P 28. ENVIRONMENTAL IMPACTS OF THE INTEGRATED DRY GRANULATION METHOD APPLICATION OF FERRONICKEL SLAG

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ABSTRACT: Environmentally responsible and rentable metallurgical industries put among their key objectives the development of utilization schemes of all of its middle – products. The smelting process of nickel oxides ores is almost slag process, where about 75% of the calcine pass to slag. In the New Ferronickel smelt plant in Kosova, produced slag is thrown in the landfill without adequate proper treatment. Such exploiting concepts, without any valorisation strategy, have resulted with the no effective manufacturing cost, irrational use of resources and high concentrations of polluting components. This slag represents the mid - product, with the high value effects in economy and environment. Developed research in terms of opportunities to use it, prove that the application of the integrated dry granulation method will transform slag into a resource with improved qualities (composition and properties - by adjusting it in the valuable aggregate for cement products, asphalt concrete and all other of the construction industry). In renewable energy source, through returning it in production process and reduce its pollution impacts. Quantitative – qualitative assessments and potential economic- environmental impacts, are research object in the laboratories of the New Co "Ferronikeli", Xella-Kosovo, AHN Group - Prishtina, "Ramtech - Zagreb, Silcapor - Kosovo, etc. Obtained results are presented in this paper

Keywords: Slag, granulation, resources, energy recuperation, products performance

1. INTRODUCTION

Results that are based in the technological analysis of the ferronickel benefit from nickel oxide ore at the smelter of Kosovo show that the melting in the electric furnace is slag process, since 75% of the calcine passes in slag. The main physical - mechanical properties of slag depend on: chemical composition, formation temperature, method of production and solidification. Slags of non ferrous metals of the ferronickel high furnaces, according to their physical-mechanical properties represent very valuable raw materials for construction and chemical industries. In this smeltery under the current scheme, slag periodically streams from electric furnaces and through special channel is subject of the granulation water process. Such processing concepts have degraded most of the technological properties, not guaranteeing the quality control (properties and composition) of slag, environmental presence and effective cost manufacturing. Lack of an adequate treatment of deposits over 8 million tons of slag, which excel with high level of pollution are exposed to atmospheric rainfalls and wind, and thus have substantially degraded not only the quality of life but also opportunities for sustainable economic development. Steams of granulation process with water, particles releasing and wool of slag (in size between 30μ dhe 5 μ), have high capability of the emission and imitation and impacts of water drainage are just some of the findings of this study, which were sufficient for most environmental organizations to evaluate this landfill as "environmental hotspot"[3]. Changing approach of the slag processing together with its reuse programs will reflect important impacts in establishing balancing relations between the rational use of natural resources, sustainable economic development and environmental sustainability. Processing by the "integrated dry granulation", will result with slag aggregates in good physical condition (appropriate for producing of cement), opportunities to regenerate energy during its cooling process, increasing its applicability in industry, improving the performance of products of specific areas of industry and generally ensure a sustainable economic growth.

2. INTEGRATED DRY GRANULATION OF MOLTEN SLAG

Until recently metallurgical industries realize over 35% of all slag production with wet method. Such processes are accompanied by high costs, environmental problems and other technical - technological difficulties of production. Some of the modern technologies of processing of steel are realizing granulation of the molten slag through the new approaches which allow controlling the cooling process of slag and regeneration of process energy. Molten slag contains approximately 80% of the overall energy of minerals melting in the electric furnace. Under the current processing method all the heat transferred with slag is lost. In regard of the heat regeneration from slag processing according project concept “Integrated dry granulation” by Dr. Dongsheng Xie, it would potentially ensure the storing of this energy (in the form of hot air and steam). Control of slag cooling process, will result with aggregates with higher content of hyaline, granulometry appropriate state and the highest level of its application. Energy returning in the technological process may include: use of hot air before ore heating in rotary furnace or any other power plant, heating the boiler for metal casting from electric furnaces, or for steam producing and energy generation. A similar concept of granulation has been the subject of studies by a huge number of scientists, particularly in Japan and United Kingdom.

For the first time in industrial conditions as a pilot project, high furnace slag is treated (re-melted at 1400-1500 ^{0}C) in quantities of 10 kg / min by the company "Sumitomo Metals Industry" in Japan (fig.1). Such design solution conceptually will be based on the two–stage process, which would include dry granulation and heat storage in the switcher. Granulator receiver and atomism of the molten slag up to the formation of steel hot granules (8000 ^{o}C), which pass in the second stage in heat exchanger to be exposed again to draft where further cooling takes place, to maximise the heat in the storage exchanger, which as a closed system prevents discharge of vapours and gases on the environment.

