Broadening of Raw Materials in the Steel Industry, by Recycling and Recovery Wastes

A. Todorut, and T. Heput

***Abstract*—**In technological processes, in addition to the main product, result a large amount of materials, called wastes, but due to the possibilities of recovery, by means of recycling and reusing it can fit in the category of by-products. These large amounts of dust from the steel industry are a major problem in terms of environmental and human health, landscape, etc. Solving these problems, the impressive amounts of waste can be done through their proper management and recovery for every type of waste. In this article it was watched the capitalizing through pelleting and briquetting of small and powdery waste aiming to obtain the sponge iron as raw material, used in blast furnaces and electric arc furnaces. The data have been processed in the Excel spreadsheet program, being presented in the form of diagrams.

***Keywords*—**Agglomeration, industry, iron, pellets, wastes.

I. Introduction

FROM the wide variety of waste resulting from processes of steel industries, powdery waste, potentials by-products, raised problems with recovery, because on the one hand, regarding the unsatisfactory grain size composition, namely the fine fraction is dispersed in large amounts, and on the other hand due to presence of heavy metals (Zn, Pb) in their composition. Today the world is put in issue capitalizing particularly by recycling powder waste generated in the steel industries, suggesting the concept of recycling their integrated [1].

Waste composition varies depending on the source of origin. These features require that the materials are very important in Fe balance of any steel plant [1].

Waste containing iron/iron and carbon are: dust and sludge of agglomeration, powder and sludge of furnaces, powder and sludge from steel with converters, red sludge from alumina industries, pyrites ash content of sulfuric acid, mill scale from the processing of plastic deformation of hot steel, and sludge result in mechanical preparation of ores or coal [1]. Development of steel industry depends on several factors, of which the most significant are: the existence of resources of raw materials (iron ore, manganese, iron and ferro-alloys) auxiliary (fluxes and oxidants) and energy (coal mine methane gas, fuel oil and electricity) distance of supply,price but not least the quality of qualitative characteristics thereof. Also the costs should not be neglected for the safety and security of employment and those on the protection of the environment. Integrated system for steel making from raw materials (iron ores, coal) assumes the existence of a technological flow composed of the following sectors: receipt and storage of raw materials, raw material preparation (plants and factories of agglomeration), furnaces, rolling mills and iron [2]. In conditions of market economy should create continuously new technologies that can enable a mode of functioning flexibly both technologically and economically, with spending on investments as small [2].

A. Todorut is with the Polytechnic University, Timisoara, Faculty of Engineering Hunedoara, CO 331128 Romania (phone: +40-0254-207582; fax: +40-0254-207501; e-mail: todorut.adela@ fih.upt.ro).

T. Heput is with the Polytechnic University, Timisoara, Faculty of Engineering Hunedoara, CO 331128 Romania (phone: +40-0254-207530; fax: +40-0254-207501; e-mail: teodor.hept@ fih.upt.ro).

II. Materials and Methods

Romanian metallurgical industries register, in present, comparative with those of developed countries, technological gaps with regard to the collection, transport, storage and use of all categories of ferrous waste, with high content of carbon, and alkaline waste solution. Worldwide realize about 80% of steel waste, while in Romania, at present, harness up to 48% of these, dumping the rest. Dumping these wastes leads to pollution of the environment by diffuse releases of noxious compounds, and the contamination of surface and groundwater. Landfill is used increasingly more in the world and in our country [6].

The high cost of raw materials used in steel industry, leading to finding solutions to lower costs and recovery of waste materials resulting from processing. One of these solutions would be turning these wastes and their re-processes like raw materials [1].

Methods of processing waste results from steel industry are: - Mechanical agglomeration processes: briquetting and pelleting; - Thermal sintering processes: agglomeration or sintering [3].

Superior waste recovery metals in general and in particular small and powdery, is an important issue, because turning them into products, so in economic goods may lead to a rational exploitation of energy resources and raw materials, thus ensuring the needs of both human society and environmental protection, major problem at the end of the second millennium and early third millennium [5].

Pulverous ferrous wastes are present in all cases in the form of oxides [7].

