NEW COATINGS AND ADDITIVES CONCEPTS
AS AN ENTIRE APPROACH
FOR DEFECT AND RESIDUE FREE CASTINGS

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INTRODUCTION

The capability and casting quality is the focus of enterprises due to the great demand of good and high-quality casting.

To have new concepts available which match the targets fast with sustainable solutions by optimization of the casting processes in particular by the core and mould coatings or sand additives is crucial.

The deep knowledge about the processes in the foundries and it’s possibility to rise the service level (Costs down, productivity, flexibility and quality up), is survival-important for the foundry.

Successful foundries use the possibilities of lever arm effects: The exploration of small changes, which cause large effects.

The correct selection and use of sand additives and coatings is one of these lever arms.

Sand additives and coatings in the core shop or the moulding department contribute only about 1 % of the total costs of the casting part. On the other hand the wrong selection or utilization of a coating can lead for a gigantic amount by fettling costs, which can rise up to 5-10% of the casting costs.

METHODOLOGY & RESULTS

Veining (also known as finning) has been a perennial problem for certain types of ferrous castings produced with chemically bonded sand cores. Engine blocks and heads can experience veins in narrow oil and water passageways that are difficult to remove and could cause blockage and engine failure. Ventilated brake rotors can experience veining in the
“windows” that is also difficult to remove and could cause uneven heating and warpage of the rotor during use. Many different casting types with cored passageways and unfavorable geometries or sand-to-metal ratios can suffer from veining defects.

Veining has long been called an “expansion defect” linked to the non-linear expansion of silica sand as it is heated by the liquid metal during casting. The sand goes through a change in crystal structure from low or alpha quartz to high or beta quartz that results in rapid expansion, followed by contraction and then further expansion as the quartz transforms to tridymite and then cristobalite. This uneven expansion and contraction is in contrast to the more uniform and lower expansion rates of other foundry aggregates (see Figure 1.)

![Figure 1. These are the thermal expansion curves for various foundry aggregates.](image)

There have been a number of different approaches used to combat veining problems. High purity silica sand can be replaced totally or in part by other aggregates such as lake or bank sand, zircon, chromite, olivine, fused silica, or manmade materials. The lower and more uniform expansion of these materials can minimize or eliminate veining. However, these materials are also more costly than silica sand and may present special problems with molding or core making.

Sand additives have been used extensively to control veining. These fall into several categories depending on their chemistry and activity. Iron oxides were among the first sand additives¹. These create a small reduction in volume as they lose oxygen and also have a “fluxing” or softening effect on the surface of the sand grains. Red iron oxides (Fe₂O₃) are typically used at levels of 1-2% but are very fine and may impact mold and core strength. Black iron oxide (Fe₃O₄) is somewhat coarser and may be used at 1 – 4% levels. Red iron oxide has also been shown to be effective when
used in conjunction with other sand additives. However, iron oxide may have limited compatibility with certain binder systems because of acidity.

Organic materials like dextrin, starch, and wood flour are also used at relatively low levels of 0.5 – 2%. At elevated temperatures, these will burn out and provide a volume reduction and “cushion”. Like iron oxides, these materials may have negative effects on mold/core strength because the fineness of the material increases resin demand and reduces strength.

Engineered Sand Additives (ESA’s) were developed to address some of the negative issues of iron oxides and starches. They may have particle sizes more similar to sand and have less impact on mold/core strength. However, they typically need to be used at higher levels to be effective against veining. One type of ESA is in the form of hollow spheres. It is believed that these crush and provide a volume reduction and cushion when subjected to compressive stresses. Other ESAs have low expansion rates and reportedly act as fluxes at elevated temperatures.

Other strategies have also been used. Coating or “wash” on the mold or core surface can provide some veining resistance with a low expansion layer and insulating effects that may slow the flow of heat into the surrounding sand. More angular sand can be used to reduce core density and allow space for expansion to occur. Cores can be blown at lower than normal blow pressure to produce cores with intentionally low density to allow for expansion.

VEINING MEASUREMENT

Test castings have been developed over the years to measure the veining characteristics of different sand and binder systems. Two types of test casting are typically used: a step cone or a 2 x 2 (50mm x 50mm) penetration casting. The step cone core and casting are shown in Figure 2 and the 2x2 penetration mold, cores and sectioned casting are shown in Figure 3.

![Figure 2 – The step cone core (left), casting (center), and sectioned casting (right) are shown above.](image)
The level of veining is determined visually and given a numeric ranking of 1 to 5 with level 1 having virtually no veining and level 5 exhibiting very severe veining. The measurement method is somewhat subjective, but additional quantification can be accomplished by identifying the severity and location of the vein and using a weighted formula to calculate a veining “score”. Studies by Giese and Thiel have shown that “the defect analysis technique was demonstrated to be a viable procedure as an evaluation tool in assessing foundry materials to prevent core related defects.”

The 2 x 2 casting test provides an advantage in that four separate cores can be tested per casting, although cores are typically tested in duplicate to improve accuracy. It also seems to be somewhat more severe in that veins will still appear in the 2 x 2 when step cone cores of the same composition appear free of defects.

*Figure 3 – The 2 x 2 cores and mold (left) and a sectioned casting (right) exhibiting the veining defect are shown above.*

- **ANTI-VEINING AND ANTI-PENETRATION ADDITIVE WITH THE SCOPE TO POUR UNCOATED CORES**

There has been a lot of effort in the last years to eliminating coating process in the foundries. In some areas the target has been successful implemented, e.g. for less demanded Ductile Iron castings.

