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- SINCE 1932 -



COATINGS

Coating for improved inner cleanliness

Automated Intelligent Coating Concept for ferrous foundries

METALLURGICAL AND POURING CONTROL

Increasing the consistency of iron casting properties and reducing foundry rejects by the use of FERROLAB[®] V Thermal Analysis Equipment

MELT SHOP REFRACTORIES

The benefits of bottom pour technologies in steel foundries

VESUVIUS

EDITORIAL

Dear Readers,

Welcome to our 269th edition of our in-house technical journal of Foundry Practice. The journal, now in its 87th year, is designed to inform foundrymen of Foseco's latest technologies and application techniques to ensure the ongoing advancement of our customer's foundry practice.

This edition highlights a new generation of coatings as well as the most modern equipment to control the coating application. Furthermore, it presents the new Thermal Analysis Equipment from Foseco and the latest technology for Flow Control in bottom pour ladles.



COATING FOR IMPROVED INNER CLEANLINESS

Just a coating can help automotive manufacturers to achieve the demanding Euro 7 Emission norms that will come in place in 2020. Diesel engines have become very efficient in recent years, but they have room for further improvement in efficiency and emission reductions. The new SEMCO* IC coating achieves the highest level ever in cleanliness inside the intricate cavities of a cylinder head and block.

AUTOMATED INTELLIGENT COATING CONCEPT FOR FERROUS FOUNDRIES

Like other industries, the most advanced foundries are evolving towards Industry 4.0. This is not just more automation, but the measurement, registration, analysis and development of algorithms to predict the stability of the very complex foundry process. The new ICU (Intelligent Coating Unit) developed by Foseco moves in this direction being the most modern equipment to guarantee the correct application parameters of a coating, making this important operation much more robust.

INCREASING THE CONSISTENCY OF IRON CASTING PROPERTIES AND REDUCING FOUNDRY REJECTS BY THE USE OF FERROLAB* V THERMAL ANALYSIS EQUIPMENT

Thermal analysis is key to producing iron castings with consistent quality over time. However, the current Thermal Analysis systems in the market are too complicated for most foundry's operators to use on a daily basis. For this purpose, Foseco has developed FERROLAB V - a simpler and more robust equipment to be used by operators that is easy to interpret yet providing the most relevant information to assure the quality of the castings.

THE BENEFITS OF BOTTOM POUR TECHNOLOGIES IN STEEL FOUNDRIES

Flow control in steel foundries is an aspect of the foundry process which often does not receive the required attention deserved by its fundamental importance. This article shows the best practice for bottom pour ladles as well as the future trends in automated pouring devices and the application of new Foseco nozzle technology.

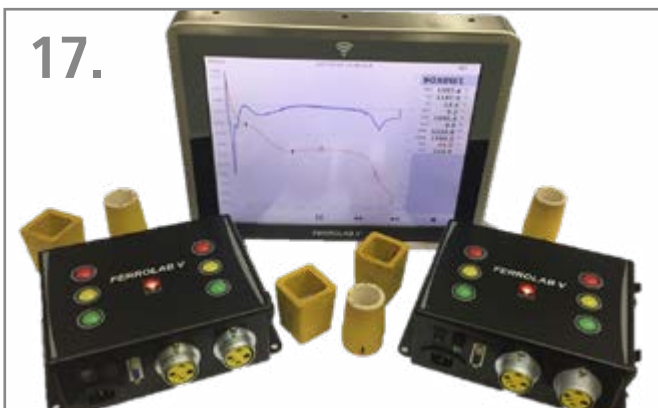
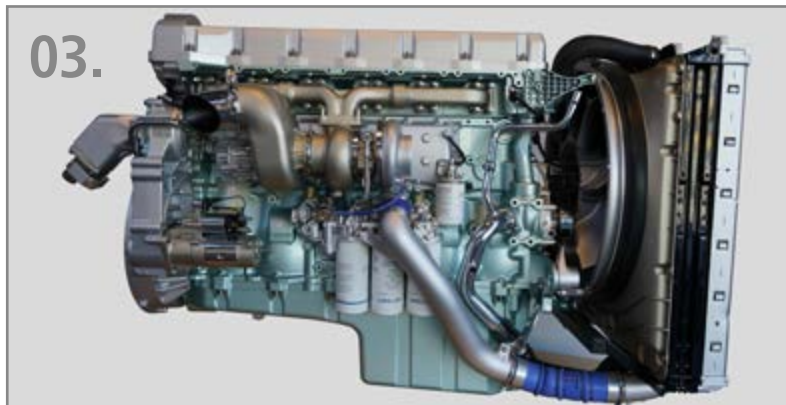
I hope you enjoy reading this edition and take advantage of it to further improve your foundry technology.

A stylized, handwritten signature in dark ink, consisting of several overlapping horizontal and diagonal strokes.

TXEMA CABANAS

Area Director Foundry South Europe

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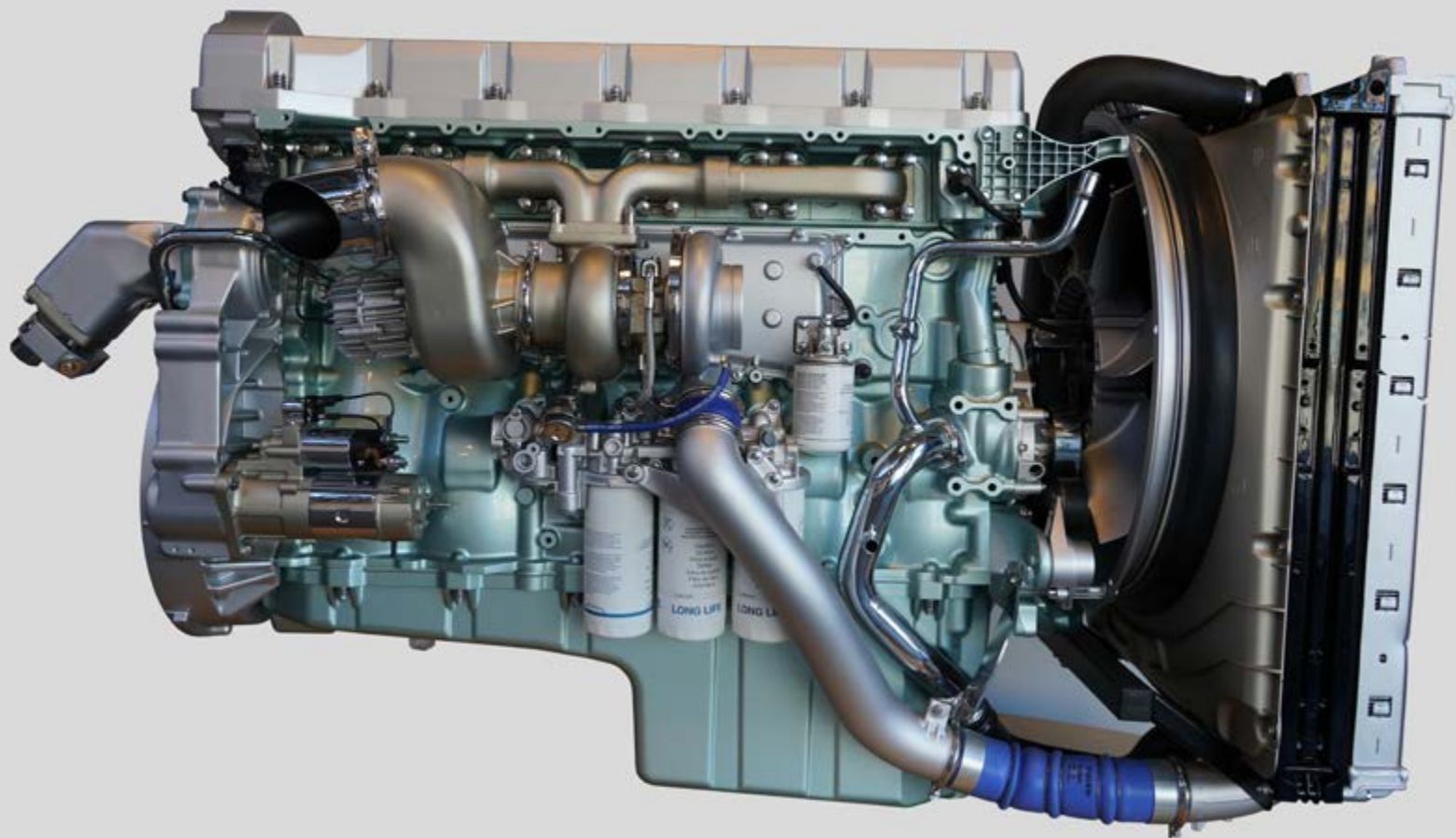
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COATING FOR IMPROVED INNER CLEANLINESS