Research and experiments conducted in laboratory phase, aimed at establishing the most effective method of waste recovery and finely powdered ferrous in a strong steel industry restructuring. That recovery processes were pelleting, briquetting and agglomeration. As recovery procedures we considered pelleting, briquetting and agglomeration. For experiments, on recovery through pelleting, were used the following waste: furnace dust, steel dust, red mud and like binder it was used bentonite. The qualitative characteristics of these wastes are presented in Table I. and Fig. 1, Fig. 2, Fig. 3. As shown, the wastes used for pelleting, have a very fine grain composition.

TABLE I
WASTE CHEMICAL COMPOSITION

No.crt.	Chemical composition %	Steel dust	Furnance dust	Red mud	Mill scale
1	SiO_2	2,65	6.06	9.41	0.51
2	CaO	5,55	5.81	0	0
3	MgO	2,85	1.59	0.59	0
4	Al_2O_3	0,27	2.04	21.22	0
5	MnO	3,96	0.29	0.27	0.89
6	Fe	43,4	31.19	26.15	0
7	Cu	0	0	0.043	0
8	ZnO	13,04	0	0	0
9	Pb	1,45	0	0.31	0
10	Cd	0,05	0	0	0
11	C	3,4	36.82	1.55	0
12	S	0,72	0	0	0
13	P	0,19	0.046	0	0
14	Zn	0	0.1	0.17	0
15	TiO_2	0	0	4.5	0
16	Na_2O	0	0	6.25	0
17	K_2O	0	0	0.29	0
18	As	0	0	0.013	0
19	Fe_2O_3	0	0	0	86.53
20	FeO	0	0	0	7.38
21	Other oxides	0	0	0	74.69

SiO_2= silicon dioxide, CaO= calcium oxide, MgO= magnesium oxide, Al_2O_3= alumina, MnO= manganese oxide, Fe= iron, Cu= cooper, ZnO= zinc oxide, Pb = lead, Cd= cadmium, C= carbon, S= sulphur, P= phosphorus, Zn= zinc, TiO_2= titanium dioxide, Na_2O= sodium oxide, K_2O= potassium dioxide, As= arsenium, Fe_2O_3= trioxide of iron, FeO= oxide of iron

