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- SINCE 1932 -

VESUVIUS

EDITORIAL

Dear Readers,
Welcome to our 267th 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 advancements of our customer´s foundry practice. This edition highlights the latest developments in feeding and filtration technology within FOSECO. In addition, we present an overview of the development of the SEDEX iron filter family. Good methoding needs reliable simulation technology, which we demonstrate with the newest release of the FOSECO Pro Module.

ADVANCES IN THE POURING OF STEEL CASTINGS WITH A SHROUDED METAL STREAM
Turbulence during pouring and the generation of oxides are preventing high integrity steel castings to reach the highest quality performance standards and decrease fettling and repair time, and costs. FOSECO has developed the HOLLOTEX shroud together with a novel bayonet system and a filter box to minimize turbulence in the pouring process. Several case studies demonstrate the benefits and cost advantages, which have been achieved as well as much faster process times.

SEDEX - ONE PRODUCT FAMILY WITH A RANGE OF PERFORMANCE PROPERTIES TO MEET DIFFERENT REQUIREMENTS
Even after more than 30 years of successful iron filtration with SEDEX “state of the art” iron filtration, the product family has developed further. This article demonstrates the benefits of SEDEX, SEDEX SUPER FLOW and SEDEX *ULTRA*, the selection criteria for the relevant filter and the advantages, which can be achieved by use of specific application examples.

NEW FEEDEX K TECHNOLOGY - VAK
Increasingly complex casting designs as well as faster and higher - pressure moulding lines require spot feeders with a high ability to resist moulding pressure. FEEDEX VAK technology is the latest generation of patented collapsible breaker core technology with a novel breaker core design, delivering highest feed consistency and lowest fettling costs due to reduced neck contact area.

VIRTUAL EXPERIMENTATION WITH THE FOSECO PRO MODULE
The latest developments in Foseco’s sleeve and recipe technology are integrated into the FOSECO Pro Module for MAGMASOFT®; facilitating virtual experimentation and delivering faster, more reliable and optimised solutions using the new generation of autonomous engineering tools.

PRECISION FEEDING IN LARGE CASTINGS
Jobbing iron applications are increasingly challenged by constructional changes which makes safe feeding practices difficult. SCK (Sleeve Construction Kit) technology has been developed to reduce feeder volumes and aperture areas to save fettling time and costs.

