

Capitalization possibilities of small ferrous and pulverous waste in the iron production industry

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Abstract. Small ferrous and pulverous waste are resulted from the industry and can be processed through agglomeration, briquetting or pelleting based on the granulometric features of the waste. For the current paper, the agglomeration/ briquetting method has been used and it has been made for waste resulting from the iron production industry. The laboratory experiments are pressed, together with the qualitative and quantitative tests of the experimental agglomerate/briquette. The achievement of by-products can be used as raw material in the making cast iron or steel and it permits an efficient optimizing of resources in the context of durable development, also bringing along economical and ecological advantages.

1. Introduction

In 2017 96.3% from the total of raw material used in the iron industry was turned into useful material in the following manner [1]: 63.60% was turned into steel by-products and 32.70% were turned into other by products. These other by-products are used in the industry or other sectors (for instance, cinder is used the cement industry and process gases are used for heating). These are only a few of the numerous applications of by-products from the iron producing industry. This industry does significant efforts to be 100% efficient in resource using, especially for using fully the by-products [2], [3].

The processing of small pulverous waste that result from the iron industry represents an ensemble of technological operations in which these waste are processed in the conditions required by the user. The technological operations are deciding the capitalization process of secondary products (small, pulverous waste) [4-6].

Based on processes of reducing the oxidant materials, the solution proposed in the current paper have in view the capitalization of secondary materials from pulverous small waste. The implementation of technologies depends on the nature of materials put under process and the form of the finite product.

The agglomeration/ briquetting have the advantage of allowing a varied type of waste that has iron in their composition to be processed. The recycled by-products made from small, pulverous waste are used in the iron industry as raw material in the manufacture of cast iron or steel. These are put under operation of manipulations and transport, hence they must have a great resistance to cracking and squashing in order not to be degraded during transportation. [7], [8]

2. Experimental research in the laboratory phase

The current paper presents the research and results obtained after laboratory trials regarding the capitalization means of ferrous slam using the technologies of briquetting and agglomeration.



Samples were taken from the ferrous slam that comes from the iron processing industry in order to determine the chemical and granulometric composition – as show in Figures 1 and 2.