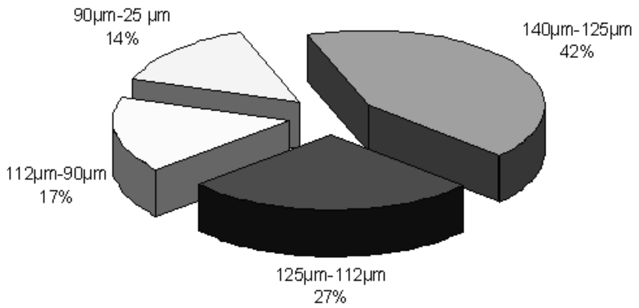


Fig. 1 Grain size composition of furnace dust

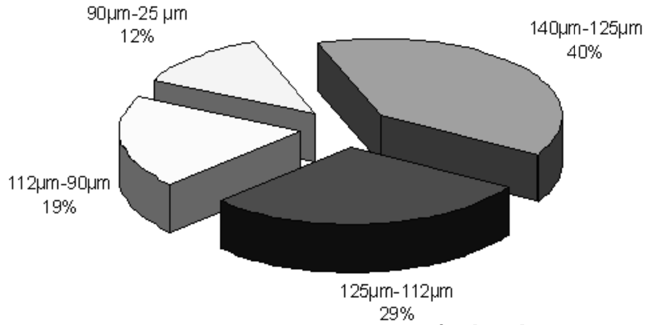


Fig. 2 Grain size composition of red mud

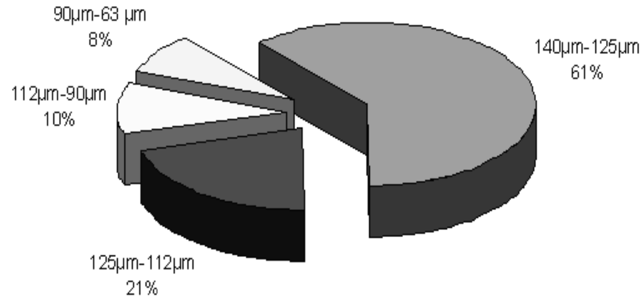


Fig. 3 Grain size composition of steelwork dust

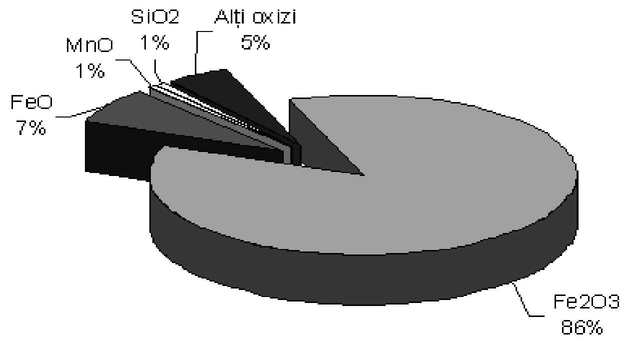


Fig. 4 Chemical composition of mill scale

As small waste it was used mill scale, in the briquetting and agglomeration processes, qualitative characteristics are presented in Table I and Fig. 4. Mill scale has various sizes and shapes: thicknesses from 0.1 to 50.00 mm, lengths and widths of the order of cm. In particular the mill scale came from rolling presents quantities of oil [1].Briquetting is to obtain products of different shapes, (average diameter less than 2mm, preferably less than 1.5 mm) after some pressing operations on specialized equipment. To obtain briquettes, the raw material as finely grain than the aforementioned (mill scale, ferrous fraction steelworks slag, etc.) be subjected to grinding in advance. The cluster is established as a preparation stage, appearing in the flow of production of pig iron, respectively sponge iron. Agglomeration process allows flexibility in agglomeration conversion of a variety of materials (both in terms of grain size and chemical composition), the fine ores from iron boiler dust caught in sewage, exhaust gases from agglomeration furnace, steelworks, iron ore concentrates and other materials containing powdery iron [3].

III. Experiments and Results

A. Process of Pelleting

The need for correct recovery, small metal waste and powder, we have determined to call the pelleting process, briquetting and sintering them. Waste powders were sieved using mesh sizes of the site less than 140 µm.

Pellet formulation composition is shown in Fig. 5. Waste sieved and prepared for the pellet, were homogenized with binder (bentonite) in pelleting plant Fig. 6, and then the process for obtaining pellets after the flow of technological presented in Fig. 7.

In the process of pelleting is carried out powdery materials processing, by rolling under the action of water and combined with that of binder, in pellets of different sizes.

The process of pelleting was 15 min. It was obtained a quantity of 5 kg of pellets; they were subjected to the sieving process, resulting in a rate of 83%% pellets with diameter over 10 mm (Fig. 8) and 17% micropelletes of dimensions 10mm (Fig. 9).