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

HEINZ NELISSEN
Area Director Foundry North Europe

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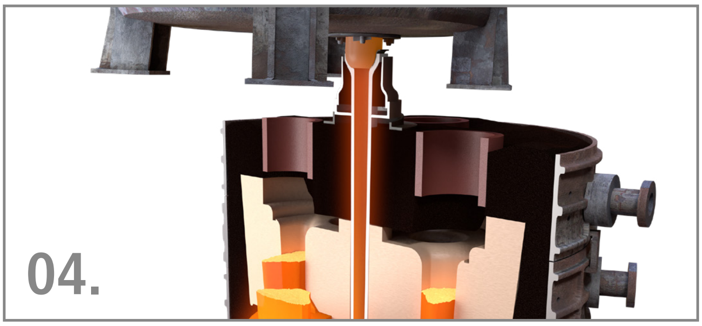
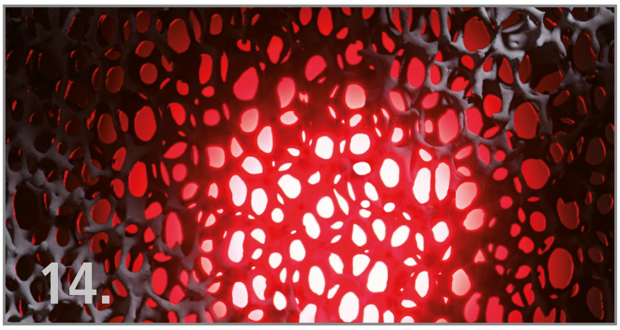
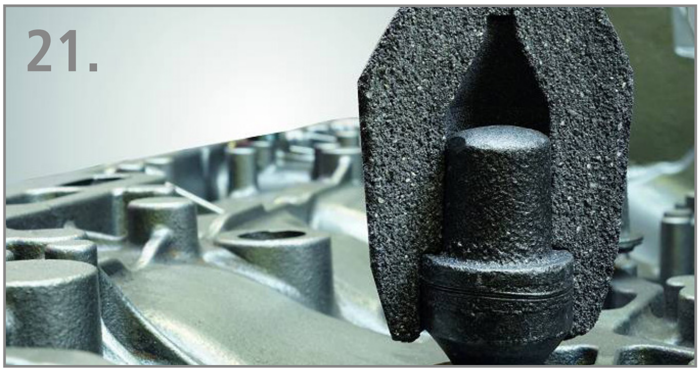
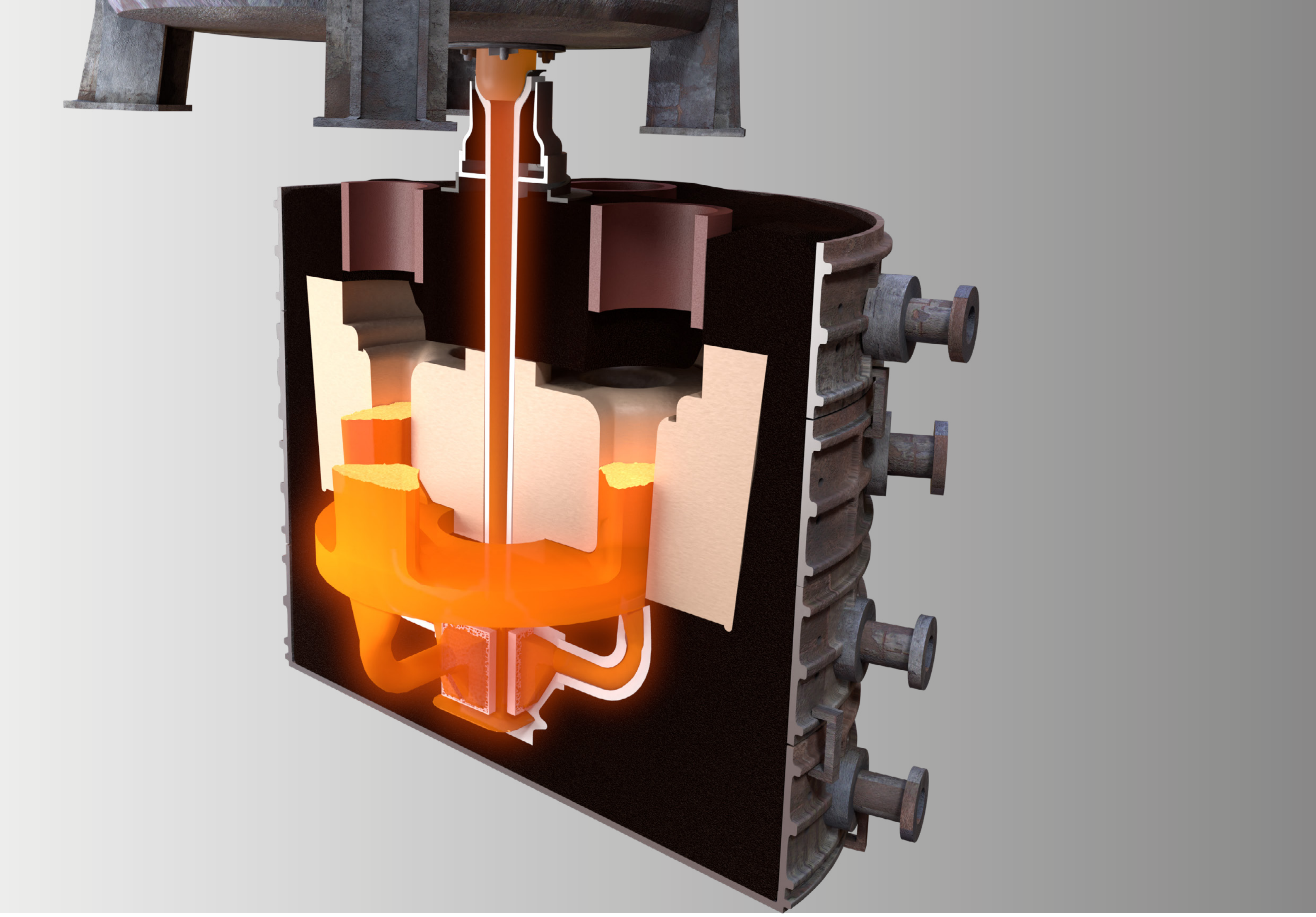








ADVANCES IN THE POURING OF STEEL CASTINGS WITH A SHROUDED METAL STREAM

Authors: David Hrabina, Foseco / Petr Filip, UNEX

Thin oxide films rapidly form on a liquid metal surface when exposed to the atmosphere. These protect the melt from further oxidation or gas enrichment. However, these surface films become brittle, tear and are then entrained in the molten metal. The melting temperatures of most oxide films are far greater than the temperature of the melt, so once formed they remain solid. These films float through buoyancy forces, as they have a lower density than molten metal, but this process is slow due to their extremely small size (just several nanometres having almost no volume). Oxide bi-films generated within conventional molten metal casting process have no time to float. They unfurl and agglomerate during the casting process. These bi-films have high surface activity and grow into bigger non-metallic agglomerations as solidification advances. Foundries increase pouring temperature hoping gas bubbles and related impurities float, but an increased pouring temperature is not beneficial to castings quality and cast surface appearance.

NEW TRENDS IN CASTINGS DESIGN OPTIMIZATION & QUALITY REQUIREMENT

Designers use advanced software to simulate stress analysis and optimise casting weight and design. Their aim is to increase strength focusing on critical zones to achieve maximum casting performance. This trend has forced casting buyers to increase the quality demand, constantly pushing conventional technological limits to meet them. The Czech foundry, UNEX, produces "high value" castings for world-known leaders, in the mining and earth moving industry. Critical casting zones have always been inspected by Magnetic Particle Inspection (MPI), X-ray and ultrasonic methods. The latest quality requirements provide new challenges including X-ray level I for complex castings in carbon steel and high strength low alloy steel weighing up to several tons. "Hairline cracks" (**Figures 1a & 1b**) revealed through MPI are limited to 2 mm length on cast surfaces, detected after heat treatment and quenching. This can require extensive and repeated defect removal and welding with several cycles until all defects are repaired; as these are repaired other defects became apparent. This process is expensive and significantly reduces production capacity. Comprehensive metallographic and Scanning Electron Microscope (SEM) investigation of MPI detected linear defects called "hairline cracks". The origin of these defects was found to be bi-film related.

A further challenge is achieving X-ray level I. Customers require level I X-ray (Level II just for non-critical zones) on 5 castings following each other in production to be accepted without internal defect repair to achieve production approval.