All industrial analysis of the process for the ferronickel benefit in Kosovo, argue the possibilities of the slag processing by the "integrated dry granulation” method. The main impacts of the process would be: improvement of physical - mechanical properties of slag, energy regeneration via hot air (with approximate temperature of 600 ^{0}C), increasing the possibilities of exploitation of mid-process products provided, optimization of manufacturing process and environmental acceptance.

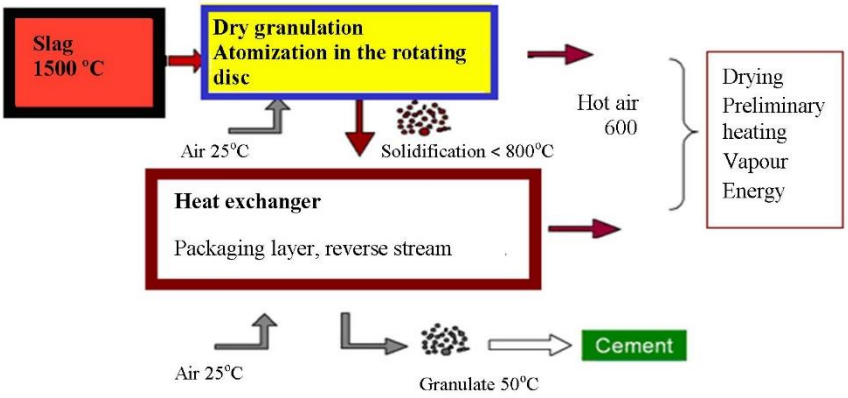

Fig .1 Concept of integrated dry granulation designed according CSRIO's

3. ECONOMIC-ENVIRONMENTAL IMPACTS BY APPLICATION OF THE "INTEGRATED DRY GRANULATION" METHOD OF FE-NI SLAG

Overall level of slag utilization of Ni, Cr and Cu, and knowledge about the behaviour of their products is still low. Association’s reports of (Samaria, NAS, NAPA, etc.) that deal with quantity - quality assessments of metallurgical slag prove the validity and its application areas are exclusively dependent on solution design, methods of processing, marketing and organization of slag market. Practice of using the Fe-Ni slag produced in "Falcondo" in Bonao, argue that a more effective utilization of resources and energy resources through all stages of the calcine of electric furnaces in the smelter of "Ferronikeli“ in Kosovo produced by current technological parameters, does not guarantee likable technical qualities, environmental presence and production manufacturing effective cost, and degrade most of its properties. Designed solutions by new methods of processing, will increase the requirements for valorisation of

over 1.200.000 t ore / year, 11.000 t Ni / year, and over 800.000 t slag/year, while according to the current approach, all mid-products of process are unused and the rate of utilization of the metal is still not high. Keeping under control parameters of slag cooling process is the main condition in the improvement of technical qualities of slag. Fulfilment of technical criteria such as structural construction, favourable relations between hyaline and crystalline phases, good interactive capability between its constituent components, correction and keeping under control of any negative attribute of slag are some of the conditions that will affect the growth of its applicability in the industry. Mineralogical construction and concentration of minerals, olivine, pyroxene, trydimite, magnesiumwustite, crystobalite, montiqelit, mervinit and minerals, besides the constituent components of the process greatly depend on the slag processing method.

Even under the current parameters ferronickel slag of Kosovo progresses with most of the physical - mechanical properties (table 1) compared with the quality of mineral aggregates which are assessed as highly precious by technical performance and by the level of applicability in the construction industry.

According to the basic data from the study, quality and standard technical requirements for construction mineralsandezitet, basalt and other eruptive aggregates, their replacement with the ferronickel slag aggregate processed according to method "integrated dry granulations" will display special effects through:

- Advanced technical qualities compared with traditional aggregates which are accompanied by technological difficulties and high costs during phases as: research, mining, exploration, washing, purifying, comminution, drying, homogenization, environmental protection , etc..
-Heat maximizing in storage exchanger and its return in the process will increase the production capacity, the utilization of metal coefficient, oxidation-reduction capabilities of ore in rotary furnace, and it will reduce specific energy consumption and eliminate the majority of technical-technological barriers and generally optimize the process.
- Savings of connecting materials (gypsum, lime, cement, bitumen, etc.) in cases where it is used as aggregate to replace the traditional aggregate or as additional material.
- Benefits from increased performance of slag products through the long- life, the coefficient of friction, resistance towards environmental impacts during exploitation etc when it will be used as aggregate for asphalt concrete production
- Benefits from capital decreasing of production costs, savings in maintenance and management of industrial landfills, re-cultivation, etc.

