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MODEL OF CONVERTER DUSTS AND IRON-BEARING SLURRIES MANAGEMENT IN BRIQUETTING

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An important problem in metallurgy of iron and steel is management of hydrated, fine-grained, iron-bearing waste which can be formed as a result of gas scrubbing. The article presents a model of application of converter slurry in a closed-circuit flow system. The correct preparation of slag, namely briquetting with defined additives, allows for application of such slag in the steel-making process as the substitute for scrap metal.

Key words: metallurgy, waste, converter, dust, management

INTRODUCTION

Raw material steelworks with full production cycle are institutions with complex manufacturing systems. A complex manufacturing system is a system which has a relatively big number of elements and/or between those elements there is a relatively high level of complex interactions, the so-called relations [1]. A characteristic feature of most technological processes in steelworks is their constant and divergent character of work. Due to the necessity to maintain the continuity of processes conduction their structure is a serial-parallel system. The analysed steelworks is a real system in which the conducted processes begin with the preparation of the charge for production of pig in blast-furnace and next in converters the processing into steel begins. Another step is outside-furnace upgrading in order to achieve the required chemical composition and the proper purity of the liquid raw material. In the process of continuous casting of steel the ingots of required shape are achieved. Main final products in the analysed steelworks are hot-rolled sections. Those products constitute about 95 % of all products in the steelworks. The analysis refers to a period of twelve months during which the production of final products reached over 2,5 million Mg.

IDENTIFICATION OF GENERATED WASTE TYPES AND PLACES OF THEIR ORIGIN IN RAW MATERIALS STEELWORKS

Steel manufacturing requires the involvement of a lot of charging materials and energy. At the same time, during manufacturing of final steel products, a significant amount of waste is generated. Depending on the required properties of the final products the weight of the generated waste varies between 0,4 to 0,7 Mg per one tonne of steel products. In the analysed steelworks the technologies applied and the types of final products shape the streams of generated waste in terms of their amount, quality and their chemical composition. Organisational structure in the analysed steelworks consists of more than 20 organisational units (UNITS). Waste amounts generated in the units directly connected with the production were analysed, and the units were:

1) CSU – Coking and Sintering Unit;
2) PPU – Pig Production Unit;
3) CMS – Converter Melting Shop Unit;
4) CSC – Continuous Steel Casting Unit;
5) RU – Rolling Unit.

In technological cycle of the analysed steelworks with full production cycle about ninety different types of waste are formed in eleven legislatively standardised groups. Most of them belong to a group of dangerous waste (about 11 % in relation to the whole weight of produced waste).

In the analysed steelworks, the policy of waste management is directed towards minimisation of the destructive influence on the surrounding, taking into account the economical calculation. The methods of waste management applied in the steelworks are: inner steelworks recovery, sales to outer recipients, disposal, storage and stockpiling. Figure 1 shows percentage amounts of waste subject to a given method of management compared with the whole weight of waste produced in production units..

Figure 1 shows that 95 % of weight of all waste produced in the steelworks in manufacturing processes is used again or disposed. The biggest rate of economic application is found among solid waste such as: clinker from iron-making process, melting losses and mill scale. Such waste is fully used in so-called closed circuit (inside steelworks) [3] or is sold and becomes an income is the economic calculation.

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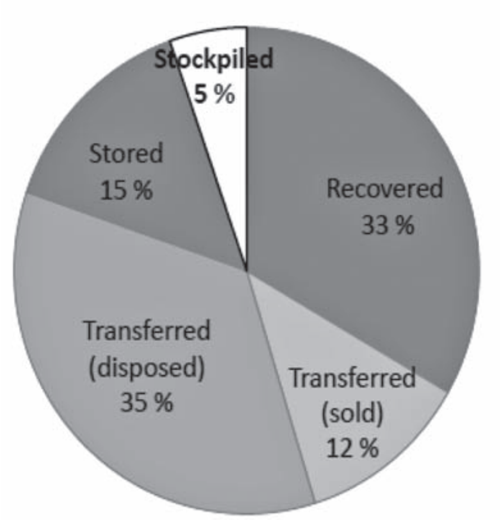

Figure 1 Structure of waste management [2]

In logistics approach, in reference to waste, the process of storage is a different process than the process of stockpiling. Only such leftovers can be stored in storehouses which can be later used again or disposed. Waste which are meant to be stockpiled later cannot be stored in storehouses [4,5]. There are no environmental fees for the process of storage contrary to the process of stockpiling, but the process of storing in storehouses cannot be longer than 36 months from the date of production. In logistics approach storage is necessary and recommended in order to gather the economic amount of transport [6] or in order to achieve the right properties of such waste i.e. temperature.