PRINCIPLE OF BI-FILM FORMATION

The surface tension of molten low alloy and carbon steel is approximately 20-25 times greater than the surface tension of water at room temperature and is affected by many parameters including chemical composition, temperature etc. However, the viscosity of molten low alloy and carbon steel are nearly identical to water viscosity at room temperature.

Due to this similarity, water modelling is used worldwide to simulate the flow behaviour of molten metal. The principle of air entrainment into liquid metal and bi-film formation, is affected by the molten metal surface tension and velocity. The molten metal surface is covered by an oxide film including the metal in the pouring cup. The air from the meniscus of both oxide films gets entrained into the metal and bi-films are produced as shown in **Figure 2a**. Water modelling shows this process in detail (**Figure 2b**) [1].

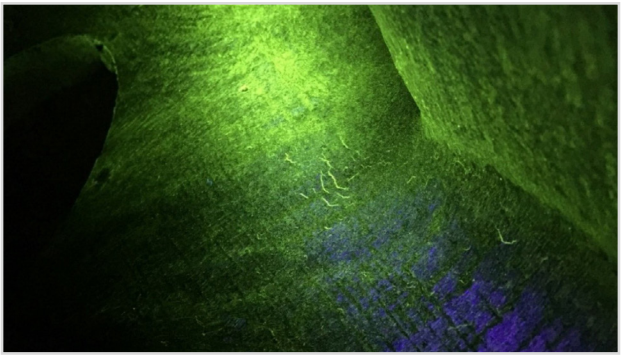


Fig. 1a: Hairline cracks on cast surface of low alloy steel

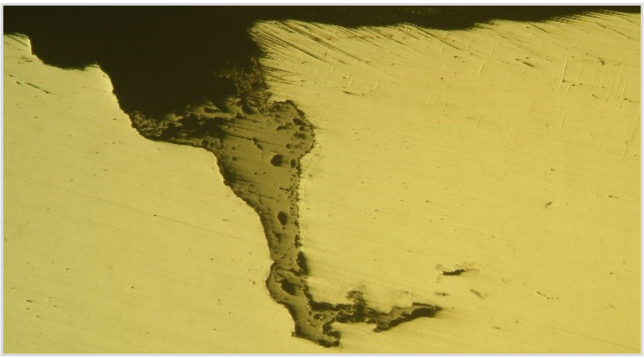


Fig. 1b: Vertical section of this hairline crack Mag.100x

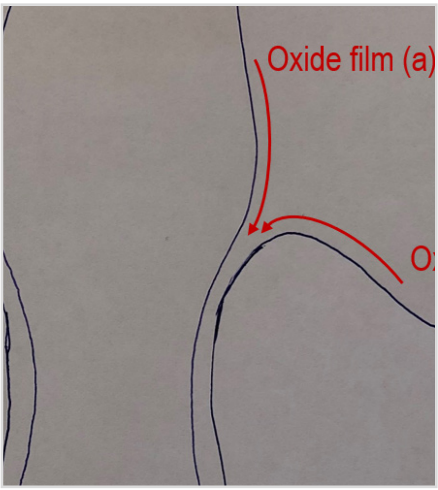


Fig. 2a: Air entrainment and bi-film formation principal

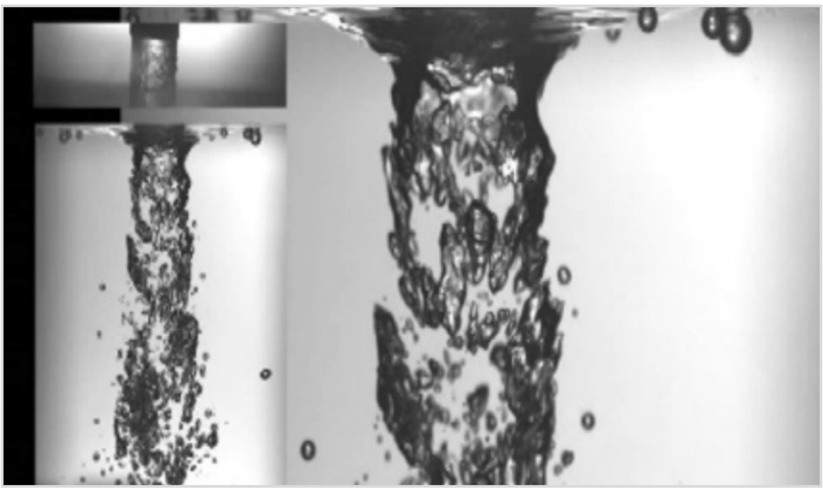


Fig. 2b: Air Entrainment Mechanism [1]

The same principle of air entrainment and bi-film formation within casting process is applicable for metal being tapped into the ladle from the melting furnace as well. **Figure 2c** shows metal tapping from an EAF and **Figure 2d** shows water modelling displaying high levels of air entrainment. Argon purging through a purge plug (PP) is installed at the ladle bottom for optimally more than 10 minutes provides some inclusions and bi-film removal. More efficient metal cleaning process at the ladle will be of advantage but this paper is focused to casting process only.

