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THE IMPACT OF COMMON ADDITIVES ON CASTING SURFACE QUALITY

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Abstract

Modern foundries are being challenged by current trends such as lightweight construction, advanced core and casting design with controlled material properties, and high precision requirements. Core production plays a critical role in casting, as the cores have a significant impact on the final quality. One key factor is the choice of materials for molds and cores, with silica sand being the most commonly used. However, even the highest-quality silica sand cannot always prevent defects in the final casting. A possible solution to reduce such defects is the addition of additives to the mold and core mixtures. This paper explores the effects of commonly available additives on the surface quality of test castings. In the study, five additives were tested, including energy ash, and 14 test castings were evaluated using visual comparators to assess surface quality.
***Keywords**: Mechanical Properties, Casting Defects, Core Mixture, Additives*

1. INTRODUCTION

The cold-box process, introduced in 1968, remains a standard for efficient core and mold making, using an amine gas catalyst to harden phenolic-urethane resin-coated sand. It combines the advantages of both the CO2 process (controlled curing) and the hot-box process (organic binders). The cold-box-amine method uses dry silica sand mixed with phenolic resin and polyisocyanate, with tertiary amines as the catalyst. This method minimizes common defects like veining caused by uneven thermal expansion in casting. While silica sand is widely used, its limitations can lead to surface defects. Additives such as sawdust-based materials and iron oxide have become effective in reducing these issues by making the sand mixture more flexible and reducing stress. This paper evaluates the effectiveness of various additives in improving surface quality in castings.

2. EXPERIMENTAL

In order to determine of the influence of core composition on surface quality a new testing metod was suggested and various additives commonly used in foundries were selected.

2.1 Materials

High-quality silica sand from Biala Gora locality BG and several types of commonly available additives for the cores production were selected and tested. The basic parameters of tested silica sands are summarized in Table 1.

Table 1. *Basic parameters of tested silica sand BG*

Sand	SiO_2 [%]	Fe_2O_3 [%]	Flushable fraction [%]	Refractoriness [˚C]	d_{50} [mm]
BG	>99.5	0,04	max. 0.2	> 1600	0.25

The binder consists of component I and component II. Component I consists of a liquid yellow synthetic resin with a density of 1.07 – 1.08 g.cm^{-3} called Gasharz 6747. Component II consists of a liquid solution of a modified brown isocanate with a density of 1.21 – 1.23 g.cm^{-3} in a separate solvent. The binder consisting of components I and II was added to the core mixture in a ratio 50:50 in an amount 0.9 %.

5 types of commonly available additives were selected and tested: Anti-Finnning agent NO2 from Sand Team spol. s.r.o.; Feranex 8718 from Hüttenes Albertus CZ s.r.o.; Veinseal I-35 from Hüttenes Albertus CZ s.r.o.; No Coating X05 Extra of F.lli Mazzon s.p.a.; Sand additive 031 from Sand Team spol. s.r.o.

2.2 Determination of flexural strenght

This strenght test is determined by applying a bending load to a normalized test bar after 1, 4 and 24 hours. 18 standard test bars were made from each tested core mixture by injecting the core mixture into a mold intended for the production of such test bars.

2.3 New test casting

To evaluate the surface quality, a new block-shaped test casting with dimensions of 210x210x210 mm with two teardrop-shaped cavities passing through the casting was designed (Figure 2). The weight of the test casting was 21 kg. The cavities in the test casting represent the places most thermally and chemically stressed. In these places is easily observable the effect of the application of additives in the core mixture on the surface quality of the casting.

