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Research article

MATERIAL BALANCE OF THE TECHNOLOGICAL PROCESS IN THE NEW FOUNDRY OF NEW FERRONIKEL IN DRENAS 2017

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[2] New Foundry of the New Ferronickel in Drenas, Republic of Kosovo.

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ABSTRACT
Experimental and industrial research of the technological process during the year 2017, including planning, is presented in this paper. That research was conducted in the new Foundry of new Ferronickel in Drenas, which is in the village of Cikatove, Drenas, the Republic of Kosovo. According to initial calculations, an amount of ore which would enter the process was determined, however the anticipated amount was different from the one used during the process. The same applies to fuel. Difference between the planned and the actual amount of ore used during the year 2017 resulted from the percentage of Ni in the amount of ore used in the foundry, demand for an Fe-Ni ferroalloy etc. The technological process in the foundry serves the purpose of processing ore of iron-nickel with a high percentage of Ni in its composition. The material balance of the technological process in the new Foundry of new Ferronickel in Drenas, presented in this paper, is based on experimental and industrial data of the technological process acquired in the foundry. The material balance includes the technological process starting from calculation of the amount of ore and fuel, both making up the load for the rotary kiln. Additional contributors to the material balance are calculation of the amount of: fuel, which impacts the increase of temperature in rotary kilns, charge for the electric furnaces, metal and slags from the electric furnaces, metal and slags from the refining process (convertors) and mathematical calculation of the final product which is the ferroalloy of Fe-Ni. While preparing the material balance we have noticed greater acquisition of Ni than planned. The greater amount of Ni was produced by a smaller amount of ore than originally planned.
KEYWORDS: foundry, ore, fuel, calcine, silicate, oxide

1. Introduction

The new Foundry of new Ferronickel in Drenas is located near the source "Old Cikatove", 37 km northwest of Pristina. Metallurgy in the Republic of Kosovo so far has been oriented towards processing ore of local mines, such as Golesh and Cikatove, and imported (since 2007) ore from: Indonesia, Philippines, Guatemala, Albania, Macedonia and Turkey. Processing is performed with an electro-reduction process, to prepare Fe-Ni as the final product. Fundamental establishment and equipment of the foundry are: two rotary kilns by "Schmid" (Copenhagen), two rotary kilns by "Elkem"-Spikerverket (Oslo) and two convertors LD by "Krupp" (Dusseldorf). In the new foundry in new Ferronickel in Drenas, the process of Fe-Ni production passes through following stages: Fe-Ni ore and fuels are being processed and then delivered to appropriate bunkers where they enter the rotary kiln on conveyor belts. The fuel enters at a temperature of over 500℃ and by means of special equipment. Owing to heavy-oil and Pet Kok in the fuel, the temperature in the rotary kiln increase to over 700℃

and this contributes to qualitative production of calcine [8]. The calcine produced by the rotary kilns is sent to the electric furnace through special pipes, where the Fe-Ni metal production process and the quantity of slag are performed. Metal produced in the electric furnace is sent to the converter for refining, in which an amount of limestone is added, and oxygen is blown into. After refining, metal is poured into special equipment where Fe-Ni metal is produced, in a form of granules of size of 2-4 cm, while the remaining slag in the converter is divided into metallic and non-metallic parts, and the metallic one undergoes processing again [1-8].

In the new foundry of new Ferronickel in Drenas in 2017, following Fe-Ni ores were used: from Kosovo (mines: Gllavice and Qikatove), Albania and Guatemala. Ores were composed of oxide and silicate. An annual, average content of Ni in Guatemalan ore is higher (Ni = 2%) compared to Kosovar (Ni = 1,5%) and Albanian ores (0.99%) [6]. In Figure 1, there is a view of both rotary kilns in the Foundry, in which the frying process of the Fe-Ni ore is performed.

Fig. 1. View of Two Rotary Kilns in New Ferronickel in Ferronickel Street, 13000, Drenas (Glogovac) Kosovo.

The planned amount of ores of Fe-Ni is different from the amount used (Fig. 2). The used amount of fuel in 2017: Kosovar lignite (dry), Kosovar lignite (wet), Russian coal, steam coal, Pljevljan lignite, dry coal, Pet Kok and heavy oil. The amount of fuels at the planning stage: lignite (wet), coal, steam coal, biomass. Also, the amount of used fuel in tons is different from the planned amount to be used.

