New Coatings and Additives Concepts – As An Entire Approach for Defect- and Residue-Free Castings

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1. Introduction

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

To have new concepts available which match the targets fast with sustainable solutions by optimization of casting processes, in particular the core- and mould-coatings or sand additives, is crucial[1].

Deep knowledge about the processes in foundries and the possibilitiy to raise the service level *(costs down; productivity, flexibility and quality up),* is important for the survival of the foundry.

Successful foundries use the possibilities of '**lever arm effects**' – the exploration of small changes, which cause large effects.

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 cost of the cast component. On the other hand, wrong selection or utilization of a coating can lead to a gigantic amount of fettling costs, which can rise up to 5 - 10 % of the total casting costs.

2. 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-passage ways 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 passage ways and unfavourable geometries or "sand: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 molten metal during casting.

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 tridamite, and then crystoballite. This uneven expansion and contraction is in contrast to the more uniform and lower expansion rates of other foundry aggregates *(Fig. 1).*

There have been a number of different approaches used to combat veining problems[3]. 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 moulding or coremaking.

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 additives[4]. 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 (Fe_2O_3) are typically used at levels of 1 - 2 %, but are very fine and may impact mould and core strength. **Black** iron oxide (Fe_3O_4) 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[5]. However, iron oxide may have limited compatibility with certain binder systems because of acidity.

This paper was presented at the 60th Indian Foundry Congress held during March 2012 in Bengaluru. It contains useful information about scientific testing and results evaluation for (i) developing new sand additives for moulds and cores produced by using chemically-bonded sand, and (ii) new coatings – for producing defect-free castings.

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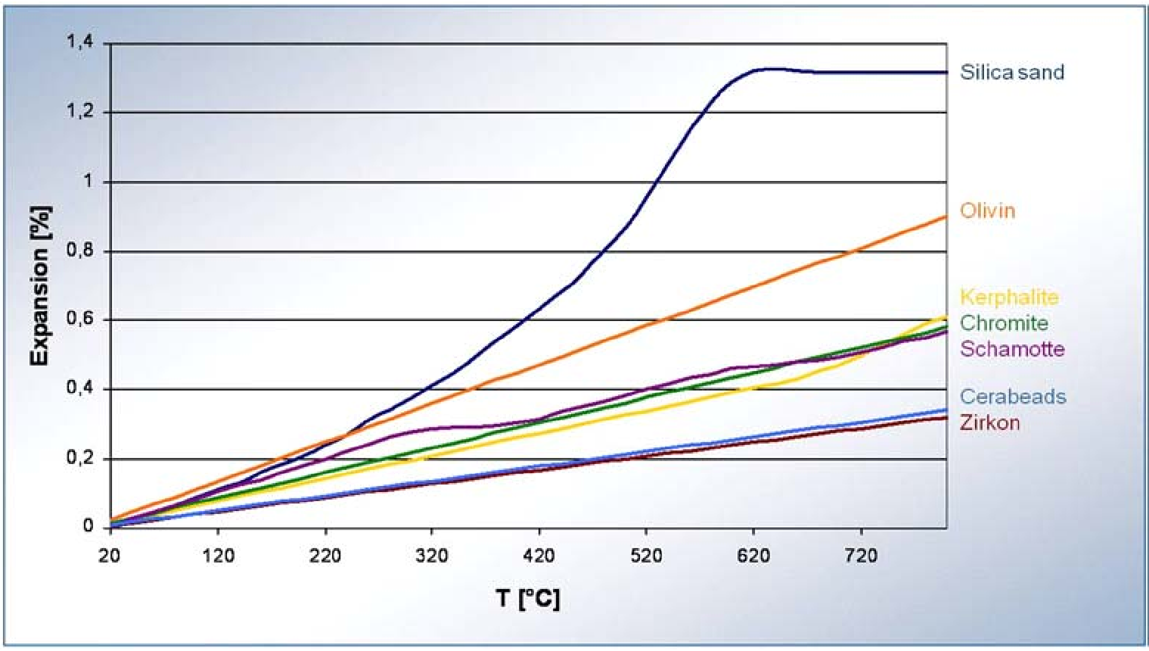


***Fig. 1 :** Thermal expansion curves for various foundry aggregates*[2]

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 mould/ 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 mould/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[6]. It is believed that these get crushed and provide 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 mould 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 intentional low density to allow for expansion.

3. Veining Measurement

Test castings have been developed over the years to measure the veining characteristics of different sand and binder systems[7]. Two types of test casting are typically used: (i) a step cone, or (ii) a 2 x 2 inch (50 mm x 50 mm) penetration casting. The step cone core, casting, and sectional casting are shown in *Fig. 2;* and the 2 x 2 inch penetration mould, cores and sectioned casting are shown in *Fig. 3.*

***Fig. 2 :** The Step Cone core (left), casting (center), and sectioned casting (right)*

***Fig. 3 :** The 2 x 2 inch cores and mould (left) and a sectioned casting (right) exhibiting the veining defect*

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

- **Anti-Veining and Anti-Penetration Additive with the Scope to Pour Uncoated Cores**

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

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

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

- **Antiveining Coating**

  Special requirements from the casting quality are to have no veins along the parting line of the core box.

