Research on the recovery of waste in plastic deformation processes

M. L. Strugariu, T. Hepuț

Abstract — The conversion of iron or steel into sheet, wire or rods requires hot and cold mechanical transformation stages frequently employing water as a lubricant and coolant. Contaminants include hydraulic oils, tallow and particulate solids. Many steel industry wastewaters are contaminated by hydraulic oil also known as soluble oil.This paper presents experimentation (as a laboratory phase) on the possibility of recovery oily Mill Scale by sintering. Based on the experimental results in laboratory phase, a processing technology is proposed for this waste in order to obtain briquetting. Recovery of oily mill scale has both environmental and economical effects by reducing the amounts deposited. Briquetting process has the advantage that it allows a wide range of wastes containing iron both in terms of chemical composition (primarily iron content) and granulometric composition. For industrial areas, especially in the profile steel, recovery of waste by briquetting considered the most viable technological solution.

Keywords — mill scale, waste, briquette, recovery, experimentation, briquetting

I. Introduction

The development of metallurgical industry is related to solving the major problems arising from industry-nature relationship strictly targeted on controlling pollution and protecting natural and energetic resources[3]. The concerns pursued in the strategies to develop steel plants all over the world enroll in two directions:

- The development of advanced technologies that substantially reduce emissions
- The increased yields of by-products recovery and recycling up to 100%.

The concern to meeting the requirements on environmental protection and the need to harmonize economic development processes, should lead to recovery of waste by technologies that provide the best solution both economically and environmentally [8]. Compared with the practice and trends worldwide, Romanian steel industry recorded sluggishness, both in the collection, transport and waste disposal, as regards solutions recycling and / or their utilization.[1]

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Depending on the specific conditions of each factory and local market requirements, of each material used, any waste can become a by-product and any by-product may become waste[6].The administration of secondary materials must represent a problem of strategy in the internal practice of the company, taking into account the following objectives:

- reducing to the minimal level the quantity of secondary products;
- minimizing through recycling the quantity of secondary products obtained from a technological process;
- increasing the degree of recovery (transforming wastes in useful sub-products for other sectors of economy);
- dominating through supervising and control of problems with a negative impact upon the environment, that can occur when treating and transporting waste[11]-[12].

II. Problem Formulations

Providing that mill scale is very rich in iron, the mill scale deposits are of great economic importance.

Currently, a mill scale remelting process does not exist and procedures based on pyro-metallurgical ore require large investments and can not be applied to small businesses. Oily mill scale from wastewater treatment, in terms of recovery, becomes a problem because of hydrocarbons in significant amounts (2-4%) in its composition. The use of oily mill scale can cause smothered burns in electrostatic precipitation. [2]

Because of this the oil ratio in mill scale is limited to 0.1-0.5%. Recycling in large quantities requires its treatment to reduce the oil content.Trimming low-oil can be recycled to congestion; water can be reused in the process or at other stages of technological flux and used oil is usually burned in a special facility as an auxiliary fuel[8].

III. Problem Solutions

In this context, today, the specialists in steelmaking industry contribute to improve the existent technologies to and replace them with other technologies with minimum pollution[5]. These technologies are more expensive but very efficient in time, from the environmental point of view and also from the population health estate [12].

Until now, at national level, recycling of this waste was accomplished by sintering at sinter units within steel plants and by pelletizing at units within chemical industry (for example recycling iron sludge generated in chemical industry.

*Recovery by sintering.*In this processing technology, pulverous ferrous wastes (steel plants dust) compose the agglomeration charge in a proportion of 2-3% (sometimes together with other ferrous wastes like sunder, blast furnace flue dust, agglomeration dust, etc.). The obtained agglomerate is later used as raw material in furnace charge[4]. Agglomeration process in the double layer: In the classic process of sintering, the products resulting from organic lubricants and coal contained in waste vaporize and are drawn into the process gas that is discharged from the combustion and cracking before their. The part volatile sintering the mixture of hydrocarbons is considered the main cause dioxin emissions[2].

Recovery through pelletizing

This involves using steel plant dust as unique in the agglomeration charge, or in a mixture pulverous ferrous ore or other pulverous producing pellets[7]-[10].

Recovery through reduction without initial processing

These technologies require iron reduction from powder wastes either with a gaseous reduction agent, or with carbon, obtaining iron sponge, used in electric arc furnace charge[7].

At international level, in addition to the technologies mentioned above, briquetting is a common practice especially for wastes with grain size over 3 mm, and here we highlight the recycling technologies and waste management at Thyssen-Krupp Stahl AG. Mills sector is the most important source of water pollution due to particles of iron oxide (scale) and oil in suspension, resulting in the different cooling and cleaning operations taking place in the rolling process [4]. Of the technologies mentioned above, in their experiments we chose the briquetting of waste in the presence of various additives, taking into account the amount of waste available[9].

The briquettes obtained were cylindrical with a diameter of 4 cm and a height of 4-6 cm. Dimensions within the limits set provides good resistance to ensure both cracking and crushing (basic conditions for handling) and a specific surface of the corresponding reduction (acceptable). Thus, two sorts were used to scale the features presented in table 1.

Table 1. Scale features

No	Waste	Chemical composition, [%]			
		tunder	Fe	humidity	oil
1	Oil Mill Scale (A)	67.18	44.67	19.43	13.39
2	Tunder (B)	96.37	83.76	2.46	1.17

Oil Mill Scale has undergone a heating process (drying, dehydration) which led to the elimination of water and a large quantity of oil. After dehydration scale had the following composition: Fe 62.04%, water 2.46% and oil 2.11%.

Experiments were performed in the presence on a total of two lots, each lot being produced in lighter after a number of 7 recipes. [2]

Raw materials (ferrous material) base is the scale, its share of ferrous materials ranging from 55-100%. Note that besides the scale we used iron powder and waste, to ensure a better link between particle scale. The following procedures will be performed within this technology:

Suppling with raw materials and auxiliary units is assured from ferrous waste and binder providers. Separate silos are used for storage of raw materials.

Determination of chemical and granulometric composition of materials under processing. Granulometric fraction>1 mm must not exceed 10%. If the iron content is less than 30% in agglomerated sludge, the proportion of sludge is reduced with 2% in briquetting batch and the proportion of mill scale is equally increased.

Distribution of materials according to the set recipe for a briquetting batch weighing 2 kg.