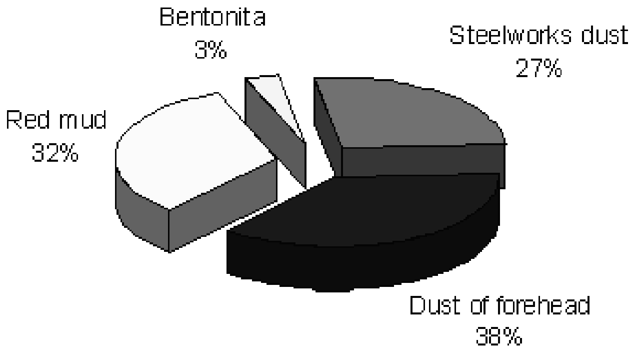


Fig. 5 Component pellets recipe

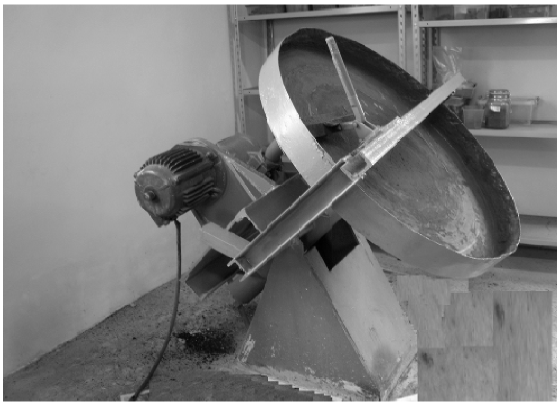


Fig. 6 Pelleting installation

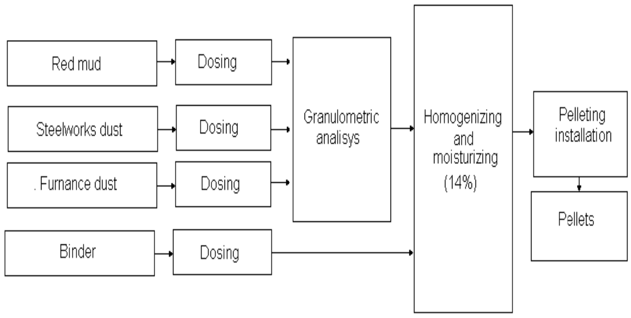


Fig. 7 Flow of obtaining pellets

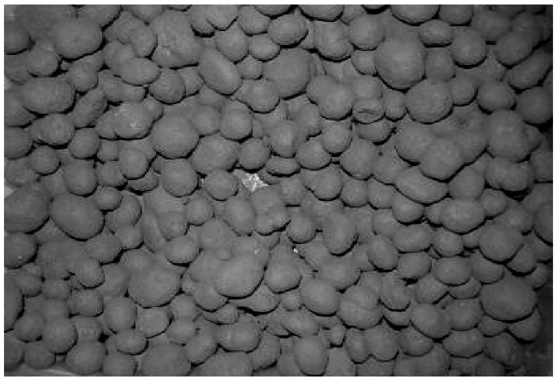


Fig. 8 Pellets

Fig. 9 Micropellets

Were produced three batches of pellets, which are hardened by firing, using the diagram shown in Fig. 10. During the hardening process takes place a process of reduction, reduction scheme is shown in Fig. 11.

From each batch were determined for five pellets, compressive strength ranging between 180 to 210 daN. From this point of view, appropriate for use in load furnaces or direct reduction plants.

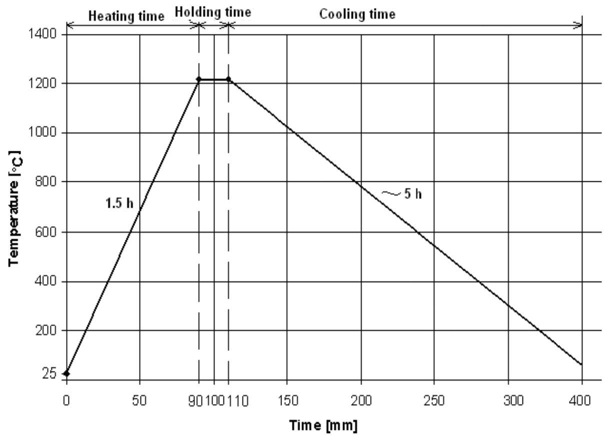


Fig. 10 Diagram of hardening of the pellets

In Fig. 11 are presented schematically the processes occurring in combustion / reduction pellets.

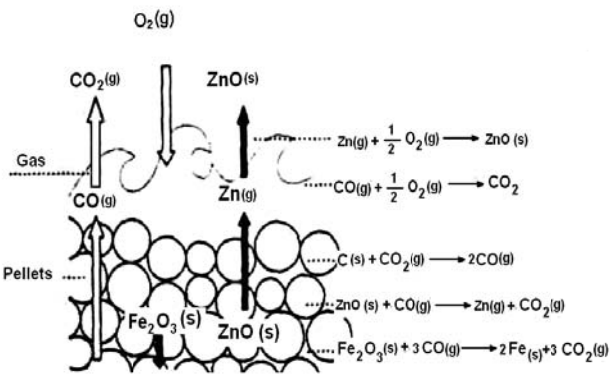


Fig. 11 The process of reduction of pellets

B. Briquetting Process

Mill scale has undergone a process of grinding with ball mills and then drying in oven, shown in diagram 12.

Dried mill scale has been subjected to briquetting process, side by the wastes listed in Table I, using as a binder, a rate of 8%, Na2SiO3 (sodium silicate).

