A. HAXHIAJ, E. HAXHIAJ

ISSN 0543-5846
METABK 51(4) 469-472 (2012)
UDC – UDK 669.187:621.745=111

OPTIMIZATION OF THE MELTING PROCESS OF ELECTRICAL FURNACES IN DRENAS

Received – Prispjelo: 2011-11-18
Accepted – Prihvaćeno: 2012-03-20
Preliminary Note – Prethodno priopćenje

The weight, composition and loads are the main parameters of the melting process in electrical furnace. The charge is roasted in rotary furnace. Roasting of charge which consists of Drenas and Albanians ore is done at about 950°C. Also, article has the experimental analyses that modify some parameters of the production which are the reduction of quantity of limestone and the increase of quantity of quartz in the charge. The paper analysis the possibility of mixing the ore from Kosova with lateritic ore from Albania with the aim of reducing the acidity of weight which is loaded in the electrical furnace. The composition of the furnace must satisfy the ratio 1:10 of ore from Kosova and Albania.

Keywords: furnace, melting, charge, optimization

Optimizacija procesa taljenje u elektro pećima u Drenasu. Masa, sastav i opterećenje najvažniji su parametri procesa taljenja u električnim pećima. Prženje se obavlja u rotacionim pećima. Prženje uloška rude Drenasa i Albanije provodi se pri 950°C. U radu je provedena eksperimentalna analiza promjene nekih parametara što dovodi u proizvodnji do smanjenja količine vapnenca i povećanja količine kvarca u ulošku. Takoder je razmotrena mogućnost miješanja rude iz Albanije s rudom iz Kosova, kako bi se smanjila kiselost uloška koji se dodatno dozira u električnoj peći za taljenje. Sastav uloška treba zadovoljiti omjer 1:10 rude iz Kosova i Albanije.

Ključne riječi: peć, taljenje, uložak, optimizacija

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 Kosova 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 ($CaCO_3$)– 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 (SiO_2)– 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.

A. Haxhiaj, Faculty of Mining and Metallurgy, University of Prishtina, E. Haxhiaj, American University in Kosovo, Republic of Kosovo

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 granularmetric composition of the ore of Kosova which is processed is 70 % with 5 mm diameter and 20 % humidity composition. The chemical composition is 1,32 % Ni, 0.07 % Co, 24 % Fe_2O_3, 46 % SiO_2, 8 % MgO, 2,2 % Al_2O_3, 1,2 % Cr_2O_3, 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:

Fe_2O_3+C=FeO+CO / Qkj (1)
FeO+C=Fe+CO / Qkj (2)
NiO+C=Ni+CO / Qkj (3)

We have these technological effects:

Reduction of 70-80 % of the quantity of Fe_2O_3 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 $CaCO_3$

The composition of gasses on exiting the rotational furnace is 9 % CO_2, 0.1 % CO, 30 % N_2, 5 % O_2, 0,1 % SO_2 and dusts of 50 grm^{-3}. 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 sufficiently 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 continuous 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

$NiO+CO=Ni+CO_2$ (4)
$Ni_2SiO_2+2CO_2=2Ni+SiO_2+2CO_2$ (5)
$CO+CO=CO+CO_2$ (6)
$CO_2SiO_4+2CO=2CO+SiO_2+2CO_2$ (7)

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 metals and the lowering of the quality of iron-nickel. The electrical furnaces in Drenas produce iron-nickel with this chemical composition: 14 % Ni,0.7% CO, 80 % Fe. The temperature of the melting process is about 1 450-1 500 °C which depends on the composition of silica and carbon within iron-nickel. The density of iron-nickel is about 7,8-8,2tm^{-3}. The produced slag is composed of: 0,12 % Co, 0,1 % Ni, 14 % Fe, 5,6 % SiO_2, 9,2 % Al_2O_3, 14 % CaO. The temperature of slag in exit of furnace is about 1 200-1 300 °C. The gases of the electrical furnace have 60-70 % CO and can be used as combustible matter for heating the rotational furnaces. The quantity of dusts in gasses is about 1 % of the mass of the charge and the chemical composition of them depends on the chemical composition of the ore [4].

