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RECYCLING EXPERIMENTS ON PULVEROUS WASTES RESULTED FROM FERROUS INDUSTRY, MINING AND ENERGETIC SECTORS

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Abstract: The implementation in the industrial practices of the accounting technologies of the ferrous powdery wastes, now stored in the regional ponds of the nearby ferrous industry, mining and energetic sectors, assure in time the repossession of this place occupied by the wastes, to the natural environment. The recovery through pelletizing of the pulverous ferrous wastes stored in the regional ponds can be significant for the environmental protection, given by the increase of recovery for pulverous wastes and reduction of depository spaces for these wastes. The economical aspect is reflected by transferring depositary expenses to other purposes. In the paper some researches and relevant results are presented, regarding the obtaining of the pellets, using wastes resulted from ferrous industry (steel dust, agglomerating–furnace dust), mining (red mud, galvanically sludge) and energetic (thermal power plant ash) sectors. In addition, in the pellets recipes, graphite is used as the reducing agent, respectively bentonite and lime are used as binders.
Keywords: ferrous pulverous wastes, pellets, environmental protection

The deposition of the small and pulverous waste leads to both the pollution of the natural environment by diffuse emissions of harmful compounds and also the contamination of surface and groundwater, areas that go far beyond the perimeters of deposition. Waste recycling processes reduce the negative environmental impact of the deposition.

Recycling is a process to change waste materials into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials and reduce water pollution (from landfilling) by reducing the need for conventional waste disposal. [1–4, 15–20] Recycling of pulverous wastes has emerged as a viable alternative to reduce pressure on the existing reserves of metals. [15–20] It is far more economical for the industries and is also eco–friendly. Therefore, the research suggests that by reusing products, recycling wastes, and making environmentally by–products, businesses can cut costs and increase profits. [15–20] Cost savings take the form of:

- lower waste disposal costs;
- lower waste treatment costs;
- savings on natural materials;
- a reduction in regulatory compliance costs;
- lower storage costs;

Figure 1. Recovery of ferrous wastes strategies

The waste has become a major problem for the various industrial sectors. Concepts like prevention, reuse, recycling, recovery, disposal and their ranking are on the order of the day in the management of the different streams of waste. But the implementation of these concepts implies the very good knowledge of waste characteristics.

For Romania the recovery of ferrous wastes represents a priority for the durable development strategy because the natural resources of some raw materials categories are poor or insufficient and the resources can substitute part of the raw materials with significant low costs.[1–4, 11] Comparatively with the practice and the world wide manifested tendencies, the Romanian industry registers gaps in the powder wastes collection, transportation and storage area, as well as in that of the recovery technologies area by their recycling or reusing. [5–20] Thereby, the approach of the superior recovery of small and powder ferrous wastes problem was considered necessary and convenient.

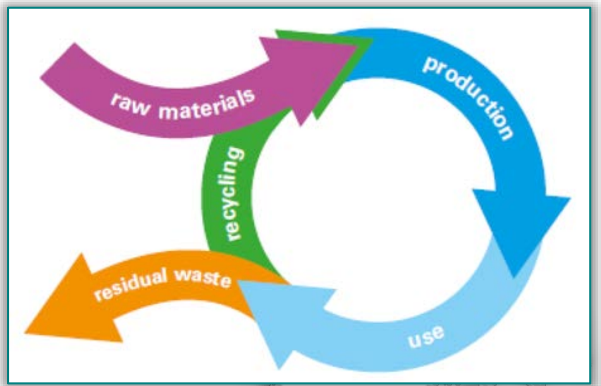

Figure 2. The recycling in the circular economy

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 secondary products obtained from a technological process
- ¤ increasing the degree of recovery (transforming wastes in useful by–products for other sectors)
- ¤ dominating through supervising and control of problems with a negative impact upon the environment, that can occur when treating and transporting wastes.

Today, the man–caused deposits can be equated with the exploitable deposits of natural resources. [1–4] There exist the two ways to increase the volumes of natural resources:

- » by improving the prospecting, delivery and storage methods, deals with the technologies of deposits exploitation, and
- » by increasing the effectiveness of their usage, with the technologies of their usage or the, so called, resource–saving technologies, from the basis of stable development concept.