About 5 % of the weight of all generated waste is sent to the storage yard to be stockpiled which forms 82 thousand Mg per year. Table 1 presents types of waste which are sent to storage yard.

The biggest amount of waste stockpiled in storage yards is waste from heat treatment of iron, more than 58 thousand tonnes. The biggest amount here is slurry from gas scrubbing of waste gasses generated in the converter melting shop unit (CMS). They form 41 % of the whole weight of waste sent to storage yards.

APPLICATION OF CONVERTER SLURRY

All fine-grained waste produced in five manufacturing units of the steelworks as well as slug created in the process of gas scrubbing constitute about 8 %. Figure 2 presents the amount of waste generated in CMS – Converter Melting Shop Unit of the analysed steelworks.

It was thought, in the initial stage of the attempts to solve the problem that the management of iron-bearing oxide waste can be solved by adding them to a converter and they would become clinker. This idea, however, has changed due to research conducted in the USA [7]. It has shown that 95 % of iron included in oxides becomes steel. At the same time the increase of use of pig-iron in iron-making processes was observed which resulted from the necessity to provide the re-

Table 1 **Types of waste sent to storage yard according to units [2]**

Number of wastes group	Unit	Quantity of wastes sent to storage yard according to units / Mg
10 - Waste from thermal processes	CSU	9 538,900
	PPU	10 519,100
	CMS	37 396,350
	RU	933,220
11 - Waste from chemical treatment and metal surface coating	RU	17,880
12 - Waste from forming and physical and mechanical treatment of metal surfaces	CSU	30,000
	RU	96,970
15 - Waste from packaging: sorbents, fabrics for wiping, filtering materials	CSU	7,940
	PPU	1,650
	CMS	2,300
	CSC	39,240
	RU	140,620
16 - Waste not included in other groups	CSU	25,001
	PPU	1 660,820
	CMS	2 553,700
	CSC	1 693,780
	RU	208,990
17 - Waste from constructing, renovations, disassembly of building units and infrastructure	CSU	4 009,920
	PPU	6 028,300
	CMS	3 669,230
	CSC	4,220
	RU	2 503,480
19 - Waste from installations for waste management	CMS	34,740
20 - Municipal waste with fractions for selective	CSU	390,710
	PPU	30,500
	CMS	14,000
	RU	560,530

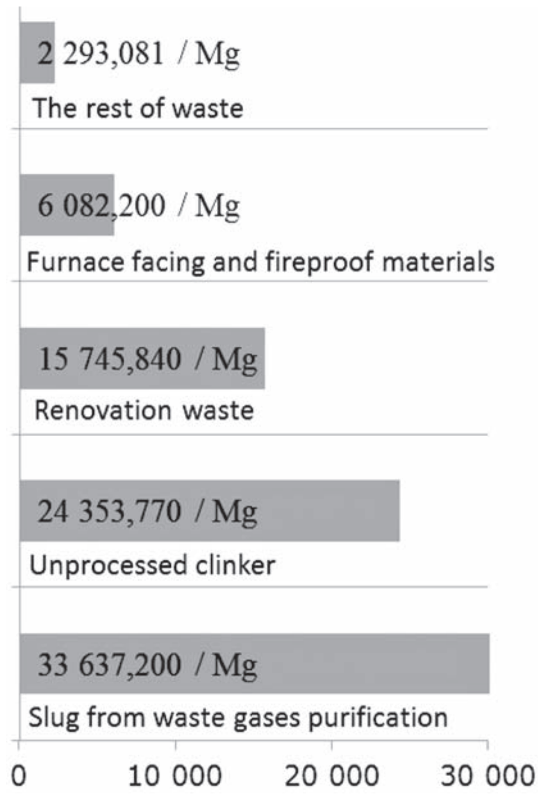

Figure 2 Waste sent to storage yard from CMS unit [2]

quired amount of heat energy needed to reduce iron oxides. This negative phenomenon can be eliminated by adding some exothermic, iron-bearing additive to the oxide waste [8]. It should serve as the source of heat energy and provide the creation of reduction atmosphere in the surrounding of iron oxides. Coke breeze or fine coal can serve as such material. Tests conducted in the USA have shown that iron-bearing oxide waste can be recycled in steel-making furnaces and at the same time serve as substitute of scrap metal.

It is a well-known fact that the biggest indicator in steel-making process is observed in the amount of waste which includes a lot of Fe. That is why a sample of converter slurry which was formed during gas scrubbing of waste gases was used in the tests. Table 2 presents the chemical analysis of sample from the analysed steelworks – number I, and the results of analyses of other samples published in topic literature. Samples II, III and IV are described in Niesler M. [9]. A characteristic feature of such waste is its big hydration – over 30 %. In order to reduce the amount of water in it a process of drying is conducted.

