T. LIS, K. NOWACKI, K. ŁAKOMY

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DETERMINATION OF PHYSICO-CHEMICAL PROPERTIES OF FINE-GRAINED WASTE FROM THE CLEANING OF IRON CASTING

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In the European Union one of the most important activities is the recovery and recycling of waste including foundry waste. In the article waste arising from production of iron casting was presented. Selected physic-chemical properties of iron-bearing waste were defined. Opportunities of waste management are related to their chemical construction as well as some physical properties. On the basic the results of research the solutions of foundry waste management were proposed.

Key words: iron casting, fine-grained waste, chemical composition, microstructure, physico-chemical properties

INTRODUCTION

Substances referred to as *waste* are subject to rigorous legal regulations the purpose of which is to protect human health and natural environment. Restricting waste generation is the most fundamental principle of rational use of natural and anthropogenic resources, whereas the main goal of waste utilization is recovery of valuable components (e.g. energy or metal). Decisive for the choice of the waste utilization technology, not only the economic but also the environmental protection aspects are taken into consideration.

Next to mining and power engineering, the metallurgical industry generates large quantities of waste. In summary consumption of metal participation steel and cast steel is more than 92 %, hence the steel industry is one of the sectors of the economy that generate the most products. A characteristic feature of the waste materials is a significant element content, often comparable with its contents in natural raw materials.

This paper presents the results of the analysis of the chemical composition and selected physical properties of fine-grained waste.

RECYCLING OF WASTE MATERIALS CONTAINING IRON

In accordance with current legislation, the holder of waste shall, in the first place to prevent waste (Figure 1), and then - the preparation for reuse, recycling and other recovery methods (ie. energy reuse). At the end of the permitted waste disposal - disposal is acceptable only when it is not possible to carry out reuse [1,2]. As is clear from the Framework Directive of 19 November 2008 of the waste [1], recycling and other recovery should be a priority in waste disposal. Still growing waste stream puts increasing demands for creators processing methods of various fractions.

In the foundry industry currently the most important is the recycling of raw materials and material. Production of cast steel, cast iron alloys are subject to nearly 100 % recyclable and waste production process to a much lesser extent, and many of them can be a valuable source of iron - as a feed material. Recycling of waste metallurgical generates the following benefits [3,4]:

- reduce consumption of natural resources,
- reduction of landfill sites,
- the reduction or elimination of costs associated with waste disposal and / or purchase of raw materials for production.

Experiences of countries with the most advanced environmental protection show that the minimization of waste production “at source”, ie preventing them is the most effective strategy for waste management. Reduc-

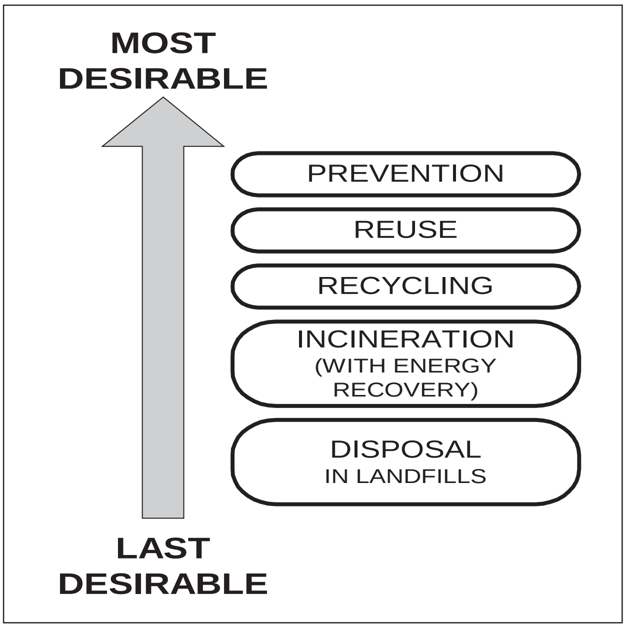

Figure 1 European hierarchy of waste [2]

T. Lis, K. Nowacki, K. Łakomy - Silesian University of Technology, Department of Production Engineering, Katowice, Poland

ing the amount of waste generated brings tangible economic benefits to raising the efficiency of technological processes, stimulating the development of technology and organization of production, reducing costs related to transportation, disposal and storage of waste. The basis for waste management is their classification according to relevant criteria [5].

In the foundry industry at all stages of production waste is generated. During cleaning cast waste is produced as a fine solid (loose). For fine-grained materials include substances, which include grain sizes from 0,05 mm to 2,0 mm [6]. These materials are often found with different admixtures and impurities. Waste from cleaning castings contain in their chemical composition of iron - in addition to other ingredients. Not only the chemical composition but also the physical properties of the dust often determine the way of their development.