Author: Christoph Genzler

The following article is the result of a long-lasting cooperation between two companies which have committed during times when the internet, social media and smart phones were in their infancy, to commonly develop future visions.

One company located in Skovde, Sweden has developed a new metal pouring process (FPC – Future Process for Casting) and they run their new foundry based on this technology.

The subject presented in this article was commonly developed over the last 20 years. The coating technology discussed delivers multiple improvements to inner cleanliness or in other words reduces the quantity of remaining particles in inner critical channels. Obviously, this improves engine lifetime and additionally reduces downtime due to, for example the exchange of oil or coolant liquids – a still hot current subject.



Particle adherence using conventional coating



Very clean internal surfaces even in narrow channels

INTRODUCTION

Nov. 16, 2017 (WASHINGTON)

The following is a statement from Allen Schaeffer, Executive Director of the Diesel Technology Forum. ^[1]

"Diesel is the most energy efficient internal combustion engine. It has achieved dominance as the technology of choice in the trucking industry over many decades and challenges from many other fuel types. Still, today, diesel offers a unique combination of unmatched features: proven fuel efficiency, economical operation, power, reliability, durability, availability, easy access to fueling and service facilities, and now near-zero emissions performance."

"We all benefit from a more efficient freight system. Fuel and powertrain choices are one part of that. The greatest opportunity for efficiency gains, fuel savings, lower greenhouse gas emissions and cleaner air – now – is to get more truckers into the newest generation of more fuel efficient and near-zero emissions clean diesel technology, as rapidly as possible."

Legal requirements

"The legal requirements for diesel engines have been tightened several times. Diesel engines are used in various types of vehicles, for various types of traffic, and with varying loads.

To be able to measure emissions in a comparable way, they are measured in relation to the work performed by an engine and the units used are grams per kilowatt-hour. For certification, a well defined fuel is used, very similar to standard fuel but with closer tolerances."^[2] (Table 1).

Euro 7 Emission Norms – 2020 CO₂ Goals:

"Euro 7 emission norms are expected to be implemented in 2020, with a CO₂ emission target of 95 grams per kilometer. The Euro 6 CO₂ target of 130 gm/km will then have to be reduced by 27% with a slew of technology adoptions and enhancements."^[4] This applies for cars and vans, but has not been defined for trucks, yet.

The influence of a coating manufacturer to the final engine life and performance by coating selection applied seems to be very limited in this context and even more if we think about an impact on performance of the engine itself. In the past all a coating could do was to ensure a defect free component.

Today the influence of a coating applied at a thickness of about 3 human hairs goes way beyond the actual cast component. It can modify the metal matrix and the performance of the final engine.

Let's ask the question: What determines a powerful and environmentally friendly engine?

Legal requirements and limit values					
	Law from	NOx g/kWh	PM g/kWh	HC g/kWh	CO g/kWh
R49.00	1982	18	-	3.50	14
Euro 0	1990	14.4	-	2.40	11.2
Euro 1	1993	8.0	0.36	1.10	4.5
Euro 2	1996	7.0	0.15	1.10	4.0
Euro 3	2001	5.0	0.10	0.66	2.1
Euro 4	2006	3.5	0.02	0.46	1.5
Euro 5	2009	2.0	0.02	0.46	1.5
Euro 6	2013	0.4	0.01	0.13	1.5

Table 1. EU emission standards for heavy-duty diesel engines: Steady-state testing ^[3]

COATING FOR IMPROVED INNER CLEANLINESS

The frequency of modern engines regarding service intervals is becoming longer and longer. In effect the mileage until an oil change is required has increased by 3 times on average from 5,000km to now ca 15,000km sometimes even 30,000km. In addition the technical demands on the oil itself have become more severe.

But what if this modern engine runs not on ordinary streets, motorways and on shore, but off shore on the sea where the next fuel and service station might be some considerable sea miles away. In this case the engine needs to be the most reliable part of the total machinery. Volvo has a marine department called Penta, which designs and manufactures complete engines for not just high performance power boats (<http://www.frauscherboats.com/>), but also for sea rescue boats, towboats and others. In order to extend the competitiveness of this department and to raise the engine performance ahead of all competition new ways had to be developed which involve all different steps in cast component manufacturing.

What was considered in the past to be engine oil performance has now grown into a new dimension: Inner Cleanliness.

Coatings are usually applied on sand cores that build the inner geometries and complexities of an engine. In particular, thin sections in the engine block or cylinder head are prone to defects and also sand adherence due to shot blast kinetic energy loss.

If a coating could contribute to the inner cleanliness of a cylinder-block or head all the following manufacturing steps from heat treatment up to final machining would become easier and more efficient and the economic value would increase.



