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Opening Material as the Possibility of Elimination Veining in Foundries

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Abstract

The main bulk density representation in the molding material is opening material, refractory granular material with a particle size of 0.02 mm. It forms a shell molds and cores, and therefore in addition to activating the surface of the grain is one of the most important features angularity and particle size of grains. These last two features specify the porosity and therefore the permeability of the mixture, and thermal dilatation of tension from braking dilation, the thermal conductivity of the mixture and even largely affect the strength of molds and cores, and thus the surface quality of castings. [1]

Today foundries, which use the cast iron for produce of casts, are struggling with surface defects on the casts. One of these defects are veining. They can be eliminated in several ways. Veining are foundry defects, which arise as a result of tensions generated at the interface of the mold and metal. This tension also arises due to abrupt thermal expansion of silica sand and is therefore in the development of veining on the surface of casts deal primarily influences and characteristics of the filler material – opening material in the production of iron castings.

Keywords: Molding mixture, Cold -box - amine, A casting defect, Opening material, Veining

1. Introduction

Previous investigations have demonstrated that the veining are result of tensile stress which is exerted on the interface due to dilatation of the sand in subsurface layers of mold. This situation occures due to the loss amount of silica filler material in the temperature 573 ° C (1063F). There is uneven distribution of temperature in different places of the opening material of various distances from the source of heat - molten metal, which then creates an uneven thermal expansion and associated stress. When the forces on the surface of the mold or core are high, cracking opening material and the liquid metal has the opportunity to penetrate into these gaps. [2]. Dilatation of each grain (mikrodilatation) manifests itself as makrodilatation molds or cores. Makrodilatation - then its value depends on the degree of freedom in mikrodilatation each grain (additives, binder content, grain shape, degree of densification). The largest tension value is for monofraction sand with rounded grains. [2]

A full range of casting surface defects is result from the increased thermal stress in the face of the foundry mold. These include scabs, veining and also increases. The most effective approaches to preventing defects from the tension is replacement of opening material for opening material with flowing curves with lower value of thermal expansion (strain), without modification changes. The values of thermal expansion of silica sand and several types of non silica sands can be compared according to the following Fig.1. [2,3]

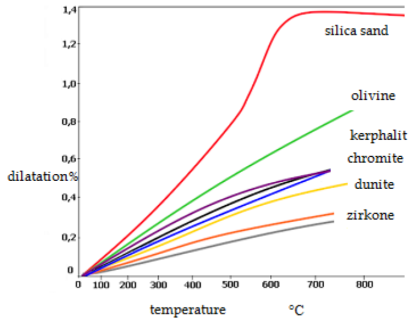


Fig. 1. Thermal expansion of silica sand and several types of non silica sands [2]

2. Theoretical part

The following Fig.2 shows the linear expansion of the silica sand-bonded by phenol - urethane binder (PUNB) [2]. It can be seen that the sample volume and the length is sharply increased at 573 ° C, where transformation from alpha quartz to beta take place. This change is accompanied by a magnification of 0.9 and 1.6%, depending on the purity of the sand.

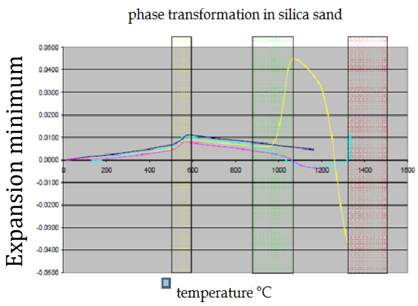


Fig. 2. Linear expansion of silica sand bonded by phenol - urethane binder (PUNB) [2]