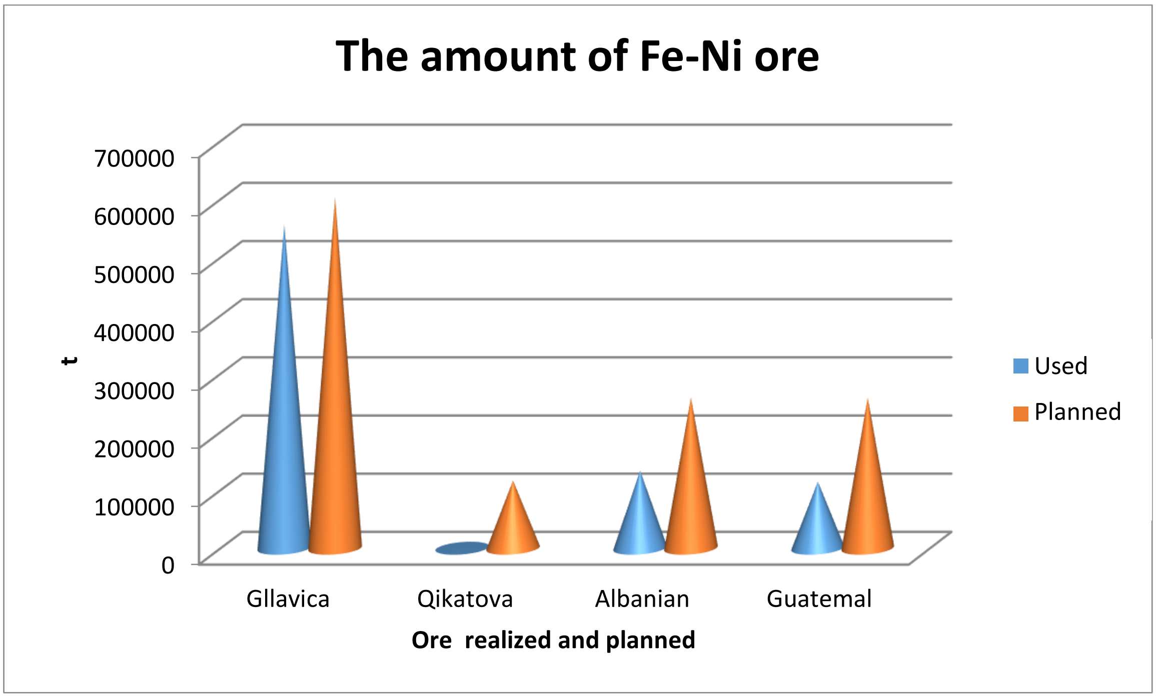

Fig. 2. Graphic representation of the planned and realized amount of ore in 2017

2. Description of the technological process

2.1. The Rotary Kiln Work

The Fe-Ni metal production process in the new foundry of new Ferronickel in Drenas begins with processing of ore and fuel which are delivered into the rotary kiln through special machinery. The rotary kiln department consists of two furnaces, which length is 100 m, and diameter 5m each (Fig.1).

The process is divided into three areas:

- drying area
- heating area
- frying area

In the first zone, humidity of surface is removed. In the second zone, crystalline humidity is removed, while in the third zone, the frying process is performed which develops at temperatures over 700°C, [1], [6]. The reactions which are developed in rotary kilns, presented in Figure 1, [1,6,9]:

$$NiO + CO = Ni + CO_2 \tag{1}$$

$$3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2 \tag{2}$$

$$Fe_3O_4 + CO = 3FeO + CO_2 \tag{3}$$

$$FeO + CO = Fe + CO_2 \tag{4}$$

2.2. Electric Furnace

In the foundry in Drenas, there are two “Elkem” electrical furnaces, with three electrodes, where the calcine produced by rotary kilns is subjected to melting, and as products an amount of metal and slag are received. Reactions in the electric furnaces [1,6,9]:

