ACTA TECHNICA CORVINIENSIS
– Bulletin of Engineering
Tome IX [2016] , Fascicule 1 [January – March]
ISSN: 2067 – 3809

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THE Matlab ANALYSIS OF SMALL AND POWDERY FERROUS WASTES DESTINED FOR THE PRODUCTION OF BRIQUETTES IN SOME LABORATORY EXPERIMENTS

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Abstract: In most industrialized countries pollution of air, water and landscape has a common cause: discharge of manufacturing wastes in the environment without a real concern of avoiding it. Measures needed to combat pollution require considerable investment and significant operating expenses, especially in the steel industry. In the industrial sector, in most cases, in addition to the main product, there are one or more products which can be returned to the steel circuit after a quick processing. By combining economic imperative to maximize the recovery of scrap with the social aspect of action to combat environmental pollution in order to restore and maintain the ecological balance, a particular attention must be paid to waste recovery problem. The paper approaches the problem of fine and pulverous wastes recovery from mining and steel industry.
Keywords: pollution, environment, steel industry, usage, wastes, briquetting, Matlab analysis

INTRODUCTION

The alteration of global ecosystems, because of consumption and production, shows how important is the process of rethinking the use of natural resources by the economy and society. For industry, the problem of managing the recovery (recovery, recycling) is an environmental and economic priority [4,12,13]. For human communities and natural ecosystems in the steel industry and mining sites, pollution and risk do not disappear with the cessation of mining and processing of minerals, furthermore, it continues, the sites remain sources of pollution and risk.

Figure 1. The waste management hierarchy

Wastes contain substances resulting from industrial activity where they are produced and disposal of these wastes from the production cycle is achieved by a proper recovery: recovery and / or disposal for recycling and stabilization/solidification for storage in landfills [10,11,13].

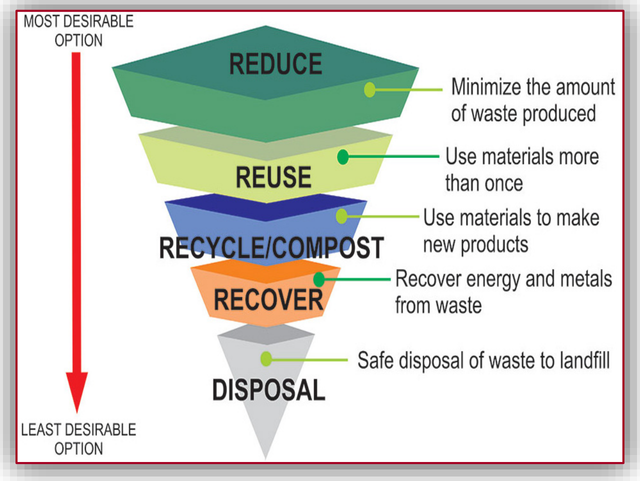

Figure 2. The waste most & least desirable options

Recovery includes the collection, transport, storage, selection and processing of certain waste, which can be returned to a flow sheet by internal and/or external recycling. Internal recycling (direct recycling) consists of reintroducing the recovered industrial wastes in the same flow sheet that generated them, and external recycling (reuse) is the industrial activity that reintroduces the recovered waste in a flow sheet that is completely different from the one which generated it. By combining economic imperative to maximize the recovery of scrap with the social aspect of action to combat environmental pollution in order to restore and maintain the ecological balance, a particular attention must be paid to waste recovery problem [5–13].

Benefits on economical (chain added value, jobs in the recycling sector, etc.), ecological (increased recycling rates, application of high standard processes, etc.) and social (industrial safety) level are increasing the significance of small and powdery ferrous wastes recycling.

LABORATORY EXPERIMENTS

Briquetting is the method by which pieces of spherical, oval or rectangular forms are obtained from fine/small and pulverous waste during compressing operations on specialized equipment, followed by a drying–roasting process in order to increase their mechanical characteristics [5–13].Briquetting applies to pulverous wastes (powder resulting from dedusting plants) and also to fine products obtained by precipitation. For waste briquetting (at 50–60°C) inorganic binders are used (limewash, Na_2SiO_3) and sometimes organic binders (sulphite liquor, heavy tars etc.).