Upon further heating, sand loses length and volume due to softening of the surface of the sand grains. This loss of volume at temperatures above 573°C (1063F) is the leading cause of veining. As the temperature of the moulds or cores on the surface is increased, the length and volume of the sand decreases. The cooling of sand just below the surface increases the volume when passing the alpha to beta transformation quartz. The combination of sand on the surface and the extension of the sand in subsurface causes the failure of strength, resulting in the formation of veining. For the casting of aluminum alloys avoiding the formation of veining, with respect to the lower temperature casting of aluminum alloys, in which no transformation of the silica to cristobalite [2,4,5].
Adjusted sand additives work on two principles. The first uses the high temperature phase change that occurs in the sand at a temperature of about 870°C (1598F). The following Fig.3 shows the main phase silica, for which the technology concerns are in place. The first phase is alpha quartz, which is stable from room temperature to about 573 °C (1063F). The second phase is the beta crystal. This phase of silica sand is less stable than the alpha quartz, and there is the high viscosity of the solid, indicating a certain surface softening. It should be noted, that this change will occur, regardless of the type of binder. Volume loss in this stage can range from 50 to 100% of the original length of the sample. If the viscosity is sufficient for softening the surface of the sand grains to create a liquid phase to be formed is called tridymite. Elements such as sodium, lithium or aluminum may force a change in phase which is related to the linear change of three times greater than the original alpha / beta expansion. Engineered Sand Additive (ESA), which is often used in the foundry industry is forcing tridymite to transformation of sand, leading to a high increase of the temperature volume. The resulting increase in volume by up to 12 weight % eliminates tension of surface and thereby effectively removes the veining in the casting of iron. [1,2,6,7]

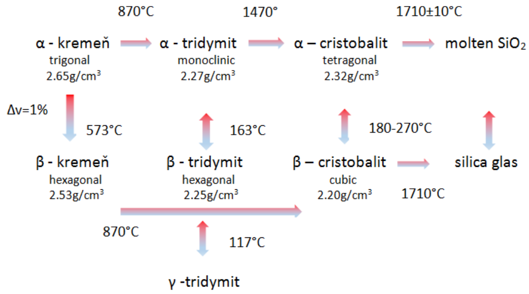


Fig. 3. Mechanism of polymorphic transformations SiO_2

For the above-described characteristics of quartz sand it is necessary to pay attention to the characteristics of these opening materials and, if necessary, replace them non silica sands with continuous thermal dilatation. [1,8,9,10]

3. Experimental part, results, discussion

As a part of the research, several experiments were carried out to compare the surface quality of castings. Observed cores for castings - brake discs with a diameter of 632 mm were produced by technology cold-box-amine. Composition of the core mixture was different, as shown in the following Tab.1 and Fig. 4.
Two kinds of opening material No.1 and No.2 with various binder amount were used. For the first experiments 1a and 1b 100 kg of silica sand No1 and 0.9% binder - component A and B was used. The results showed, that the surface of the castings was on average over 23.5% with veining. To reduce the occurrence of veining a dosage of 110 kg quartz opening materials No1 and 0.8% binder - components A and B have been tried. The results were significantly better, the percentage of veining on the surface of castings was reduced by more than a half. Precisely for this reason it was used dosage of only 110 kg opening material in further examinations. One of the ways to prevent the veining is using silica sand from another location, if necessary with higher chemical and mineralogical purity. Accordingly, in a further experiment an opening material No.2 was tried, result was again reduction of veining up to 10.83%. This result at No.2 opening material is related to particle shape and particle size composition.

Table 1.
Composition of the core mixture

experiment		1.	2.	3.	4.
Opening material kg		110 No.1	110 No.2	85 No.1 35 Cr	85 No.1 20 Kerphalit
component A wt %		Gasharz 0,8			
component B wt %		Activator 0,8			
coat		With coat			
Veining on surface of casts %		10	10	1,0	1,0
		11	10	1,0	0,5
		12	11	1,0	1,0
		10	10	1,0	0,5
		15	12	1,0	1,0
		15	10	1,0	0,5
		14	10	1,0	1,0
		15	12	1,0	1,0
		11	10	1,0	0,5
		14	11	0,1	1,0
		13	12		
		13	12		