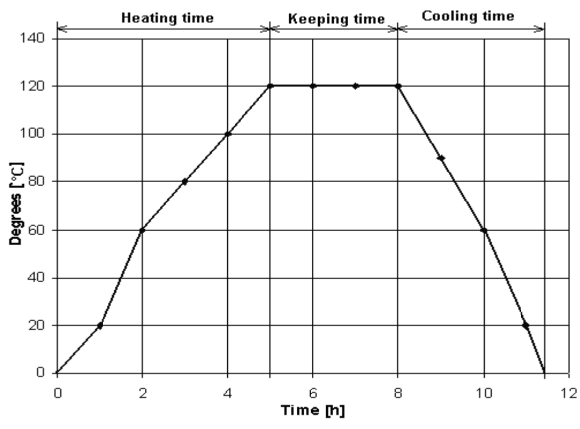


Fig. 12 Chart of drying scale

These materials were mixed, and briquetting charge was subject to briquetting process with the press in Fig. 13. Briquettes obtained (Fig. 14) were allowed to dry for 28 days, in the natural environment, to achieve a higher resistance. In Fig. 15 is presented the flow for obtaining briquettes.

Fig. 13 Briquetting Press

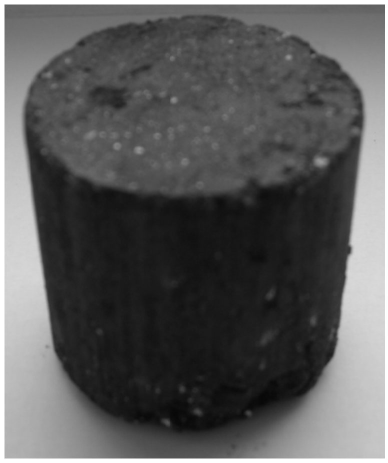


Fig. 14 Briquette

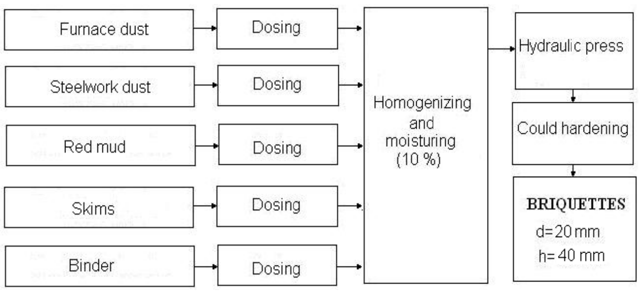


Fig. 15 Flow for obtaining briquettes

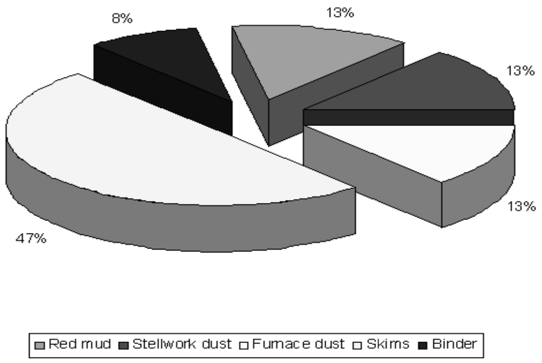


Fig. 16 Recipe of briquettes

Briquetting batch weight was 1,0 kg and a briquette weight is 110 -120 grams, so were produced in each batch 8 briquettes. In this experiments were produced three batches.

From each batch were chosen for two briquettes and then were determined resistance to cracking and crushing, as follows: resistance to cracking from 0.74 - 0.85 kN/cm2 and crushing resistance from 0.80 - 0.99 kN / cm2, crusher with a range 0.06-014 kN / cm2. From the point of view of this parameter correspond to recovery in steel lighters (aggregate reduction, electric arc furnaces, etc.)

C. Agglomeration Process

Agglomeration is a complex physicochemical process, which makes conversion of small materials in pieces. Hardened pellets (grain over 10mm) form a protective layer of the grating. The congestion charge was composed of raw micopelltes, grain skims was less than 3mm, limestone whit grain less than 2 mm (as fuel) and coke under 3mm grain in proportion of 13% (Fig. 17). Batch of agglomeration was introduced in the cluster installation compacted and leveled on top.

After these technological operations is folded cover with burner (installed in the lid) above the box and turn on the burner, as a result, the process of agglomeration is prepared (after the burner off) by switching fuel from the surface layer. Continue burning coal is provided by air suction installation by means of an extractor creating a depression under the agglomeration grill installation.