Cooling of 1 (ton) of slag melt in temperature of 1500 °C to environment temperature, contains heat from 1.8 to 2.5 GJ. Calculation of produced amount of slag from electric furnace (2 * 1280 t / day), its preservation and its return in the process would be a valuable potential energy. Keeping and re-use of energy released by the cooling process can serve the function of:

- drying in the oxidation reduction process of ore, through returning of the hot air,
- ecreasing of specific energy consumption (according to empirical data, slag transfers 80% of the overall heat from the melting of the nickel oxide ores and raising of the temperature of 1°C is equivalent to the reduction of specific consumption of electricity in electric furnace of 5.6 (kWh / t charge),
- pre- reduction of ores and partial reduction to the metal, with energy savings of about 300 (kWh / t fry) electric furnace,
- reduction of manufacturing costs, the technological progress and increasing production capacities, and the economy of the whole production process,
- regeneration of energy through the production of steam for production of electricity, production of technological steam for drying of the ore, heating of the boilers for the metal acceptation,
- as the environmental requirements are increasing, Kosovo slag landfill, according to the present state is counted as "environmental hotspot" because of the non utilization and growing layer of slag. Slag processing by integrating closed system will increase the degree of applicability of this mid-product, will reduce the polluting effects from useless expenditure during slag cooling, will reduce pollution from vapour release, other solid particles and overall reduction of heat emissions from “greenhouse effect" which comes during the heat release in the atmosphere,

- reducing water consumption and its content in slag (according the current method contains 15-20% water), and which will also decrease the polluting effects of Ni, Co, Cu, Fe +2, Fe +3, and other heavy metals transferred by water drainage during transport and slag storage .

Table 1. Properties of some types of mineral aggregate and slag of the Ferronickel in Kosovo

Properties	Andezite	Bazalt	FeNi slag
Durability against consumption and erosion (cm3/50 cm2)	8,05	8,65	7,52
Specific density (g/cm3)	2.640	3.250	2.80±3
Inhale of water for large grain aggregate(%)	0.80	0.73	0.56
Tha sand equivalent (%)	76,2	76,5	95,3
Inhale of bitumen by aggregate (%)	100/90	100/95	100/98
Illustrative values of the rock	63	59	55
Sustainability from dynamic shocks (breaking and consumption) – LA % (m/m)	12	11,8	10
Sustainability of crushing in cylinders % (m/m)	10,1- 14,5	11,3 – 13,2	19,7 - 20,3

4. DISCUSSION OF RESULTS

Slag of electric furnaces "of Fe-Ni smelter" in Kosovo is melted ore, created during the reduction of nickel oxide ore. It represents a complex oxide system with excellent physical - mechanical properties. Processing of slag according the current manner does not guarantee control of the solidification process, and thus the physical - mechanical properties. Cooling under the pressure of water has stimulated high concentrations of crystalline phase, weakening the binding properties, small fractions and generally degradation of technical properties that limit its application. Slag production by "integrated dry granulations" method enables slag products with high content og hyaline, appropriate for the benefit of quality cements. Use of heat released during slag cooling will be used to produce steam and electricity production. Estimates of economy and manufacturing costs of slag processing according to the study(having in consideration slag with high content and regeneration of energy) would result in savings up to 23% of electricity consumption, 48% of fuel oil consumption, 27% of manufacturing costs, and overall optimization of the production process of feronickel .

5. CONCLUSION

Processing of the feronickel slag with “integrated dry granulations" method would be a key factor for valorisation of deposit of 8 million tonnes in valuable resources, which still continue to be treated as industrial residue problem for the environment, increasing the coefficient of metal, reducing maintenance costs for environmental protection, generation of new working places, reducing imports and generally increase the gross domestic product. The application of the method of "integrated dry granulations", compilation of the program on industrial waste management, marketing and organization of the right market of slag will ensure not only slag open market, but also the energy regeneration benefits through savings on water, energy resources (electricity and fuel oil) etc, and optimization of process through recovering of energy accumulated during the slag cooling process.

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