After dosing, the materials are introduced into the mixing drum, the time set for this operation is 10min

After mixing, the material (2 kg material / batch) is introduced into the briquetting machine.

The waste consisted of electric steelworks dust, red mud, tailings concentrate sideritic and sintering furnace sludge. Experiments were performed in the presence of various additives, taking into account the quantity of waste available. Also, for binding, lime powder and cement were used in Table 2 are shown in Figures 1-3 and the composition of recipes, issues during the experiments and examples of lighters results.

Table 2. Recipes component

Component	R1	R2	R3	R4	R5	R6	R7
Lot 1 [%]							
Tunder A	75	0	41.66	50	29.16	29.16	33.33
Tunder B	0	75	41.66	25	50	29.16	41.67
Red mud	8.34	8.34	4.16	8.34	12.50	29.16	8.34
Cement	16.66	16.66	12.52	16.66	8.34	12.52	16.66
Lot 2 [%]							
Tunder A	62.5	0	33.33	50	50	29.16	62.5
Tunder B	0	62.5	33.33	0	25	29.16	20.83
Siderit waste	20.83	20.83	16.66	0	0	0	0
Red mud	8.33	8.33	4.16	33.33	4.16	33.33	8.33
Lime powder	8.34	8.44	29.18	16.67	20.84	8.35	8.34

After waste briquetting, briquettes obtained were subjected to a hardening process by drying in an oven at 220^0C and maintained for 1 hour, during which were released a series of emissions from contained waste oils. Also, lighter in composition which was hardened cement was used in air for 7 days. Subsequently, all experimental groups was determined that resistance to cracking and compression crushing resistance. Compression tests were analyzed on a universal tensile-compression testing machine.

Fig.1. Testing equipment

Fig. 2. Installation of briquetting

Fig. 3. Testing briquettes

To assess the briquettes quality in terms of resistance to handling and transportation, three technological characteristics were determined by experimentation: resistance to cracking, resistance to crushing, shredding range. The data obtained have made several load-dependent components that demonstrate the influence of briquetting of these indicators is shown in figure bellows.

A number of correlations made for a lot I (figure 4…7) and for lot II (figure 8…11) experimental recipes are shown in the figure above, so we represented variation of R_f, R_s, I_s depending on the proportion of tunder A-B-red mud and cement.