Expansion of use of secondary raw materials, such as scrap and other ferrous metallurgy wastes, are an important factor of metal industry development from the point of view of its provision with raw materials. Recycling and utilization of wastes with content of useful elements is important not only from the point of view of their usage as an alternative source of raw materials, but regarding the environmental problems also. [1–4, 15–20]

The analysis has allowed us to formulate a scientific problem with the solution in two directions: [1–4, 15–20]

- » On the one hand, waste processing and using it as a relatively cheap raw material for metallurgical manufacture, noticeably lowers expenditures on mix material and improves the quality and competitive strength, and above all lowers the net cost of the finished product. Therefore, recycling and recovery of wastes and their use as low–cost metallurgical raw material entails the considerable reduction of charge costs, increase in the finished products quality, competitiveness and prime cost.
- » On the other hand, the solution of the ecological problem of purification of whole regions where many man–caused waste deposits have been accumulated and reclaiming of current storage of waste of the mentioned above manufactures. Therefore, is a solution for salvation of ecological problems of the entire regions possessing enormous deposits of industrial wastes as well as utilization of current wastes.

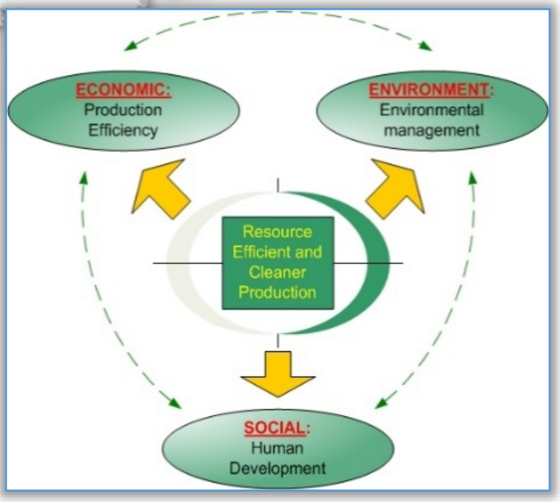

Figure 3. Resource efficient and cleaner production

A mixture charge for use in all kinds of metallurgical processes, ensures the industrial wastes recycling in the form of iron–and–carbon containing pellets ensures a considerable increase in technical and economical characteristics of metal works processes with the simultaneous improvement of ecological situation. [1–4, 15–20]

Recovery and reuse recyclable resources represent the means of give back total settlement of the requirements of the economic growth process and the restrictive character of the resources. At the same time the activity of recycling deep interferes with the activity of the environment protection, to increase recycling by decreasing the polluting pressure on the environment.

MATERIALS

Our paper presents in the following lines the experiments and the results regarding the re–introduction into the economical circuit of the following ferrous pulverous wastes: steel dust and agglomerating–furnace dust.

The wastes from mining sector (red mud, galvanically sludge) and energetic sector (thermal power plant ash), together with the steel dust and the agglomerating dust were subjects of the pelletizing process, in presence of graphite, used as the reducing agent, respectively bentonite and lime, used as binders. The experiments were put into practice in the iron laboratories of the Faculty of Engineering in Hunedoara. [15–20]

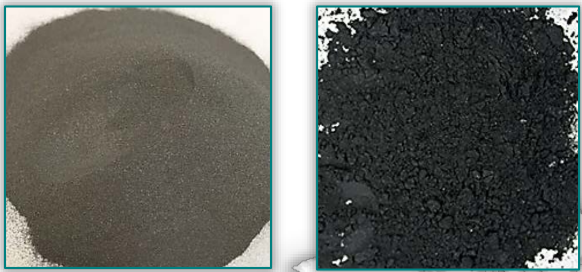

Figure 4. Steel dust and Agglomerating–furnace dust

Figure 5. Galvanically sludge

Figure 6. Red mud

Figure 7. Graphite and Bentonite

Figure 8. Lime and Thermal power plant ash

The recipes compositions for the pelletizing charges in Table 1 are presented. At preparation of the recipes, we have in consideration the following distribution of the components:

- The first four (4) recipes (R1-R4) are prepared without thermal power plant ash (and large variations of other components), as are presented in Table 1 and Figures 9-12.
- The next three (3) recipes (R5-R7) are prepared without graphite (and large variations of other components), as are presented in Table 1 and Figures 13-15.
- The next two (2) recipes (R8-R9) are prepared without thermal power plant ash, graphite and lime (with steel dust or with agglomerating-furnace dust as main component), as are presented in Table 1 and Figures 16-17.
- The next two (2) recipes (R10-R11) are prepared without thermal power plant ash, graphite, lime and red mud (with steel dust or with agglomerating-furnace dust as main component), as are presented in Table 1 and Figures 18-19.
- The last two (2) recipes (R12-R13) are prepared without thermal power plant ash and agglomerating-furnace dust (without red mud or without galvanically sludge), as are presented in Table 1 and Figures 20-21.

