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SELECTION CRITERIA OF LUSTROUS CARBON CARRIERS IN THE ASPECT OF PROPERTIES OF GREENSAND SYSTEM

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Carbonaceous additives have often been regarded as problem ones to solve and improve the surface finish of iron castings, but at the same time they cause other issues such as increased loss on ignition, total fines and moisture in greensand systems. With the correct selection of carbonaceous additive, the combination of low ash, high volatile and lustrous carbon content coupled with the key element grading size, ensures that produced castings are free from metal penetration and surface related problems.

Key words: lustrous carbon, bentonite, green sand system, carbonaceous additive.

INTRODUCTION

Most of castings produced in the European Union are made with use of classic moulding sands, bentonite-based sands containing lustrous carbon carrier (Figure 1). The most popular carbonaceous additive is still coal dust. A search for substitutes of coal dust with increased ability to form lustrous carbon is underway.

Bentonite-based sands used for producing moulds are regarded as ecological. Nevertheless, after adding to them coal dust and LC carriers they become harmful to natural environment. After pouring liquid metal into moulds, during high-temperature pyrolysis of organic additives leading to the formation of lustrous carbon, released are volatile organic compounds (VOC) and polycyclic compounds of aromatic hydrocarbons (PAHs) and benzol hydrocarbons (BTEX), which were not involved in thermal reactions of polycondensation and polymerization. They are particularly harmful due to their carcinogenic, mutagenic and teratogenic effect. Other possible harmful compounds emitted from moulds are dioxins and furans [2].

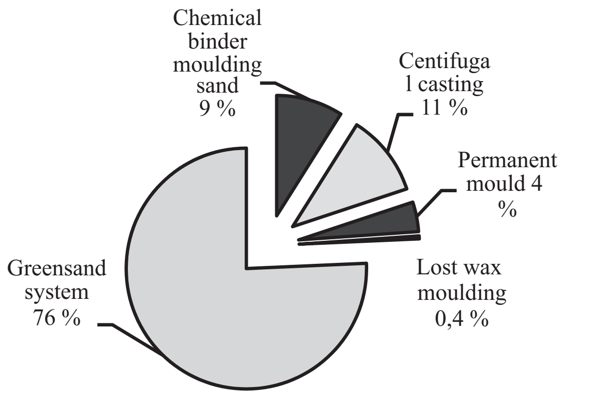

Figure 1 Share of greensand system moulding [1]

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Generally, for refreshing of system sand, fresh sand 100 - 200 kg/t metal, bentonite 40 -60 kg/t and lustrous carbon carriers 15-25 kg/t are used. The main reasons for which additives containing carbon having the properties of forming lustrous carbon are added to classic bentonite-based sands are:

– improvement of casting surface quality,
– decreased labour consumption for casting cleaning,
– decrease of sand adhesion to casting,
– limitation of casting defects caused by adsorption of N,
– improvement of knockout properties.

PROPERTIES OF LUSTROUS CARBON CARRIERS, THEIR ROLE IN MOULDING SAND

When selecting hard coal and carbonaceous additives one must take into consideration chemical properties such as: volatiles content, moisture content, sulphur content, chlorides content and physical properties such as: ability to create lustrous carbon, degree of fineness. Requirements for coal dust are specified in PN-91/H-11008.

Volatiles content, one of the main parameters for evaluation of coal dust and lustrous carbon carriers. The norm for coal dust specifies a range 30 ÷ 40 %. Volatiles content in carbonaceous materials often reaches as much as 99 %, nevertheless they show much increased ability to form lustrous carbon. Due to this, it is possible to minimize their addition to moulding sand, which eliminates defects resulting from too high gas excretion ability of the sand.

Ash content maximal ash content specified by the norm is 4 %, due to the increase of ash quantity during recycling of bentonite-based moulding sand. If ash is very fine, it is necessary to use extra quantity of water and binder and decrease moulding sand permeability. In view of these adverse for the moulding sand phenomena, it is required to use materials with the lowest ash content.

Moisture content in coal dust is present in two forms: as surface moisture and chemically combined moisture. In good quality coals, chemically bounded water should amount to 2 – 4 %. Moisture content for coal dust. This parameter is particularly important for reasons of work safety, dust self-ignition properties and explosiveness. Transport of coal dust is subject to ADR regulations. Only a mixture of bentonite, coal dust and lustrous carbon carrier with 75 % bentonite content ensures safe handling and transport.