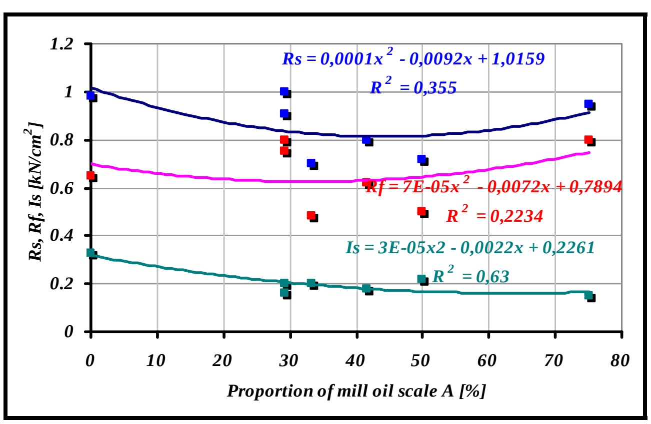

Fig. 4. Variation of R_f, R_s, I_s depending on A

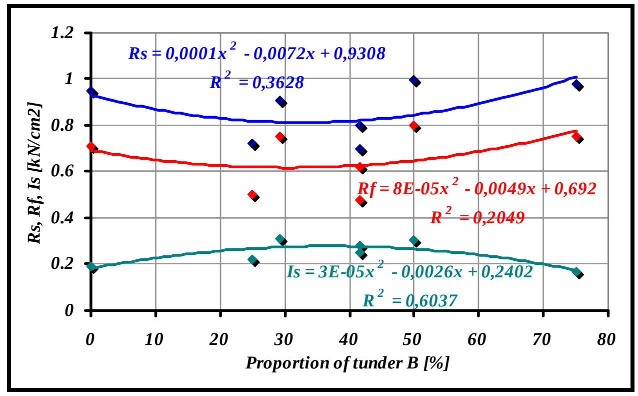

Fig. 5. Variation of R_f, R_s, I_s depending on tunder B

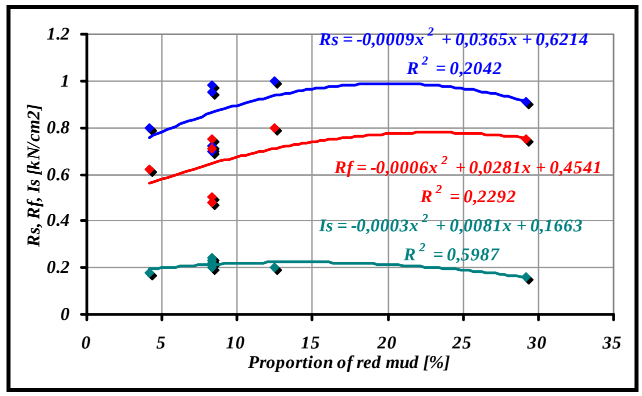

Fig. 6.Variation of R_f, R_s, I_s depending on red mud

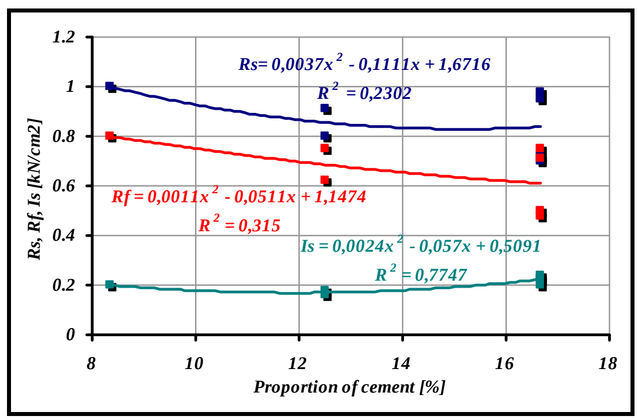

Fig. 7. Variation of R_f, R_s, I_s depending on cement

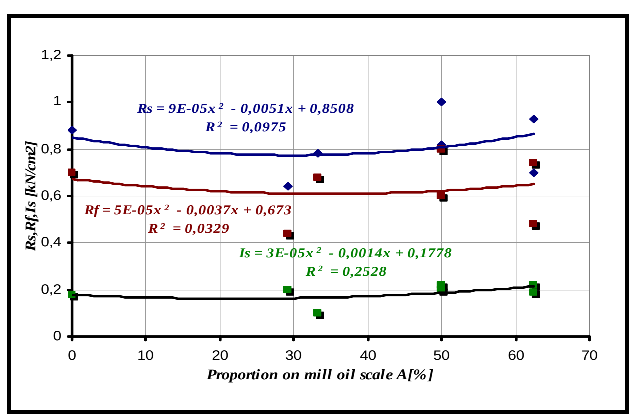

Fig. 8. Variation of R_f, R_s, I_s depending on A

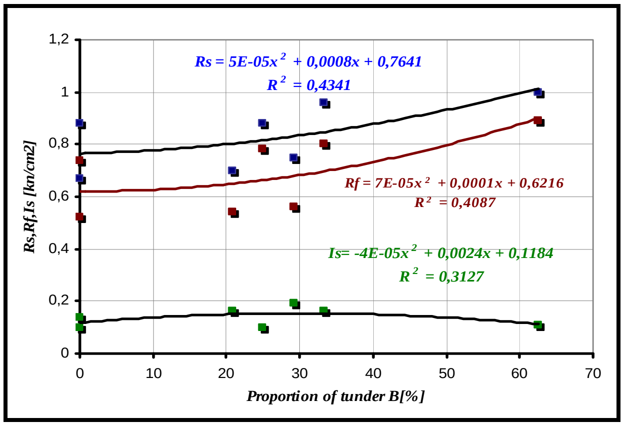

Fig. 9. Variation of R_f, R_s, I_s depending on tunder B

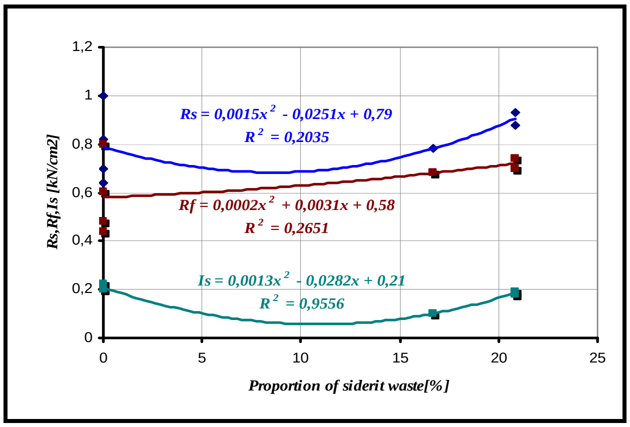

Fig. 10. Variation of R_f, R_s, I_s depending on siderit waste

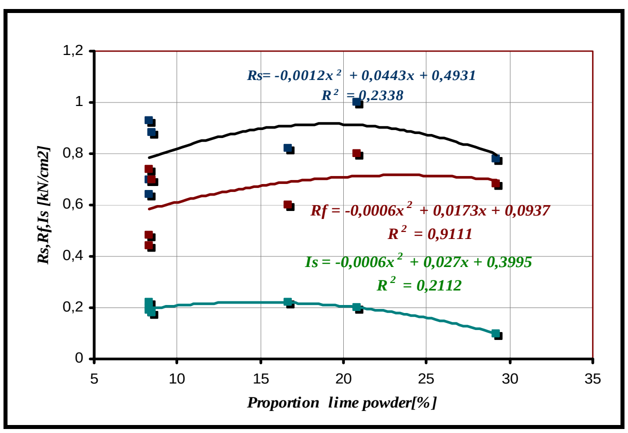

Fig. 11. Variation of R_f, R_s, I_s depending on lime powder

Next, there are shown the results of the multidimensional processing of experimental data. For the statistical and mathematical analysis, there were used the cases described in the above mentioned seven recipes. Using the Matlab calculation and graphical programs we determinate some correlations between the main components (Oil mill scale, Mill scale and Red mud) and the mechanical behavior (Rf, Rs and Is). The results in Figures 12-20 are presented.

Also, in Figures 21-29 the correlation between the main components (Cement, Mill scale and Red mud) and the mechanical behavior (Rf, Rs and Is) are presented.

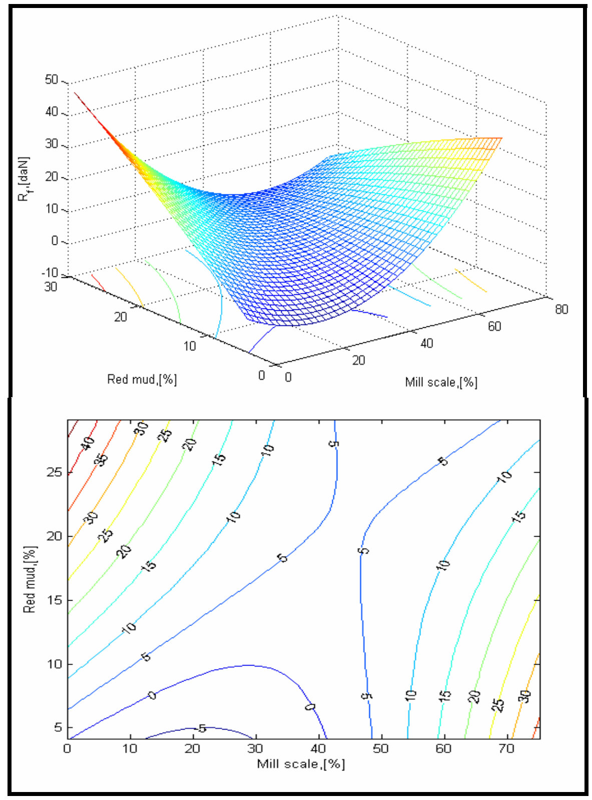

Fig. 12. The regression surface and the level curves in the correlations Mill scale, Red mud and Rf

