Improving foundry profitability through the use of RHEOTEC* XL Coatings

Background

High production iron foundries everywhere are facing enormous pressures to produce increasingly complex, high performance automotive and other castings, to ever-increasing quality specifications - while attempting all the time to reduce casting production costs.

Refractory core coatings are fundamental to obtaining satisfactory casting surface quality and are used extensively on resin-bonded cores and core packages in production iron foundries. As the need for more complex, critical castings and higher quality standards grows, the function and performance of the core coating utilized in the process becomes critical.

The impact of a high performance core coating on the overall production cost of a typical grey iron casting can be significant. Fettling, cleaning, and casting inspection operations can often contribute as much as 20 - 25% of the total production cost of an iron casting. While some of this time and cost is associated with the removal of gating systems and "flash", time-consuming repair of surface defects and the removal of adhered sand / coating residue from internal cavities are major cost components which can be directly affected by the core coating performance and application.

The material cost of coating is typically a fraction of the total manufacturing costs and usually would be less than 1% of total production costs.

The experience of production iron foundries in using the RHEOTEC XL range of premium core coatings in the past 3-4 years has been extremely positive. This paper provides an overview of the technology and provides examples of how RHEOTEC XL coatings have improved the profitability of foundries in many different markets and in different casting applications.

How RHEOTEC XL coatings function

RHEOTEC XL coatings are water-based slurries containing a special blend of refractory fillers that have been engineered specifically to meet the most stringent demands of grey and ductile iron casting producers.

As with the proven standard RHEOTEC products, RHEOTEC XL coatings are formulated and manufactured under tight quality control process conditions to provide excellent application behaviour and stability and consistency in use. Specially selected surfactants ensure controlled substrate wetting with no foaming tendency, for defect free core and casting surfaces and less remedial work on coated cores. Levelling of the coating layer is excellent, resulting in a consistent film thickness and a uniform layer that is free from runs, drips and curtain defects, even on complex core assemblies.

The engineered RHEOTEC XL coating refractory system provides superior as-cast surface finish quality in the most critical applications - in particular the coating technology has been optimized to eliminate or dramatically reduce veining defects.

Veining (or finning) defects (figure 1) occur when metal enters cracks in the core surface which result from thermal stresses generated by the expansion of silica sand during casting. In severe cases, the metal can actually penetrate the core completely causing a total blockage of an internal cavity, rather than simply causing a surface vein or fin defect.

Figure 1: Veining in a sectioned diesel cylinder head casting

Veining severity varies significantly, depending on core type, sand quality and type, casting configuration, and metal composition.

The superior anti-veining and overall casting quality provided by RHEOTEC XL coatings is a direct result of the optimized application behaviour and the engineered refractory system which ensures that the thermal shock experienced by the core during casting is substantially delayed and diminished.

Controlled penetration of refractory fillers into the core substrate produces a high insulation value and a coating layer with an enhanced "hot strength" that inhibits the formation of core surface cracks at casting temperatures.

The effect of RHEOTEC* XL coating chemistry on the temperature profile of a standard AFS compression core during pouring was studied through the use of thermocouples embedded in the core (figure 2).

Figure 2: Coated test piece cores

The highly insulating nature of RHEOTEC XL coatings is illustrated in Figure 3. The chart shows a comparison of core temperature vs. time after pouring, for a RHEOTEC XL coated core and a core coated with conventional aluminosilicate coating. The temperature increase at a 3 mm distance below the core surface was measured for a period of time after the test block had been poured.

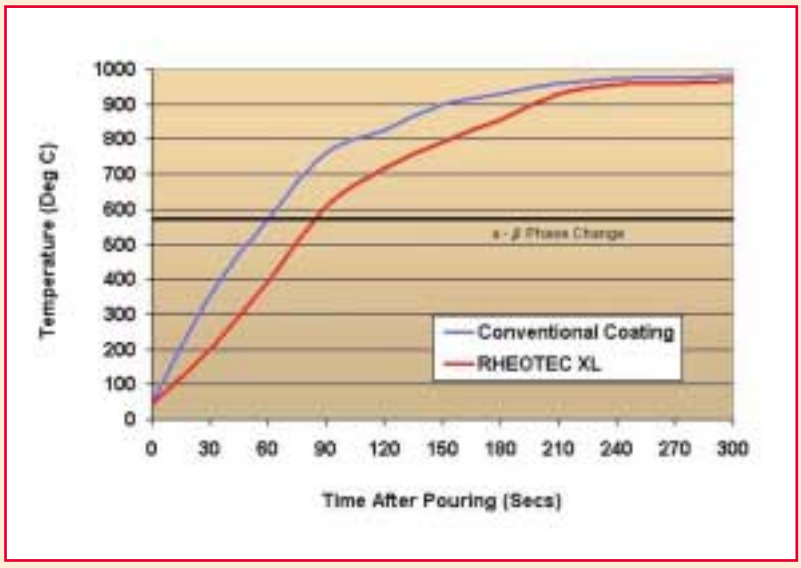

Figure 3: Comparison of thermal behaviour of a RHEOTEC XL coated core vs conventional coated core