Fig. 2c: Tapping causes air entrainment and bi-films

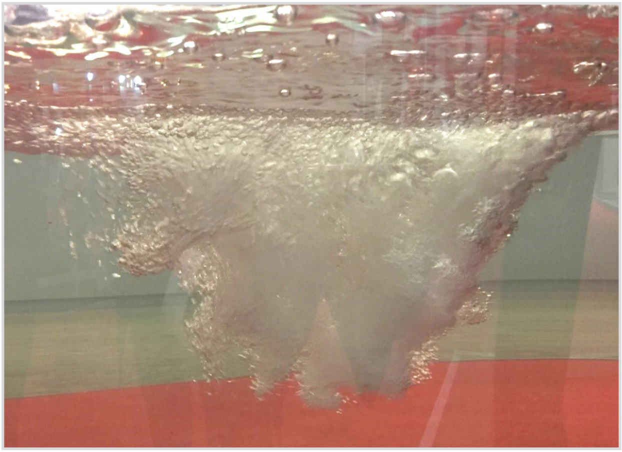


Fig. 2d: Water modelling of tapping process

AIR ENTRAINMENT AND BI-FILM EFFECT TO CASTINGS QUALITY:

Entrained air is compressible and changes its volume through temperature and pressure variations inside the casting's cavity. Floating and expanding air bubbles leave oxide bi-film trails behind contaminating molten metal as described in detail by professor John Campbell [2] (**Figure 3a**). Oxide bi-film galaxies are found at dendrite boundaries, these disconnect primary metallic grains from each other limiting the castings mechanical properties significantly. Bi-films can initiate hot tearing during solidification and act as nucleation for non-metallic inclusions formation and segregation of elements precipitated at grain boundaries such as sulfur, carbon, and others. Metallic matrix discontinuities will allow hot tearing and the formation of "hairline cracks" during heat treatment and quenching. Bi-films also contain cavities with residual atmospheric gases which inflate during the final unpressurised solidification stage, they cannot be fed properly as mushy metal approaching solidification will limit feeding distances (**Figure 3b**). Ultrasonic waves do not pass through such affected sections although they are not visually apparent when the defects are repaired.

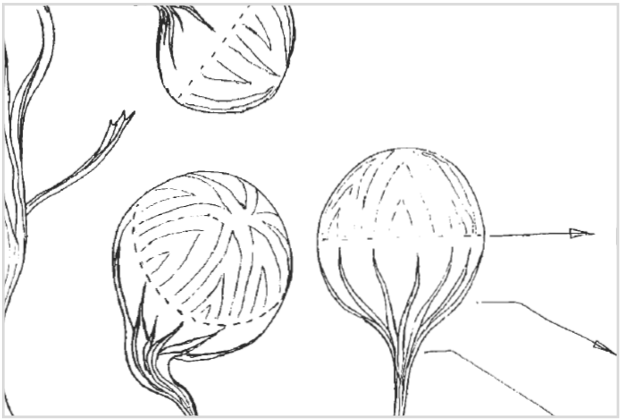
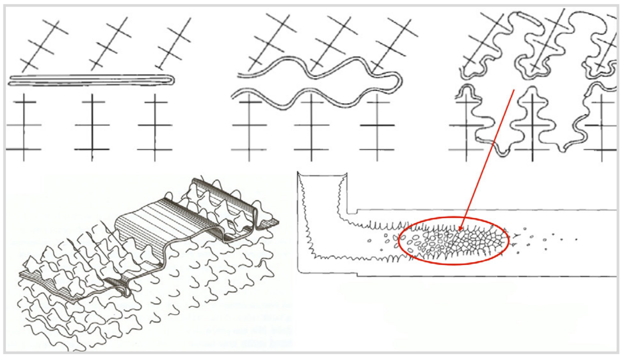


Fig. 3a: Air bubbles and bi-film trails behind



3b: Bi-film among grain boundaries and micro porosity formation [1]

SHROUD METAL STREAM PROTECTION TO IMPROVE CASTINGS QUALITY

To protect molten steel from air entrainment and bi-film formation during the casting process, the HOLLOTEX Shroud, has been developed to meet the increasing casting quality standards and faster delivery requirements. The new shrouding process is applicable at foundries meeting the latest H&S standards and differentiates itself from ladle shrouds in steel plant applications which are operated using robotic manipulators. Foundries require the ability to cast several moulds from the pouring ladle. They also demand a safe, quick, and flexible way to operate a shroud system; having the shroud fixed to the ladle is not considered to be safe and practical for foundry use. The HOLLOTEX Shroud meets these requirements, it is positioned in the mould and lifted towards the ladle nozzle using a simple, efficient and reliable mechanical bayonet lifting system.

SHROUD INSTALLATION AND OPERATION PRINCIPAL

The HOLLOTEX Shroud (**Figure 4a & b**) consists of a nozzle with a hemispherical outlet, a seamless sealing gasket and a pouring shroud inserted through an already assembled mould into the filter box, which is installed in the mould at the base of the casting. The installation process begins with the filter box and the running system assembly being moulded in the drag (**Figure 5a**). The cope is moulded to incorporate a hole for the shroud and a groove in the top of the mould to locate the metallic lifting system. The lifting system is installed into this pre-moulded groove just before the cope moulding box is ready for assembly (**Figure 5b**). The cope and drag boxes are clamped together and the shroud is inserted through the mould cavity into the filter box at the base of the casting (**Figure 6a**). A sealing gasket is applied to the hemispherical shroud's inlet just before the pouring ladle is positioned. The bayonet lifting system is operated manually by metallic handles rotating it round a vertical axis lifting the shroud inside it towards the nozzle installed in the ladle (a cam system). This lifting system is self-locking, so once twisted and sealed, the ladle operator can start pouring without physically holding it within the casting process (**Figure 6b**). The hemispherical nozzle is self-centring so even if the ladle position is not perfectly aligned over the HOLLOTEX Shroud a seal can be achieved. The Pouring shroud delivers the molten metal into the filter box without air entrainment and metal oxidation (**Figure 7a**). The filter box is designed to eliminate metal splashing at the beginning of pouring and then distributes molten metal through STELEX ZR ULTRA filters into the ceramic hollowware which forms the gating system (**Figure 7b**). The shroud is tapered to ensure it fills with metal and keeps the sprue system pressurised. During development, the Shroud was first evaluated in the FOSECO global Research and Development centre based at Enschede in the Netherlands to prove functionality of the concept and to ensure all related health and safety aspects were addressed before progressing to production trials at UNEX foundry.