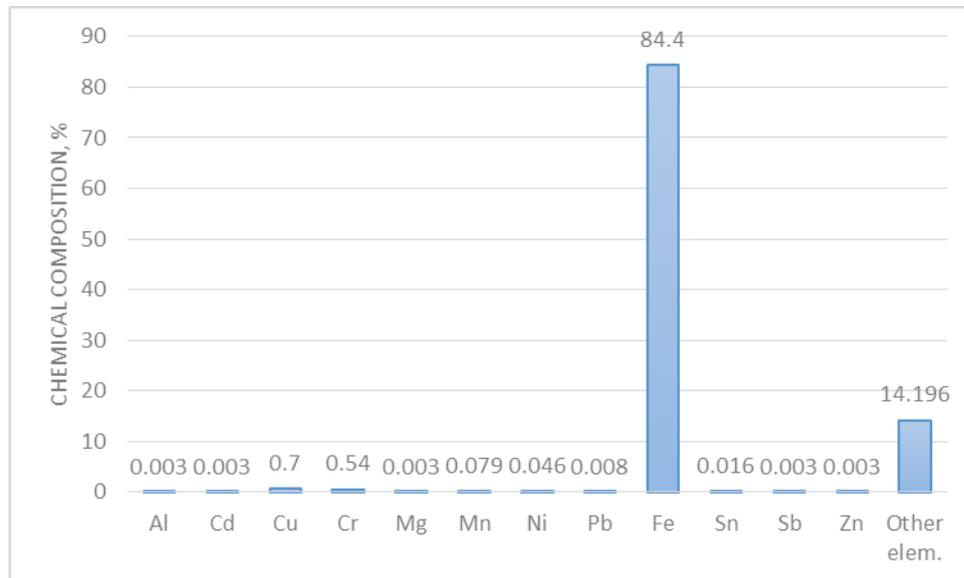


Figure 1. Ferrous sludge chemical composition

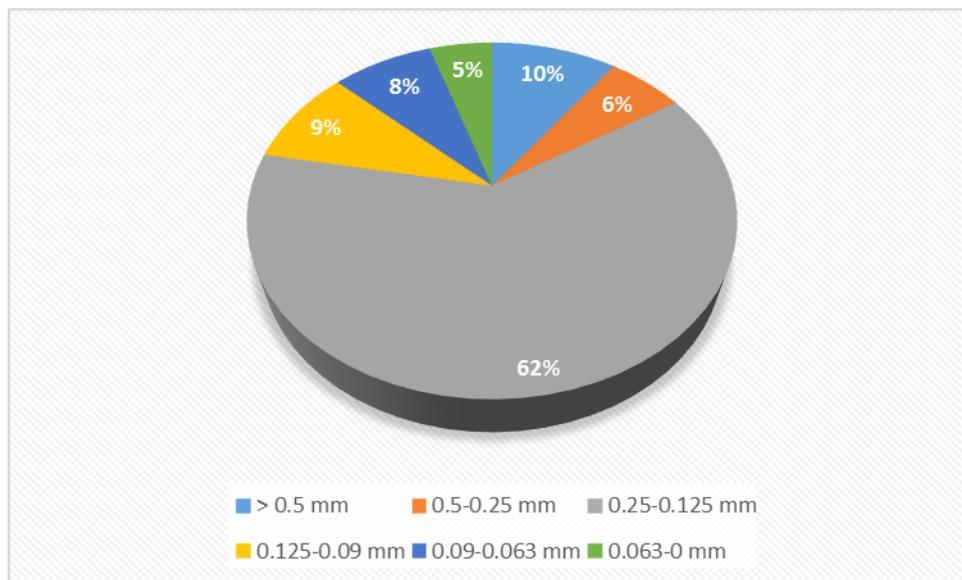


Figure 2. Ferrous sludge granulometric classes

After analyzing the chemical and granulometric composition of ferrous slam two processing methods were considered (the technological flow is presented in Figure 3):

- Method I – processing through agglomeration;
- Method II – processing through briquetting.