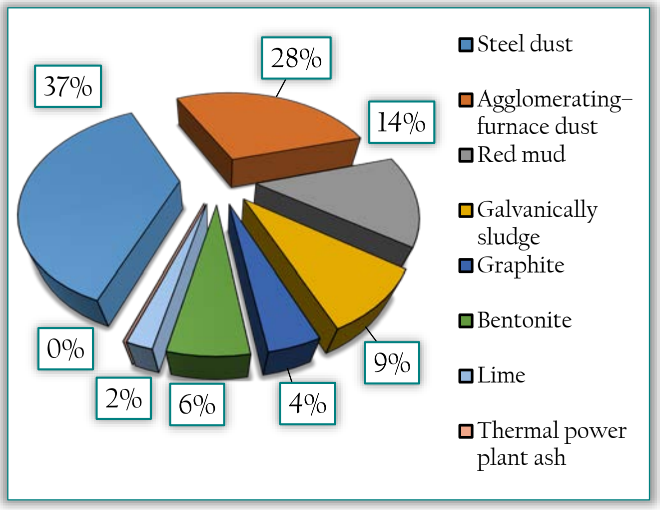

Figure 9. The recipe R1: Without thermal power plant ash (and large variations of other components)

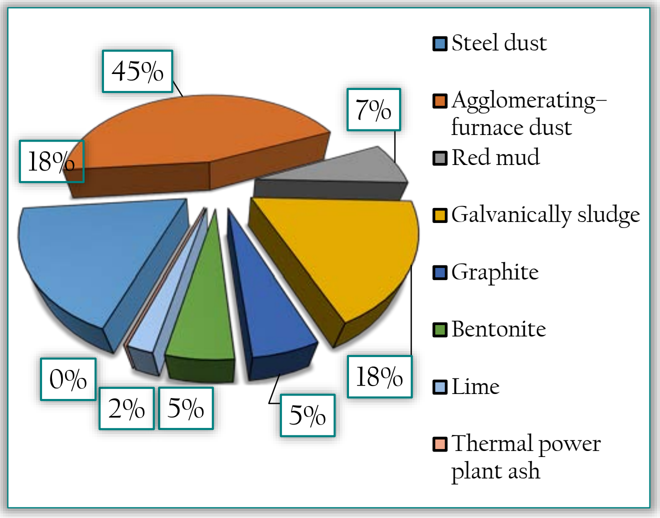

Figure 10. The recipe R2: Without thermal power plant ash (and large variations of other components)

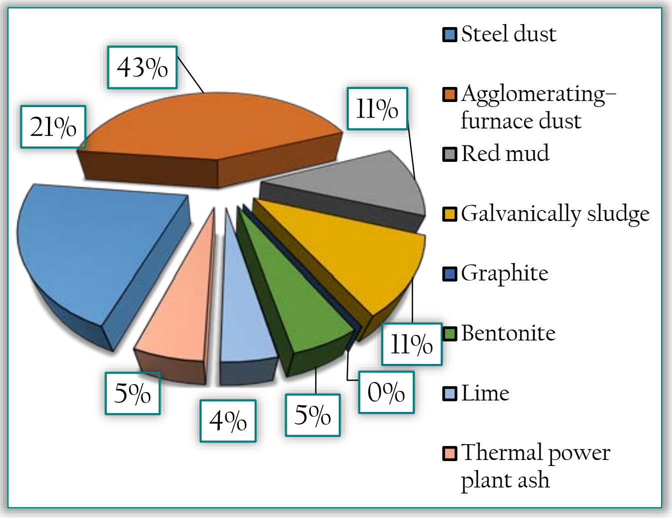

Figure 13. The recipe R5: Without graphite (and large variations of other components)