Table 2 **Chemical analyses of converter slurry [9]**

Ingredient	Number of converter slurry sample			
	I / %	II / %	III / %	IV / %
FeO	77,64	65,75	61,92	62,92
$Fe_{całk.}$	60,35	60,21	57,52	59,02
Al_2O_3	0,92	0,27	0,053	0,051
C	1,64	1,88	1,78	1,72
CaO	12,93	6,04	8,46	9,41
Cl	0,07	0,09	0,14	0,14
K_2O	0,52	0,062	0,075	0,075
Na_2O	0,19	0,11	0,14	0,14
MgO	0,74	1,86	2,14	2,21
P	0,057	0,086	0,049	0,049
Pb	0,22	0,18	0,27	0,24
S	0,1	0,15	0,13	0,13
SiO_2	3,04	2,72	2,14	2,21
Zn	2,44	2,85	6,79	5,87

After evaporation, a precipitate is formed which includes more than 75 % of iron oxides and the grains of which do not exceed the size of 15 μm which is shown in grain distribution picture shown in Figure 3.

Measurements of the tested sample were conducted with the use of laser diffraction with the use of the device Malvern Mastersizer 2000. The measurement was conducted with the use of liquid dispersion in distilled water with coefficient of light refraction of 1,33.

Due to significant hydration and grain refinement the converter slurry cannot be used directly in the technological processes in steelworks. They can be applied after drying and forming them into solid body form. At present, a lot of different technological solutions are applied to achieve the form which would be integrated, such as layered granulation, briquetting or compacting [10]. It can be concluded, on the basis of present experience, that the most effective method of integration of

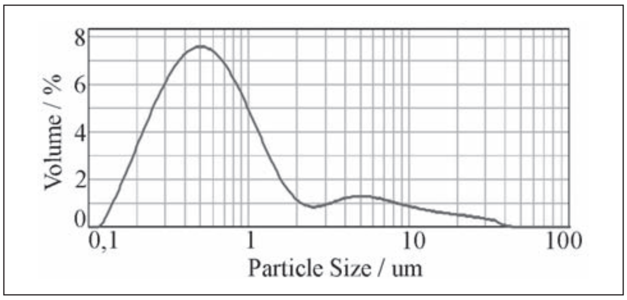

Figure 3 Particle size distribution of sample

converter slurry is briquetting [8, 9]. Here, the molasses and burnt lime was used as binding agent in order to eliminate the costly drying. The exothermic additive was coke breeze. Prepared mixture was seasoned for the period of 24 hours in order to enable the conversion of burnt lime. Tests of briquetting of converter slurry were conducted in press LPW 450. On the basis of results analysis it was stated that briquettes reach the required mechanical resistance after 48 hours of seasoning. Next, the achieved briquettes were subject to analysis [8] in thermal test. They were heated in a silt furnace from room temperature to temperature of 950 °C at a rate of 5 degrees per minute. The following step was to hold the briquettes in maximum temperature for about an hour. After cooling the furnace the briquettes were assessed in visual terms. It was found that they kept a compact structure and changed their volume only slightly. Due to the fact that the experiment was conducted in oxidising atmosphere an iron oxide appeared in the surface of the briquettes.

Collected sample of converter slurry includes about 77 % of iron oxides. Such property signifies economic justification for application of such waste as a substitute of scrap metal. Converter slurry, after giving them an integrated form of solid pieces, can form a component for steel-making furnace charge in the CMS – Converter Melting Shop unit. By full application of converter slurry in steel-making process the relation of non-managed waste from the production units would be only 3 % in comparison to current 5 %. Taking into account the fact that in order to use an exothermal substance as an additive, in the creation of solid form the waste coded 05 06 99 could also be used up. In the analysed steelworks it is the waste from coke dust generated in CSU – Coking and sintering unit. Such type of waste is mostly used again but not in the total amount. Above 1 200 Mg of this type of waste per year is not fully managed and taken care of.

CONCLUSIONS

The article focuses mainly on waste flow directed towards storage yards which are about 5 % of the whole weight of produced waste. Most of such waste consists of slurry from gas scrubbing from the CMS – Converter melting shop unit. Annually, the steelworks generates 33,5 thousand Mg of this type of waste which is more than 2 % of the whole weight of created waste. The main factor determining the financial efficiency in the use of converter slurry was big involvement of iron oxides (about 77 % of iron oxides) which could serve as the replacement for steel scrap metal after the process of integration. The choice of type (or types) of binding elements has influence on the resistance parameters of created briquettes, their size and thermal-chemical reactions in the processes of steel manufacturing.

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Note: The responsible translator for English language is D. Grochal, Poland