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INFLUENCE OF ADDITIVES IN CORE-FORMING MIXTURE

In recent years, ingredients, also known as additives, which appreciably affect the quality of the casting surface, come to the fore. Additives – lower the temperature at which SiO_2 (major component of silica sand) begins to soften and create a melt on the surface of the grains, increase the reactivity and decrease the temperature of a transition to tridimite and cristobalit. These passages support the increase of volume of subsurface sand stress and the tension for the formation of burrs and other casting defects on the surface of the core or the mold.

Nowadays, as a great emphasis is put on the quality of the casts, it is therefore necessary to pay attention to these additives, which can effectively reduce the labor intensity in the production of castings and ensure a quality surface of castings.

Keywords: Innovative Foundry Technologies and Materials, Castings Defects, Additives

1. Introduction

The reason for using additives is to eliminate the emerging tensions between grains of SiO_2. It should be borne in mind that sand does not have a distinct melting point. This material will cause that the sand becomes soft and flexible. Subsequently, the sand will be similar in properties and characteristics to the plastic which enables it to adsorb greater stress [1,2].

2. Theoretical part

Adjusted sand additives – additives work on two principles. The first uses a high temperature phase change that occurs in the sand at the temperature of about 870°C (1598°F). There are four main phases of quartz in which concerns of technologists are justified. The first phase is alpha SiO_2, which is stable from room temperature to 573°C (1063°F). The second phase is the beta SiO_2. This phase of silica sand is less stable than the alpha SiO_2, and the viscosity of the solid is decreased, which indicates a certain surface softening. It should be noted that this change will occur, regardless of the type of a binder. The volume loss in this stage can range from 50 to 100% of the original length of the sample [1,3].

If the viscosity is sufficient for softening of the surface of the sand grains to create a liquid, a phase called tridymite is formed. Engineered Sand Additive (ESA) is often used in the foundry industry. It forces the tridymite to transform the sand**,** which subsequently leads to a radical temperature increase of the volume. The resulting increase in volume by up to 12%, reverses the surface tension and thereby effectively removes the flash gutters in the casting of iron. Therefore, while the sand used in combination with the ESA is heated above 1050°C (1922°F), softening and the loss of capacity occurs. Looking at the expansion of quartz sands with the additions of iron oxide, it can be seen that even when there is a softening, the phase of alpha SiO_2 does not change to beta SiO_2 and tridymite. The volume loss continues along with the increased temperature until the change at the fourth stage [2,4].

This phase consists of passing from the beta SiO_2 to beta cristobalite, and is linked to a volume change of 14.7%, which occurs at about 1470°C (2678°F). This increase mimics the action of the ESA at temperatures of cast of iron casting, and reduces the occurrence of burrs by reducing the tensile stress acting on the surface of the core or mold, by enlarging. Along with the transformation of cristobalite and associated expansion, the point of sintering the sand will decrease. Unfortunately, the reduction of burrs using the iron oxide can reach high costs.

Sand ingredients – additives comprising organic materials such as sacharides or dextrin, provide a slight dampening effect on the passage of the transformation of alpha / beta. But mainly they act as a carbon source for the high temperature of sintering sand. It was demonstrated that all of the accessible oxygen in the cavity of the mold is absorbed shortly after filling mold with the liquid metal. In the absence of oxygen, the organic substances are decomposed by the carbon which bounds on the surface of the sand grains, increasing the viscosity and the tensile strength on the surface of the sand. This increase in tensile strength withstands any stresses and reduces the occurrence of burrs (Fig. 1) [2,3,5].

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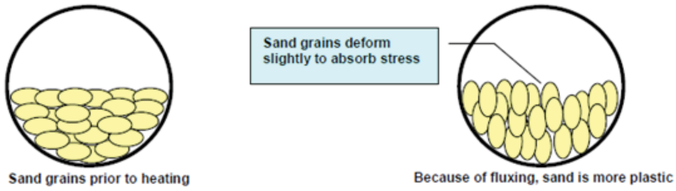

Fig. 1. Influence of additives [4]

3. Experimental part

Additives are components for the production of cores by cold-box-amine technology, which limit the occurrence of burrs at high temperatures. They are recommended as additives to silica sand, before the addition of the resin. The dosage is usually in the range of 0.5-0.75% by weight of sand. It provides better flow of cores and better dimensional stability.

Methodology for verification of sands and additives influence on the surface quality of castings in practice.

Machine shooter KSA 40 is a machine that uses compressed air to shoot the core sand mixture with a binder into the core boxes. After the shot, flushing air or supplied gas will be led into the core boxes, using fumigation apparatus and gas supply panels. This causes rapid curing of the mixed sand in core boxes. The core hardens [4,6].