Figure 1. Contaminated coolant

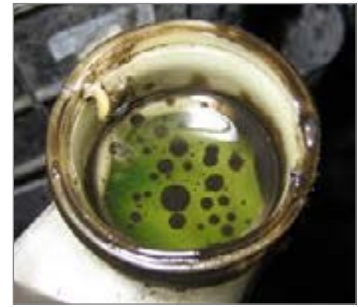


Figure 2. Residues in oil



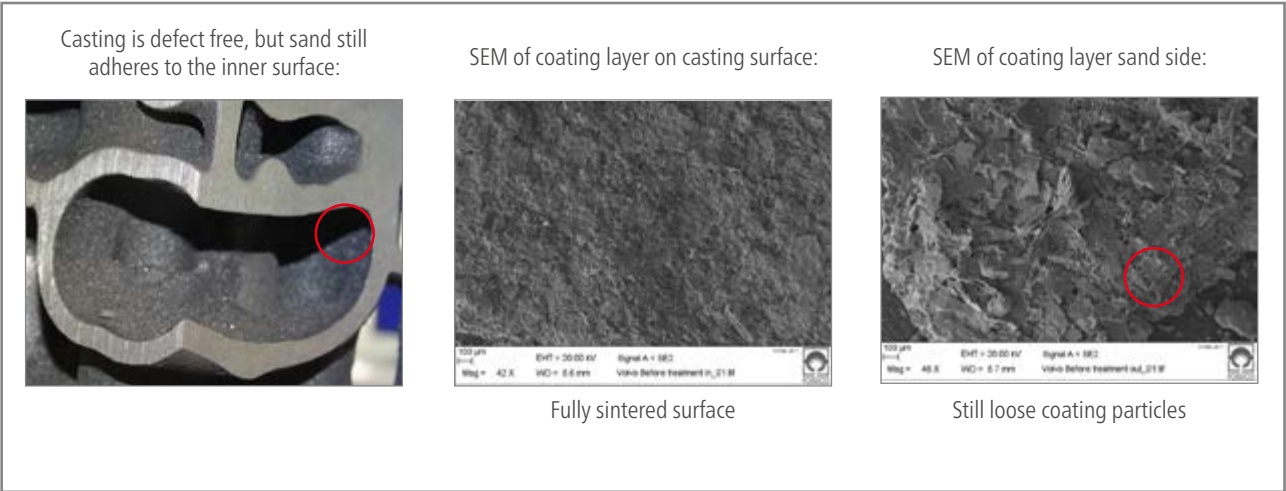
Figure 3. Euro 6 Diesel Engine

The investigation of this “inner cleanliness” concept is not simple because a common industrial standard is not yet defined. All engine manufacturers use internal standards, hence there is a wide spread of OEM demands. Also, a method for testing did not exist, hence the Volvo/Foseco cooperation had to establish a reproducible and repeatable way of evaluating remaining particles inside a casting.

But before we go further, let us consider the coating in more detail:

After casting, the very complex cylinder head part has to undergo a number of treatments. This consists of sand shake-out, heat treatment and final shot blasting. The resulting casting surface for a conventional coating is shown in figures 4-6 at each of the process stages.

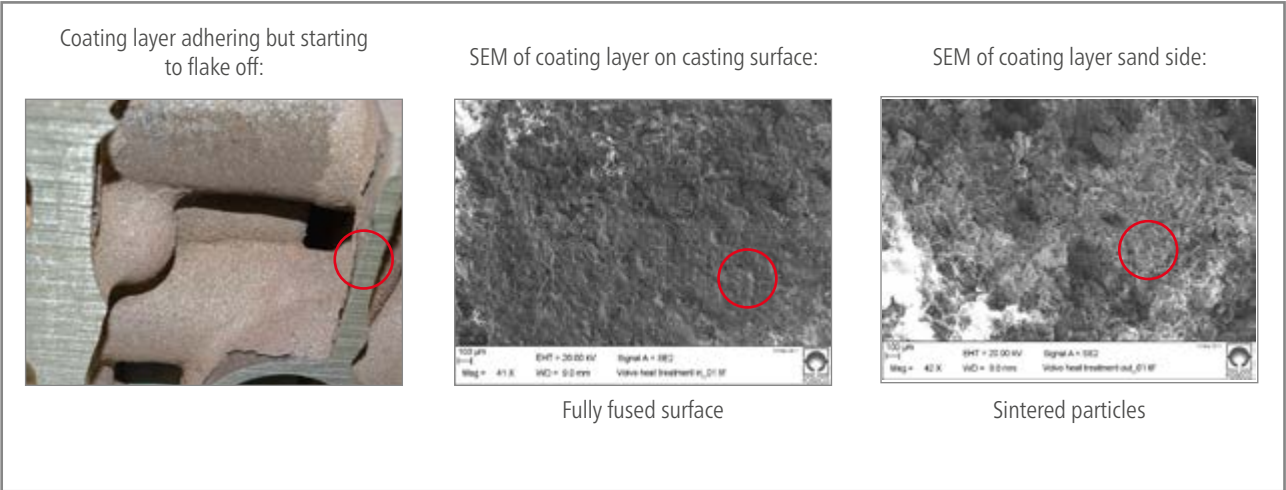
As coating is the first material the metal contacts when entering the mould cavity, the coating usually adheres to the cast surface in the as-cast state.



Fully sintered surface

Still loose coating particles

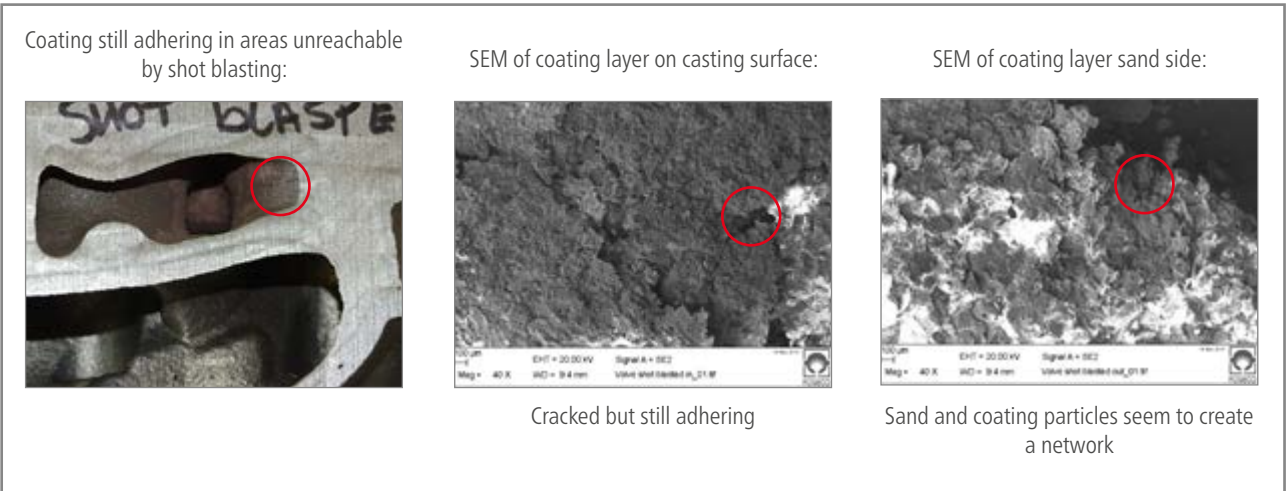
Figure 4. Immediately after shake-out



Fully fused surface

Sintered particles

Figure 5. After heat treatment



Cracked but still adhering

Sand and coating particles seem to create a network

Figure 6. After shot blasting

WHAT CAN BE ALTERED IN A COATING TO MAKE IT LESS ADHERING TO THE CASTING AFTER FINAL SHOT BLASTING?