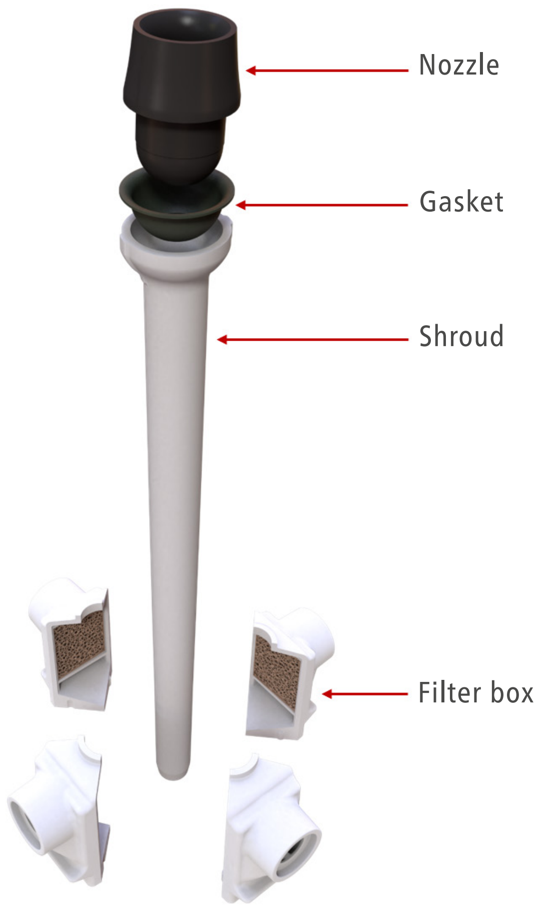


Fig. 4a: HOLLOTEX Shroud set assembly

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Fig. 5a: Filter box and running system installation in drag

Fig. 5b: Bayonet lifting system on the top of mould

Fig. 6a: HOLLOTEX Shroud insertion into assembled mould

Fig. 6b: Metal casting through HOLLOTEX Shroud

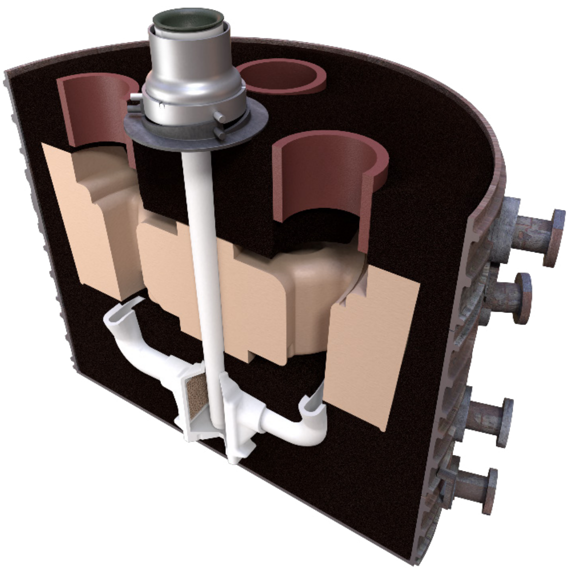

Fig. 7a: HOLLOTEX Shroud system applied in the mould

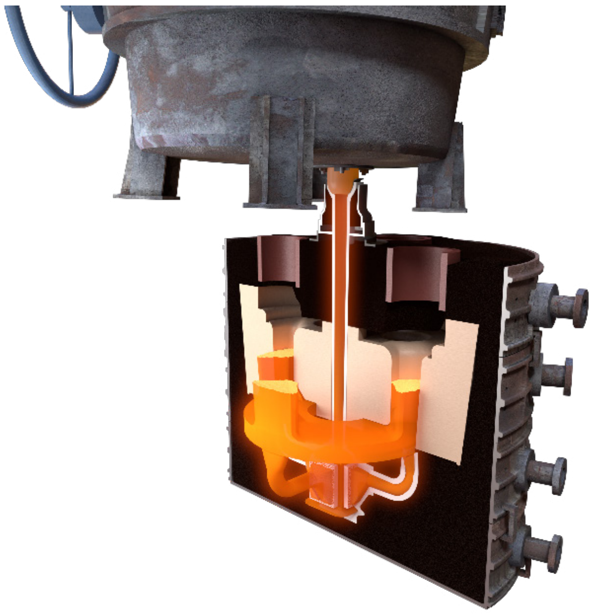

Fig. 7b: HOLLOTEX Shroud system during pouring

The HOLLOTEX Shroud system is also applicable for inclined moulds being cast uphill or simply placed on uneven foundry is safely connectible to the ladle nozzle despite not always being installed perfectly upright. It can also be used even if the ladle is not perfectly aligned above the Shroud (**Figure 8a & b**).