Sulphur content specified in the norm for coal dust amounts to max.0,8 %. In case of castings made of spheroid cast iron, it is necessary to maintain low sulphur content in bentonite-based moulding sand in order to facilitate effective formation of globular graphite. In case of too much sulphur in the surface layer there can occur flake graphite in place of globular graphite and defects in form of pinholes. It is recommended to maintain a 0,12 % level of sulphur content in the moulding sand. Particular attention must be paid to the choice of grade of coal. Coal dust used for bentonite-based moulding sands should come from the processing of high quality coal.

Too high chlorides content adversely affects bentonite swelling process and deactivation in moulding sand, which results in a decrease of wet tensile strength. It is recommended to use materials with low chlorides content. There is also a danger of creating organic halogen derivatives during pyrolysis.

The ability to form lustrous carbon is the main parameter determining the efficiency of coal dust or its substitute. Lustrous carbon is the main factor deciding about the quality of casting surface. Lustrous carbon – pyrographite is a microcrystal form of coal, its formation process takes place in the temperature range of 650 – 1200 °C. The ability of coal dust to form lustrous carbon is set at minimum 9 %, coal dust substitutes show the ability to form lustrous carbon of about 60 %, it allows the quantity of carrier used in moulding sand to be limited [3].

Proper fulfilment of the role of coal dust and lustrous carbon carriers in moulding sand depends also on its grain composition. A general principle is that a coal dust grain was not greater than a medium size grain of matrix used for making the moulding sand. Selection of the degree of grind depends on the required casting surface and forming technology. When particularly good surface is required in case of small castings one must use fine sand together with fine coal dust. In high-pressure forming it is recommended to use dust with increased granularity in view of the improvement of moulding sand permeability and decrease of the rate of volatiles release.

The main reasons for using in classic moulding sands materials having properties of forming lustrous carbon and coal dust:

– Lustrous carbon is deposited on moulding sand grain surface forming a compact and non-wettable by liquid metal protective layer on the metal/moulding interface,
– The layer adheres best to moulding sand grains if its thickness does not exceed 0,1 μm. This protective layer prevents mechanical penetration of liquid alloy into the moulding sand interior and improves the casting surface roughness. It also separates the moulding material from alloy, preventing reactions between oxides of casting alloy and moulding sand components(Figure 2),
– Coal dust during decomposition process turns to semi-coke which reduces wall movements. In this way less probable are defects caused by surface enlargement of moulding sand resulting from large expansion of quartz [4].

From contemporary literature we know about the existence of pyrolytic carbon fractions containing fractions of:

lustrous and amorphic carbon formed during the process of high-temperature pyrolysis. Pyrolysis process takes place in two stages:

1 st stage: coal+ C-additives $\xrightarrow{900°C}$ coke+ tar+ water$_{(1)}$+ gas$_{(1)}$

2nd sage: tar+ water$_{(1)}$+gas$_{(1)}$ $\xrightarrow{1100°C}$ PC+ water$_{(2)}$+gas$_{(2)}$

where:
PC- Pyrolysis carbon
PC=LC+AC
LC- lustrous carbon
AC- amorphous carbon

Gas$_{(1)}$ is a mixture of aromatic and aliphatic hydrocarbons; gas$_{(2)}$ represents simple gases difficult to decompose (CO2, CO, H2, CH4…).

Semi-coke represents the third form of coal emerging from the pyrolysis reaction of lustrous carbon carrier [5].

Coal dust contributes to the formation of reducing atmosphere in bentonite-based moulding sands during the casting process by removing oxygen contained in pores of the moulding sand [6,7].

The ability to create a surrounding layer on the grain surface is attributed to carbonaceous additives. Layer surrounding improves moulding sand fluidity and decreases casting surface roughness.