One aspect is the coating flake formation. After pouring, the coating layer forms a ceramic shell that breaks down into flakes during shake out and further cleaning steps. These flakes could be used as a carrier for the debris adhering to them. By engineering the coating to form strong and well defined flakes that readily detach from the casting surface and do not themselves contribute (e.g. by disintegration) to further particle formation, it is possible to improve the cleaning of the casting even at inaccessible positions.

During trials the newly developed coating demonstrates how the correct ceramic shell formation helps to remove almost all remaining particulates, leaving a very clean casting surface (Figure 7 and 8). The result is an engine that performs better, longer and more efficiently.



Figure 7. Casting section only after shake out



Figure 8. Cast Surface right after shot blasting



FURTHER COATING PROPERTIES

Besides the coating flake effect, two more characteristics are important to produce a defect-free casting, which are Gas Permeability and Anti-Veining Properties.

Gas Permeability:

During the pouring process gas is developed by the binder combustion in a sand core. This means that the gas pressure behind a coating layer increases rapidly during the pouring process. In cases where the gas permeability is too low, coating can flake off and cause scabbing defects in areas that cannot be cleaned (in particular on cylinder head castings) and hence will lead to scrap. Reading above about coating flake formation could lead to the idea that this new coating is very impermeable or in other words has a very low gas permeability. The opposite applies (Figures 9 and 10)

Foseco has developed a special test that enables the determination of a gas permeability in ambient and elevated temperatures.

Point A: Time at which the sample is put in the heated atmosphere

Point B: Time at which the sample scabs – immediate pressure drop

Distance A – B: Scabbing Resistance

In the above example, two values can be observed:

1. The lower the value on $\Delta p \rightarrow$ the lower the pressure resistance \rightarrow the higher the gas permeability in ambient conditions
2. The longer the curve expands the greater the scabbing resistance \rightarrow the higher the gas permeability in elevated temperature conditions (here 1100°C)

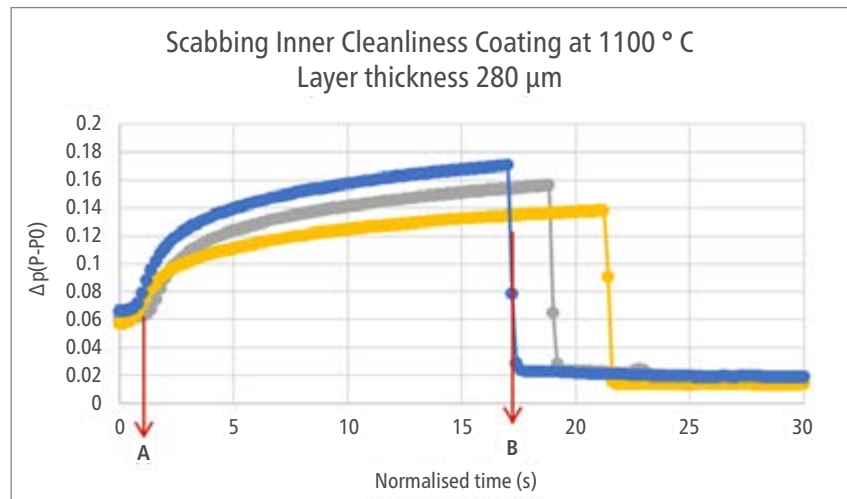


Figure 9. SEMCO* IC coating; showing extended resistance to scab formation

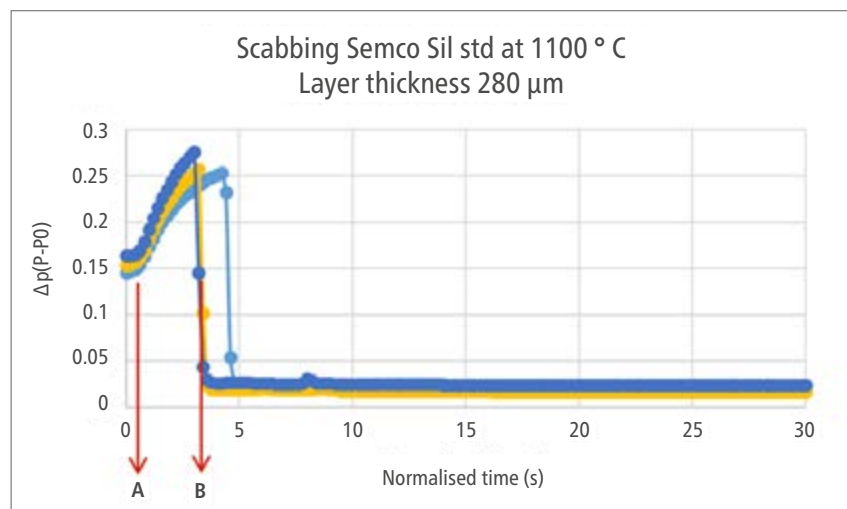


Figure 10. Conventional coating; showing poor scabbing resistance



ALTHOUGH THE NEW INNER CLEANLINESS COATING IS STRONGER IN TERMS OF CERAMIC FLAKE FORMATION, THE GAS PERMEABILITY IS STILL BETTER THAN A CONVENTIONAL COATING.



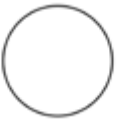
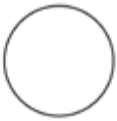


Core Composition	Silica Sand PU Cold Box Binder Zircon / Solvent Coating	Silica Sand PU Cold Box Binder Cold / Solvent Coating	Silica Sand PU Cold Box Binder Alu.silicate / Solvent Coating	Silica Sand PU Cold Box Binder Alu.silicate / Water Coating	Silica Sand PU Cold Box Binder Coke / Solvent Coating	Silica Sand PU Cold Box Binder Zircon / Solvent Coating
Result						
	Crack Formation	Veining	Good	Good	Veining	Crack Formation

Figure 11. Coating





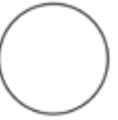
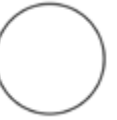
Core Composition	Silica Sand Sodiumsilicate Binder Coke / solvent Coating	Silica Sand PU Cold Box Binder Cold / Solvent Coating	Silica Sand Furan (Phosphoric Acid) Coke / Solvent Coating	Silica Sand Furan (PTS Acid) Coke / Solvent Coating	Silica Sand Alkali Phenol Resin Coke / Solvent Coating	Silica Sand Bentonite Coke / Solvent Coating
Result						
	Good	Strong Veining	Good - some spots on surface	Some Veining	Good	Good

Figure 12. Binder

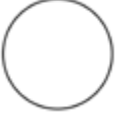
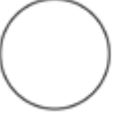
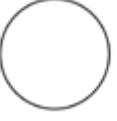



Core Composition	Special Sand PU Cold Box Binder Zircon / Solvent coating	Chromite Sand PU Cold Box Binder Zircon / Solvent Coating	Zircon Sand PU Cold Box Binder Zircon / Solvent Coating	Silica Sand PU Cold Box Binder Zircon / Solvent Coating	Silica Sand PU Cold Box Binder Uncoated	Silica Sand PU Cold Box Binder Coke / Solvent Coating
Result						
	Good	Good	Good	Veining	Veining and Metal Penetration	Veining

Figure 13. Sand

ANTI VEINING

Foundrymen consider the silica expansion at 573°C as the temperature at which the moulding material is most prone to veining defects. The best test to compare individual anti-veining properties of coatings is to conduct a veining block test. In this test, up to 6 different coatings can be compared side by side, keeping sand, binder and other parameters constant so that the pure coating performance can be determined. Figures 11-13 show an overview of options of anti-veining performance [5].