The agglomeration process in this case, it took 40 minutes. In Fig. 18 presents flow to obtain agglomeration.

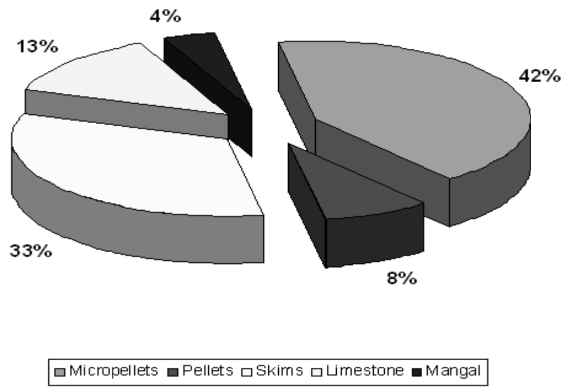


Fig. 17 Composition of agglomeration batch

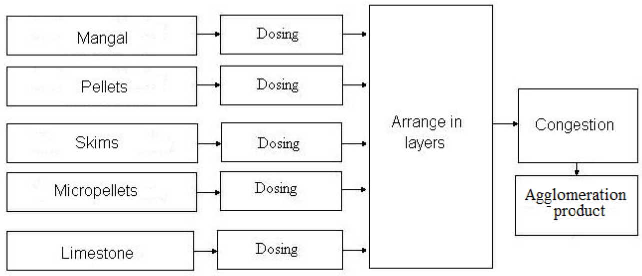
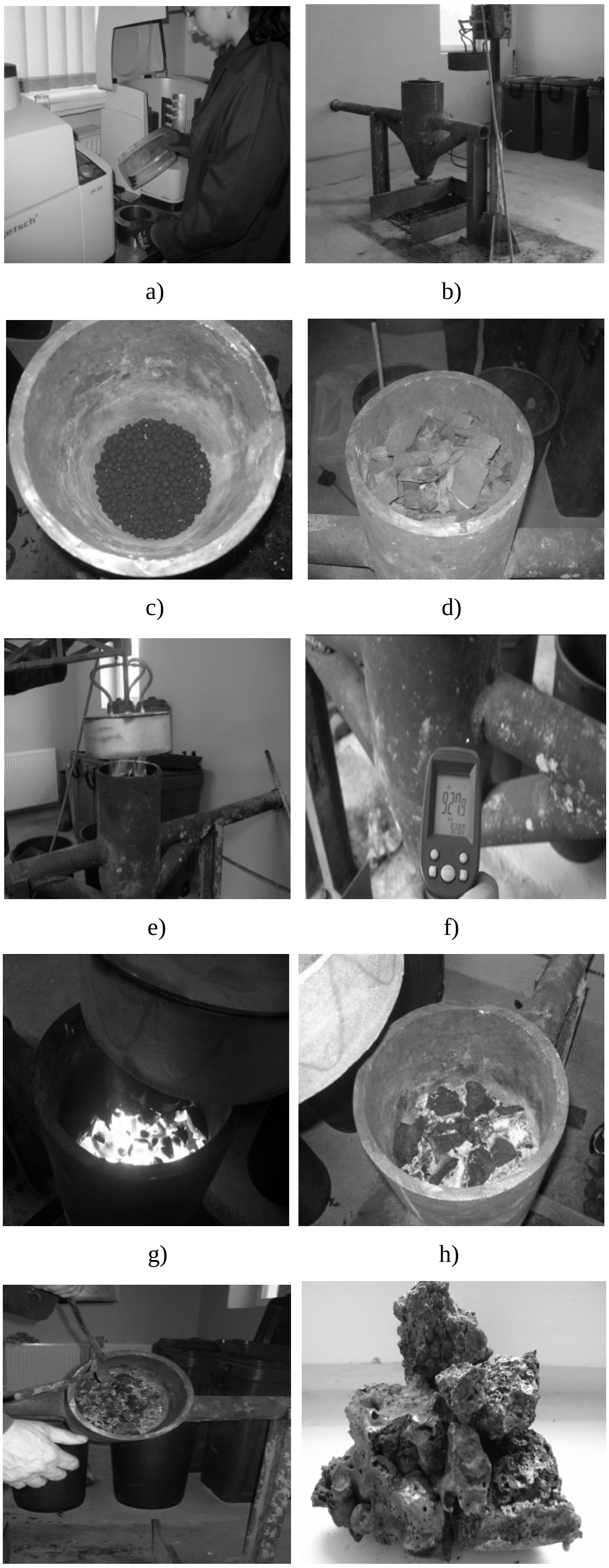


Fig. 18 Flow for obtaining agglomeration

Batch weight was 10 kg in the experiments there were three batches. In the agglomeration process, there are a number of physicochemical processes, which provide load sintering and reduction of iron oxides depending by the amount of reducing agent introduced in charge (carbon fulfill the role of heat and reduction).