The time required for the core surface to reach the temperature at which sand expansion occurs (alpha-beta phase change), is delayed by a short but significant period. This, combined with the high coating hot strength, significantly reduces the tendency for core surface cracking and subsequent vein formation.

Value to the User

In most cases, the use of RHEOTEC XL coatings will totally eliminate moderate veining, as well as adhesion of sand and core particulate matter (figure 4).

Figure 4. Penetration defect in 1.8ltr engine block oil gallery (left-hand section) eliminated through the use of RHEOTEC XL coating (right-hand section)

The performance characteristics of RHEOTEC XL core coatings provide significant casting quality and operational benefits for production iron foundries, both in the core room and in the casting finishing area. Some of the benefits reported by RHEOTEC XL users include :-

Quality Improvements:

- ❑ Superior as-cast surface finish
- ❑ Reduced retention of sand and coating material particles
- ❑ Cleaner overall internal casting passageways.

Operational Benefits:

- ❑ Elimination of costly anti-veining sand additives
- ❑ Elimination of double coating practices
- ❑ Reduced core dressing (remedial work) operations
- ❑ Simplified core room process control
- ❑ Reduced core room labour costs
- ❑ Lower casting scrap levels (due to reduced veining / metal penetration severity)
- ❑ Reduced shot-blasting costs (labour, equipment, energy, materials)
- ❑ Reduced fettling and grinding costs (labour, equipment, energy, materials)
- ❑ Reduced inspection costs
- ❑ Faster casting throughput - improved foundry productivity & capacity

Main Applications

RHEOTEC XL coatings are most suited to critical applications where dimensional accuracy and exceptional surface characteristics are required, where retained sand and coating particulate matter in internal passageways is a critical issue, and where veining is experienced. Typical casting applications include cylinder heads, engine blocks (water jacket, oil gallery), hydraulic castings, housings (differential, pump, etc.) and brake disc rotors.

RHEOTEC XL coatings are most effective and provide the greatest benefit on phenolic-urethane cores. Phenolic-urethane cold-box cores are more prone to veining defects than other systems (hot-box, shell, etc.) because of the inherent lower hot strength of the binder system. However production tests have also confirmed that RHEOTEC XL coatings are effective when used on other binder systems such as SO_2-epoxy, PF Hot-Box and Shell bonded cores.

Production experience with RHEOTEC* XL coatings

The following case-studies highlight the benefits of RHEOTEC XL coatings when targeted at the elimination of sand expansion defects such as veining and improving "strip and peel", to ensure a defect free surface without coating adherence and retained particulate. In all cases the benefits to the foundry are to be found in reduced overall cost per component. The cost savings are achieved through lower scrap and defect levels resulting in reduced processing times, both in the coreshop and the finishing shop. The overall effect is improved productivity and the elimination of production bottlenecks, with reduced labour requirements and no need for further capital investment in the finishing shop.

Case Study 1. Grey iron diesel engine 6-cylinder head

The case-study is based on the experiences of a high production cylinder block and head foundry located in Brazil, whose main customers include Cummins, General Motors, Peugeot, Daimler Chrysler and Mack Truck. The foundry has an output of approximately 300,000 tonnes of finished castings per annum, with between 50 and 60 percent of these being for direct export.

Details of the cylinder head casting and its manufacturing parameters are as follows :-

- ❑ Weight : 91.2 Kg
- ❑ Castings per mold : 2
- ❑ Pouring temperature : 1400-1420°C
- ❑ Castings per year : 144,000
- ❑ Core Package : Phenolic-Urethane Cold Box

Significant veining defects were typically encountered within the internal channels of the casting (figure 6) which required excessive cleaning times to eliminate, resulting in a production bottleneck within the finishing department of the foundry.

Figure 6: Extensive veining prior to use of RHEOTEC XL coating

The objectives of the customer were to remove this bottleneck by improving the as-cast quality of the internal channels by preventing the vein formation. This would reduce significantly the subsequent fettling and cleaning times and avoid further capital expenditure aimed at increasing the capacity of the finishing shop to accommodate the moulding line capacity.