The Main Technical-Technological Indices of Electrical Furnaces

The furnace is sealed with magnesium bricks. In the middle of the wall of magne-sium bricks and metallic body of the furnace which is cooled with water there is a layer of compressed graphite. The floor of the furnace is build up of magnesium bricks over which is placed a layer of dolo-mite of about 1 500 mm width. The specific power of the furnace is 167,5 kWm^{-3}, the capacity expressed in dry ore is 1 476 $t(24h)^{-1}$, the specific consumption of electrical power is 630 $kWht_x^{-1}$ [1].

THE PROCESS IN ROTATIONAL FURNACE

During the roasting of the furnace is necessary to lower the acidity of the charge which is done by loading the calcium carbonate in the charge. In some cases the percentage of the calcium carbonate is 12-15 % $CaCO_3$ to normalize the acidity of slag. In this case, the specific consumption of electrical power increases and the cost of production increases and the productivity of rotational furnace decreases. The case when we minimize the quantity of calcium carbonate in the charge for roasting we see some problems in the roasting process; the temperature increases in the pod of the furnace, the acidity of the slag increases which causes different problems in the roasting process. The normalization and the minimization of these problems in the rotational furnaces in Drenas is worked out by mixing the ore from Kosova with the ore from Albania of lateritic type which has this chemical com-position: 28,50 % Fe, 23,32 % Si, 5,97 % Mg, 2,83 % Al, 0,89 % Ni, 8.06 % Co, 1,83 % Cr. In a timeline of more than three months of experimental work and the calculations of the process and the quality of the charge acquired from the rotational furnace we conclude that the ore from Kosova should be mixed with the ore from Albania at 1:10 ratio [3]. Respectively

Alternative I

The average monthly chemical composite-on of the charge which is produced on the rotational furnace with the charge of 7 % of the ore from Albania.

Fe^0 totl: 15,84 %, CaO^0 2,54 %, CO 0,04 %, Cr_2O_3 1,07 %, Al_2O_3 2,17 %, MgO^0 15,36 %, MnO 0,36 %, SiO_2 49,78%, Ni $1,23^0$ %, C-fix^0 3,50 %.

Alternative II

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^0 totl: ^{0}19,85 %, CaO^0 5,08^0 %, CO^0 0,05^0 %, Cr_2O_3 1,76 %, $Al_2O_3^0$ 4,08 %, MgO^0 12, 62 %, MnO 0,39^0 %, SiO_2 41,25 %, Ni^0 1,11^0 %, C-fix^0 3,0^0 %, 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 technolog-ical 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 composit-ion of slag

0,09 % Ni, 18,57 % Fe, 5,25 % CaO, 57,82 % SiO_2, 12,73 % MgO, 20,09 % FeO, 2,23 % Al_2O_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_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_2, 16,59 % MgO, 17,6 % FeO, 2,23 % Al_2O_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_{charge}=1 356 t(24h)$^{-1}$

The acquired quantity of nickel is:

G_{Ni}=13,45 t(24h)$^{-1}$

G_{Ni}=403,5 t(720h)$^{-1}$

G_{Ni}=403,5 x 12=4 842 tyr^{-1}

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

$$G_{slag}=G_{charge}\ x\ \%_{\ slag\ in\ charge}\ t/h \quad (8)$$

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

$$G_{dust}=G_{charge}\ x\ \%_{\ of\ dust\ in\ charge}\ t/h \quad (9)$$

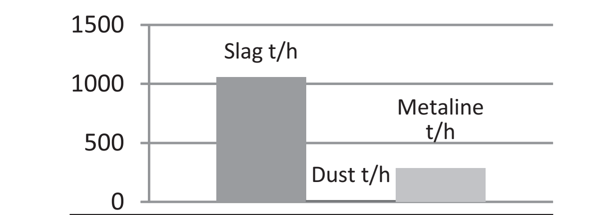
The quantity (Fe-Ni) is calculated with the expression:

$$G_{metaline}=G_{charge}-G_{slag}-G_{dust}\ t/h \quad (10)$$

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

Table 1 **The quantity of slag, dusts, and metaline**

Alternative I / Time/ h	Slag/ t/h	Dust/ t/h	Metalin/ t/h
24 h	1 057,68	13,56	284,76
720 h	31 730,4	406,8	8 542,8
Year h	380 764,8	4 881,6	102 504



The quantity of slag, dusts, and metaline

Alternative II

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

G_{charge}=1 140 t(24h)$^{-1}$

The acquired quantity of nickel is:

G_{Ni}=12,70 t(24h)$^{-1}$

G_{Ni}=371,1 t(720h)