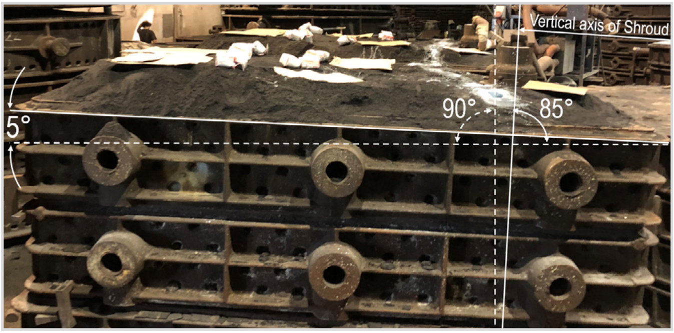

Fig. 8a: The HOLLOTEX Shroud allows to cast moulds uphill as well

Fig. 8b: Ladle in position. Ready to twist bayonet by steel bars and connect shroud to the nozzle

CASE STUDY: SMALL PLANET CARRIER

A planet carrier made from low alloy high strength steel (G 42CrMo4 QT), poured weight 750 kg, was selected for the first HOLLOTEX Shroud trial for commercial castings. The upper part of the lower flange (thickness 16 mm) suffered from linear "hairline crack" defect accumulations in an area with limited access for welding. Melting was undertaken using a medium frequency 4 t capacity induction furnace. Five castings were poured from a stopper operated bottom-pour ladle, with a capacity of 5 t. The pouring time was between 20-24 s. The nozzle and shroud outlet diameter were 80 and 35 mm respectively. This HOLLOTEX Shroud technology enables the use of a universal nozzle diameter for any casting size; the metal flow rate is determined by the shroud outlet diameter and is not dependent on the nozzle diameter (**Figure 9a & b)**. This means that small and heavy castings can be poured from the same ladle.

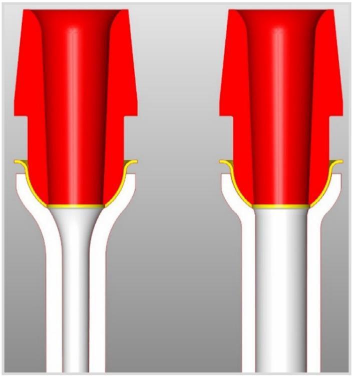

Fig. 9a: The universal nozzle for any Shroud size

Fig. 9b: Nozzle installed at the ladle ready to use

Defects found on MPI were almost eliminated when comparing the shrouded casting to the conventional method (Figure 10a &10b). The shrouded castings successfully passed the X-ray Level I and ultrasonic inspection. A specimen from a conventionally cast carrier was taken for SEM investigation at Saarbrücken University, Germany. Complex formations of secondary slag wrapped in thin oxide films were detected (**Figure 10c & d**). Some were attached to the casting surface, but others were found hidden several millimetres under the surface making them difficult to detect, even with DC-MPI. These defects are usually found following welding of previously detected defects. They are near the crystalline grain boundaries but disconnected due to entrained bi-films. This leads to repeated MPI inspection and welding cycles.

Fig. 10a: Shrouded casting

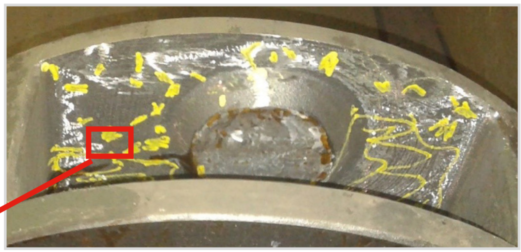

Fig. 10b: Conventionally cast

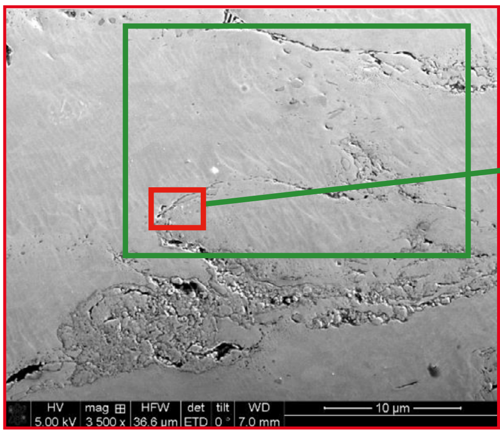

Fig. 10c: SEM of hairline crack from Saarbrücken Univ.

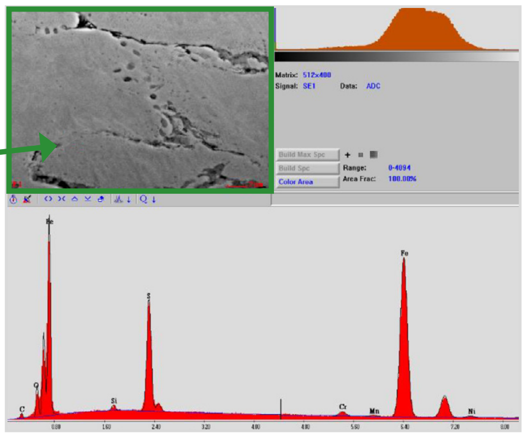

Fig. 10d: EDX analysis showed O, Fe, Ni, Si, S, Cr, Mn presence

CASE STUDY: HEAVY PLANET CARRIER

Following these encouraging results, a heavier planet carrier, poured weight 2500 kg produced in the same low alloy high strength steel, was used for further trials. These castings were much thicker having an exponentially longer solidification time which allows bi-films and inclusions to float, unfurl, and accumulate beneath the surface (5-12 mm deep). Quenching as the final heat treatment operation initialises stress and disconnects grain boundaries through bi-film residuals cause them to fail on MPI. The welded parts must be tempered which decreases the final mechanical properties. Melting was undertaken in an Electric Arc Furnace (EAF); the molten metal was transferred to an 8.5 t capacity bottom-pour ladle.