Methodology for preparing the core mixture in the operating conditions

New, returnable sand is conveyed to the mixer 100 MRI by means of two screw feeders. Their dosage amount is determined by the time of screws running, when it is possible to accurately determine the amount of time necessary for given amount of sand by means of a calibration.

Methodology for microscopic analysis

Semi-quantitative EDX microanalysis of samples was performed by scanning electron microscope JEOL JSM 7000F, using point and surface elemental analysis of selected microstructures. Spatial distribution of elements was evaluated by elemental maps of the relevant microstructural areas of monitored samples (EDS analysis).

Methodology for determination of flexural strength and tensile strength

For the tensile strength was used a body in the shape of eight, stressed by the tension of 5 cm^2 at the measurement point F in range Rm1-0-130N/cm^2.

For the flexural strength was used a body in the shape of spicules with the flexural cross-section of 5 cm^2 (22, 4×22, 4 mm) at the measurement point B in range Rg1-0-870N / cm^2 [4,7-9].

4. Results

The following Fig. 2 shows a detail of the burr, which originated in manufactured castings. After the EDX analysis, it is clear by looking at the picture that there is an engineered flash, since in the area of the liquid metal containing iron oxides (red ferous) are the oxides of silica SiO_2 (green), which are the main component of quartz sand used in the process of manufacturing molds, and cores. It follows that after casting the liquid metal into the mold, the metal got to interact with the core. As the result of increased subsurface stress, which was the consequence of the transformation changes of the silica sand, it led to the penetration of the liquid metal into the core, which affected the existence of the casting burrs on the surface, deteriorating the quality of produced castings.

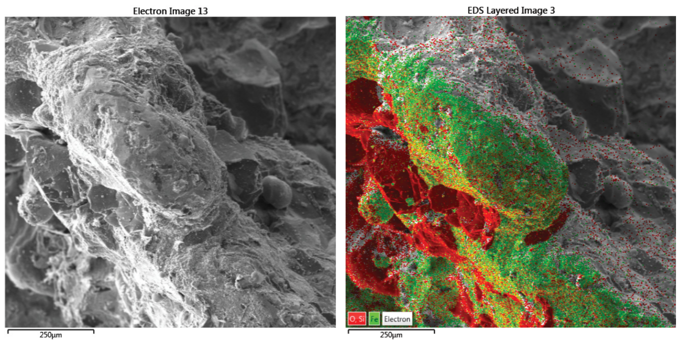

Fig. 2. Detail of the burr on the castings, using silica sand ST in nuclear mixtures

Currently, there is a number of additives on the market designed to improve the casting surface and thus significantly affect the quality of castings. In terms of eliminating burrs, using additives is one of the simplest and the most effective methods and therefore the analysis of additives is very important. Since the technical data sheets from suppliers of such ingredients do not often contain basic parameters, several analysis were performed to define the additives used in foundries Eurocast Košice Ltd.

One of the first analyses of additives was performed by an EDX microscopic analysis (Fig. 3), which attempted to determine what the individual components of the additive may resemble.

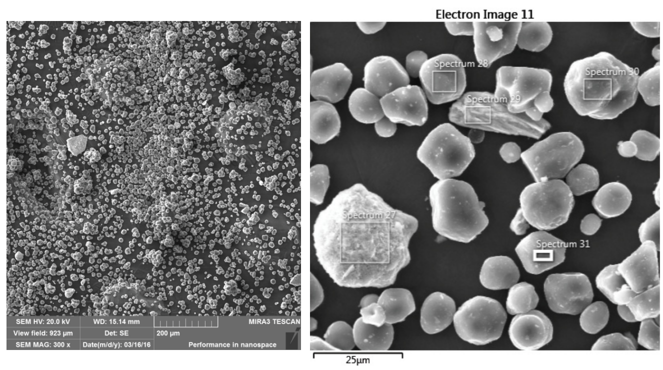

Fig. 3. EDX microscopic analysis of Additive 1

Surface and point analysis of different spectra of the sample taken, was made.

From the above analyses, different representation of elements in the samples taken is seen, or, more like of their oxides. The shape of individual grains of additives was yet unknown for the foundry industry in the context of the use of molding compounds.