Table 2. *The final chemical analysis of cast iron*

Element	C	Si	Mn	P	S	Cr	Cu	Sn	Mg	Sc
Content [%]	3,7-3,85	2,2-2,4	0,4-0,65	max. 0,05	max. 0,015	max. 0,1	0-0,3	max. 0,01	0,03-0,05	1,04-1,07

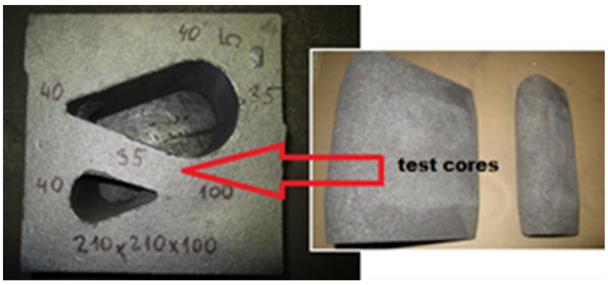

Figure 1. *The new test casting and manufactured cores*

The test castings were cast from ductile iron EN-GJS 500-7-cold. of the prescribed chemical composition, which can be seen in Table 2. After making a series of 14 cores (each core was made from the same mixture twice), test castings were cast at a temperature of 1380˚C.

2.4 Classification of surface defects on casting by visual contact comparators

To evaluate the area of the casting, a visual control without optical tools is required, with appropriate Scrat visual comparators according to the category and seriousness of the level. In Table 3. the most common defects categories and severity levels within each category.

3. RESULTS AND DISCUSSION

3.1 Results of flexural strength

The following figure (Figure 2) shows the flexural strenght results of standardized test bars made of core mixture with the addition of the tested types of additives after 1, 4 and 24 hours.

From the measured results of the strenghts of the individual standardized test bars, it can be seen that the flexural strenght increases with time. The lowest flexural strenghts after 24 hours achieved standardized test bars with the ANTI-Finn (187,5 N/cm2). The standardized test bars with the additives NO COATING X05, VEINSEAL I-35 and energy ash had approximately the same flexural strenght values after 24 hours (215,2 N/cm2, 223,2 N/cm2, 225,8 N/cm2). The highest strenght after 24 hours had the standardized test bar made of core mixture with the additive FERANEX 8718 (275,34 N/cm2). The core mixture consisting of quartz sand without the addition of additive and core mixture containing the additive Sand additive 031 had a bit lower value (257,33 N/cm2, 238,3 N/cm2).

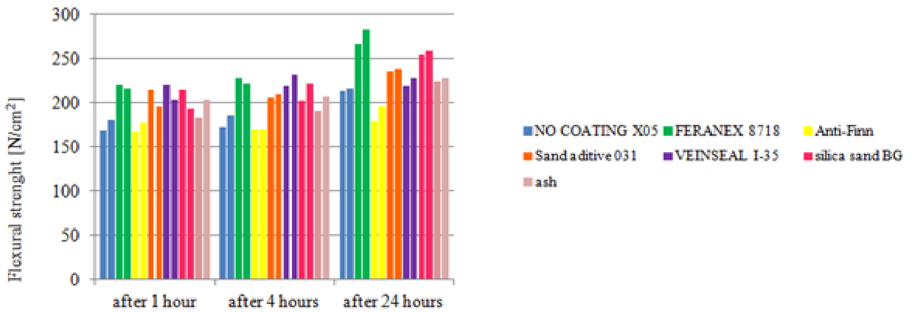

Figure 2. *The flexural strenght results of standardized test bar after 1, 4 and 24 hours*

3.2 Experiments

The following table (Table 5) shows 14 experiments, based on which the influence of different types of addditives on the occurence surface defects was evaluated. The surface quality of test castings was evaluated using standards accorging to the standard STN EN 1370 - classification of surface defects into steel and steel castings by visual contact comparators (Table 3).