Experiments on the production of briquettes were conducted within the laboratory of the Doctoral School of the Faculty of Engineering Hunedoara, University Politehnica Timişoara. Determination of waste chemical composition was carried out in the laboratories of ArcelorMittal Hunedoara Company.

To obtain briquettes, the raw material is subjected to fine grinding, which usually is performed in ball mills. Wastes which are substandard in terms of grain size are ground with these mills. Recipes with pulverous wastes are prepared. Homogenization of waste is done manually or in mixing plant with the addition of binders, and to obtain briquettes, the press is equipped with a mold chosen in accordance with the type of desired briquette. The proportions of wastes were determined in 13 recipes, compliance with these recipes is mandatory in order to obtain briquettes with appropriate quality standards [5–13].

Once the briquettes are obtained, they are subjected to hardening processes after a diagram heating/holding/cooling, and then dried and tested to determine the qualitative characteristics (compression tests to determine resistance to cracking, crushing and grinding interval).

For recovery of small and pulverous wastes as briquettes from steel industry, energy and mining, we considered the following wastes: agglomeration–furnaces dust, steel dust, galvanic sludges (two different types) and red mud from bauxite refining (bauxite residue). As binder we considered the following three types of powdery materials: limewash, bentonite and graphite [5,6,10–13].

Using the Matlab program, we plotted the dependencies between the same correlation parameters, presented in Figures 3–14. In fact, in this mathematical experiment using the Matlab, we verified the regression equations obtained in Matlab (through the coefficients of multiple determination of the same type of equations), and we plotted the regression surfaces and, additionally, the correlation diagrams for the proportion of the small and pulverous wastes used in the recipes which assure the optimal resistance to crushing and the resistance to cracking of the obtained briquettes.

RESULTS OF THE Matlab ANALYSIS

Although polynomial regression is technically a special case of multiple linear regression, the interpretation of a fitted polynomial regression model requires a somewhat different perspective.

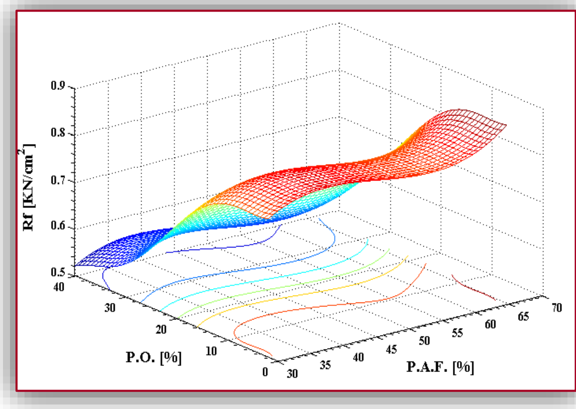

Figure 3. The regression surface determined by the briquettes resistance to crushing depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination: R^2=0.9994282003)

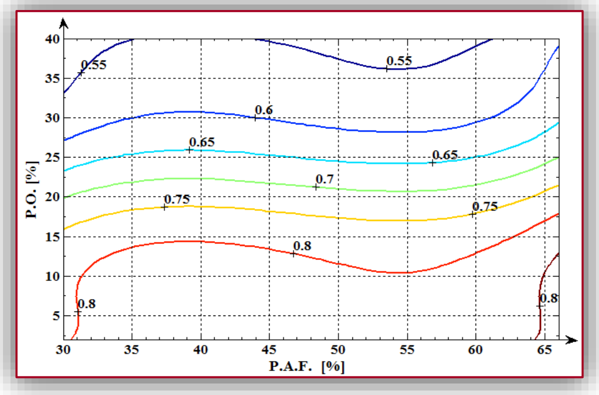

Figure 4. The correlation diagram determined by the briquettes resistance to crushing depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination: R^2=0.9994282003)