The conventional practice uses argon purging through a purge plug (PP) fitted in the base of the ladle. The metal temperature is not measured during the pouring process but is measured during argon purging. This process continues until the metal reaches the required temperature and the ladle is transferred to the pouring area, the mould pouring process starts within 5-6 minutes from argon disconnection. The temperature requirement at argon disconnection for conventional cast planet carriers, through ceramic foam filters, was 1575-1580 °C.

The first shrouded castings (70 mm diameter shroud outlet) were poured at this same temperature. The pouring time was in the range of 20-24 s, this is significantly faster than conventional production (40-60 s cast from a nozzle diameter 90 mm). The most probable reason for this slow conventional pouring is ladle operators throttling the stopper during pouring to avoid metal overflow and metal splashing injuries. The first shroud test of these heavier planet carriers demonstrated a Health and Safety improvement and consistency in pouring time due to the stopper being fully opened during the casting process. Unexpectedly MPI did not show significant reduction of hairline cracks formation (**Figure 11a**). Rapid pouring speed causing turbulent mould filling was suspected to be the cause.

To eliminate metal re-oxidation associated with turbulent pouring, the mould cavity was filled with argon just before the next shroud test. The results, however, were not improved despite the oxygen level within the mould being reduced from 20.9 % to 0.3 % according to the Greisinger GOX 100 oxygen detector measured just before the stopper opening. Argon disappeared from the mould quickly once pouring commenced. The detector showed an oxygen level of 15.8 % within the first 2 s of pouring. This test was repeated with the same results on more moulds which did not provide measurable MPI defects reduction.

To eliminate the mould filling turbulence, the shroud was redesigned to give an outlet diameter of 45 mm. The aim was to reduce the metal flow rate and keep the whole system pressurised during the whole casting process and provide laminar flow especially at the beginning of mould filling. The metal temperature at the end of the argon purging in the ladle was reduced to 1550 °C, the subsequent pouring time was in the range of 40-45 s. There were no problems with foam filters priming in the filter box, and after shake-out the castings still had thin metal flash at the parting line indicating further pouring temperature reduction would be possible. MPI found linear defects in critical zones being mostly in the accepted length of 2 mm (**Figure 11b)** and X-ray and ultrasonic inspection found those castings acceptable according to Level I. The shroud trial was extended to a bigger serial production to confirm results, metal temperature after argon purging was further reduced to 1530 °C. A minimal pouring temperature was targeted to reduce hot tearing defects caused by linear contraction within the solidification process. Such a low pouring temperature is not applicable to a conventional pouring process due to cold shut and misrun parts but using the HOLLOTEX Shroud this is possible. There were no metal freezing issues within the casting process when the nozzle was connected to the HOLLOTEX Shroud, however, pouring of the separate test blocks was problematic due to metal freezing at the nozzle outlet. Subsequently test blocks have been integrated with the castings so they are poured through the shroud at the same time. Based on these results, the shroud was implemented into regular serial production of those castings and more than 100 pieces have already been cast successfully providing very constant in terms of MPI, and X-ray results. The HOLLOTEX Shroud has now been implemented into production of even heavier planet carriers (3500 kg poured weight) successfully.

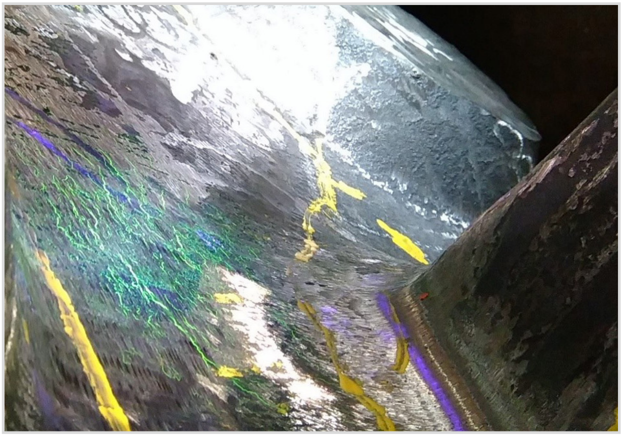

Fig. 11a: Hairline cracks from turbulent mould filling

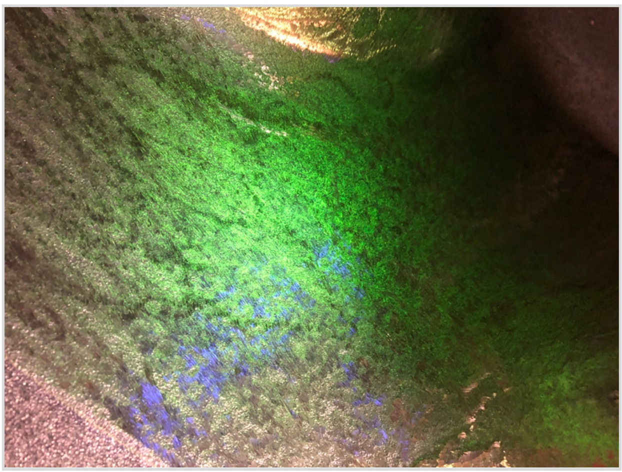

Fig. 11b: The same surface with choked conical shroud

CASE STUDY: MINING TRUCK WHEEL HUB

The Material used was GS-22 NiMoCr 56. Poured weight is 1200 kg. Melting undertaken in an EAF. Argon purging through PP was performed in the ladle for 5-6 minutes. A shroud outlet diameter of 35 mm was used. At a pouring temperature 1560-1570 °C a pouring time of 35-40 s was achieved. Six castings were poured from one ladle proving shroud technology can be used on a series of castings (**Figure 12a & b**). The castings passed ultrasonic inspection successfully with almost no MPI detected defects and passed through production process with no delay and additional rework expenses (**Figure 12c & d**).