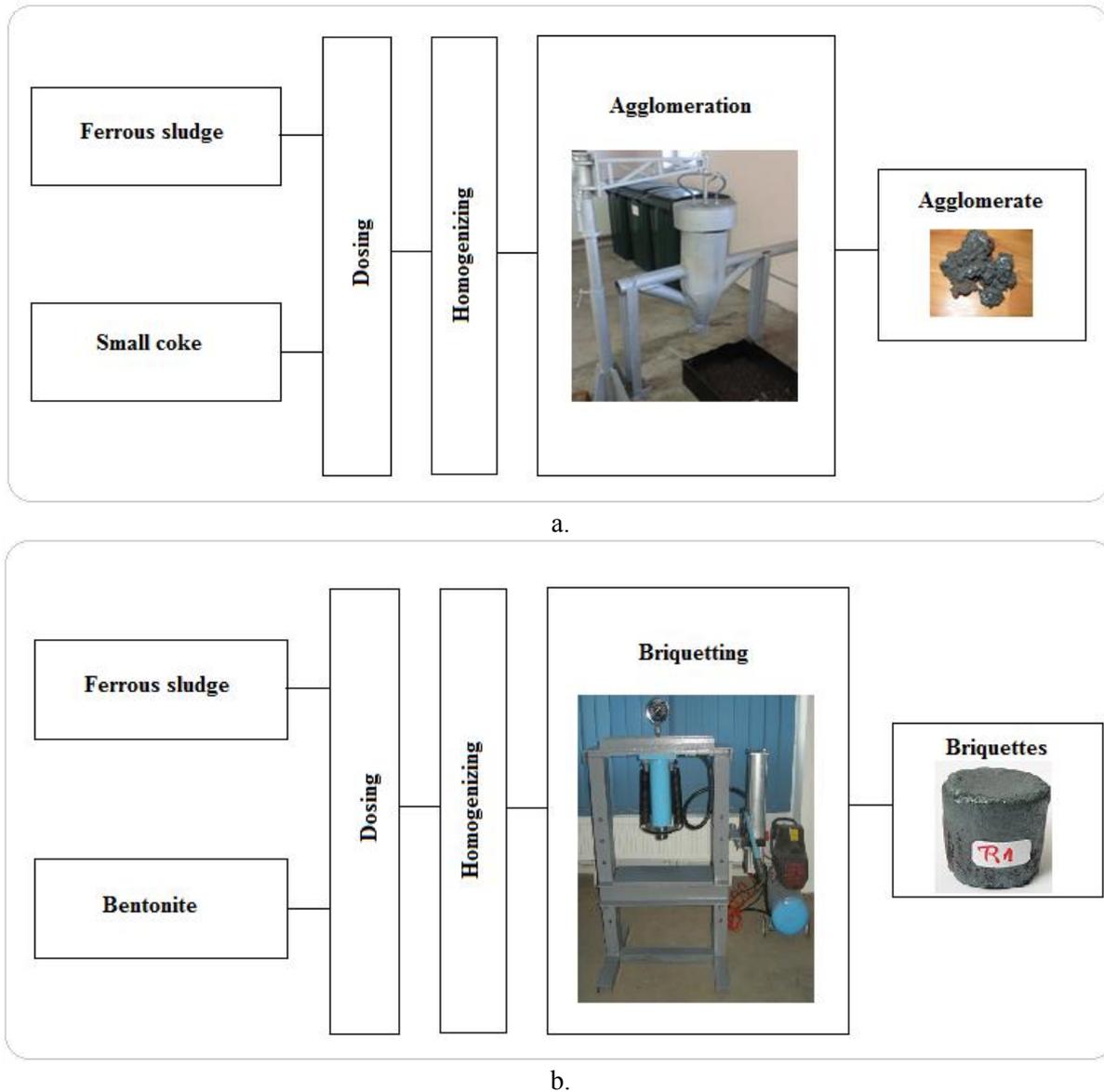


Figure 3. The technologic flux of obtaining agglomerate/briquettes:

a – agglomeration, b – briquetting

Method I – processing through agglomeration

The processing of waste in laboratory was made in an agglomeration device. The heat produced from burning a fossil fuel is introduced in the agglomeration mix. This mix is constituted from ferrous sludge and fossil fuel. During the process, besides the integration of particles, a series of chemical transformations take place. The agglomeration mix is put on the grid of the agglomeration device. The fuel is lit with a single flame above the agglomeration mix. The combustion air and the gases resulted from the burn are vacuumed on the lower side of the grid, otherwise they will run through the mixing layer. The burning zone is moving up and down due to the occlusion process, while the burning is finished at the grid's level.

In the grid of the agglomeration device's layer the following zones can be distinguished [9], [10]:

- The superior area in which the agglomerate can be found;

- The burning zone where the fossil fuel burning take place and the agglomeration of particles is produced;
- The pre-heating zone and drying of the agglomeration mix;
- The raw mix zone.

For the agglomeration process, the thermic regime of the entire experiment needs to be conducted in a manner that doesn't reduce the agglomerate. These requirements are made at a content of 18-22% FeO in the agglomeration mix.

The entire conclusions from the time of the experiment and the resulted agglomerate are presented in Figure 4.



Figure 4. Aspects during laboratory experiments (agglomeration)

From the standpoint of the chemical composition, the criteria of quality of the agglomerate are: the content of useful metal, the quantity and composition of gangue, the iron value of the malign elements, the uniformity of the composition. The reducibility is appreciated based on the content of FeO, which cannot be above 22 % [6].

The resulted experimental agglomerate was subjected to testing, the samples have been analysed by SEM (Figure 5). The obtained results are presented in Figures 6-8.