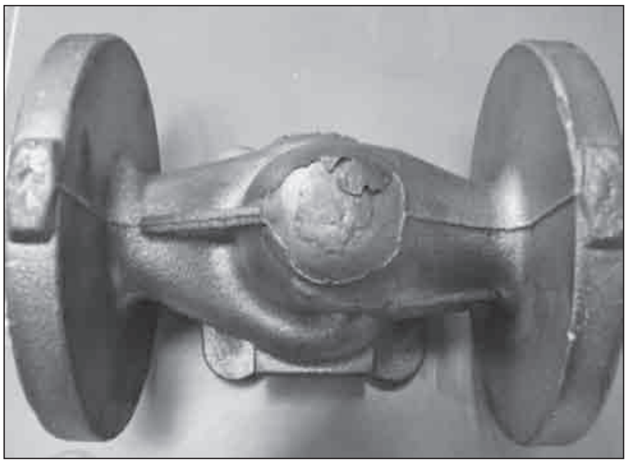

Figure 2 Defects associated with too high LC content in moulding sand

RESULTS AND DISCUSSIONS

The object of the study were different types of coal dust and lustrous carbon carriers that may constitute replacements of coal dust in the greensand system. The tests were made on materials containing carbon (Table 1):

- coal dust of hard coal from different coalmines
- coal dust of brown coal
- cyclic hydrocarbon resins, coumarone-indene resins,
- plastics, ready-to-use carrier concentrate containing coal dust, plastics.

Table1 **List of carrier parameters**

Item no.	Sample	Volatiles content / %	Ash content / %	Lustrous carbon content /%
1	Coal dust sample 1	33,97	2,2	9,5
2	Coall dust sample 2	35,9	3,6	9,5
3	Coal dust sample 3	32,98	3,8	10
4	Coal dust sample 4	30,66	5,6	9,0
5	Brown coal dust sample1	47,20	3,10	15,50
6	Brown coal dust sample 2	44,80	5,70	14,00
7	Product PET	88,2	0,25	24,0
8	Polypropylen	96,0	1,10	38,0
9	Ready to use carrier concentrate, sample 1	63,4	9,00	27,7
10	Ready to use carrier concentrate sample 2	70,9	3,30	33
11	Hydrocarbon resin	95,4	0,50	55
12	Coumarone-indene resin	95,0	0,40	53,9

In these materials the following parameters were determined:

- The content of volatiles standard by PN-81/G04516 [8].
- The content of Ash standard by PN-ISO 1171 [9].
- The content of Lustrous carbon standard by BN-88/4024-09 [10].

Coal dust contains about 30 – 35 % volatile matter and the ability to create lustrous carbon at 10 %. The amount of ash was between 2,2 % to ,6 %. Dusts from brown coal had a higher volatile matter content of 45 %. Also the ability to create a lustrous carbon was greater than the dust from coal (15 %). Plastic materials and synthetic resins exhibited a very high content of volatile matter at a level even above 96 %.

Plastic materials and synthetic resins exhibited a very high content of volatile. The same time their ability to create a lustrous carbon was very high (over 50 %). For each type of substance showed only minimal ash content, which resulted from the fact that almost all of the material underwent transformation in gas phase. Ready to use carrier concentrate showed values in between coal dust, as well as plastics and resins, both in the amount of volatiles generated and the ability to form a lustrous of carbon or ash formed.

CONCLUSION

Foundries seek to reduce costs, produce good quality castings and maintain safe working conditions. Mixtures containing bentonite, coal dust substitute, and some part of coal dust enable the following. Due to the large harmfulness coal dust, in addition to the moulding sand of bentonite.

The companies producing mixtures for the foundry industry are performing intensive investigations attempting to develop coal-contenting additions, with could substitute traditional coal dust in terms of casting quality, and also would be better for the environment and the workers [11-13]. These works are also carried out in the Zakładach Górniczo- Metalowych Zębiec S.A. (Poland).

In the selection alternatives of coal dust import duties include the following parameters: volatile matter content, the ability to create a lustrous carbon and ash content.The results showed that the plastics and synthetic resins generate a much higher amount of volatile and lustrous carbon content than coal dust or brown coal dust. But to assess their usefulness and impact of technology on the quality of the castings obtained it is necessary to conduct trial heats and measurement gas emissions. Dust the tested brown coals have better test parameters (volatile matter content and the ability to create lustrous carbon) than the dust from the coal. Taking into account the lower price of brown coal relative to coal, it would be economically reasonable use of this alternative. However, this requires a process of trial and measurement of emissions from gas.

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Note: The responsible translator for English language: Tadeusz Lipski, Krakow, Poland