  For production of the cores there is a strong demand to have no deformation of the cores during drying process. Examples of the coating generation

Table 1

Effect of the Selected Additive on Penetration, Veining and Surface Finish

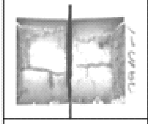
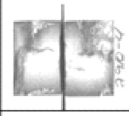
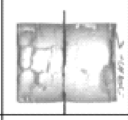
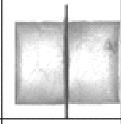
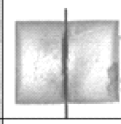
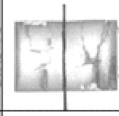
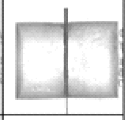
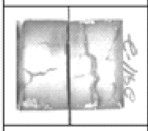
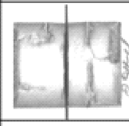
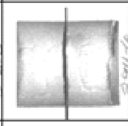
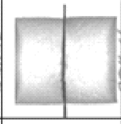
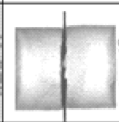
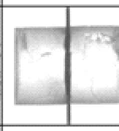
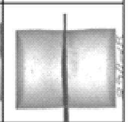
	No Add.	1% W	1% RIO	2.5% ESA 1	4% ESA 2	6% ESA 3	6% ESA 4
EU Haltern H32 Sand, 1.6% Ecocure 30/60, DMEA							
Penetration	1.25	2.5	1.5	1.25	1.75	1.75	1.5
Veining	3.25	3.25	2.75	1.0	1.0	2.75	1.0
Surface Finish	2.75	2.75	2.5	2.5	2.5	2.0	2.25
SA Veiga Sand, 1.2% 405/605 Binder, DMPA							
Penetration	1.25	1.75	1.25	1.25	1.25	1.25	1.25
Veining	2.75	3.0	1.75	1.25	1.0	1.5	1.0
Surface Finish	2.0	2.25	2.5	2.5	2.5	2.0	1.75

Fig. 4 : Brake disk with veining

Fig. 5 : MIRATEC BD prevent in the parting line veining defect

MIRATEC BD show that the coating eliminates the veining, and by the improved application properties, the cores can be dipped in a reduced cycle which has been improved 100 % without getting drops on the core.

- **High Gas Permeable Coatings against Scabbing**

Scabs and Gas defects are among the unpleasant defects in mass production foundries, because these lead to scrap.

ASK developed within the framework of a development project different extremely gas-permeable coatings which suppress these defects.

Cast components in which the cores are highly thermally loaded, by a critical low mould filling on special areas, tend to suffer by scab formation. Based on the MIRATEC MB 501, a coating that shows good results (especially in mass production castings) to avoid veining and penetration, the feature “increased gas permeability” was implemented. Furthermore, the coating should have rapid draining property and low gloss time due to desired reduced cycle time during the dipping process.

The new coating, which fulfils this profile, is the MIRATEC AH 501. By implementation of this coating the scab defects could be removed both in hydraulics cast component (Core package:Cold Box + Shell sand), as also in Axle Housing (Cold Box core).

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

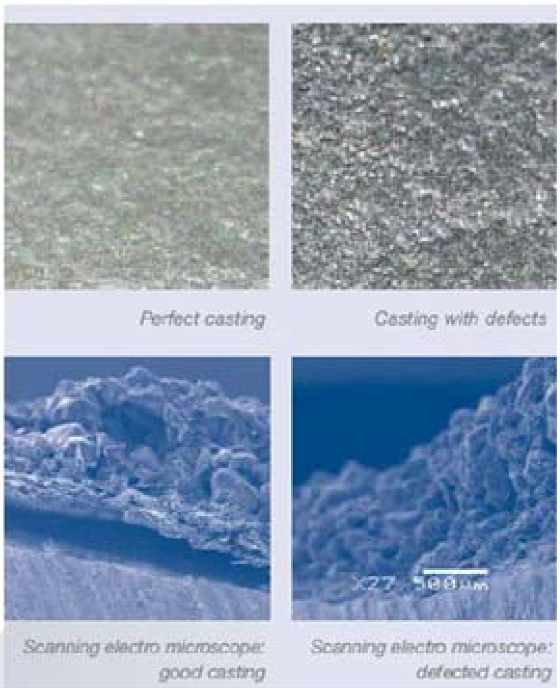


Fig. 6 : Comparison of MIRATEC TS (left) and Conventional Coating (right)

- **Residue-free Castings with MIRATEC TS**

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

Fig. 7 : Casting surface with MIRATEC TS

A special coating based on good anti-veining and anti-penetration properties has been developed, which reduces the coating residue after metal pouring to a minimum. SEM investigations show that the coating has self-releasing properties after metal pouring.

