Pulverous ferrous waste processing by agglomeration

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Abstract. The current paper presents the results obtained after the laboratory testing of the agglomeration process of pulverous ferrous waste. The obtained products are destined for use in the steel industry, as raw material for the production of steel. When choosing the procedure and technologies of capitalization we took into consideration the features of the waste, the destination of the obtained product and the existing processing facilities. The superior valorification of iron and steel waste represents an important matter because their transformation into by-products leads to a rational use of raw material and energy resources, thus ensuring both the satisfaction of human society and the protection of the environment.

1. Introduction
The worldwide strategies of metallurgical developments consist in developing performant technologies in order to reduce emissions while also grow the capability of by-product recovery and recycling. [1]

The ecological concept applied to metallurgical engineering implies the development of those technological fluxes in closed coil in which none of the resources are eliminated, all the materials are continuously reused, no dangerous waste or other product is evacuated in the environment [2], [3]. This field constantly tries to identify and implement the most efficient methods that retain all potential sources of iron inside the cycle of production – use- recycle with the purpose of protecting natural resources, cost reduction and to minimize the impact of wastes on the environment [4], [5].

The preoccupation about respecting the legislative requirements and the need to harmonize processes during economic growth with a rational segmentation of material and energetical resources, must lead to the capitalization of waste through technologies that offer the optimal solution both economically and ecologically [6]. It’s necessary to promote technologies that ensure [7-10]:
- the rigorous segmentation of wastes;
- the controlled storage of all waste categories;
- the reduction of the quantities and harmfulness of the obtained waste.

2. Experimental research in the laboratory phase
The paper presents the capitalization methods of the ferrous sludge (10.02.12 – waste obtained after the clearance of cooling liquids) the came from a local plant that produces metallic powder.

The choice of the capitalization procedure must be made having in view the features of the waste, the destination of the obtained product and the existing processing equipment in the waste area. We chose processing the waste through agglomeration in order to valorificate it as agglomerate. The resulting product can be used as raw material in the steel processing ovens [11].
The chemical (Table 1) and granulometric (Figure 1) composition of the used sludge was determined.

Table 1. Chemical composition of ferrous sludge

| Chemical composition, [%] ASTM E 1479/2016 |
|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Mo               | Ca              | Cu              | Cr              | Mg              | Mn              | Ni              | P               | Fe              | S               | As              |
| 0.07             | 0.06            | 0.05            | 0.04            | 0.05            | 0.18            | 0.03            | 77.09           | 0.02            | 0.005           | 0.03            | 22.26           |

Figure 1. Ferrous sludge granulometric classes

By analysing the chemical and granulometric sludge composition of the used waste that has to be put under the test must be pelletized. The ferrous sludge was put up for the pelletizing process described in Figure 2. These aspects from the time of experiments (pellets/micropellets) are shown in Figure 3.

In Figure 4 the obtained micro pellets are shown.

The obtained micropellets were used to obtain the agglomerate. The agglomeration recipe was made up from: 90% micro pellets and 10% charred coal.

The scheme of the agglomeration appliance that was used during the experiments is shown in Figure 5, and the technological flux of the agglomerate production is shown Figure 6.

The height of the agglomerate layer is decided based on its permeability, the aspiration capacity, the mineral composition of the mixture and the vertical speed of agglomerating.

The agglomeration process starts when the fuel is lit in the batch and the agglomeration happens in the superficial layer. Through the superficial layer of the agglomerate air is vacuumed from the atmosphere and the burn process is continued.

After all the fuel in the appliance is lit we can differentiate the zones shown in Figure 7.

The burning temperature in the superficial layer in which the fuel’s ignition is energized can reach up to 1000-1200grC, after as the ignition zone lowers, the temperature slowly rises up to 1300-1400grC, in the inferior layers [12], [13].

The physical-chemical process that come along with agglomeration are [14], [15]:
- Processes that take place while the matter is gas and solid form during the temperature rise in the agglomeration mix from environmental temperature to the apparition if liquid phases (burning fuel, eliminating humidity, dissociating carbonates, dissociating and oxidating sulphides, decomposing hydroxide and the complex interaction between the components of the agglomeration mix and the resulted product).
- Processes that take place during the liquid-solid-gas phases from the moment the liquid phase appears and until the maximum temperature is reached (the soaking of the material, the formation of the liquid phase and the complex interaction between the three phases).
- Processes that take place during the cooling of the agglomerate between the inspired air and the solid phases, such as the interior of the solid phases from maximum temperature to environmental temperature (the formation of the mineralogical structure of the agglomerate).

![Technological flux of obtaining micropelets](image1.jpg)

**Figure 2.** Technological flux of obtaining micropelets

![Aspects during laboratory experiments (micropellets)](image2.jpg)

**Figure 3.** Aspects during laboratory experiments (micropellets)
Figure 4. Micropellets

Figure 5. Schematic representation of the agglomeration installation

Figure 6. The technologic flux of obtaining agglomerate

Figure 7. Areas specific to the agglomeration process
These aspects from the time of experiments (agglomeration) are shown in Figure 8 and SEM image are shown in Figures 9-10.

![Figure 8](image1.png)

**Figure 8.** Aspects during laboratory experiments

![Figure 9](image2.png)

**Figure 9.** SEM Image (spectrum 1)
The lightly fusible materials that have been formed during the agglomeration process will melt firstly, dissolving with them the remaining compound of the layer. The schemes of the processes that forego the melting of the layer to agglomeration are typical for the agglomerate layer and the type of material that is being agglomerated. Through the agglomeration process a total and partial elimination of the harmful substances from the raw materials is obtained: sulphur, zinc and arsenic are eliminated.

The process of agglomeration, which is generally characterized by the agglomeration speed and the quality of the end product, is influenced by the following factors [11-16]:

- the quality of the prepared raw material that ensures a high level of permeability, which is also influenced by the granulometric composition of the waste, the shape of the granules and their equability, the level of moisture in the batch;
- the quality of the ignition in the batch that is influenced by the nature of the used fuel and adjacent mixture, the quality if the ignition air and the type of combustion appliances used;
- the use of certain influences in the agglomeration mixture;
- the mineral composition of the used waste.

3. Conclusions
Analysing the chemical and granulometric components of ferrous waste from metallic powders plant results show that this waste can be capitalized through recycling.

The procedures through which pulverous ferrous waste can be recycled in the iron industry are: agglomeration, briquetting and pelleting. The first two are recommended for wastes with a varied granulometric componence material.

![Figure 10. SEM Image (spectrum 2)]
This makes the experimental procedure easy and cost effective by companies which process and recycle these types of waste.

An important interest is shared in non-conventional recycling of waste in order to obtain a product with high metal iron composite. The experimental agglomeration obtained have a high amount of iron 60%Fe. It is necessary to intensify the capitalization process of these waste for both economical (they represent a source of iron), technological and ecological reasons.

Wastes represent, on one hand, a problem for the environment and on the other hand a business opportunity. In order to efficiently solve these problems and also develop a successful business it’s obvious that the market for waste reuse and recycle is necessary. This market is created through a simulation of all actors on the waste market and a precise regulation of the charges that fall unto each of them: waste generators, the ones involved in the capitalization and special companies that collect, by-treat, transport and deliver the waste in controlled conditions.

The ecological advantages are: cutting down the amount of powdery wastes by their continuous recycling, the diminishing of soil pollution with metallurgical waste by reducing the dumping areas, the valorization by recycling of these wastes, without any negative impact upon the environment.

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