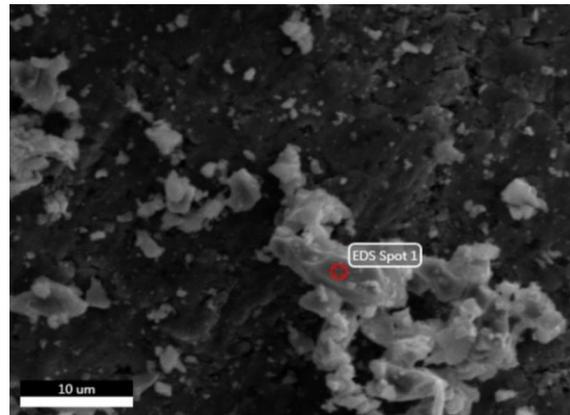


Figure 5. SEM Analysis for experimental agglomerate

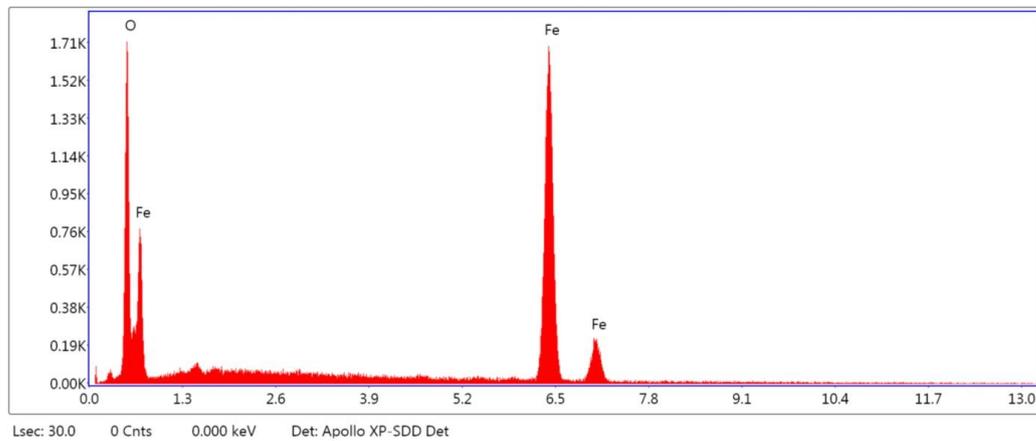
The porosity of the experimental agglomerate is suitable. The granulation of the agglomerate obtained through razing can be measured only after the cooling process. The resistance of the agglomerate is a very important factor and it has been determined on the Rubin drum. The resistance indicator of the experimental agglomerate is less than 20%.

Method II – processing through briquetting

The ferrous sludge has been put under the operation of briquetting. Briquettes with added bond were obtained (bentonite 5-10%). A cylindrical mold has been used. The obtained briquettes are used as raw material in steel burning ovens.



(a) SEM image

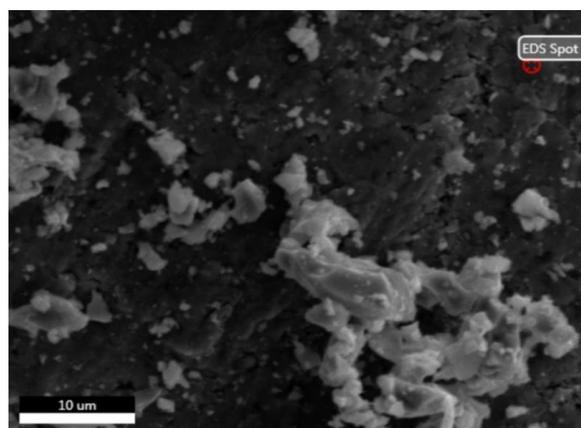


(b) EDS Spectrum Selected Area (47.77%Fe)