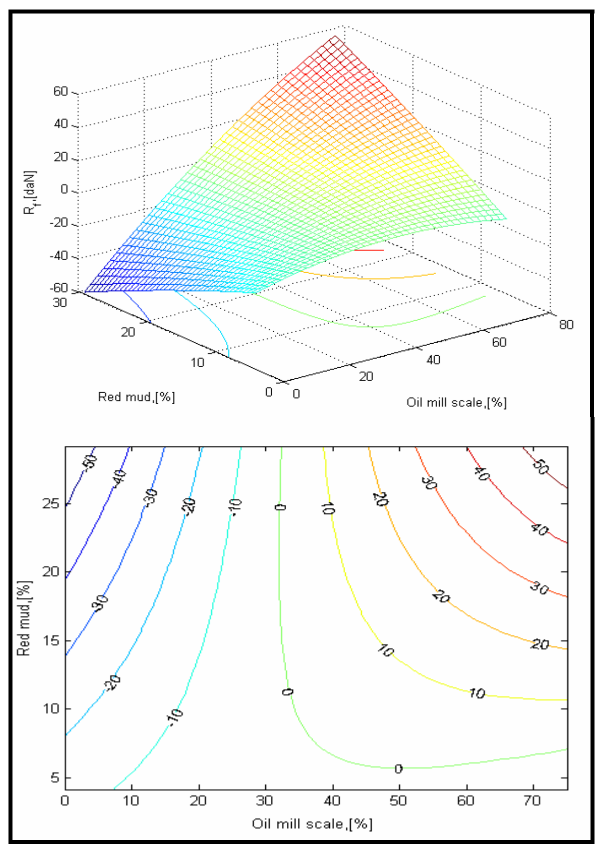

Fig. 13. The regression surface and the level curves in the correlations Oil mill scale, Red mud and Rf

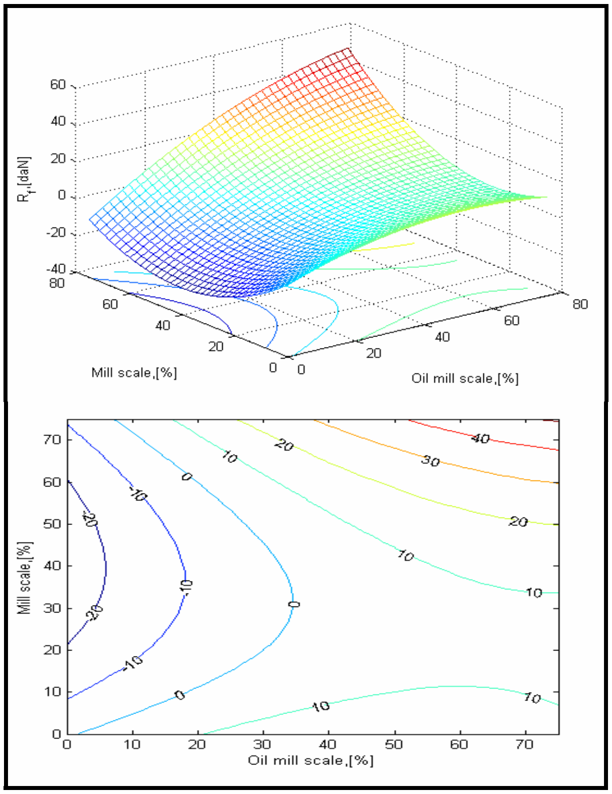

Fig. 14. The regression surface and the level curves in the correlations Mill scale, Oil mill scale and Rf

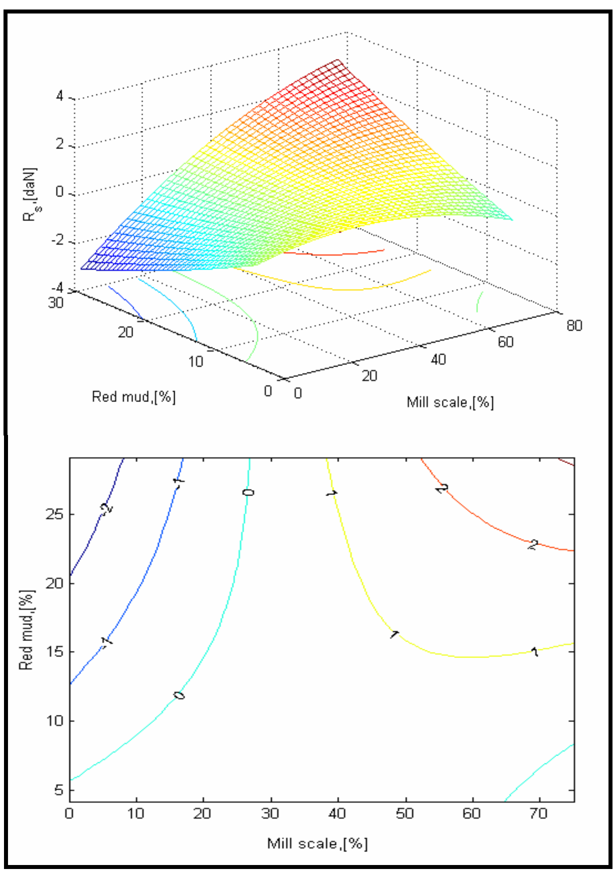

Fig. 15. The regression surface and the level curves in the correlations Mill scale, Red mud and Rs

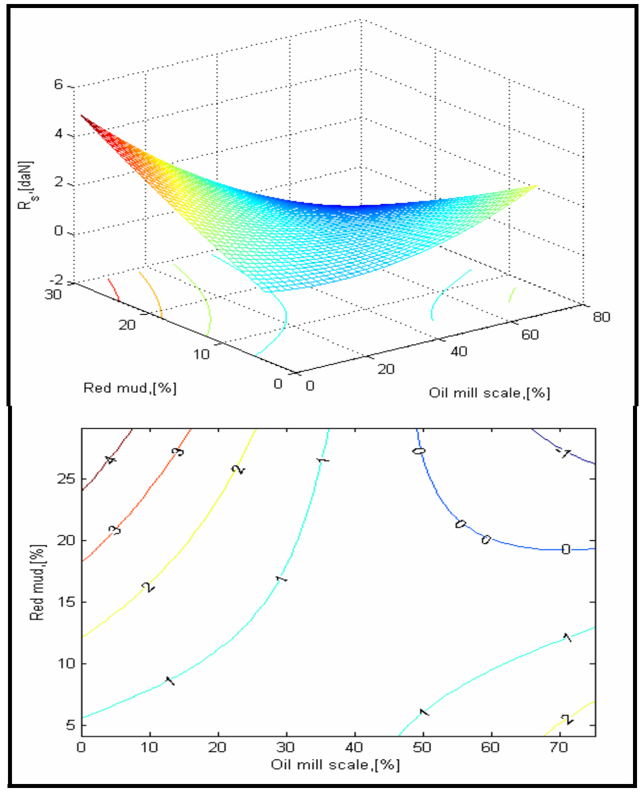

Fig. 16. The regression surface and the level curves in the correlations Oil mill scale, Red mud and Rs