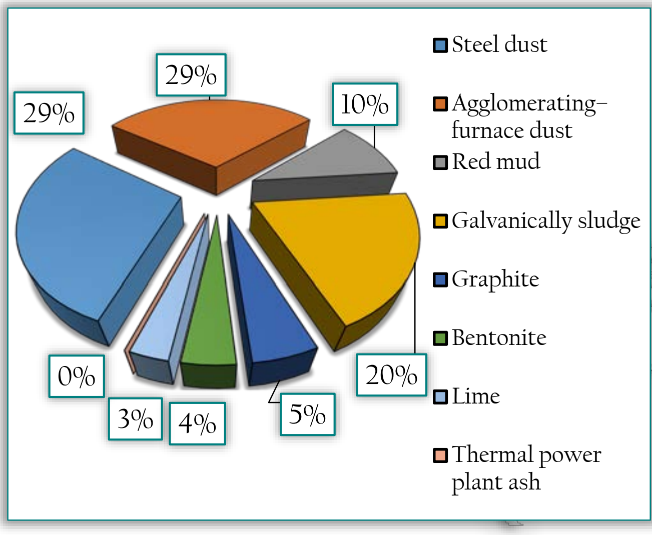

Figure 11. The recipe R3: Without thermal power plant ash (and large variations of other components)

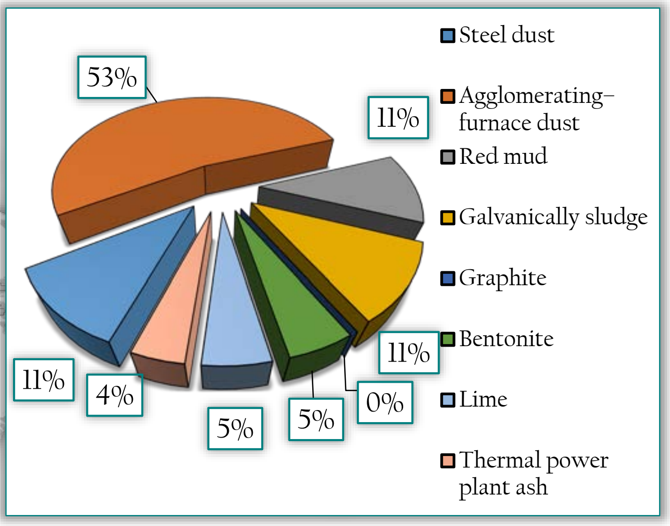

Figure 14. The recipe R6: Without graphite (and large variations of other components)

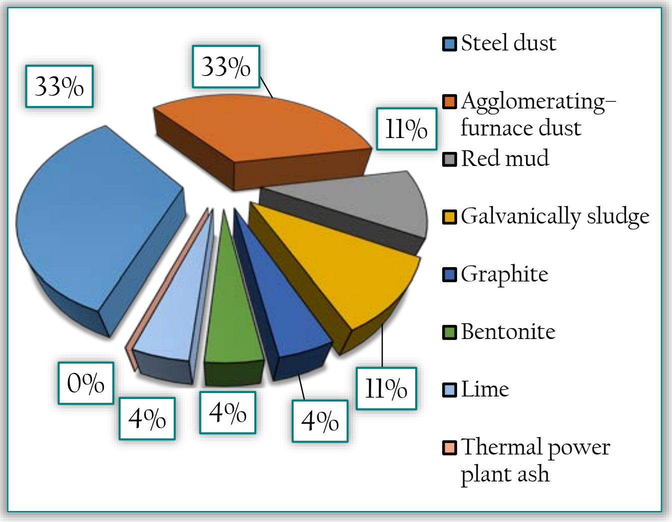

Figure 12. The recipe R4: Without thermal power plant ash (and large variations of other components)

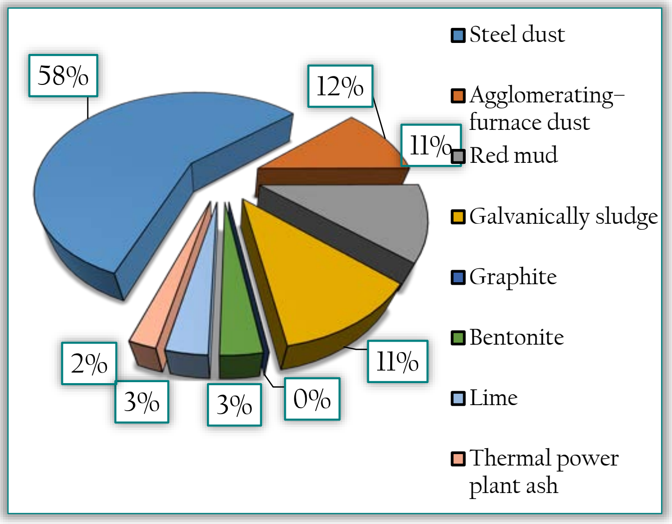

Figure 15. The recipe R7: Without graphite (and large variations of other components)