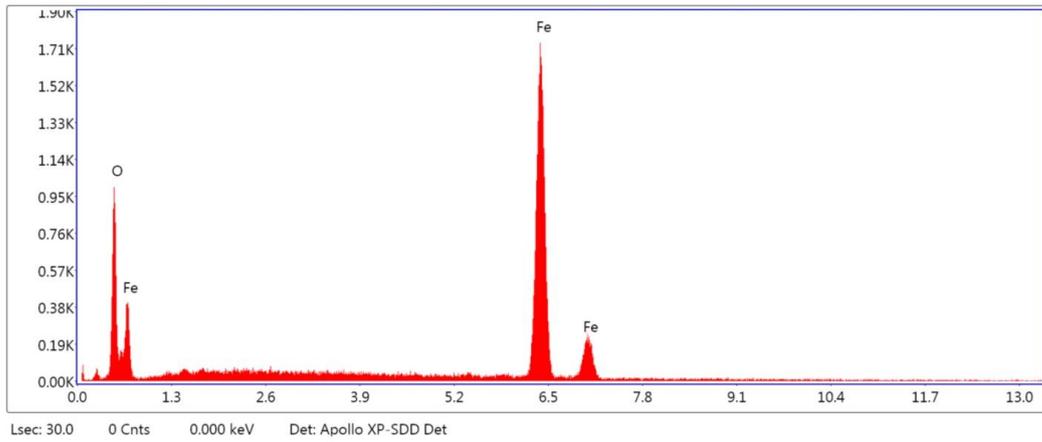
Figure 6. EDS results for experimental agglomerate (EDS Spot 1)

Aspects from the time of experiments and the resulted agglomerate are shown in Figure 9.

The experimental briquettes underwent SEM analysis in which cracking and smashing have been tested (Figure 10). The obtained results are shown in Figure 11.

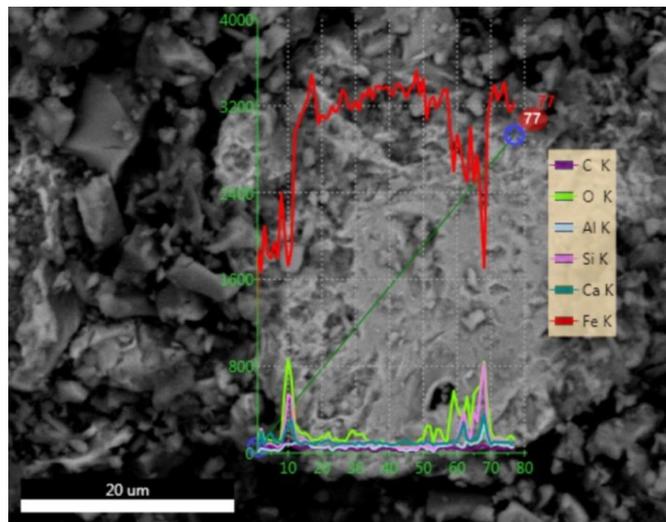


(a) SEM image



(b) EDS Spectrum Selected Area (60.88%Fe)

Figure 7. EDS results for experimental agglomerate (EDS Spot 2)



(a) SEM image



(b) EDS Spectrum Selected Area (linear analysis)

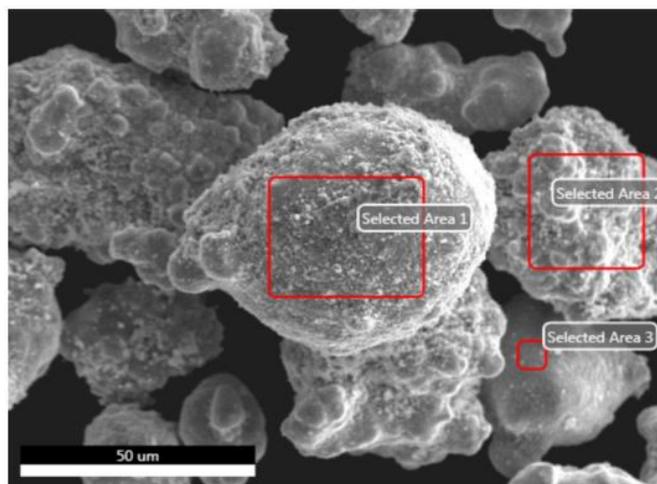
Figure 8. EDS results for experimental agglomerate