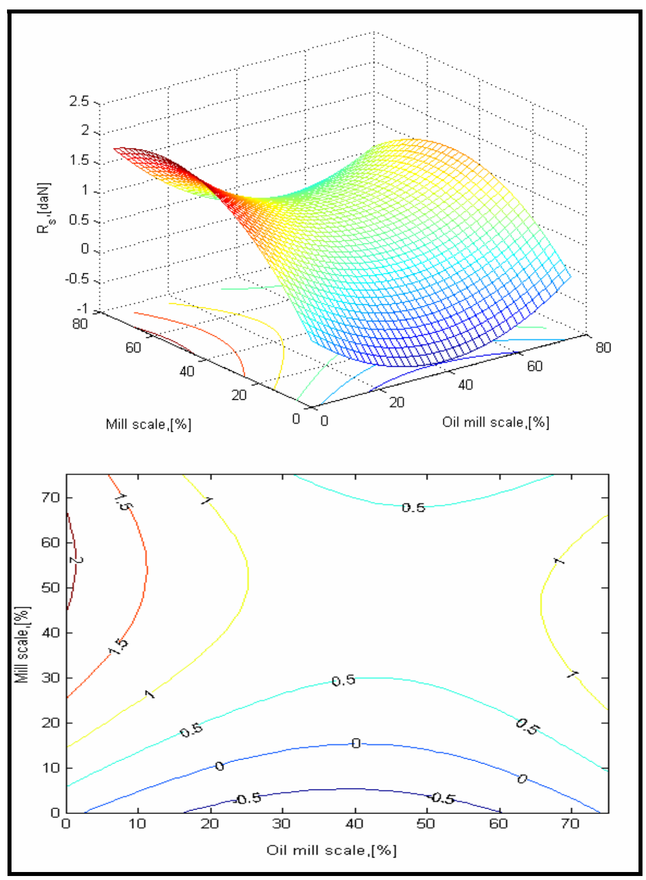

Fig. 17. The regression surface and the level curves in the correlations Mill scale, Oil mill scale and Rs

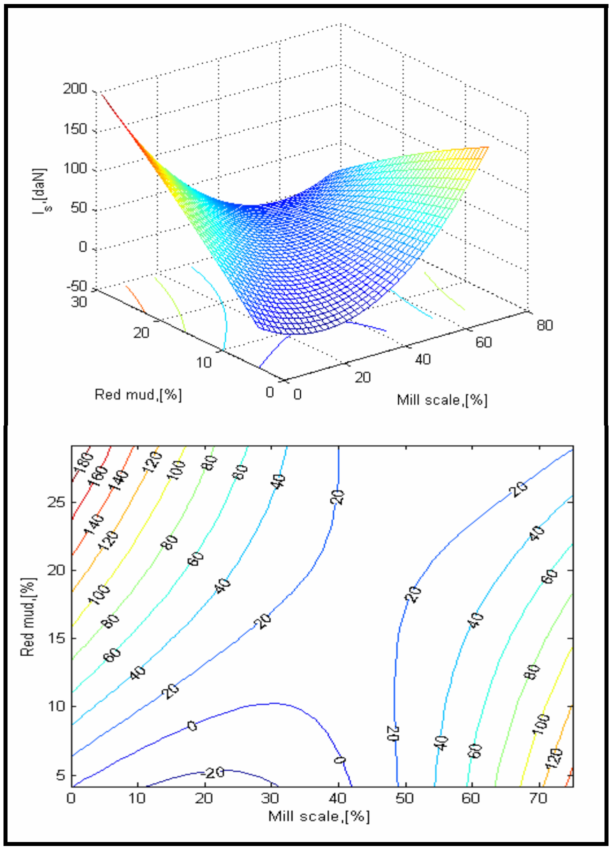

Fig. 18. The regression surface and the level curves in the correlations Mill scale, Red mud and Is

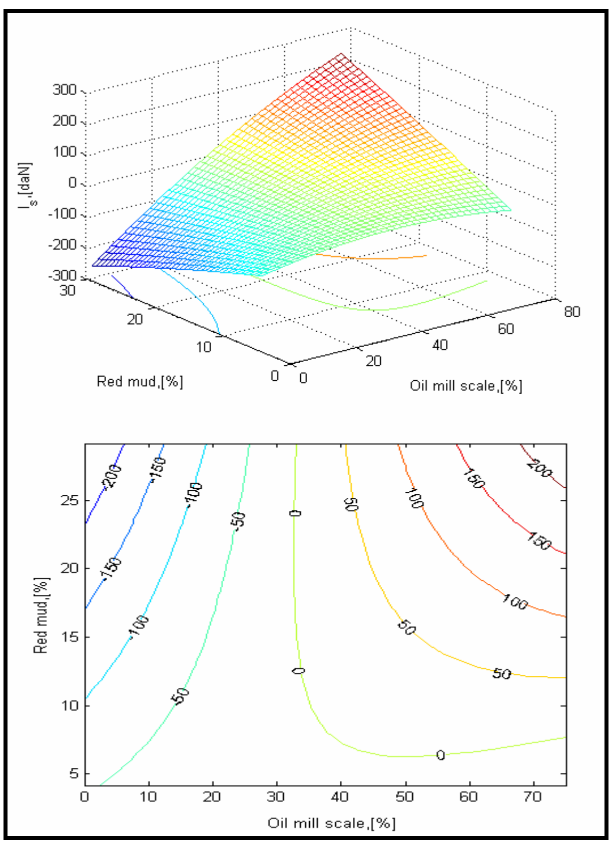

Fig. 19. The regression surface and the level curves in the correlations Mill scale, Oil mill scale and Is