Coating Application

The RHEOTEC XL coating was trialled against the current coating practice, as outlined in the table below. It should be noted that the RHEOTEC XL coating was applied as one layer by using an automated dipping machine, and that the layer build-up was equivalent to that achieved by a double dipping operation with the traditional coating.

	"Old" Practice	RHEOTEC XL Practice
Coating	Graphite-based	RHEOTEC XL
Core Sand	Silica 50/55	No Change
Coating Method	Water-Jacket manually pre-coated prior to auto dipping of core assembly	Single coat only of core assembly
Baumé	33	34
Coating Thickness	0.22 - 0.24 mm	No Change
Drying Conditions	Gas Convection – 180°C for 40 mins.	No Change

RHEOTEC XL coating performance

The internal channels were observed to be free from any veining defects, and there was also a reduction in the amount of retained particulate after the shot blasting operation (see figure 7). The total benefits to the foundry in using RHEOTEC XL coating are summarised below :-

- ❑ Improved coreshop productivity through the elimination of the double dipping operation
- ❑ Elimination of the operator applying the "pre-coat"

Figure 7: Defect free internal channels when using a single coating application of RHEOTEC XL

- ❑ Reduced cleaning room labour – from 12 to 4 operators
- ❑ Increased cylinder head output – from 30 to 60 heads per hour
- ❑ Lower overall cylinder head production costs
- ❑ Zero expenditure on increasing cleaning shop capacity

Case Study 2. Grey Iron 2.0 Litre Petrol Engine Block

This case study is based on the development work that took place between FOSECO and a high production automotive foundry located in Australia. The foundry is producing approximately 63,000 tonnes per annum of finished castings and supplies customers such as General Motors, Daewoo, Isuzu and Opel throughout Australia and Europe.

The problematic casting is shown sectioned in Figure 8, and highlights typical levels of both veining and retained particulate experienced when using the previous coating practice.

- ❑ Weight : 23 kg (2 per mold)
- ❑ Pouring temperature : 1420°C
- ❑ Castings per year : 600,000
- ❑ Core Package : PF Hot-Box Water-Jacket

The objectives of the customer were to improve the internal finish of the water-jacket area, through eliminating the formation of veining defects and reducing the amount of retained particulate.

Figure 8: Veining and retained particulate levels prior to use of RHEOTEC XL coatings

Reduced cleaning requirements would eliminate the production bottleneck within the finishing shop, allowing higher productivity and reducing overall production costs per unit.

Coating Application

A coating from the RHEOTEC XL range was compared directly with the established coating practice as outlined in the table below. Again it should be noted that the superior rheological properties of the RHEOTEC XL coating allowed for a one dip application.

	"Old" Practice	RHEOTEC XL Practice
Coating	Talc / Aluminosilicate product	RHEOTEC XL-C coating supplied RFU at 34 Baumé
Sand Additive	3% anti-veining sand additive	No Change
Coating Method	PF Hot-Box water-jacket core manually dipped, dried, assembled with slab core and re-dipped	Single coat of RHEOTEC XL-C coating to water-jacket/slab core assembly
Baumé	28 - 32	32 - 35
Coating Thickness	0.45 - 0.65 mm (wet)	Same
Drying Parameters	Gas Convection – 250°C	Same (with no pre-coat cycle)

RHEOTEC XL coating performance

The single layer of RHEOTEC XL coating produced a clean, defect free internal water-jacket area with significantly less retained particulate (figure 9).

Figure 9: RHEOTEC XL coated water-jacket core and resulting defect free internal finish

The customer benefits resulting from this performance are summarised below :

- ❑ Less retained particulate and zero veining in the water-jacket area
- ❑ Reduced casting scrap – 35% reduction in water-jacket related defects
- ❑ Overall 15 – 20% productivity increase
- ❑ Reduced labour in casting inspection and finishing

- ❑ Reduced labour in coreshop
- ❑ Finishing area bottleneck eliminated
- ❑ Lower drying oven energy costs, due to single dip operation

Conclusion

To maintain a competitive edge within the foundry market, production iron foundries need to produce increasingly complex, higher quality castings, at increased production levels and with lower overall costs. A key factor in achieving this goal is the reduction of costly cleaning and finishing operations that can also be a major process bottle-neck.

This competitive edge can be achieved by using RHEOTEC XL coating to optimise casting surface integrity in a cost effective manner, and to help ensure the consistency and quality of the components being cast.