CHEMICAL COMPOSITION OF THE STUDIED FINE-GRAINED WASTE

The study of the chemical composition were fine wastes from treatment of steel castings in three foundries F1, F2 and F3 – in each foundry samples of cleaning of iron casting of current production. In order to obtain accurate results with the material incorporated in each of the samples were obtained after three attempts weight of ~ 0.1 g, have been analyzed and determined the mean value and standard deviation of these elements in samples. Analysis of chemical composition was performed by means of:

- carbon and sulfur analyzer LECO CS 844,
- oxygen analyzer LECO ONH 836,
- a Scanning Electron Microscope (SEM) Hitachi S 3400N equipped with Electro Dispersive Spectrometry (EDS) detector Scientific Thermo Noran System 7, and Wavelength Dispersive X-ray Spectrometer (WDS) MagnaRay.

Table 1 show results of the quantitative analysis of chemical composition in the test samples of waste.

Figure 2 show the view under microscope of the tested fine-grained wastes.

The research material has been glued to the titanium washers, in effect, this element was excluded from the

Table 1 **Results of the quantitative analysis of chemical composition in the samples of fine grained waste / wt %**

Element	F1A	F1B	F1C	F2A	F2B	F3A	F3B	F3C
C	3,32	2,64	4,17	0,46	0,26	0,99	0,19	0,25
O	5,39	39,17	3,68	6,92	13,47	10,53	40,45	36,87
Fe	87,77	26,40	86,00	36,40	36,70	68,73	18,99	22,21
Mn	0,53	0,43	0,37	1,37	0,97	0,63	0,54	0,43
Si	1,77	28,33	3,23	2,47	19,37	16,82	37,10	37,73
Cr	0,01	0,01	0,07	1,07	19,47	0,27	0,14	0,19
Al	0,23	1,63	1,87	1,00	6,50	0,91	0,86	0,96
Mg	0,01	0,43	0,07	0,17	1,40	0,12	0,13	0,23
S	< 0,01	< 0,01	0,07	< 0,01	0,30	0,18	0,13	0,06
Ca	0,10	0,53	0,47	0,13	0,20	0,17	0,20	0,17