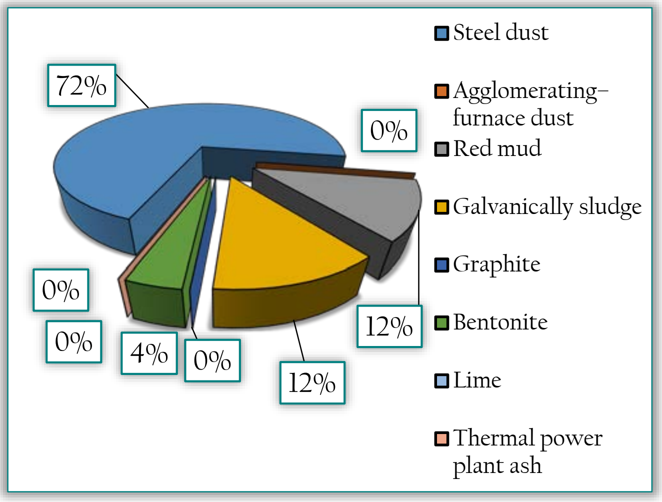

Figure 16. The recipe R8: Without thermal power plant ash, graphite and lime (with steel dust)

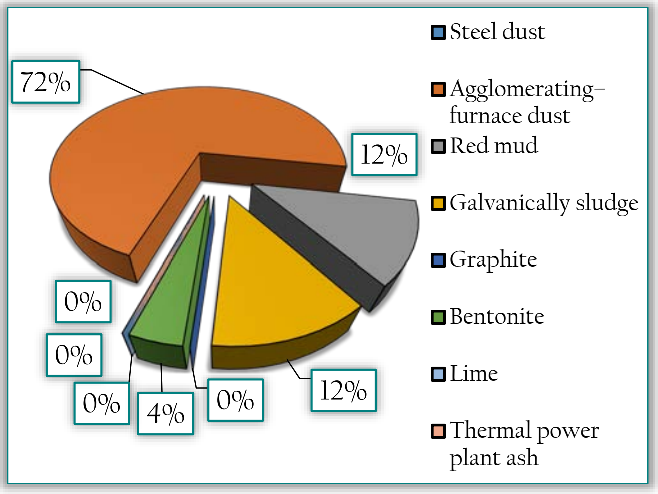

Figure 19. The recipe R11: Without thermal power plant ash, graphite, lime and red mud (with agglomerating-furnace dust)

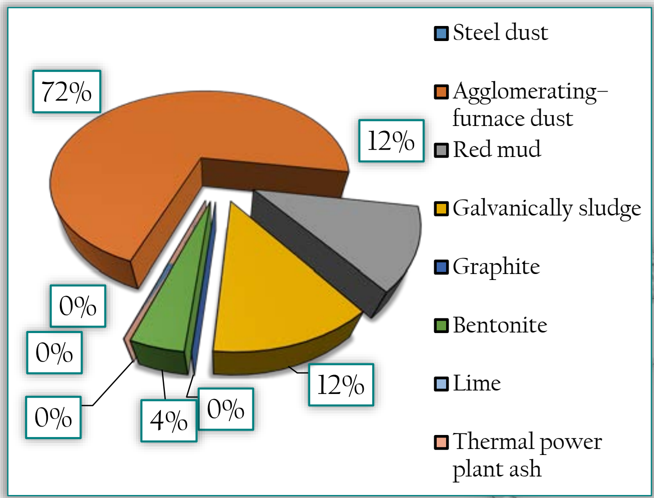

Figure 17. The recipe R9: Without thermal power plant ash, graphite and lime (with agglomerating-furnace dust)