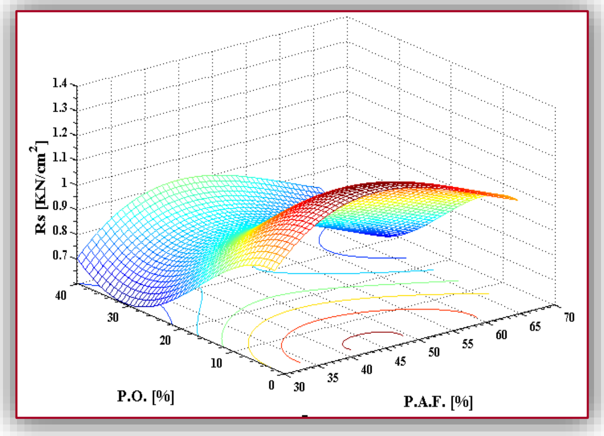

Figure 5. The regression surface determined by the briquettes resistance to cracking depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination: R^2=0.9910367990)

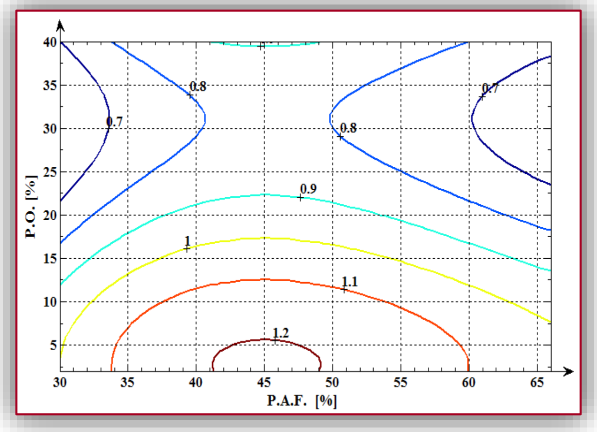

Figure 6. The correlation diagram determined by the briquettes resistance to cracking depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination: R^2=0.9910367990)

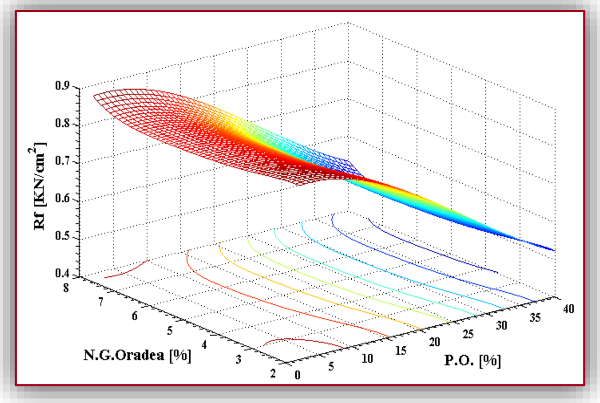

Figure 7. The regression surface determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination: R^2=0.9994749743)

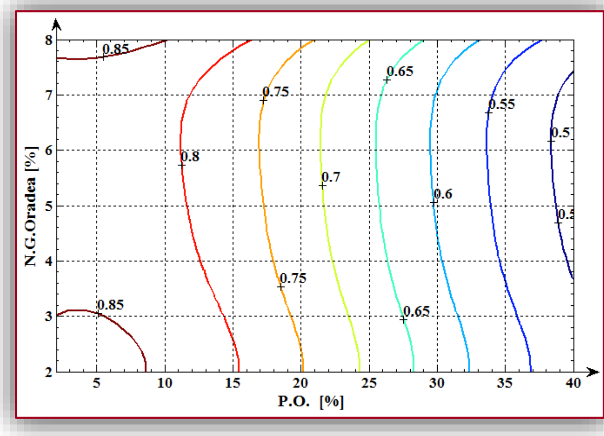

Figure 8. The correlation diagram determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination: R^2=0.9994749743)

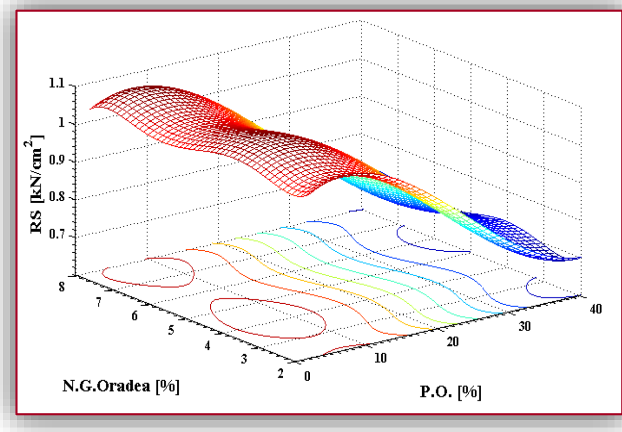

Figure 9. The regression surface determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination: R^2=0.9941040618)