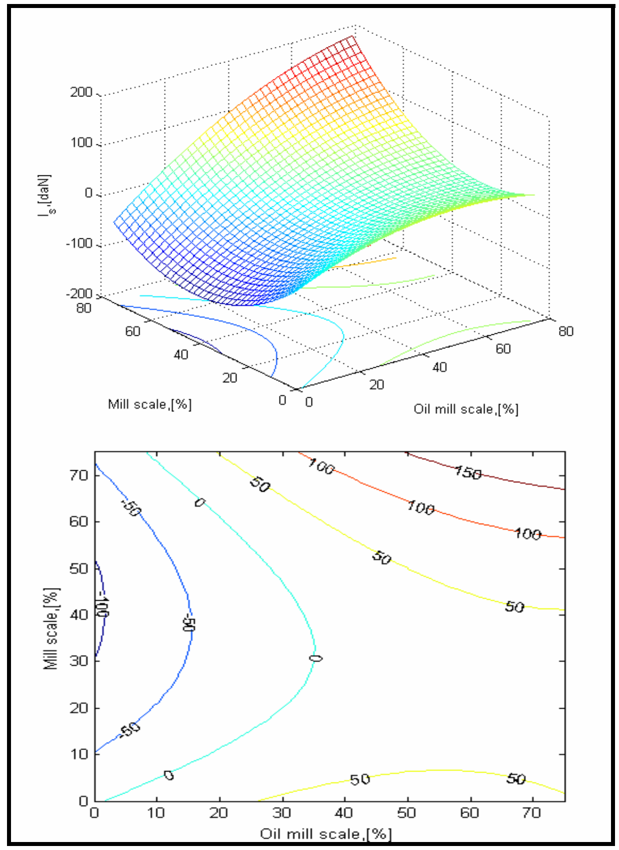

Fig. 20. The regression surface and the level curves in the correlations Mill scale, Oil mill scale and Is

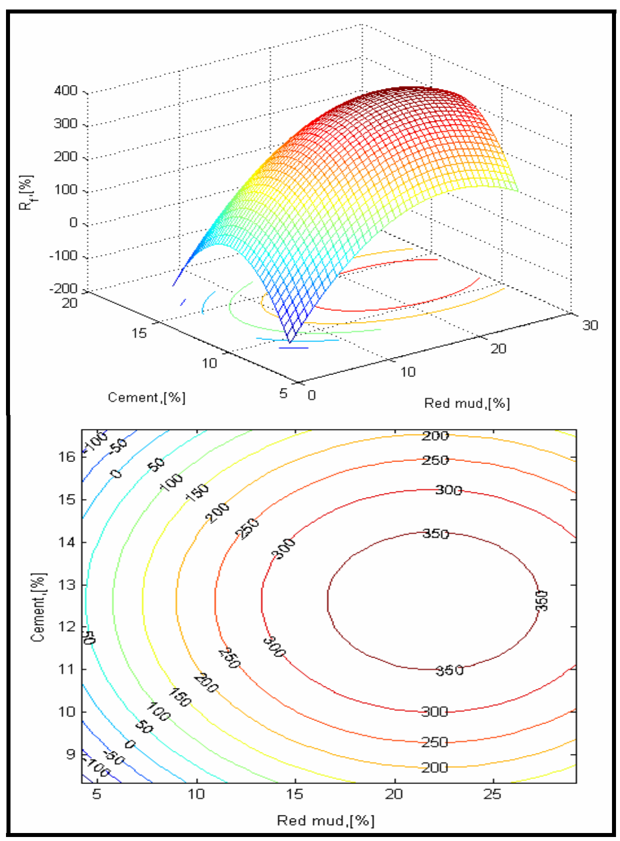

Fig. 21. The regression surface and the level curves in the correlations Cement, Red mud and Rf

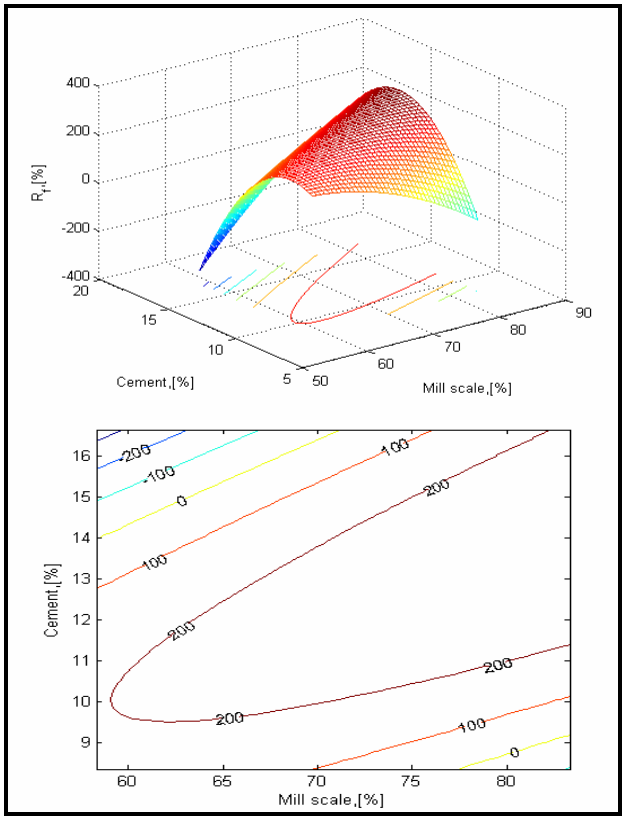

Fig. 22. The regression surface and the level curves in the correlations Cement, Mill scale and Rf

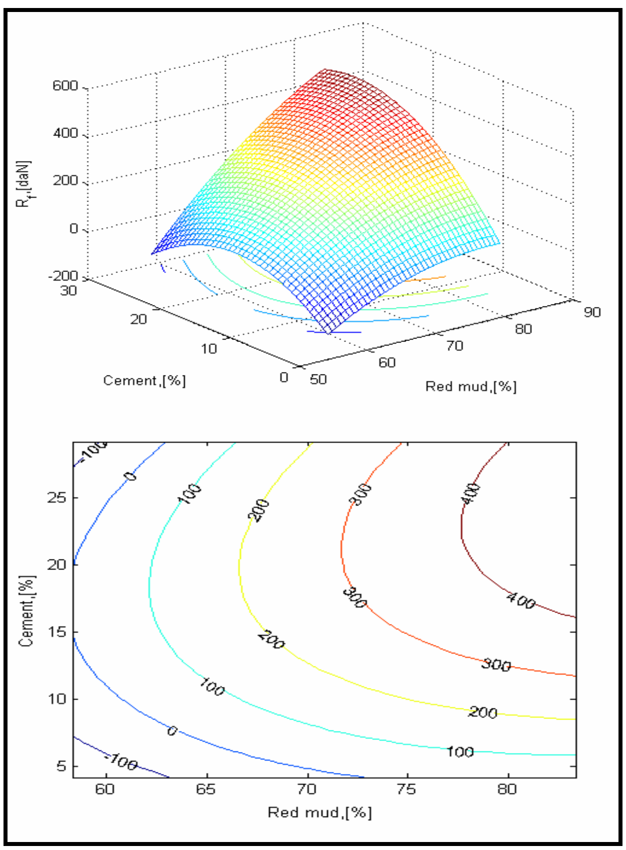

Fig. 23. The regression surface and the level curves in the correlations Cement, Red mud and Rf