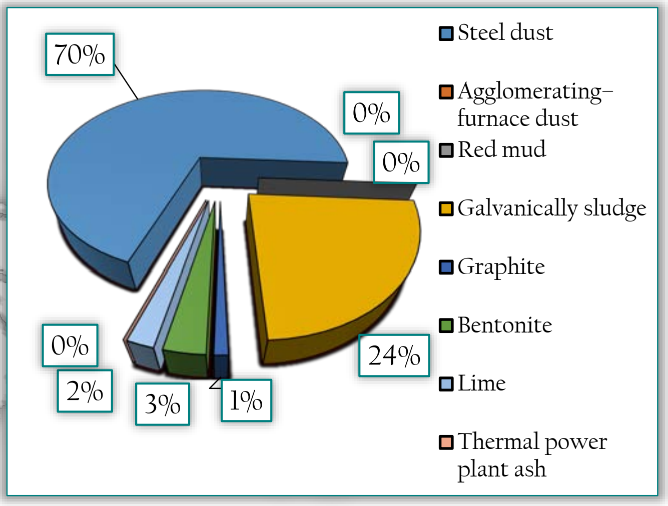

Figure 20. The recipe R12: Without thermal power plant ash and agglomerating-furnace dust (without red mud)

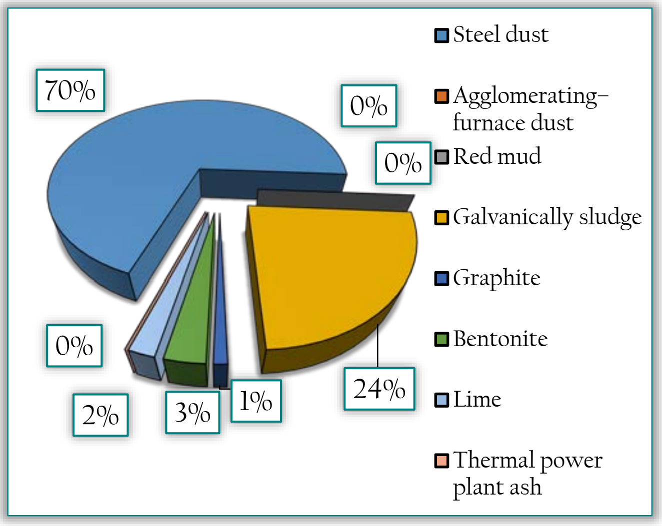

Figure 18. The recipe R10: Without thermal power plant ash, graphite, lime and red mud (with steel dust)

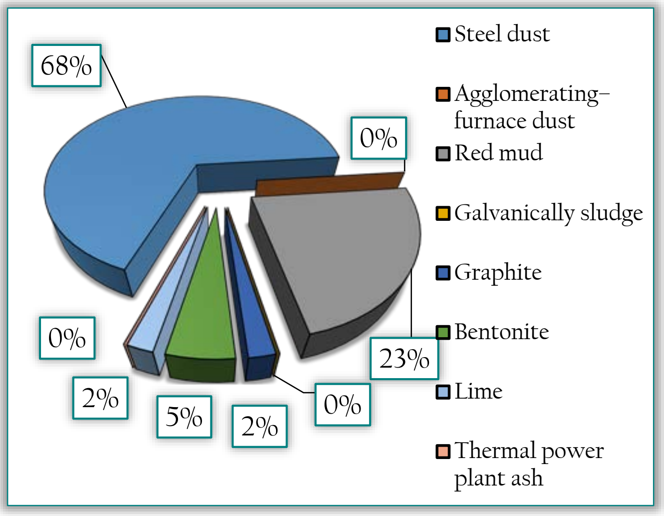

Figure 21. The recipe R13: without thermal power plant ash and agglomerating-furnace dust (without galvanically sludge)

Table 1. The pelletizing recipes, [%]

	Wastes type	R1	R2	R3	R4	R5	R6	R7
1.	Steel dust	37	18	29	32	21	11	57
2.	Agglomerating–furnace dust	28	45	29	32	42	53	11
3.	Red mud	14	7	10	10	11	11	11
4.	Galvanically sludge	9	18	20	10	11	11	11
5.	Graphite	4	5	5	4	–	–	–
6.	Bentonite	6	5	4	4	5	5	3
7.	Lime	2	2	3	4	4	5	3
8.	Thermal power plant ash	–	–	–	–	5	4	2