Comparing the conventional product (figure 14) with the new inner cleanliness coating (figure 15). It can be seen that the SEMCO* IC has higher resistance to vein formation.



Figure 14. Conventional Coating



Figure 15. Inner Cleanliness Coating

SUMMARY

A specially developed coating that can improve inner cleanliness in very complex engine components will help the automotive industry to achieve even more stringent emission demands than the current applied Euro 6 standard, but moreover also extend service intervals that will help to limit further resource depletion and improve our heritage for the next generations.

ACKNOWLEDGMENT

I would like to specifically acknowledge the extraordinary cooperation with two outstanding foundry experts; Tore Nilsson and Sten Bergman, Volvo GT0. Without their expertise and support this project could not have been taken so far.

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SEMCO IC for Inner Cleanliness?*

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AUTOMATED INTELLIGENT COATING CONCEPT FOR FERROUS FOUNDRIES



Author: Christoph Genzler

Today, automation of coating control and preparation is an established process in many foundries. Since the introduction of density measurement and automatic online-monitoring by Foseco in 2008 substantial developments have taken place leading to significant improvements of the measurement method and equipment functionality. The following article will demonstrate how, by intelligent control, a great number of new automation applications become possible.

AUTOMATED COATING CONTROL

There are two widely adopted techniques for measuring coating density; by a pressure differential or by volume/mass determination. The current methods of achieving this have some disadvantages, e.g. the use of measuring sensors with moving parts that require thorough and regular cleaning to ensure consistency of operation or to accept delays and inaccuracies in density measurement due to external influences such as machine vibration.



TO OVERCOME THESE ISSUES A NEW DESIGN PHILOSOPHY HAS BEEN ADOPTED:

- There should be as few moving parts installed as possible
- The unit's components should be designed as maintenance-free wherever possible
- The achieved measuring accuracy and speed should surpass current technology
- It should be possible to integrate the measuring 'intelligence' directly into other applications, e.g. dip tanks, flooding or spraying units without having to invest in a centralised preparation unit.

Furthermore, the unit should be compact and sturdy in order to withstand the rough foundry environment.

IMPLEMENTATION

When considering the equation for the pressure in a liquid:

$$p = \rho gh$$

Where:

p = pressure in a liquid
 g = gravity at surface of liquid
 ρ = density of the liquid
 h = column height of liquid

It follows that if you measure the pressure at two different heights, the formula can be rearranged for density, so that:

$$\rho = \frac{\Delta p}{g \cdot \Delta h}$$

One can recognise that the density is related in a linear way to the measured pressure difference⁽⁵⁾.

For example, the pressures in a tank of coating are measured at two fixed depths, and a difference between the two pressures is recorded at 0.50 bar. After adding 100 litres of water to the tank the pressure difference decreases to 0.25 bar. It follows that since all other factors have remained constant, a halving of the pressure difference is due to the overall density of the liquid in the tank reducing by 50%. Note that the coating and water will need to be mixed to achieve a homogenous density.

THE INTELLIGENT COATING UNIT (ICU)

The ICU consists of a coating homogenisation tank, in which the pressure probes are incorporated into the surface of the tank and do not limit the effectiveness of the mixing unit. The PLC control continuously monitors the density of the coating, automatically adding water or undiluted coating to maintain the required density at all times. The control unit also controls the mixer timing and speed to ensure homogeneity of the coating. From this tank, coating is supplied to one or more coating application stations for use. Excess coating is returned to the tank via a filter configuration for re-checking and homogenisation.



THE PRESSURE PROBES ARE EXTREMELY ROBUST WITH A GUARANTEED LIFE TIME/ WARRANTY OF UP TO 10 YEARS.

They also allow the ICU to monitor each measurement automatically and provide the possibility to determine any sedimentation tendency of the coating. Until today this has not been possible with other units and provides significant benefit. When considering a possible contamination by bacteria in a water coating it is important to understand that this will not result in any change of the density. The coating will change, however, regarding its properties like matt time, flow length and sedimentation tendency which will affect indirectly the structure of the layer - a parameter which must be kept constant unconditionally⁽¹⁾. By measuring sedimentation rate it is possible to monitor rheological changes in the coating and affect appropriate action.

It is also advisable and possible to integrate within a pressure sensor a coating temperature monitoring programme for registering at least critical product temperatures and fluctuations that may cause concern⁽³⁾.



The advantages are:

1. Optimised processing of diluted coating.
2. Continuous monitoring and recording of coating density
3. Automatic dosage of coating or dilutant to maintain density
4. Coating application (applied layer thickness) is more consistent and predictable.
5. Reduction of maintenance down-time



Figure 1. ICU - Intelligent Coating Unit

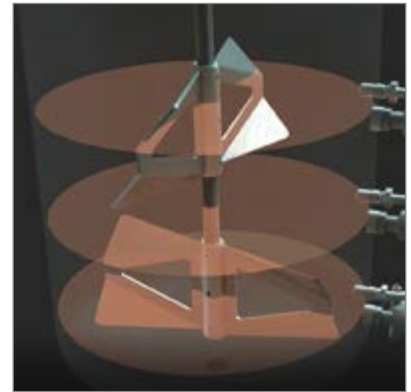


Figure 2. Pressure Sensors



Figure 3. Optional UV treatment



Figure 4. Integrated timer control

MEASUREMENT ACCURACY

The self-control and calibration is affected by means of a third sensor (Figure 2) enabling comparison of three separate differential pressures (top-bottom; top-middle; middle-bottom) and which thereby not only monitors the homogeneity in the vessel but also displays simultaneously a possible increased sedimentation tendency.

The pressure sensors which are used are also employed, for example, in sludge conveyance and fracking. This means that they are very robust and designed for long service life. There is no need to move the sensors for cleaning as they are maintenance-free. It is now possible to achieve a measurement accuracy enabling a max. tolerance of 0.1 % of the desired value. For example, a range from 1.1498 to 1.522, when the desired density value is 1.1510.

OPERATION

During filling or returning of the coating, turbulence may introduce air inclusions and, thereby, undesirable foaming. In the ICU this is prevented by a novel filling technique.

Another weak point of existing plants are the shear forces, which due to stirring or pumping act negatively on the coating by effecting the balanced rheological properties of the product. A shear force, which is too high (for example due to circulation in a measuring tank) can change the character and behaviour of the coating completely.