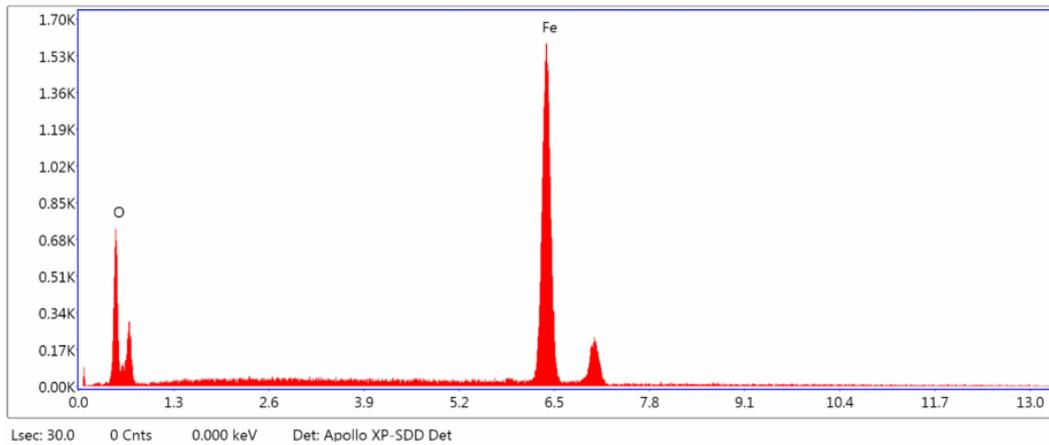
Figure 9. Aspects during laboratory experiments (agglomeration)



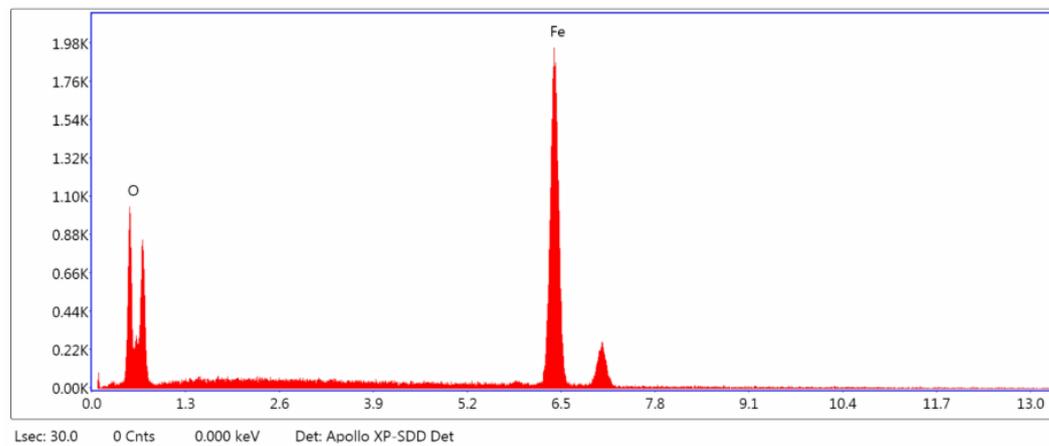
Figure 10. SEM Analysis for experimental briquettes