G_{Ni}=4 453,2 tyr^{-1}

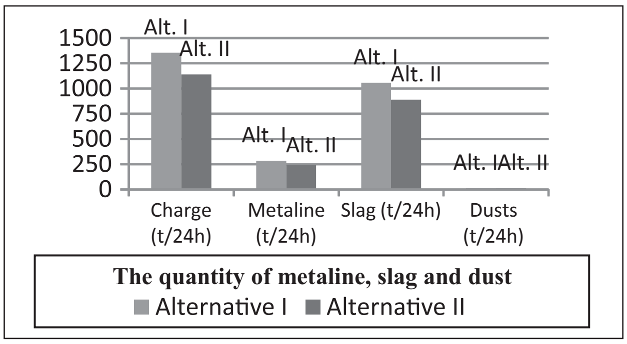
Based on expressions (8), (9) and (10) we have presented the quantities of slag, dusts, and metaline-Tables 2, 3.

Table 2 **The quantity of slag, dusts, and metaline**

Alternative II / Time h	Slag/ t/h	Dusts/ t/h	Metalin/ t/h
24 h	889,2	11,40	239,4
720 h	26 676	342	718
Year h	320 112	4 104	86 184

Table 3 **The quantity of metaline, slag and dust per 24h**

Alternative	Charge/ t/24h	Metali/ t/24h	Slag/ t/24h	Dusts/ t/24h
Alte. I	1 356	284,76	1 057,68	13,56
Alte. II	1 140	239,4	889,2	11,40



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]:

$$G^{Ni}_{slag}=G_{slag}\ x\ \%\ Ni_{slag} \qquad (11)$$

Alternative I

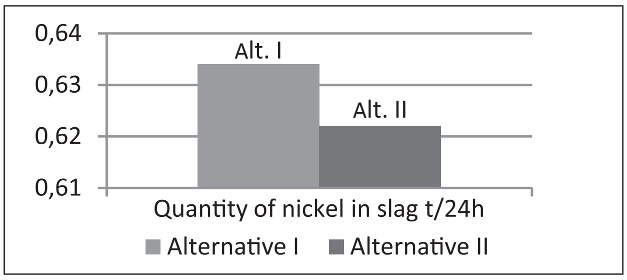
$G^{Ni}_{slag}=1057,68\ x\ 0,06\ \%=0,634\ t(24h)^{-1}$

Alternative II

$G^{Ni}_{slag}=889,2\ x\ 0,07\ \%=0,622\ t(24h)^{-1}$ –Table 4

Table 4 **Presents the quantity of nickel in slag**

Alternative	The quantity of nickel in slag/ t/24h	Quantity of nickel in slag/ t/24h	Quantity of nickel in slag/ t/24h
Alte. I	0,634	19,02	231,532
Alte. II	0,622	18,66	277,03



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 simultaneo-usly 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 Kosova 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 the electr-ical furnaces in Drenas. The parameters used during the production of ferro-nickel and the experimental and laboratorial analyses done in the melting process posit-ively reflect on the increase of the capacity of electrical furnace in Drenas at 403,5 $tNi(30d)^{-1}$.

REFERENCES

[1] Agolli, F. *Metalurgjia e Metaleve me Ngjyrë*, pp 474-567 (Universiteti i Prishtinës: Prishtinë), 1985.

[2] Dimidovski, D. Onišćen B. and Linov V. *Metalurgija feronikela*, (Metalurgija: Moskva), 1983.

[3] Haxhiaj, A. and Drelich, J. Constituents and Porosity of Lead Concentrate Pellets Produced in the Trepçe Plant, in *2nd International Symposium on High-Temperature Metallurgical Processing* (ed: J-Y. Hwang) pp 289-299 (TMS Annual Meeting & Exhibition: San Diego, California), 2011.

[4] Murati, N. *Metalurgjia e Feronikelit,* pp 50-105 (Universiteti i Prishtinës: Prishtinë), 1995.

[5] Pan, J., Zhou, A., Zhu, D. and Zheng, G. Study of Strengthen Pelletization of Nickel Laterite, in *2nd International Symposium on High-Temperature Metallurgical Processing* (ed: J-Y. Hwang) pp 355-363, (TMS Annual Meeting & Exhibition: San Diego, California), 2011.

Note: The responsible translator for English language is Agim Podrimçaku, Republic of Kosova.