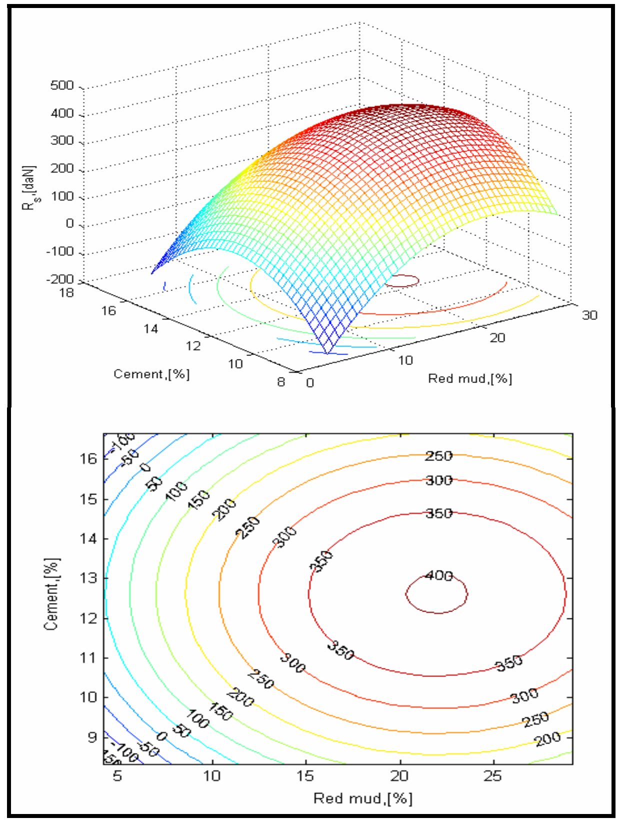

Fig. 24. The regression surface and the level curves in the correlations Cement, Red mud and Rs

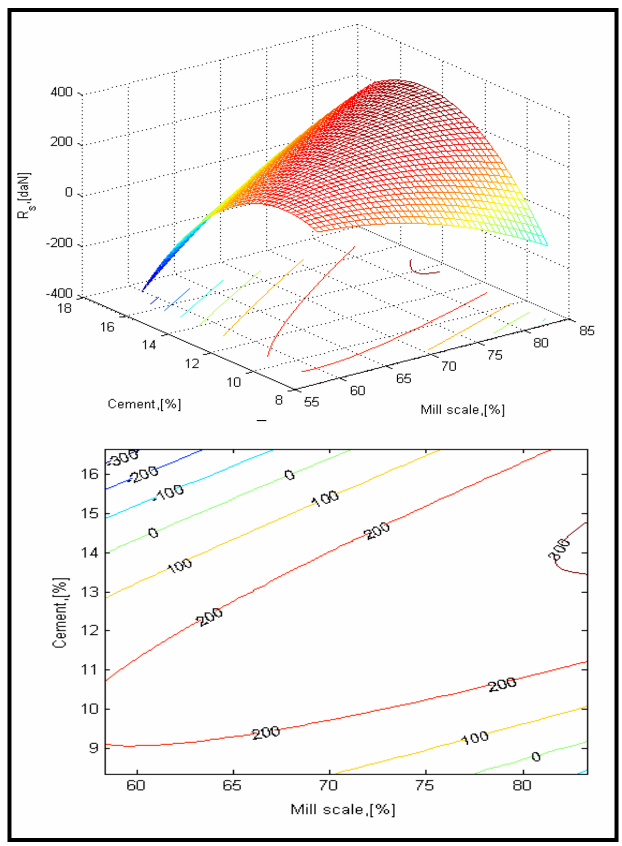

Fig. 25. The regression surface and the level curves in the correlations Cement, Mill scale and Rs

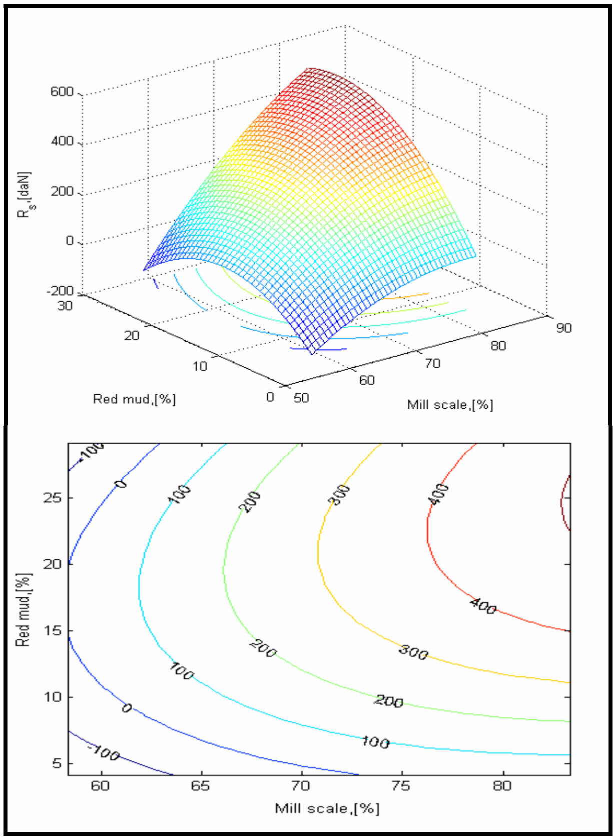

Fig. 26. The regression surface and the level curves in the correlations Mill scale, Red mud and Rs