$$\mathrm{NiSiO_3 + 0{,}5C = Ni + SiO_2 + SiO_2 + 0{,}5CO_2} \tag{5}$$

$$\mathrm{NiSiO_3 + C = Ni + SiO_2 + CO} \quad (6)$$

$$CoSi\mathrm{O_3 + 0{,}5C = Co + SiO_2} + 0.5CO_2 \quad (7)$$

$$\mathrm{NiSiO_3 + CO = Ni + SiO_2 + CO_2} \quad (8)$$

$$\mathrm{C0SiO_3 + CO = Co + SiO_2 + CO_2} \quad (9)$$

$$NiO + 0.5C = Ni + 0.5\mathrm{O_2} \quad (10)$$

$$NiO + C = Ni + CO \quad (11)$$

$$\mathrm{SiO_2 + 2C = Si + 2CO} \quad (12)$$

$$C\mathrm{r_2O_3 + 3C = 2Cr + 3CO} \quad (13)$$

$$\mathrm{Fe_2O_3 + 3C = 2Fe + CO} \quad (14)$$

$$FeO + 0.5C = Fe + 0.5CO_2 \quad (15)$$

$$\mathrm{3Fe_2O_3 + CO = 2Fe_3O_4} + CO_2 \quad (16)$$

$$\mathrm{Fe_3O_4 + CO = 3FeO} + CO_2 \quad (17)$$

$$FeO + CO = Fe + CO_2 \quad (18)$$

3. Discussion of results

Additionally, the material balance of the technological process in the new Foundry of the Ferronickel in Drenas, based on calculation of the process, will be presented [6], [7].

From Fig. 3, the utilisation coefficient of the entire Fe-Ni production process during 2017 reaches 91.43%, this calculation is made starting from the amount of Fe-Ni in the entrance of the rotary kilns, process of frying, producing Fe-Ni metal in rotary furnaces and refining process in the converter (final product) [6].

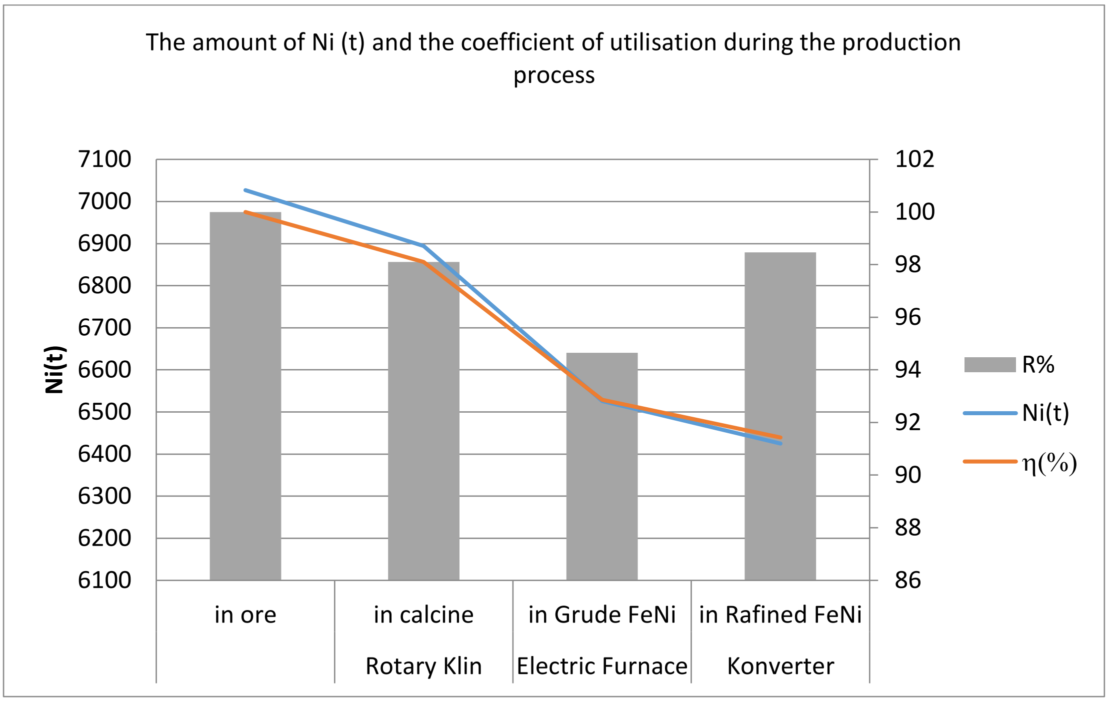

Fig. 3. Graphic representation of Ni (t), coefficient of Fe-Ni (η) ore utilisation, the coefficient of utilisation at certain stages of the process (R).