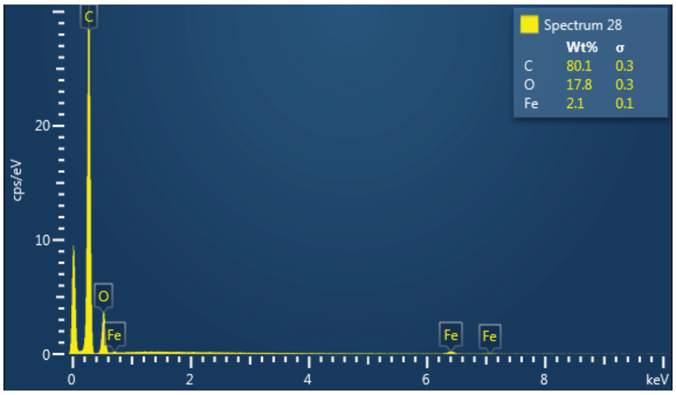

Fig. 4. Surface analysis of spectrum of the sample taken of Additive 1

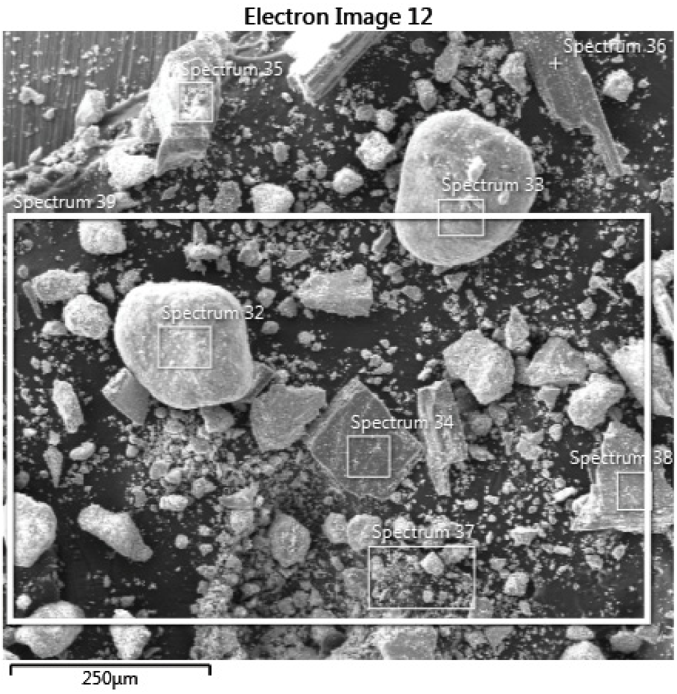

Fig. 5. Microscopic EDX analysis of Additive 2

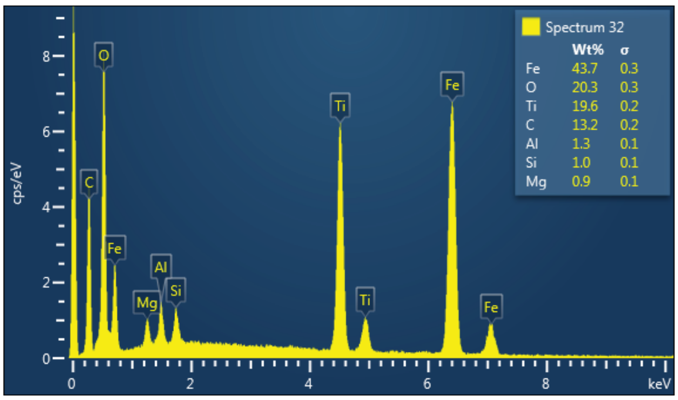

Fig. 6. Surface EDX analysis of Additive 2

From EDX analysis follows that the composition of the additive 2 is very difficult to assess by the results. Therefore the analysis of the chemical composition was made, which the results are shown in the Table 1.

The results of surface and point analysis were surprising for the reason that, as shown in Fig. 4, some seeds of samples contained significant amounts of carbon with the absence of other elements. Another chemical analysis was therefore carried out. The chemical composition of additives, was done by a combination of the analytical methods: AAS elemental analysis of prepared solutions and optical quantification methods. The control of chemical composition was carried out using a mobile spectrometer Niton XL3 Goldd (Table 1).

TABLE 1

Chemical composition of additives

	Si	**Fe**	**CaO**	**MgO**	**Al_2O_3**	
Additive 1	0,367	9,304	0,572	0	0,155	
Additive 2	14,365	34,443	0,397	0	6,756	
	SiO_2	**P_2O_5**	**K_2O**	**MnO**	**Fe_2O_3**	**TiO**
Additive 1	0,786	0,633	0	0	13,305	
Additive 2	30,785	0,746	0,314	0,345	49,254	3,62

From the results of EDX analysis and chemical composition it was not possible to determine what kind of material it was. Further analyses were carried out and one of them was the submission of samples for analyzing with the light microscope (Fig. 7)

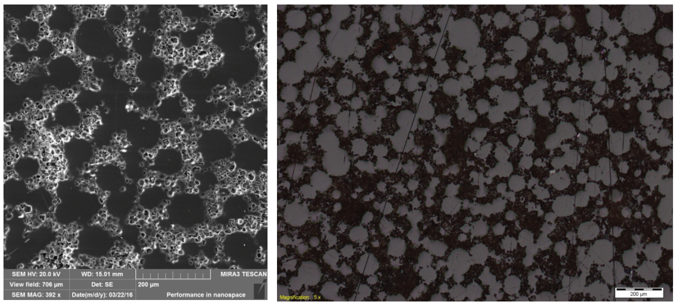

Fig. 7. Analysis of Additive 1 with the light microscope

These microscopic images brought an assumption that given additive is based on an organic base, since formed chains (Fig. 7) resemble the organic components, particularly insoluble polysaccharide. This assumption was made on the basis of results of performed analyses, and of course, based on the study of the available literature.