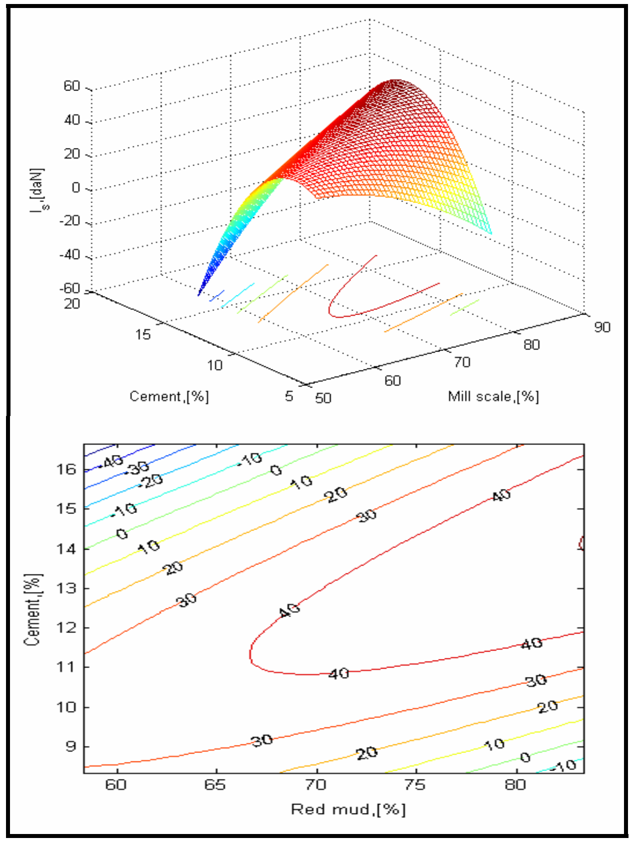

Fig. 28. The regression surface and the level curves in the correlations Cement, Mill scale and Is

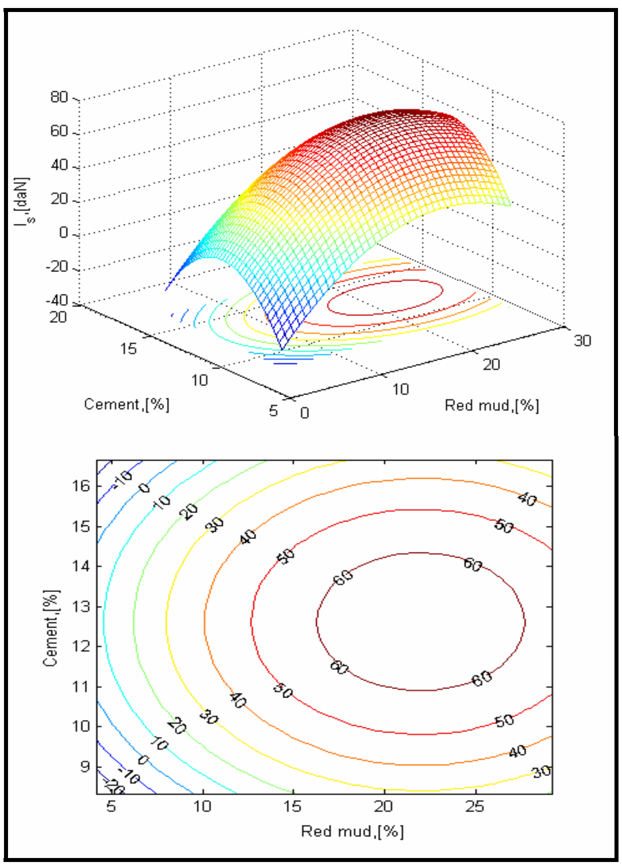

Fig. 27. The regression surface and the level curves in the correlations Cement, Red mud and Is

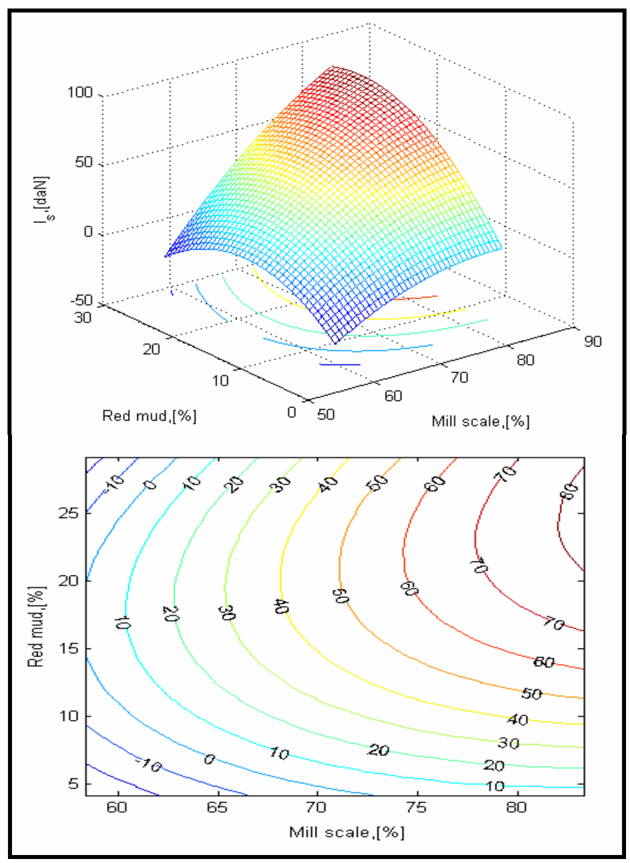

Fig. 29. The regression surface and the level curves in the correlations Mill scale, Red mud and Is

IV. Conclusion

From research conducted on the recovery of waste powder in a small and especially oil mill scale these conclusion:

- these wastes can be processed in briquettes provided the scale has to undergo an operation in advance of dehydration, which eliminates the massive oil and water;
- recipe using red mud and concentrate made from the waste sideritic better determine the link between grains scale;
- the analysis results obtained from processing data in Excel result of variation within the components used to produce lighter, namely: 10-22% oil mill scale A, 40-60% tunder B, 20-30% red mud and for biding 12-15% cement.

Dependent similar to those outlined above have been obtained for lot 2. Are the optimal loading area has the highest value Is.

We believe that based on experiential recovery of waste by strengthening the hot waste (burning briquette) may have been a reduction process leading to a high degree of metallization.

Briquetting process has the advantage that it allows a wide range of wastes containing iron both in terms of chemical composition (primarily iron content) and granulometric composition.

For industrial areas, especially in the profile steel, recovery of waste by briquetting considered the most viable technological solution.

Recovery of oily mill scale has both environmental and economical effects by reducing the amounts deposited.

Besides this economical aspect - which is primordial - in ferrous powdery wastes re-usage we can mainly solve the problem of environmental pollution (air - water - soil) through depositing these industrial scraps.

Acknowledgements

"This work was partially supported by the strategic grant POSDRU 107/1.5/S/77265, inside POSDRU Romania 2007-2013 co-financed by the European Social Fund – Investing in People."

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