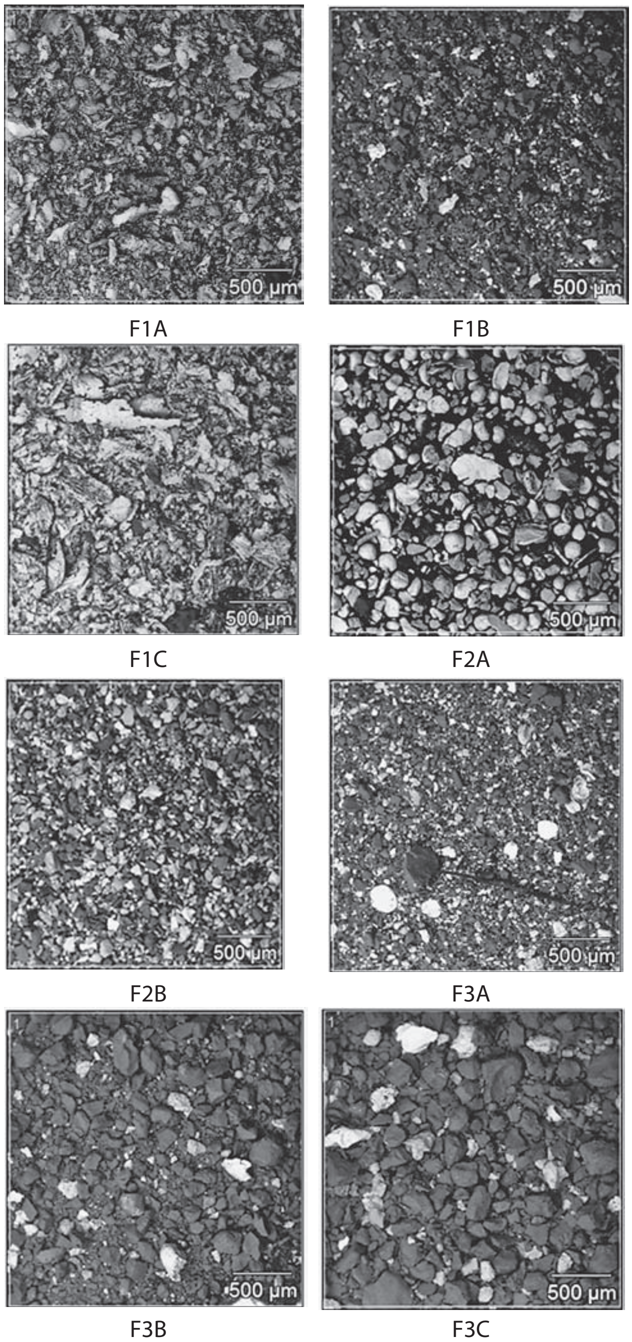

Figure 2 View under microscope of the tested fine-grained wastes

results of quantitative X-ray microanalysis (excitation area is so large that in addition to the test material also includes a substrate to which the attached material. For each measurement takes into account a predetermined value C and O.

PHYSICAL PROPERTIES OF THE FINE-GRAINED WASTE

For test fine-grained waste identified the following sizes belonging to the basic physical properties of the dust [4]:

– grain size distribution,
– damoness (content H_2O).

One of the most important dust properties is its grain composition being a quantitative distribution of dust

Table 2 **The physical properties of studied fine-grained wastes / wt %**

		F1A	F1B	F1C	F2A	F2B	F3A	F3B	F3C
Grain size distribution / mm	> 2	-	-	-	-	-	29,89	0,88	0,81
	2 - 1	0,17	0,21	0,14	0,16	-	26,45	0,81	0,93
	1 – 0.5	0,61	0,98	0,74	0,08	0,04	7,15	2,12	2,94
	0,5 – 0,2	5,44	4,26	3,59	4,39	3,47	3,59	32,61	33,28
	0,2 – 0,1	27,22	26,11	24,92	74,22	17,10	3,78	52,68	53,14
	0,1 – 0,63	27,50	26,90	27,58	18,18	35,67	5,90	9,94	7,75
	< 0,63	39,06	41,54	43,03	2,97	43,71	23,24	0,95	1,15
Content water		0,05	0,07	0,07	0,01	0,01	0,01	0,02	0,02

particles with regard to their size. This feature is determined by means of a multi-sieve elutriator by appropriately choosing the set of sieves corresponding to the range of particle dimensions. After a dust sample has been sieved, the remains on each sieve are weighed and then a respective percentage share is calculated with reference to the initial sample weight. Results for test dust are shown in Table 2.

Interms of apparent bulk density, loose materials are classified as follows:

– light, for which $r_z < 0,6$ g/cm^3;
– medium-weight, for which $0,6 \le r_z \le 1,1$ g/cm^3;
– heavy, for which $1,1 \le r_z \le 2,0$ g/cm^3.

Knowing the bulk dust density is required for various purposes, including to:

– choose the type and means of transport,
– determine the pressure in walls and outlets of containers,
– properly fill dust containers.

Dampness considerably affects other physical and chemical properties of loose bodies, including dusts, and particularly the coefficient of external and internal friction, strength, elasticity, etc. The measure of dust dampness is its water content. The water may be bounded chemically, physically-chemically, and mechanically. Chemically bounded water forms a chemical compound. Dust containing water being only chemically bounded is a dry one. Physically and chemically bounded water makes the solid bodies (dust particles) change their properties. This kind of water can be removed in the drying process which may be accompanied by altering of the current structure and properties of the relevant body. Mechanically bounded water may form a thin film on the surface of particles or fill the free spaces between them. The mechanically bounded water can be evaporated by drying. The test dust was dried at 105 ^{o}C for 24 hours – results are shown in Table 2.

CONCLUSION

The chemical composition analysis conducted for the fine-grained wastes studied implies that the main components are iron, silicon, aluminum and chromium. Percentages of the elements in the tested waste are diverse, and no doubt depend on the chemical composition and quantity of cleaned sand casting used in the cleaning process.

The iron content greater than 50 % is eligible waste for re-use thereof as feed material to steelmaking process. The test sample waste with a high iron content (above 60 %) have a silicon content of a few percent. Test fine waste should be re-used for the recovery of iron and / or alloying element - eg. in a sample F2B, the chromium content 19,47 %.

Most of the tested waste has a particle size of less than 0,2 mm. Such particle size should not cause problems in granulation or briquetting of waste materials. The process of briquetting / pelleting is necessary for relaunching fine-grained waste as feedstocks.

Density of the examined fine-grained waste corresponds to their chemical composition.

The water content in the test samples is similar levels (0,01 - 0,07 % H_2O). Such H_2O should not impede the process of pelletizing or briquetting.

The content of iron and other alloying elements and the physical properties of fine-grained waste examined indicate the validity of the development of recycling technology of waste.

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