The mathematical representation of the determination of the utilisation coefficient:

$$\eta = \frac{\text{amount}_{\text{Niprod}}}{\text{amount}_{\text{Niore}}} \cdot 100\% = \frac{6425(\text{t})}{7026.87(\text{t})} . 100\% = 91.43\% \tag{19}$$

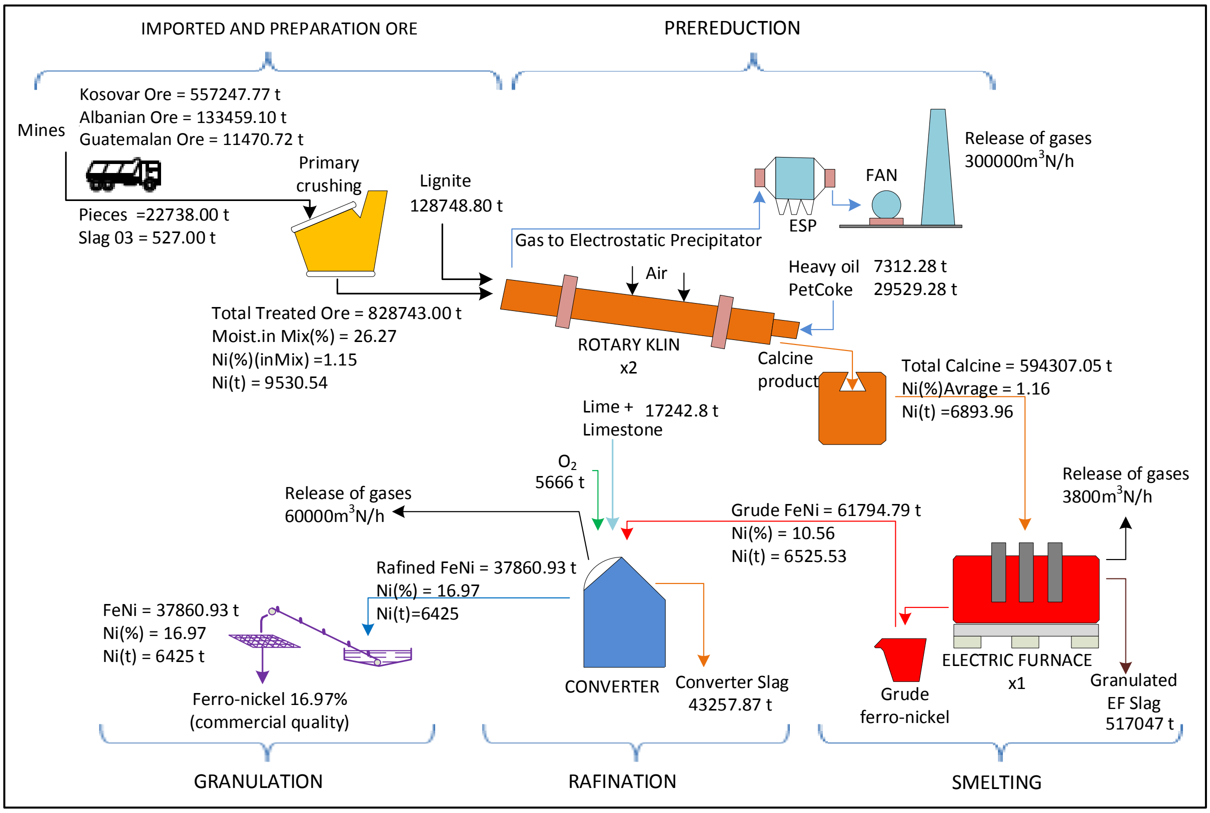

Fig. 4. Schematic representation of the Fe-Ni production process in the new foundry of new Ferronickel in Drenas - Material balance sheet of the used and planned amount in 2017 [1,6,9].

Calculation of the part of the untreated metal of Fe-Ni from the electric furnace, and the part of the refining process:

Fe-Ni (crude) + amount (limestone) + refractory material + amount (O_2) = Fe-Ni (Product) + slag + losses

$$84703,59 \text{ (t)} = 37860,93\text{(t)} + 43257,87\text{(t)} + \text{losses(t)} \tag{20}$$

$$\text{Losses(t)} = 46842,66 - 43257,87 = 3584,79\text{(t)} \tag{21}$$

The total amount of losses 3584,79 (t) is a result of the amount of gases, attachments and dust of the process (fig. 5.):