The newly developed propeller geometry enables the ICU to minimise this shear load by employing extremely low revolutions (10 - 30 rpm), whilst still ensuring a homogeneous product.

By means of UV disinfection treatment (Figure 3) the water used for dilution can be disinfected without using any chemicals. This results in longer service life of the coating and, simultaneously, less waste.



At **Eisengießerei Dinklage**, the intelligence of the ICU can be integrated directly within the dip tank.



This was taken into consideration when the ICU was designed: By means of an integrated timer control unit (Figure 4) by which the supply containers can be connected directly to the ICU, homogenised and used, thereby preventing any over-mixing. Subsequent to the container change, homogenisation of raw coating is started automatically.



Moulding / core sand is a significant source of contamination. Sand inclusions in the coating layer can cause inclusions in the casting surface, which quite often can result in expensive re-work. To avoid this, the ICU is fitted with a double-filter system (Figure 6) which not only removes these contaminants, but which can also be exchanged without interruption to production.



Many users do not need a central preparation plant but are employing stationary units like dipping tanks or flow coat stations. In such a case, as per the example at Eisengießerei Dinklage, the intelligence of the ICU can be integrated directly within the dip tank.

The accurate and fast determination of the density enables the ICU to quantify the required volumes of raw coating or respectively dilution medium in advance and replenishment can take place without delay.

Profitability analysis for an exemplary foundry:

- In the core shop there are 5 dipping tanks of which 3 are by manual operation and 2 are fitted with robots.
- Historically a dipping tank cleaning cycle of 2 times per month is undertaken, giving rise to a coating waste amount of 86.4 t/year (24 cleaning operations per year).
- By employing the ICU, it became possible to reduce the cleaning cycle to once per quarter, resulting in a saving of 64.8 tonnes of coating.

- With waste disposal costs of 0.8 euros/kg, it is possible to save 51,840 euros/year.
- The diluted coating has a cost of 0.30 euros/kg. Therefore, in this case ($64,800\text{kg} \cdot 0.3$) 19,440 euros/year less coating costs occur.

In addition to the direct coating costs, the foundry benefitted from improved casting quality. The foundry has a capacity of 54,000 tonnes per year and produces 16,000 t of a component having a defect rate of +- 5%. The costs for removing this defect are 0.15 euros/kg. By using the ICU, it was possible to reduce coating-related defects by 2.5 %. This equates to a quality related saving of (16mil kg * 2.5 % * 0.15) 60,000 euros per year.



THE USE OF THE ICU WAS THUS PAID OFF IN THE FIRST YEAR WITH 131,280 EUROS.

It is left to the reader to compare this with his own and more current values.

SUMMARY

An Intelligent Coating Unit is the next step to streamline coating handling in the foundry industry for near maintenance-free automation.

In view of the increasing demands in foundries regarding process-reliability also process-reliable coating handling is needed, as this has a substantial influence on casting quality. The ICU concept is the correct route to this target.

ACKNOWLEDGEMENT

Our special thanks go to the firm of Eisengießerei Dinklage, in particular Mr. Ploch, for valuable and trustful cooperation.

Thanks are also due to the firm of Schipper/STS at Almelo, particularly Messrs. B. Jannink, K. Smidt and M. Wolters, for the joint development of the ICU.

Further thanks go to the Foseco team for their great support.

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INCREASING THE CONSISTENCY OF IRON CASTING PROPERTIES AND REDUCING FOUNDRY REJECTS BY THE USE OF FERROLAB* V THERMAL ANALYSIS EQUIPMENT



Author: Colin Powell

Producing high quality iron castings requires high quality, consistent liquid iron.

The quality of the liquid iron depends not only on its chemistry, but also its inoculation state – the ease of forming the physical iron structure on cooling.

Thermal analysis provides a fast and cost-effective way to assess the inoculation state of liquid iron, ensuring that it can be made consistently from one batch to the next.

This article describes the simple and robust device – Foseco's FERROLAB V Thermal Analysis Equipment. It further shows how it can be used by Romi foundry in Brazil to check, adjust and record the thermal fingerprint of each batch of iron.

INTRODUCTION

To make a high quality casting it is obvious that the liquid metal used to make it must be of high quality.

Firstly, the chemistry of the iron must be correct. This usually means monitoring Carbon using a CE meter or combustion analyser, and other elements using a spectrometer and keeping them within accepted ranges.

However, having the correct chemistry of the iron is only part of the story, we also need to know that the inoculation of the iron is correct.

The number of sites available for the deposition of the first solids forming as the iron cools has a tremendous effect on the structure of the solidified iron. Though the chemical composition of the iron hardly changes, the addition of a good quality inoculant such as Foseco's INOCULIN* to a poorly inoculated iron can totally change its properties.

Inoculation affects the amounts of carbides, how much shrinkage occurs and the strength and ductility of the castings it produces.

The best way to know how a casting will solidify is to take a sample of the liquid iron and record its solidification. We can do this using FERROLAB V (five) equipment supplied by FOSECO.

The sample is poured into the INOCUP test cups and in around 300 seconds we have a clear presentation of the parameters most important for controlling the iron.

The parameters can be used initially to categorise the iron and assist in determining the correct type and amount of inoculant. The foundry can then set its own specification for ranges of the parameters acceptable when in general production.

The unit can then be employed as a quality control tool, to make sure the iron is within specification and to highlight cases when adjustment may be required.

FERROLAB V

Calculations are performed in an industrial pc that is robust enough to be used in the foundry environment, but can be located in a control cabin. The computer connects wirelessly to the FERROBOX data acquisition unit located near to the sampling station.

A simple set of traffic lights on the FERROBOX lets the operator know that the sampling cup is correctly placed and ready to use.



THE KEY TO FERROLAB V IS ITS SIMPLICITY

The FERROBOX can be placed on the melt deck and can sample two cups. Two FERROBOXES can be connected wirelessly to each computer. This allows a range of possibilities for sample taking.

For example, stable analysis of solidification parameters for up to four furnaces, or alternatively configurations for metastable analysis using tellurium containing cups or for checking inoculation after ladle treatments or immediately before pouring.

The results of the test appear colour coded. As would be expected, green is good, yellow is borderline acceptable (requires checking) and red is out of specification. General parameters are preset, but obviously these can be adjusted to the foundry's preferences.

The colour coding means that for QC purposes, operators do not need to be trained in thermal analysis, but rather can call a supervisor if the results are borderline or out of specification.

As well as critical parameters, the system displays the cooling curve and the first differential, so experienced TA users can immediately identify the characteristics of the iron.

All of the data from tests is stored and recorded, so can be used as part of the quality control record.

Previous results can be retrieved and displayed. The system allows the comparison of multiple cooling curves and derivative curves for investigative purposes.

Of course it's not just the iron in the furnace, FERROLAB allows you to look at ductile iron after the nodularising treatment, and inoculated iron right up to the moment it is poured.

The equipment is robust, and because two acquisition boxes can be connected wirelessly to one computer, you can analyse up to four cups in two different locations

The system is provided free of charge to Foseco customers that buy our inoculants, nodularisers and sampling cups. And we work together with them to ensure that they can consistently produce the highest quality iron possible.