The investigation shows that with the MIRATEC TS, the coating flakes off from the casting itself and releases a very clean surface. The residue has been reduced to half or one-third as compared with the conventional coating.

- **Protection against Graphite Degeneration in Ductile and Compacted Graphite Iron**

  Coatings have been developed which block the transport of Sulphur or Oxygen into the melt. Different mechanisms are available to maintain the targetted property.

  One is to reduce the transport of 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-adsorbing components, e.g. Calcium compounds in the coating.

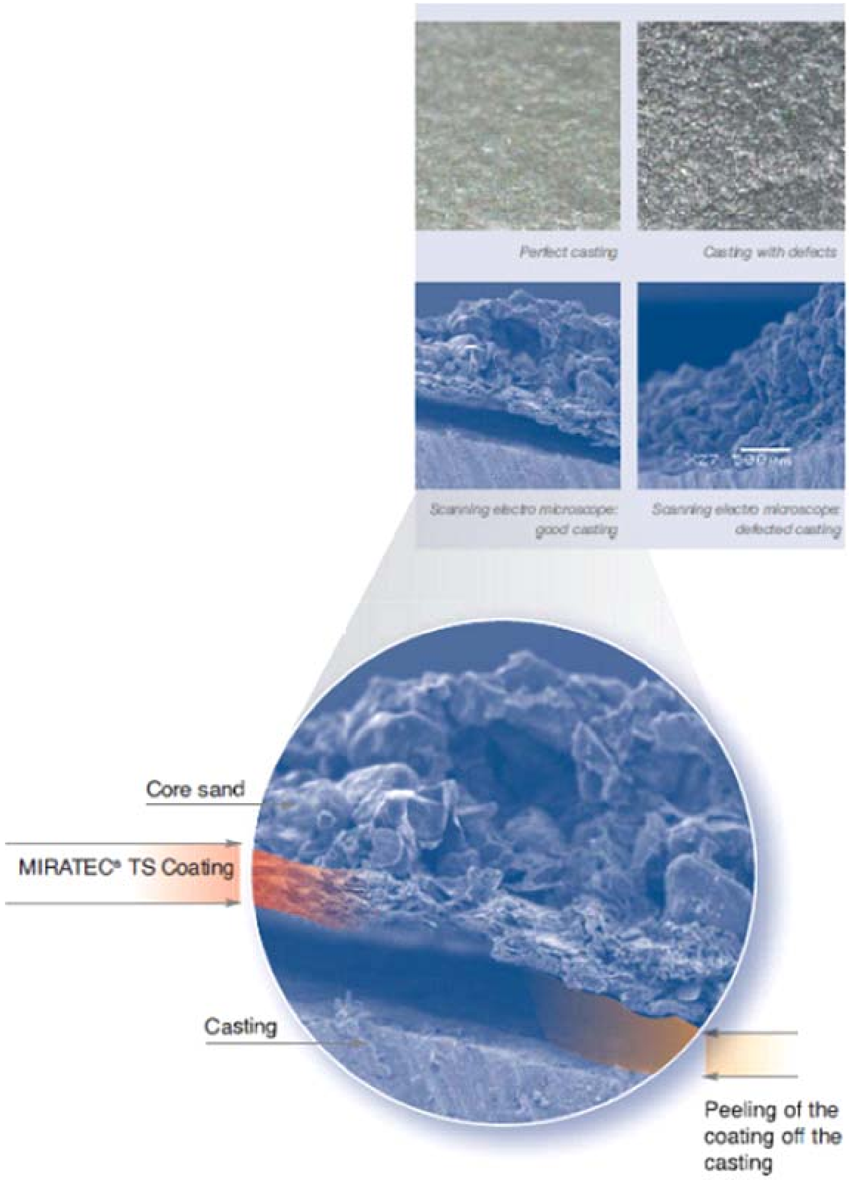


Fig. 8 : *Surface quality achieved by MIRATEC TS coating*

4. 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.

Bibliography

1. Stephan Rudolph, Gießerei-Praxis, No. 6-1993, page 105
2. Reinhard Stötzel, Diagram from Conference Transcript, 3rd Duisburg Moulding Material Day, 2000
3. Showman, R., Horvath, L., Clifford, S., Harmon, S., Lawson, E., "A Systematic Approach to Veining Control", AFS Casting Congress Proceedings, 11-005.
4. R. W. Monroe, "Use of Iron Oxide in Mold and Core Mixes for Ferrous Castings", AFS Transactions 1988.
5. S. G. Baker, J. M. Werling, "Expansion Control Method for Sand Cores", AFS Transactions 2003
6. T. J. Gilbreath, P. L. Zajac, J. Bruce, "New Sand Additive Alternative for Veining and Penetration Defects in Thin-Walled Castings", AFS Transactions 1999.
7. W. L. Tordoff, R. D. Tenaglia, "Test Casting Evaluation of Chemical Binder Systems", AFS Transactions 1980.
8. S. R. Giese, J. Thiel, "Numeric Ranking of Step Cone Test Castings", AFS Transactions 2007.