	Wastes type	R8	R9	R10	R11	R12	R13
1.	Steel dust	72	–	72	–	69	68
2.	Agglomerating–furnace dust	–	72	–	72	–	–
3.	Red mud	12	12	–	–	–	23
4.	Galvanically sludge	12	12	24	24	23	–
5.	Graphite	–	–	–	–	1	2
6.	Bentonite	4	4	4	4	3	5
7.	Lime	–	–	–	–	2	2
8.	Thermal power plant ash	–	–	–	–	–	–

RESULTS

The input pulverous wastes are prepared, blended, mixed and conditioned correctly before being fed in a controlled manner into the pelletizing disc. The material is then granulated to a size and shape that can be tailored to suit each customer's individual requirements. After pelletizing, the pellets were dried (in air stream) the process being guided in such a way as to reach a resistance of a minimal 100 daN/pellet.[11,15–20]

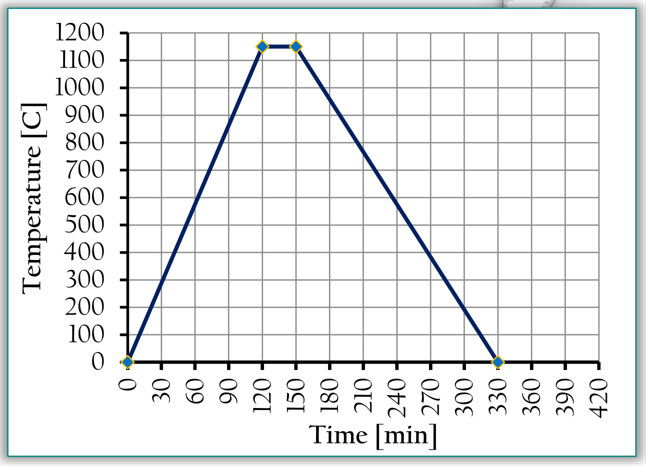

Figure 21. The diagram of hardening processes

The obtained pellets shall be subjected to the hardening processes, initially in the normal atmosphere and subsequently according to the scale of the desirable reduction, in ovens with resistance, heated to 1150°C for 2 hours, holding 0.5 hours and air cooling using a heating – holding – cooling diagram established on the basis of several experiments. (see Figure 22).

Figure 22. Pellets in the calcination oven

Figure 23. Pellets

CONCLUSIONS

The researches and experiments put into practice, led to the following considerations:

≡ two different types of pulverous ferrous wastes (steel dust and agglomerating–furnace dust) are processed through pelletising, together with two wastes from mining sector (red mud, galvanically sludge) and one from the energetic sector (thermal power plant ash), in presence of reducing agent (graphite) and binders (bentonite and lime);

≡ the utilization of these wastes presents an important interest considering the large quantities that are deposited in the ponds (especially the pulverous ferrous wastes). Due to these large quantities there is the danger of their break–down, having severe consequences upon the environment;

≡ the results allow the re–introduction into the economical circuit of some pulverous ferrous wastes which can replace a part of the waste iron, which is a deficitary raw material in the steel making processes;

≡ according to the target had in view (recuperated iron, correction of the slag's chemical composition) the quality of the pellets and the adequate recipe is chosen; technically speaking, the pulverous ferrous additions can be used to produce complex additions, which are very useful for active slag formation;

- from the point of view of the compression resistance, the pellets are adequate to be used in the electric arc furnaces which are used in steel making.
- a considerable decrease of environmental pollution would be possible in the vicinity of these ponds, and this would an action of considerable social impact (dust draws disappear through air streams, the risk of falling ill decreases, as well as that of soil sliding and water pollution);

In our country there are opportunities to bring in the productive circuit large quantities of pulverous metallic scraps, metallurgical slags and ashes from the thermal power plants that work with coal. They could be used as recycled materials and thus will reduce the quantities of exploited mineral resources. Also the organization of the collection and recovery of such waste can be very effective ways in the reduction of society's pressure upon the non-renewable resources.

The organization and management of more efficient reusable materials in our country should be as a priority from the following preconditions:

- the potential of reusable materials is high, which is a prerequisite for ensuring an efficient economy;
- the technical and technological level of this activity is modest, but can be improved without special investment efforts;

Therefore, the small and powdery ferrous waste can and must not be reused in their totality, all within the framework of the steel industry. Any tone of recovered ferrous waste and played back in the iron and steel production circuit, leads to a great savings investment and operating expenditure.

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