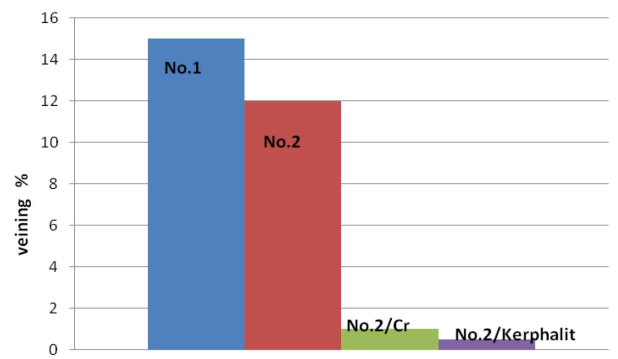


Fig. 4. Appearance veining on surface of cats in varying configurations of the core mixture

One of the ways to prevent the occurrence of veining on the surface of the casting is a usage of non silica sands with continuous thermal dilatation. Therefore an addition of 20 wt% of chromite and Kerphalit to the silica sand was used. The results showed, that the application of these sands has a great effect on foundry surface defects on the casting. The percentage of veining on the whole casting surface in such a case did not exceed 1%. The following Tab.2 and Fig.5 shows a comparison of using silica sand No.1 and No.2 in dosage 110 kg, using silica sand No.1 and 20% of chromite and silica sand No.1 with 20% Kerphalit.

For to compare the results of experiments, analysis of variance was used called ANOVA.

The significance level of α= 0.05, was tested the null hypothesis of conformity arithmetic average of four experiments tested.

The results show clearly that by adding the non silica sand to the core sand mixture, a significant improvement in surface quality is achieved. When closely comparing the use of 20% of chromite and 20% Kerphalit in the table and the picture it can be seen that the better results are achieved using Kerphalit, which have a thermal expansion smoother than chromite, and also better heat-resistant properties.

Table 2.
Analysis of variance for four experiments

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
1	12	153	12,75	3,66
2	12	130	10,83	0,88
3	10	9,1	0,91	0,08
4	10	8	0,80	0,07

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1326,95	3	442,32	**345,25**	0,00	**2,84**
Within Groups	51,25	40	1,28			
Total	1378,19	43				

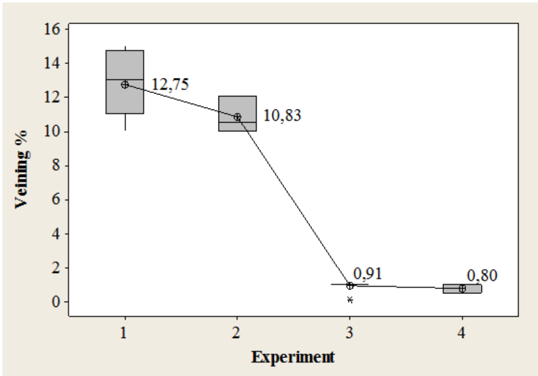


Fig. 5. Incidence of veining on the castings, using silica sand No.1, No.2 and using 20% of chromite and 20% Kerphalit

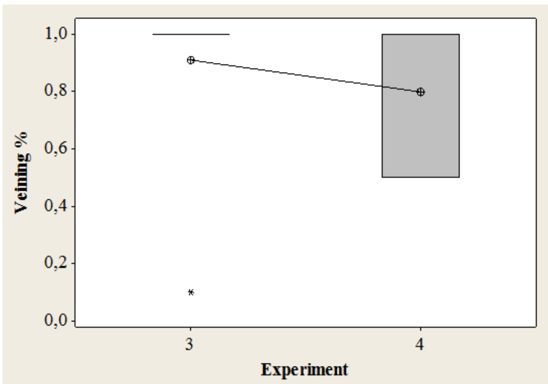
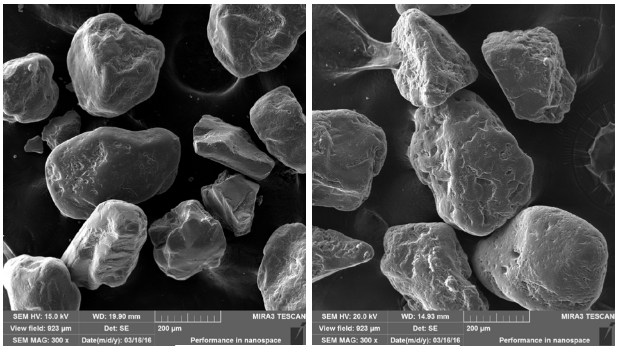