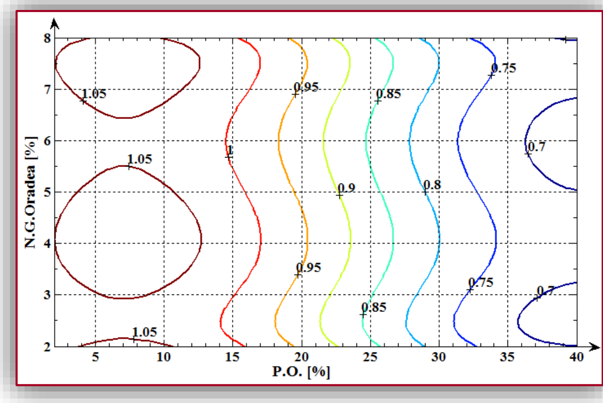

Figure 10. The correlation diagram determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination: R^2=0.9941040618)

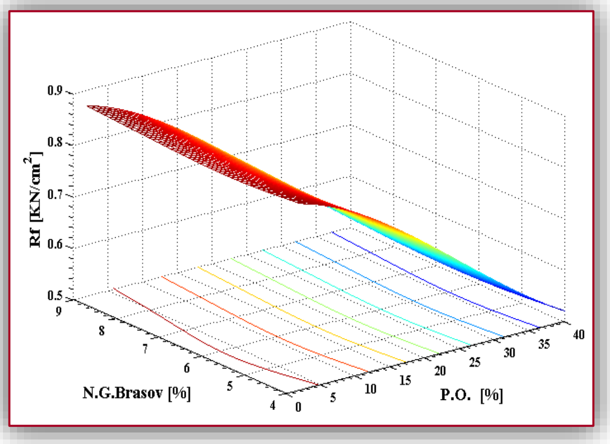

Figure 11. The regression surface determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination: R^2=0.9971393267)

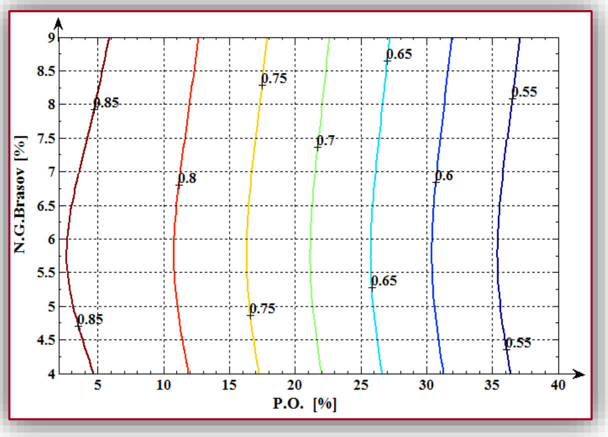

Figure 12. The correlation diagram determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination: R^2=0.9971393267)

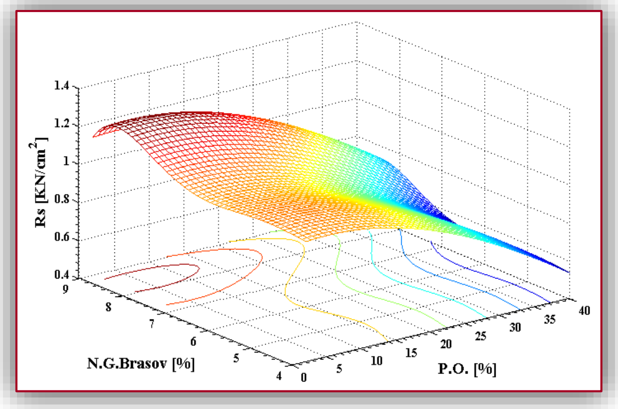

Figure 13. The regression surface determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination: R^2=0.9956932644)

