of slag, dusts and metaline.

<table>
<thead>
<tr>
<th>Time/ h</th>
<th>Slag/ t/h</th>
<th>Dusts/ t/h</th>
<th>Metaline/ t/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 h</td>
<td>1 057,68</td>
<td>13,56</td>
<td>284,76</td>
</tr>
<tr>
<td>720 h</td>
<td>31 730,4</td>
<td>406,8</td>
<td>8 542,8</td>
</tr>
<tr>
<td>Year h</td>
<td>380 764,8</td>
<td>4 881,6</td>
<td>105 504</td>
</tr>
</tbody>
</table>

Alternative II

The charge of electrical furnace with 10% of ore from Albania used in the plant is:

\[ G_{\text{charge}} = 1\,140 \, (24\,h)^{-1}\]

The acquired quantity of nickel is:

\[ G_{\text{Ni}} = 12,70 \, (24\,h)^{-1}\]

\[ G_{\text{Ni}} = 371,1 \, (720\,h)\]

\[ G_{\text{Ni}} = 4\,453,2 \, \text{tyr}^{-1}\]

Based on expressions (8), (9) and (10) we have presented the quantities of slag, dusts, and metaline.

<table>
<thead>
<tr>
<th>Time/ h</th>
<th>Slag/ t/h</th>
<th>Dusts/ t/h</th>
<th>Metaline/ t/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 h</td>
<td>889,2</td>
<td>11,40</td>
<td>239,4</td>
</tr>
<tr>
<td>720 h</td>
<td>26 676</td>
<td>342</td>
<td>718</td>
</tr>
<tr>
<td>Year h</td>
<td>320 112</td>
<td>4 104</td>
<td>86 184</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Charge/ t/24h</th>
<th>Metaline/ t/24h</th>
<th>Slag/ t/24h</th>
<th>Dusts/ t/24h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alte. I</td>
<td>1 356</td>
<td>284,76</td>
<td>1 057,68</td>
<td>13,56</td>
</tr>
<tr>
<td>Alte. II</td>
<td>1 140</td>
<td>239,4</td>
<td>889,2</td>
<td>11,40</td>
</tr>
</tbody>
</table>
The Loss of Nickel in Slag

The loss of nickel with slag is complex and depends on the quality of the charge, and the melting process in the electrical furnace that is calculated with the expression [3-5]:

\[ G_{Ni}^{slag} = G_{slag} \times % Ni_{slag} \]  

(11)

Alternative I

\[ G_{Ni}^{slag} = 1057.68 \times 0.06 \% = 0.634 \text{ t}(24\text{h})^{-1} \]

Alternative II

\[ G_{Ni}^{slag} = 889.2 \times 0.07 \% = 0.622 \text{ t}(24\text{h})^{-1} \]

Table 4 presents the quantity of nickel in slag

<table>
<thead>
<tr>
<th>Alternative</th>
<th>The quantity of nickel in slag/ t/24h</th>
<th>Quantity of nickel in slag/ t/24h</th>
<th>Quantity of nickel in slag/ t/24h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alte. I</td>
<td>0.634</td>
<td>19.02</td>
<td>231.532</td>
</tr>
<tr>
<td>Alte. II</td>
<td>0.622</td>
<td>18.66</td>
<td>277.03</td>
</tr>
</tbody>
</table>

CONCLUSIONS

Derived from laboratory, graphical and experimental analyses we can conclude that all the percentages of the composition of calcium carbonate and quartz have an important role in the optimization of the melting process in the electrical furnace. In order to have the quality and quantity of metaline in the melting process in electrical furnace we should simultaneously keep some parameters at certain value (temperature, furnace emptying) which depend on the quality of charge and the parameter of mix of the ore from Kosovo and the ore from Albania which should be 1:10 ratio. Based on the experimental and laboratorial results is found out that the production of the charge with 7 % of the ore from Albania reflects positively in the consumption of nickel in the charge. The charge produced with 10 % ore of Albania tends to lower the consumption of nickel in the charge. Moreover, it is noticed a small increase in the quantity of nickel lost with slag which negatively reflects on the economical and environmental sustainability of the melting process in electrical furnaces in Drenas. The parameters used during the production of ferro-nickel and the experimental and laboratorial analyses done in the melting process positively reflect on the increase of the capacity of electrical furnace in Drenas at 403.5 tNi(30d)^{-1}.

REFERENCES


Note: The responsible translator for English language is Agim Pudrimçaku, Republic of Kosovo.