Fig. 6. Incidence of veining on the castings using 20% and 20% of chromite and Kerphalit

By analysis of variance it was shown that the difference between the test groups is statistically significant, as demonstrated F >Fcrit. P-value - 0.00, which is below the significance level α statistic shows a significant difference between the groups.

Comparison of used silica sands No.1 a No.2

Next Fig. 7 shows a microscopic view of grains of silica sands No.1 and No.2 at a magnification of 230x.



a) b)

Fig. 7. Microscopic view of grains used silica sands a) No.1, b) No.2

The following Tab. 4 and Fig.8 present the basic characteristics of those silica sands.

Table 4.
Sieve analysis of silica sands No.1 and No.2

	No.1	No.2
Sth theoretical surface cm^2 / g:	**77,01**	**90,30**
MK calc average grain size mm	0,264	0,264
AFS	43,9	51,5
d_{50} mm:	**0,257**	**0,247**
d_{75} mm:	0,206	0,209
d_{25} mm:	0,309	0,317
The regularity of the opening material grain size d_{75} / d_{25} * 100	66,9	66,0
log w	56,3	49,8
Shares grog % below 0.100 mm	78,24	51,95

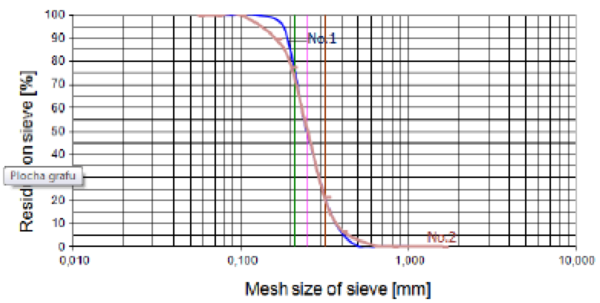


Fig. 8. Cumulative curve using silica sands

Round grain of silica sand, although suitable for organic substances - a small surface, min. consumption of the binder, but cannot withstand temperature changes and are more prone to defects caused by thermal stress. They should contain utmost min. concentration of fine grains, including shares of 0.1 mm and should not contain coarse grains from 0.5 to 0.6 mm (except for the massive castings). Also the effect of coarse share of 0.4 to 0.5 mm on the final strength is negative. The fine grains have a high surface area and increase the consumption of binders, thus reducing the thickness of the binder shell and strength of the mixture. Finest shares then act in the binder shell as the internal notches. As follows from a general overview of the main requirements for high-quality foundry sands, crucial for the fulfillment will be their genesis as any additional treatments are very expensive and difficult. From analysis of used silica sands can be seen that, despite the same values of d_{50}, it is necessary to take into account other characteristics such as grog share below 0.1 mm, which results into better strength characteristics of used grog No.1.

4.Conclusion

For producing quality castings by cold-box-amine technology is necessary to pay attention to the composition of core sand mixture. The most important role has silica sand as the basis of this mixture for its affordability. The silica sand due to its abrupt thermal dilatation causes of tension on the mold surface, thereby producing surface defects on castings –veining . So it must follow some principles of the use of silica sand.

- Silica sand must be chemical and mineralogical clean, uncoated and pores on the surface of grains.
- Option to prevent veining on the surface of the casting is the additon of non silica sand with continuous thermal dilatation if there is a possibility from the manufacturing conditions and sand costs point of view.
- To eliminate non-continuous thermal expansion of silica sand are used additives in the molding of the core mixture called additives. These additives are usually iron oxide, and are added in a proportion of 1-3%.

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