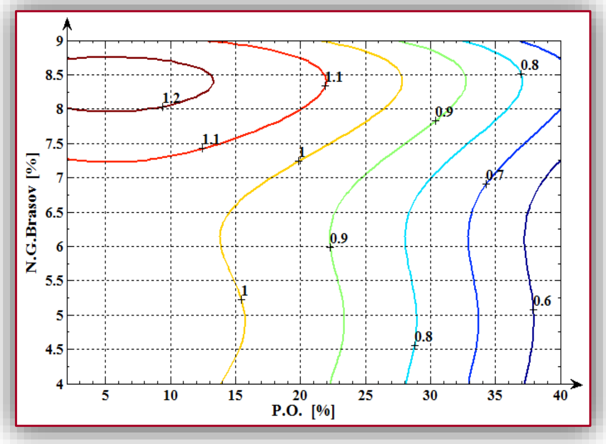

Figure 14. The correlation diagram determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination: R^2=0.9956932644)

The goal of polynomial regression is to model a non–linear relationship between the independent and dependent variables (technically, between the independent variable and the conditional mean of the dependent variable). In this sense, the experimental data were processed in the Matlab programs. We plotted the regression surfaces and the correlation diagrams between the briquettes main characteristics and the small and pulverous wastes quantities proportion.

Correlation quantifies the strength of a linear relationship between two variables. When there is no correlation between two variables, then there is no tendency for the values of the variables to increase or decrease in tandem. Two variables that are uncorrelated are not necessarily independent, however, because they might have a nonlinear relationship. We use the linear correlation to investigate whether a linear relationship exists between variables without having to assume or fit a specific model to the industrial and laboratory data. Two variables that have a small or no linear correlation might have a strong nonlinear relationship. However, calculating linear correlation before fitting a model is a useful way to identify variables that have a simple relationship.

The realization of the graphic interfaces (Figures 3 – 14) for the representations variation areas of the briquettes chemical compositions in accordance with the mechanical properties of the briquettes (resistance to cracking, resistance to crushing), completes this area of preoccupations within a processing of small and pulverous wastes from industrial steel and mining areas.

These surfaces (described by the equation), belonging to the three-dimensional space can be reproduced and therefore interpreted by technological engineers. Knowing these level curves (in the correlation diagrams) allows the correlation of the values of the two independent variables so that we can obtain a mechanical properties within the required limits.

CONCLUSIONS

Most of the reasons we recycle are environmental, although some are economic. One of the main reasons for recycling is to reduce the wastes sent to landfills. Recycling has a variety of economic impacts. For the steel companies that buy used goods, recycle them and resell new products, recycling is the source of all their income. For the industrial cities which have ferrous wastes landfills, like Hunedoara, in densely populated areas that have to pay by the ton for their landfill usage, recycling can shave millions of dollars off municipal budgets. The recycling industry can have an even broader impact. Economic analysis shows that recycling can generate three times as much revenue per ton as landfill disposal and almost six times as many jobs.

As a result of our analyses performed on products obtained by processing small and pulverous wastes from industrial steel and mining areas and the experiments conducted in the laboratory stage, we consider the following remarks:

- the studied small and pulverous wastes (steel dust, agglomeration–furnaces dust, galvanic sludges) can be processed by using the available technology like briquetting and can be reintroduced into the steel circuit with minimum investment costs;
- reintroduction of small and pulverous wastes into economic circuit has both economic and ecological effects, by releasing the occupied terrains (ponds, landfills, disused buildings) in case of deposited wastes, vacancy of areas for waste resulting routinely on technology flows.
- the results of the experiments lead to the conclusion that the analyzed wastes can be processed by briquetting (to provide mechanical strength characteristics superior to those minimum values for this method), this method allows recovery of waste with high variation limits in terms of grain size (desirably under 2 mm);
- technological alternatives presented have the advantage of offering solutions for all waste generated ferrous powder, regardless of the content of iron and non-ferrous elements, resulting in current technology flows, as well as those stored in ponds and waste dumps.
- analysis of these technologies provides environmental treatment of these types of waste allowed to be noted that for Romania is a particularly important issue because there is an amount of them deposited as dumps and continues to generate higher amounts.

We consider that can be processed both the wastes resulted in technological flows and those deposited in ponds or landfills.