ASK Chemicals has been able to develop new type of additives which enable the foundries to reduce the casting defects significant and cast more cores uncoated.

Veino Ultra is such a development, which have amazing anti-veining properties.

Based on the R&D results industrial testing are focusing first on foundries that use 70 AFS GFN sand, which is the common practice for vertical moulding, and we then continued the testing with other, coarser sands. (Figures 4-10 & 11)
Figure 4: This is a Cardan Joint casting and core produced with 5% of the ESA additive.

Figure 5: This casting was produced on a vertically parted moulding line with a core containing 5% new additive.
Figure 6: These brake rotor castings show the improvements with the new additive.

H 32/33 sand, coated
Figure 7: These castings compare the surface finish with a coated core versus the new ESA additive.

95% Sand recovered from green sand mould (reclaimed sand) + 5% ESA additive 1.6% Cold Box 419/619
Figure 8: These photos show railroad brake disks produced using the ESA additive.

Grey Iron Casting, 100 % Chromite + 5% ESA additive, 1.5% Cold Box, partially coated

Grey Iron Casting, 50 % Chromite + 50 % F33 + 5% new additive, 2.1% Cold Box, partially coated

Figure 9 and 10: These test castings show the effects of the ESA additive with chromite sand and no coating.
All the tests were satisfactory with the sand used in the foundries. The exception is shown in Figure 15. For brake disks, using AFS GFN 55, some veining and penetration was seen. Once the sand was changed to AFS GFN 65, the problems were corrected.

Effect on the bench life
At higher temperatures, the additive increases the acid demand value (ADV) of the mixed sand, which decreases the bench life. This can be addressed using binder 419/619, a cold box binder that has greater bench life. (Figure 12)

Figure 11: This is a core package produced with 5% ESA additive.

Figure 12: This graph shows the bench life of sand and the new ESA additive for two different binder systems.
Gas Evolution

The ESA additive does not produce additional gas evolution compared to sand alone. (Figure 13)

![Gas Evolution Graph](image)

Figure 13: This graph shows the gas evolution of sand alone and with different sand additives.

Effect on Core Density

Additions of 5% of ESA additive decrease the weight of the core by about 10%. This means more cores can be produced from the same weight of mixed sand and that the cores are lighter and easier to handle.

- **ANTIVEINING COATING**

Special requirements from the casting quality are to have no veins along the parting line of the core box.
For the production of the cores there is a strong demand to have no deformation of the cores during drying process.
Examples of the coating generation MIRATEC BD show that the coating eliminate the veining and by the improved application properties, the cores can be dipped in a reduced cycles which has been improved 100% without getting drops on the core.

![Image of Break disk with veining](image)

Figure 14: Break disk with veining the parting line

![Image of MIRATEC BD prevent veining defect](image)

Figure 15: MIRATEC BD prevent in veining defect
HIGH GAS PERMEABLE COATINGS AGAINST SCABBING

Scabs and gas defects are one of the defects which belong to the unpleasant one in serial foundries, because this leads to scrap. ASK developed within the framework of a development project different extremely gas-permeable coatings which suppress these defects.

Casting parts in which the cores are highly thermally loaded by a critical low mould filling on special areas, tend to suffer from scab formation. Based on the MIRATEC MB 501, a coating that shows good results (especially in the serial casting) to avoid veining and penetration, the feature “increased gas permeability” was implemented. Furthermore the coating should have to have a short draining property and a low gloss time due to a desired reduction of the cycle time during the dipping procedure.

The new coating, which fulfills this profile, is the MIRATEC AH 501. By the implementation of this coating the scab defects could be removed both from a hydraulics casting part (core package Cold Box + shell sand) and from an Axle housing (Cold Box - core).

Furthermore the cycle time of the dipping process has been able to be reduced to the half with this coating in comparison to the initial coating.

RESIDUE FREE CASTINGS WITH MIRATEC TS

OEM’s are forcing the foundries to deliver castings with a limited minimum amount of residue in their castings. For motor blocks these limits could be down to 300 mg per castings. Due to the fact, that the water jackets or oil galleries are almost impossible to shot blast, there is a serious demand on the coatings to provide flawless castings but also zero adherence of the coating on the casting surface.

A special coating based on good anti-veining and anti-penetration properties have been developed, which reduce the coating residue after pouring to a minimum. SEM investigations show, that the coating has self-releasing properties after pouring.
The investigation showed that with the MIRATEC TS the coating flakes off (release itself) from the casting surfaces and leave a very clean and smooth surface. The residue has been reduced to half or to a third compared with the conventional coating.
Coatings have been developed which block the transport of Sulphur or Oxygen into the melt. There are different mechanisms which are available, to maintain the targeted property.

One is to reduce the transport of the Sulphur or Oxygen towards the interface with the metal, by applying coatings with impregnating properties e.g. SILICO IM 801. Other mechanism is the use of Sulphur or Oxygen absorbing components e.g. Calcium compounds in the coating.

- PROTECTION AGAINST GRAPHITE DEGENERATION IN DUCTILE AND COMPACTED GRAPHITE IRON
SUMMARY:

New coating and Additive developments enable foundries to produce flawless and residue free castings in a less complicated way with less side effects and even enable coating free casting production.

Code words: Mould and core coating, sand additives, foundry, performance, casting defect.

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