As the first additive was analyzed by the light microscope, also was the additive 2, and the result is shown in the following Fig. 8.

From the above results of the chemical composition of the EDX analysis and the light microscopy was established an assumption that the additive 2 is on the basis of an iron oxide, or hematite iron ore adjusted to the required granulometry.

Assessment of the strength ratio of the core mixture to the formation of burrs on castings

The theory presents as one of the criteria for assessing the core mixture ratio of the flexural strength and tensile strength $R = \sigma_{bend}/\sigma_{pull}$.

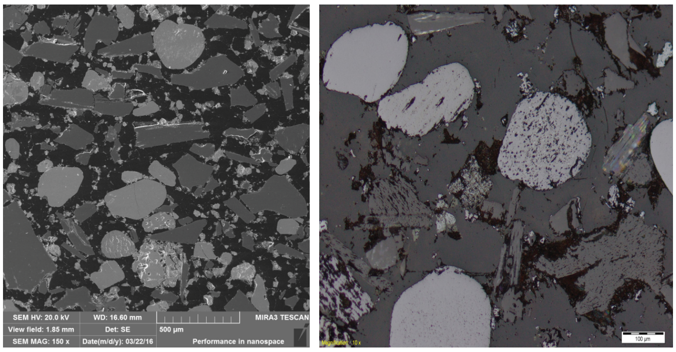

Fig. 8. Microscopic analysis of Additive 2 with a light microscope

Precisely for this reason, examinations have been made to measure the strength of core mixtures which were used in the manufacture of castings. The following Fig. 9 is a table of used core mixtures, and their measured values of flexural strength and tensile strength. It should be mentioned that these tests were carried out in laboratory conditions, so the results of the experiments are for guidance only, namely the strength values may differ from those real ones. Nevertheless, the most important parameter is the ratio of these strengths, coefficient R and in this perspective the results are applicable for formulating further conclusions.

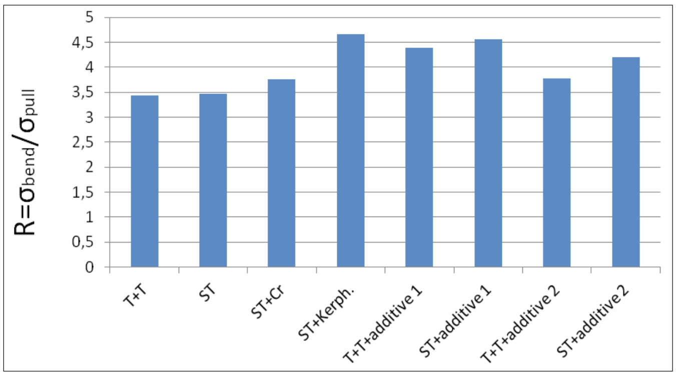

Fig. 9. Graphical representation of the coefficient R used for each core mixtures

5. Conclusions

- The first two samples of the core mixture which main component was quartz sand, (in terms of using silica sands) in the first case T + T, and the second ST reach approximately the same coefficient R. When using silica sand ST, better results were achieved. There was smaller amount of burrs found on the castings. Since the coefficient R is in each case almost the same, the difference in the surface of the castings was probably achieved by the effect of the granulometry and of the surface of the grain sand ST.
- The chart shows that (from the point of view of using a non-silica filler material) by adding a non-silica filler material into a core mixture, in this case 20hm%, higher values of the coefficient R will be achieved. The higher the value of R, the better the surface of the casting we should obtain. At a higher coefficient R there is an assumption that there will not be a significant stress of the subsurface layers of a mold and thus neither the creation of burrs.
- An additive 1 was further added to the core mixture, in combination with two types of silica sands, T+T + additive 1 and ST+ additive 1. The graph shows achieving a higher R-value than while using silica sand without adding additives. It is also seen that the additive 1 in combination with a filler material ST reaches a higher R-value, therefore it can be assumed that if using additives in a powder form they will achieve a high bonding activity with finer sand. In other experiments there was used additive 2, for which it was reaffirmed that better bonding effect is achieved with finer sand. However when comparing the two additives, better results were achieved by using the additive 1.
- To use additives – additives in the molding compounds it is true that their main task is to improve the casting surface, whether they are organic based or on the base of iron oxide. It is essential to know their effects due to proper use in the mixture.

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