Economics, as well as environmental considerations, are giving a new impetus to resource recovery and recycling. There are many different ways that materials can be recycled. The technique that is used to create the new materials from the old depends on what the material is. In the case of the present studied small and pulverous wastes within the laboratory of the Doctoral School of the Faculty of Engineering in Hunedoara, University Politehnica Timişoara, respectively steel dust, agglomeration–furnaces dust and galvanic sludges, can be processed by using the available technology like the briquetting process. These kind of small and pulverous ferrous wastes can be reintroduced into the steel making circuit with minimum investment costs. In fact, recycling of small and pulverous ferrous wastes prevents useful material resources from being wasted, reduces the consumption of raw materials and reduces energy usage during the steel manufacturing process, compared to virgin production.

The experimented researches, as well as the optimization of the manufacturing technology of these type of briquettes, allow the conclusion of direct results for these reused wastes. The beneficiaries of these results are the unit in which the briquettes are manufactured, as well as the unit that used them.

References

[1.] CIOCAN, A., Turning waste generated in small and powder metallurgy, National Publishing Group Publishing, Bucharest, 2003.
[2.] CONSTANTIN, N., NICOLAE, M., GEANTA,V., BUTNARIU, I., LEPADATU, G., Processes and alternative technologies in steel, PRINTECH, Bucharest, 2009.
[3.] CONSTANTIN, N., NICOLAE, M., RUCAI, V., Research regarding the physical and chemical characteristics of pre–reduced iron ores the analysis of the possibilities of their use in the iron and steel elaborating process, International Conference – Prereduced products and Europe, Milano – Italia, 1996, 230–239.
[4.] *** Pollution Prevention and fighting in the steel making, energy and mining industry areas through the recycling of small–size and powdering Wastes, Program PN2–Consortium–CO, Research Project nr.31–098/2007.
[5.] HEPUŢ, T., SOCALICI, A., ARDELEAN, E., ARDELEAN, M., CONSTANTIN, N., BUZDUGA, R., Recovery of ferrous waste and small bulk, Politehnica Publishing House, Timişoara, 2011

[6.] El–HUSSINY, N.A., SHALABI, M.E.H., A self–reduced intermediate product from iron and steel plants waste materials using a briquetting process, Powder Technology, Volume 205, Issues 1–3, 2011, 217–223
[7.] STRANGE, R., Method of making briquettes and product, JCS Industries, 1981
[8.] FORD, G.W Jr., Process for recovering iron from iron–rich material, Covol Technologies, 1994
[9.] VALENTI, N., Formed briquettes, process for forming the same and process for utilizing the same in the manufacture of metals, Ohio & Pennsylvania Fuels Co, Ltd., 1991
[10.] TODORUT, A.S., SOCALICI, A., Recovery of powdery waste results from technological flows in siderurgy, International Journal Of Systems Applications, Engineering & Development, Issue 3, Volume 6, 2012, 251–258
[11.] TODORUŢ, A., HEPUŢ, T., Broadening of raw materials in the steel industry, by recycling wastes, International Conference on Energy, Environmental and Chemical Engineering, Paris, France, ISSUE 71, 2012, 1466–1472.
[12.] ROBINSON, R., Recycling of metallurgical by–products within integrated iron and steelmaking, Lulea University of Technology, 2004
[13.] ŞERBAN, S.G., HEPUŢ, T., Ferrous wastes recovery possibilities in the area of steel industry – experiments in the laboratory phase on the briquettes production from fine and pulverous wastes, Acta Technica Corviniensis – Bulletin of Engineering, Fascicule 3 / 2015 [July–September], 49–56
[14.] SERBAN, S., HEPUT, T., JITIAN, S., KISS, I., The Datafit analysis of briquettes manufacturing process from fine and pulverous ferrous wastes, The V International Conference Industrial Engineering and Environmental Protection 2015 (IIZS 2015), 2015, Zrenjanin, Serbia, 417-422
[15.] SERBAN, S., HEPUT, T., JITIAN, S., KISS, I., The Matlab analysis of briquettes manufacturing process from fine and pulverous ferrous wastes, The V International Conference Industrial Engineering and Environmental Protection 2015 (IIZS 2015), 2015, Zrenjanin, Serbia, 423-426

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809