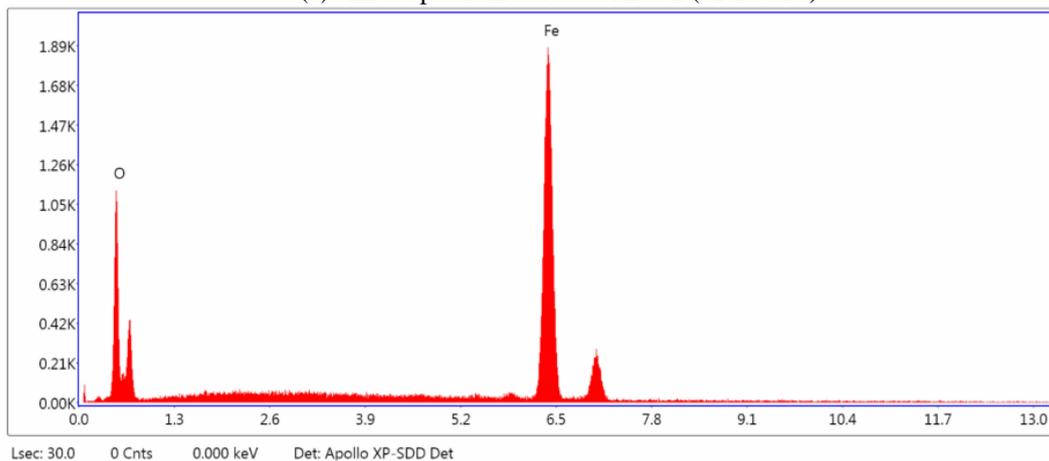
(a) SEM image



(b) EDS Spectrum Selected Area 1 (65.6%Fe)



(c) EDS Spectrum Selected Area 2 (62.24%Fe)



(d) EDS Spectrum Selected Area 2 (59.92%Fe)

Figure 11. SEM Analysis and EDS results for experimental briquette

At the obtained experimental briquettes there has been obtained a high quality as they have subjected to compression. Medium values have been obtained: 0.27kN/cm² for resistance at cracking, 0.31kN/cm² for resistance at wreckage and 0,04 kN/cm² for the spacing at wreckage. The iron content is: 59.92-65.60%.

3. Conclusions

After laboratory experiments of ferrous sludge, the following things have been ascertained:

- Analysing the chemical and granulometric composition of the sludge it concludes on the fact that it can be processed through briquetting and agglomeration;
- Ferrous sludge could be briquetted with just a small annexment of bentonite, without using further raw material, which makes the experimental process implementable at minimal costs;
- The values obtained regarding the resistance of the agglomerate it conducts to the conclusion that the product can be transported and manipulated.

The obtained by-products (briquettes and agglomerate) are destined to use as raw material in steel burning ovens as they have a content of iron of over 50%.

There is an intense need for the capitalization processes of these waste to be rushed as there are numerous economical, technological and environmental advantages in their use.

References

- [1] ***<https://www.worldsteel.org/media-centre/press-releases/2019/february-2019-crude-steel-production.html>
- [2] Ekdahl Å 2019 *Doing more with less – the case of steel industry co-products*, The fourth session of the UN Environment Assembly will gather, Nairobi, Kenya, 11 - 15 March 2019, Theme Innovative solutions for environmental challenges and sustainable consumption and production
- [3] ***Project no. 31-098/2007 *Prevention and fighting pollution in the steel making, energetic and mining industrial areas through the recycling of small-size and powdering wastes*, Program PN2 Consortium CO Responsible Heput T, Beneficiary CNMP Romania
- [4] Butnariu I, Constantin N and Dobrescu C 2018 Research on the Recycling of Pulverulent Waste from the Ferrous and Non-Ferrous Industry in Order to Reduced the Pollution, *Revista de Chimie* **69**(5) 1066-1070
- [5] Constantin N, Stanasila O and Stanasila C 2009 Alternative iron making technologies, *Metalurgia International* **14**(7) 5-7
- [6] Buzduga R V, Constantin N and Lazar E A 2015 Research on uses plant ashes in processing powders for classical moulding of steel, *IOP Conf. Ser.: Mater. Sci. Eng.* **85** 012008
- [7] Andrei V, Hritac M and Constantin N 2017 Experimental research on the behavior of the pneumatic transport of fine-grained iron, *IOP Conf. Ser.: Mater. Sci. Eng.* **163** 012011
- [8] Dragomirescu A, Constantin N and Stefan A 2017 Advanced study of thermal behaviour of CSZ comparing with the classic YSZ coating, *IOP Conf. Ser.: Mater. Sci. Eng.* **163** 012040
- [9] ***Project no. BC 13/2018 Responsible Ardelean M, Beneficiary Johnson Solution SRL Deva
- [10] Andrei V and Constantin N 2015 Experimental research on quality features of metallurgical coke, *IOP Conf. Ser.: Mater. Sci. Eng.* **85** 012004