Figure 1. FERROBOX data acquisition unit

PRACTICAL APPLICATION OF FERROLAB V AT ROMI FOUNDRY BRAZIL.

FERROLAB V equipment was installed at Romi, a medium sized foundry in Brazil producing Ductile Iron castings. The equipment was installed with one channel acting as a standard CE meter, and another performing stable analysis to give information of the casting structure.

Use of the equipment is still in the early phases, but already the foundry has started to modify the treatment process to make best use of combinations of inoculants and nodularisers on offer.

From figure 3 we can see that the standard material treated with 1.3% FSM (5% Mg) and standard inoculation is of relatively good quality, but it may still be possible to improve on this.

Figure 4 shows how the iron has been improved, firstly because its composition has been moved closer to eutectic, meaning a shorter freezing range. Secondly a preconditioning treatment and late stream inoculation have been added. These reduce the amount of undercooling before solidification and recalescence during solidification having the overall effect of moderating the solidification process and giving a better structure.

SG iron preconditioned with INOCULIN* 390 in furnace. 1.5% NODULANT* FSM, 0.3% INOCULIN 320 inoculation + 0.2% post inoculation with INOCULIN 920 (simulated with addition in cup). Comments: Nearer eutectic but higher TeMin and PAE and lower VPS than without post inoculation.

Further trials will allow Romi to further optimise their inoculation and nodularisation practices.

From this point Romi will be looking for castings that lie at the limits of their specifications and using FERROLAB V will create systems allowing them to move the quality even closer to their target.



Figure 2. Romi Foundry, Brazil



Figure 3.

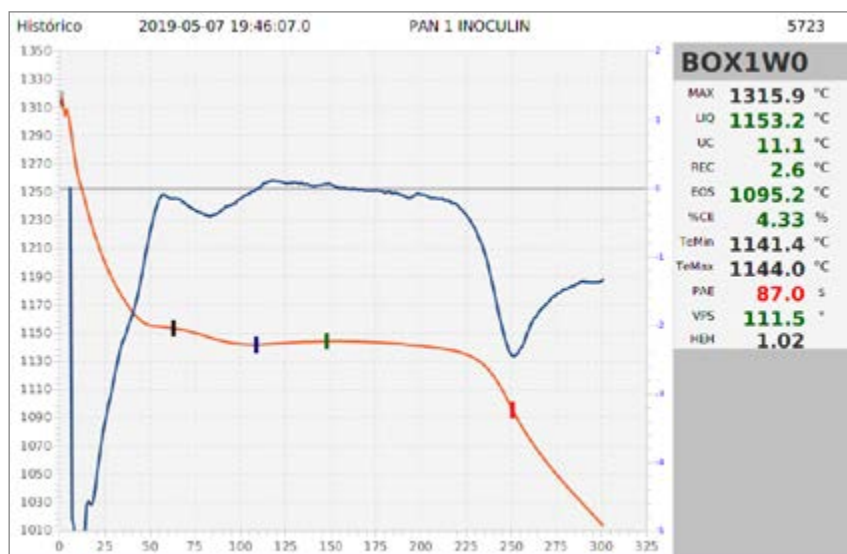


Figure 4.

| SUMMARY

FERROLAB V is a simple and highly cost effective route to increasing quality and reducing the number of defective castings by the use of Thermal Analysis.

| ACKNOWLEDGEMENT

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WATCH VIDEO



THE BENEFITS OF BOTTOM POUR TECHNOLOGIES IN STEEL FOUNDRIES

Author: Rudi Bittniok

This article is aimed at steel foundries using lip pour ladles for steel castings processes who want to change to bottom pouring technology. It presents technical solutions in steel foundries using ladles between 0.5 to 40 tonnes, reflecting one shot and multiuse Monoblock stoppers.

It highlights the importance of preheating, gives an overview of possible future steps using automated pouring devices and describes in detail the application of a new nozzle technology.

STEEL FOUNDRIES AND THEIR STOPPER TECHNOLOGY

Bottom pour ladles of sizes from 500 kg to 40 tonnes have been widely used for manufacturing steel castings for more than 30 years.

Ladles over a capacity of 40 tonnes mostly employ slide gate systems as they are mostly used for very big castings requiring a single pouring. Smaller ladles under 500 kg are simple to control without using a stopper mechanism. In these cases, and particularly for investment casters, teapot solutions are the first choice (Figure 2).

There are many ladle pouring technologies in use that could be converted to stopper applications giving benefits such as:

- Zero slag casting
- Direct placement over the sprue cup
- Shorter casting time
- Less maintenance
- Ability to gas purge

The foundry may employ different stopper configurations depending on their casting process. It is possible to choose between a monolithic stopper made from one piece of isopressed or extruded carbon ceramic (VISO* or VAPEX* Monoblock stopper) or an assembled stopper made out of a graphite head and chamotte sleeves over a metal bar.

There are two main criteria for this choice:

A. Overall length

The maximum length of currently available monoblock stoppers is 2150mm, so for ladles taller than this an assembled stopper must be used.

B. Preheating

It is mandatory to preheat all Monoblock stoppers, therefore a suitable preheating station is essential. It would be very difficult to introduce a monoblock stopper where no suitable preheating station is available.



Figure 1. Casting in a steel foundry by monoblock stopper



Figure 2. Steel investment casting by a teapot ladle



Figure 3. Long assembled stopper in a 35 tonne ladle



Figure 4. Professional preheating station for large steel casting ladles



Figure 5. Monoblock stopper after preheating, ready for filling

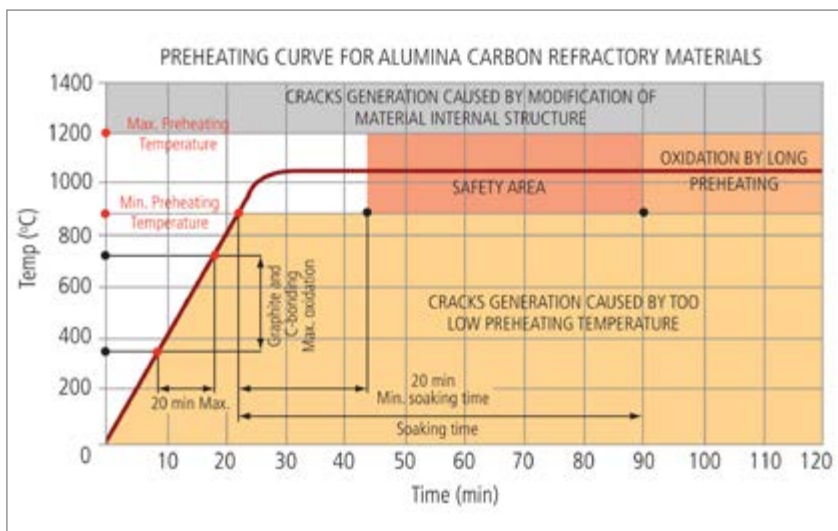


Figure 6. Preheating curve for alumina carbon refractory materials

ASSEMBLED STOPPERS

In situations where no preheating is possible or if the ladle is too tall, an assembled stopper is the only choice. Here, we use a clay graphite stopper head (ROTOLOK®) and ceramic sleeves around a metal bar, assembled using a high temperature mortar.