The agglomeration was removed from the system and allowed to cool. Agglomeration quality is directly influenced by the quality of raw materials, the degree of preparation and by the conduction process. Indicators against which quality is assessed are: chemical and mineralogical composition, agglomeration strength, agglomeration reducible and content of harmful substances. Agglomeration strength is its ability to withstand the forces of destruction to transport or fusion and reduction furnace. Agglomeration obtained was subjected to the process of failure, shock and friction by adding it to the drum Miccum. This installation has continuous rotation movements, driven electro-mechanically.

In this case rotation of installation Miccum was 3 minutes, during which, the agglomeration has undergone three attempts. As a result of such attempts, agglomeration break is subjected to granulometric size analysis, using 4 sets of site, size ranging between 2.5 cm and 1 cm. After sieving process, was obtaining a value of 15 -11% agglomeration product strength. Very good resistance of agglomeration product is because it has a high metal (56-74%). In Fig. 19 are claim a number of issues during the experiments. Experiments have conducted to the conclusions.



a) b) c) d) e) f) g) h) i) j)

Fig. 19 Aspects of experiments

IV. Conclusion

Waste used in the experiments in the laboratory phase behaved appropriately at each process recovery / recycling, and could opt local conditions for a particular process (is envisaged amount of waste available and the resulting current to technologic flow, as well as investment value, So in addition to technological indicators must be considered and the economic).

In terms of steel in Romania, as a result of strong economic restructuring after 1990, on the one hand, and on the other hand due to obtaining a share of about 35% steel as economically inefficient processes (for example Siemens-Martin steelworks in the form of ingot casting) following the decommissioning of these flows have remained very large quantities of waste deposited powder and small.

In Romania were dismantled after 1990, four Siemens Martin steelworks (One in Hunedoara with 8 x 460t/cuptor furnace was used to blow oxygen by lance load consists of hot metal scrap and 3 without use of oxygen (in Hunedoara five furnaces x100t/cuptor and one in five furnaces Resita x 250 tons / oven, of both, the load consists hot metal and scrap and one on Red Steel 2 ovens x 100t/cuptor, load consists of solid iron scrap).

With the dismantling of steel mills Siemens - Martin has been used in liquid iron charge was disposed of coke ovens. The agglomeration installation and furnaces were shut down completely and making iron flow (sintering and coke blast furnaces). In these conditions have remained relatively large quantities of sludge of sintering and blast furnaces, dust from Siemens-Martin steelworks, skims and ferrous fraction of unused steel mill slag.

Steel works mentioned above, is currently developing electric steel mills only, equipped with EBT type furnaces, to which the current flows resulting development that currently waste electric steelworks dust, which is not fully recycled.

Taking into account the above and the results of experiments performed, believe that it revealed valuable information both steel companies in Romania and other countries that have delayed economic restructuring.

Recovery by pelleting, believe is of interest both from a technical standpoint and economically if it is considered the only currently recycle dust, knowing that such recovery facilities are provided in many technological flows.

If we follow the recovery of small waste besides the powdery waste we can choose between the briquetting and agglomeration.

Expenses with briquetting are smaller but the rule applies where there is installation for reducing (for example reduction cells).

On the exploitation of the agglomeration, this procedure enables to use a larger scrap both of granulometric and in terms of chemical composition, as compared with the other two.

That can relatively easily get sponge iron (metallic 70-80%) makes this product can be successfully used in electric furnaces like load.

Each producer of steel and powder and small waste generator, (recyclable and stored in ponds and landfills) they can do their own recycling installation (Box cluster 2-4 m diameter), so the fresh product sponge iron can be reintroduced in ruling (even in warm state).

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