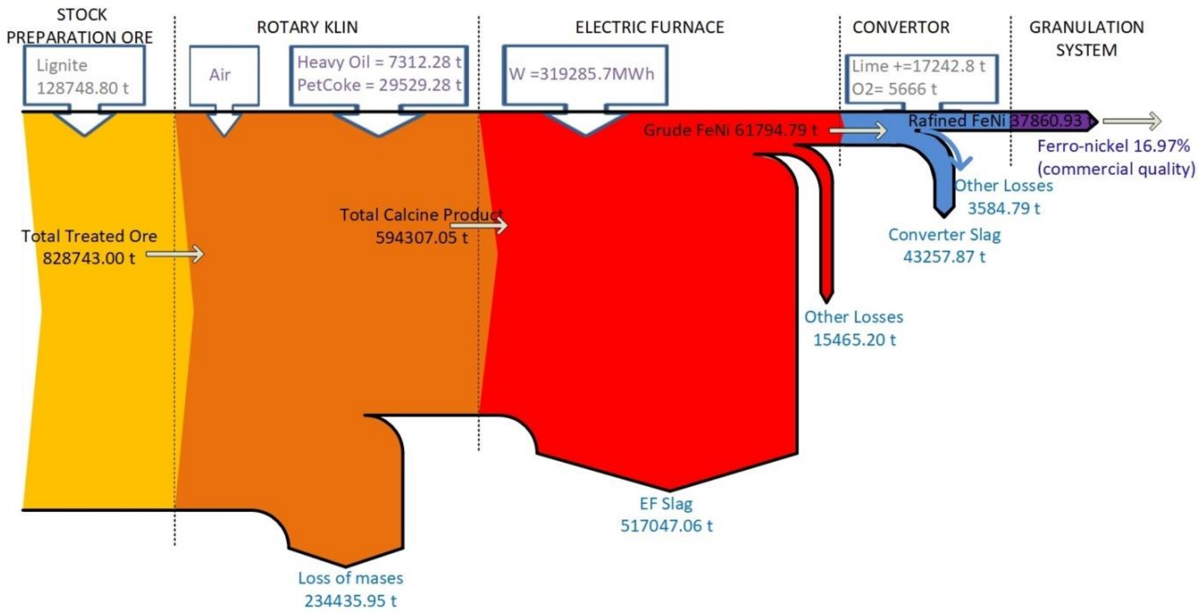

Fig. 5. The diagram of material balance of the process of the Fe-Ni production in 2017.

4. Recommendations

- Apply drying for Fe-Ni minerals [7].
- An increase in the amount of Pet Kok in relation to heavy oil over the next few years
- The amount planned to be equal to the amount used (ores and fuels).

5. Conclusions

Mathematical calculation of the material balance of the technological process of production of Fe-Ni alloy has been obtained from the technological process which has been carried out in the foundry during the year 2017. According to obtained data of the material balance of the technological process during 2017 we conclude that the foundry has used 63.93% of the amount of produced charge. Nevertheless, the amount of ore is lower than the amount of planned Fe-Ni by 36.07%. Whereas, the used amount of Ni is higher than the planned amount in 2017 by 15.14%.

The high amount of Ni in tons during determination of the material balance during 2017 comes as a result of a few factors listed below:

- The use of Guatemala ore (Ni=2%).
- The increase in amount of Pet Kok and decrease in amount of heavy oil during 2017. This results in a higher temperature in rotary kilns, acquiring the charge in a temperature above 700°C.

- Good weather conditions during the winter season (less humidity in the ore).
- The amount of ore of Fe-Ni which enters both rotary kilns is 828743 ton, of lignite is 128748.8 ton, of heavy oil is 7312.28 ton, of Pet Kok is 29529.28 ton, and as a result we acquire the charge with the amount of 594307.07 ton.
- The 594307.07-ton amount of charge is sent to the electric furnace, where we acquire 61794.79 tons of unrefined Fe-Ni metal and 517047 tons of slag amount.
- In addition, the 61794.79 ton of unrefined Fe-Ni metal is sent to the convertors, with an amount of 17242.8 tons of lime and limestone and 5666 ton of O_2 to be refined.
- With the refining process in 2017 we have acquired 37680.93 ton of Fe-Ni alloy and 43257.87 ton of slag, where the metallic part of slag is separated from the non-metallic one.
- The process is executed by acquiring the Fe-Ni alloy in the form of granules, with an amount of 6425 tons of Ni.
- From mathematical calculation of the process of the production of the Fe-Ni alloy in the new Foundry of new Ferronickel in Drenas in 2017, we can conclude that we managed to obtain the material balance of the process. According to calculation, starting from the ore, fuel, charge production and Fe-Ni alloy production we have also included calculation of the losses in all phases of the project.
- We can conclude that the purpose of this paper is positive, considering calculation of the process presented here.

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