Table 3. *Evaluation of surface quality of test castings*

Exp.	Composition of core mixture
1a	100 % silica sand BG + 1% NO COATING X05
1b	100 % silica sand BG + 1% NO COATING X05
2a	100 % silica sand BG + 1% Feranex 8718
2b	100 % silica sand BG + 1% Feranex 8718
3a	100 % silica sand BG + 1% Anti-Finn
3b	100 % silica sand BG + 1% Anti-Finn
4a	100 % silica sand BG + 1% Sand aditive 031
4b	100 % silica sand BG + 1% Sand aditive 031
5a	100 % silica sand BG + 1% VEINSEAL I-35
5b	100 % silica sand BG + 1% VEINSEAL I-35
6a	100 % silica sand BG
6b	100 % silica sand BG
7a	100 % silica sand BG + 1% ash
7b	100 % silica sand BG + 1% ash

The influence of different types of additives on the final quality of test castings was observed. In these experiments (exp.), 5 types of commonly available additives were compared. The effect of energy ash was also observed. Energy ash is not additive but in the foundry, it can be used as a molding compound in the casting of steel and cast iron. Therefore, in two experiments, was tried addition of energy ash to the mixture. The additives were added into the core mixture in an amount of 1 kg per 100 kg of mixture. Cores were produced without problems. On some places could be seen non-shot places. These places were then luted. The visual control revealed that all cavities had traces of degassing screens, but such features did not affect the final quality of the castings. Non-metallic inclusions were present in all cavities of the test castings in very small amounts. The highest values of surface roughness in large cavities of test castings were found in castings whose core mixture contained additive called No COATING X05 exp. 1b (40 % A4, 60 % A1). This was followed by test castings containing the additives Feranex exp. 2a (40 % A3, 60 % A1), Sand additive 031 exp. 4a (30 % A3, 70 % A1), Anti-Finn exp. 3a (30 % A3, 70 % A1). In the large cavities of the test castings, the lowest surface roughness value was found in the test casting without the addition of the additive exp. 6a (10 % A2, 90 % A1). In the small cavities of the test castings, the hightest value of surface roughness was found in the casting with the additive Sand additive 031 exp. 4a (60 % A3, 40 % A1) and at the same time in exp. 4b also the lowest value of surface roughness (10 % A2, 90 % A1).

Veinings, in the cavities of the test castings, were present in very small amounts (up to 1 % of the surface). It was confirmed that the test castings exp. 6a and exp 6b, the cores of which were made of the core mixture without the addition additive, had large veinings in their cavities. Also, the cavities of the test castings, to which ash was added to the core mixture, had veinings. Test castings exp. 5a, 5b, 7a and 7b, although additives were added to their cores, had long veinings in their cavities. The test castings, to the cores of which the additive called Anti-Finn exp. 3a and 3b was added, had the resulting cavities without the occurence of veinings. At the same time, the lowest values of flexural strenght (187,5 N/cm2) were measured in the standardized test bars made from this core mixture. The addition of this type af additive to the core mixture causes the sand to become softer, more flexible and consequently to be able to absorb higher stresses, thus eliminating the stress generated between the sand grains.

4. CONCLUSION

In the production of cores by the cold-box-amine method, i tis very important to define the possibilities of preventing the occurence of defects on castings, to produce strong and stable cores, and thus to reduce the occurence of defects to the lowest possible level. The obtained effects of filling the core box cavity and moulding sand compaction in processes of core production by blowing methods depend on several factors [17]. Foundries must therefore be constantly experimenting with and the most effective ingredients for a particular type of casting must be sought. Even the use of the best ingredients may not ensure 100 % removal of surface defects, which has been confirmed in this research. For the reason, all the factors that cause these castings defects must be taken into account. One of the possibilities is the addition of additives into core mixture. The following conclusions can be summarized from the performed experiments:

- The addition of the additive called Anti-Finn resulted in cavity surface of the test castings without veinings. This mixture has the smallest values of flexural strenght.
- Additives (NO COATING X05, FERANEX 8718, Sand additive 031) ensured the surface of the cavities without veinings only on large cavities of test castings).
- The group of additives (VEINSEAL I-35, energy ash) did not secure the cavities surface of the test castings without veinings.
- As was expected, the use of quartz sand without the additive addition resulted in long veinings in both cavities of the test castings.

The results of research experiments schow that in the case of problematic places in castings, i.e. highly thermally stressed and hard-to-reach places, such as cavities on test castings, the application of an additive called Anti-Finn to the core mixture in the production of cores intended for production of problematic small cavities on castings should be done.

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