THE IMPORTANCE OF PREHEATING

Preheating of a ladle with monoblock stoppers is essential. Despite the solid and dense appearance of the stopper, it still has some open porosity and therefore can pick up moisture from the environment. The use of a stopper that has not been preheated could be extremely dangerous as the rapidly expanding moisture can cause the stopper to crack. A general preheating curve appears as shown in figure 6.

During preheating and even when the ladle will be filled with molten steel, a degassing process occurs where the remaining moisture migrates through the vent hole of the stopper which is shown in figure 7.

Use of a suitable metallic stopper rod with a central vent hole is mandatory. Using an un-vented metallic rod, or one where the vent is blocked by slag could also lead to cracking as any remaining moisture would be unable to escape.

For tapping temperatures around 1600°C or higher, using the recommended stopper preheating cycle is very important.

Normally the preheating profile is controlled by the burner software program.

In cases where a non-programmable burner is used, the temperature should be monitored by thermocouples introduced via the hole in the middle stopper to the end touching the solid nose measuring the nose temperature.

This is quite important in cases where the recommended preheating temperature cannot be reached. Here the stopper solid nose temperature should reach 1000°C in 30 minutes, and the user should keep this temperature for 60 minutes.



Figure 7. Moisture migration through the vent hole



Figure 8. Top: Support rod with vent hole
Bottom: DANGER! Blocked vent hole by slag

MONOBLOCK STOPPER AND KALTEK* LADLE LINING

Sometimes a foundry needs to improve their temperature profile in the ladle. If the foundry requires a solution of an insulating ladle lining, then KALTEK is an obvious choice (Figure 9). This dry lining solution does not need to be preheated, and in this case if the customer wishes to use a Monoblock stopper, a special preheating sleeve must be used (Figure 10). Connected to a gas burner, this system just preheats the stopper but not the lining.



Figure 9. Preheating sheath for KALTEK ladles with small stopper sizes



Figure 10. Preheating construction for long monoblock stoppers

STOPPER SETTING PARAMETERS AND STEEL QUALITY OF THE STOPPER ARM

During the preheating process, the ladle structure and stopper mechanism faces a lot of thermal stress. It is recommended to use a high quality steel grade and protect the arm construction by ceramic fiber as shown in figure 12.



Figure 12. Stopper arm protection by ceramic fibre

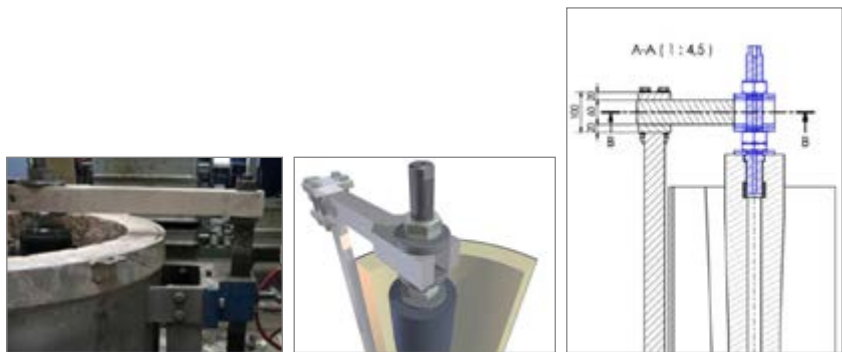


Figure 11. Crossarm for stopper ladle, all products out of heat resistant steel like SICROMAL 8. (Measurements not to scale)

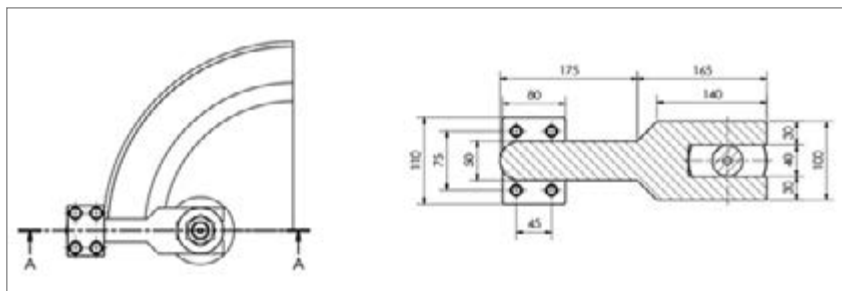
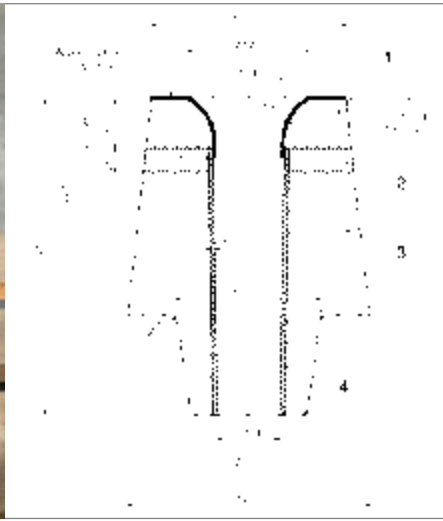


Figure 13. Cross arm details

NOZZLES

Normally a steel foundry nozzle is a One-Shot product.

As the market demands improvements, the new ZONED-NOZZLE (Figure 14) for multiple usage has been invented.



Features of zoned nozzles:

1. High quality refractory material at the top for improved erosion resistance
2. Transition layer to reduce thermal expansion
3. A main layer with good thermal shock resistance
4. Inner layer for insulation purposes

The nozzle also has a non-stick coating around the closing area.

Figure 14. Zoned nozzle

CROSS-BORE NOZZLES

Invented nearly 12 years ago, the cross-bore nozzle technology has replaced the cheap standard one shot nozzle in many steel foundries giving the benefit of a compact and controlled pouring stream and double lifetime.

This is important in case of high speed pouring with large nozzle diameters, but even for small diameters, the cross-bore nozzle could be a benefit when the pouring cup is small and the operator wants to achieve maximum control of the casting process.



Figure 15. Cross-bore nozzle



Figure 16. Cross-bore nozzle sectioned after 2 ladle journeys, showing minimum wear of the body material

THE FUTURE

The usage of bottom pour ladles is now widespread, but it is still a manual operation. Remote controlled auto pouring devices could be the future as they give a benefit in terms of safety and pouring consistency.

Some foundries are already using pneumatic controlled opening systems for increased operator safety and these work well when they are required to open only once or twice. There are also already moves to control the pouring process using a laser system. In these cases the opening is controlled by an electric mechanism.

CONCLUSION

The usage of bottom pour ladles for casting steel is already a common practice in modern foundries, but there is still significant scope for growth, especially in situations where slag is a problem.

Bottom pour ladles have the benefits of requiring less maintenance than teapot ladles and allow the steel to be poured without any ingress of slag to the stream.

The decision to use a Monoblock stopper is most reliable choice.

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