Fig. 12a: Wheel hub with HOLLOTEX Shroud

Fig. 12b: Upper casting surface after shot blasting

Fig. 12c: MPI after quenching

Fig. 12d: Upper surface after ultrasonic and MPI inspection

CASE STUDY: HEAVY MINING TRUCK WHEEL HUB

The material used was GS-22 NiMoCr 56, poured weight 3000 kg. Conventionally produced castings suffered from large defects revealed by MPI on the upper and internal surface under the core. These defects required extensive welding and repeated inspection, the most critical were small defects revealed during

final machining which led to external castings reject (**Figure 13a & b**). A HOLLOTEX Shroud with outer diameter of 45 mm was implemented on 5 castings (**Figure 13c**). Melting was carried out in an EAF and subsequent argon purging through PP in the ladle for 10 minutes. The pouring temperature was 1550-1560 °C and pouring time was in the range of 45-50 s. Sand inclusions, bubbles and MPI indications were almost eliminated (**Figure 13d**).

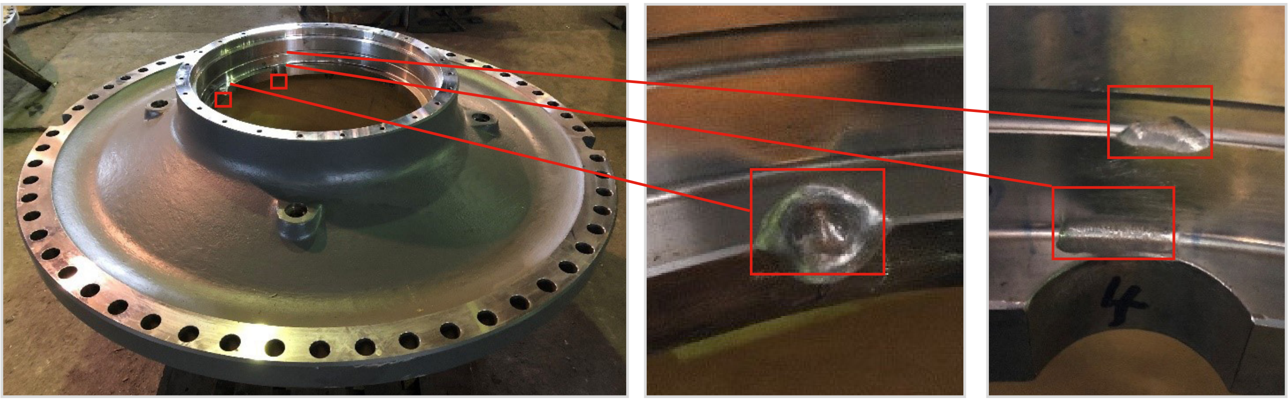

Fig. 13a: Defects after final machining

Fig. 13b: Defect removal and welding

Fig. 13c: Casting with HOLLOTEX Shroud

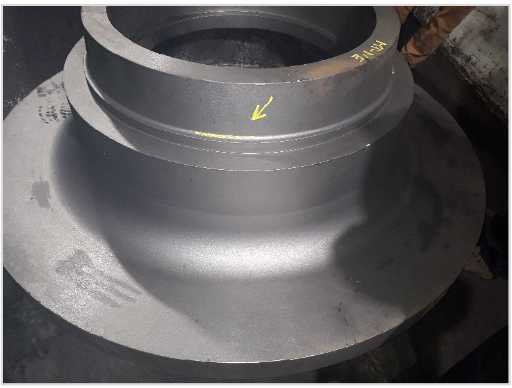

Fig.13d: Casting after MPI inspection

CASE STUDY: EXCAVATOR ARM BOOM

The material used was modified GS-24 Mn 6, poured weight 5000 kg. These complex shape castings have a large surface area and a combination of thin and thick sections being sensitive to sand inclusion galaxies, slag presence and deep gas bubbles on the upper part (**Figure 14a & b)**. There was extensive testing of various methoding solutions to reduce rework, but no satisfactory progress was achieved on these castings. A Shroud with an outlet of 45 mm was implemented in the casting of several arm booms.

Melting was carried out in an EAF and argon purging through PP in the ladle for 5-6 minutes. The pouring temperature was about 1550 °C and the pouring time between 72-90 s. The running system was connected to the bottom of the casting by thin oval ingates to reduce hot spots (**Figure 15a & b**). Sand and slag defects were not detected on the surface and castings were free from gas bubbles (**Figure 16a & b**). Significant fettling reduction was achieved which lead to increased production capacity as welding was one of the main limiting factors for the output of these castings.

Fig. 14a: Typical gas hole defects on top surface

Fig. 14b: Sand inclusions galaxies on upper part

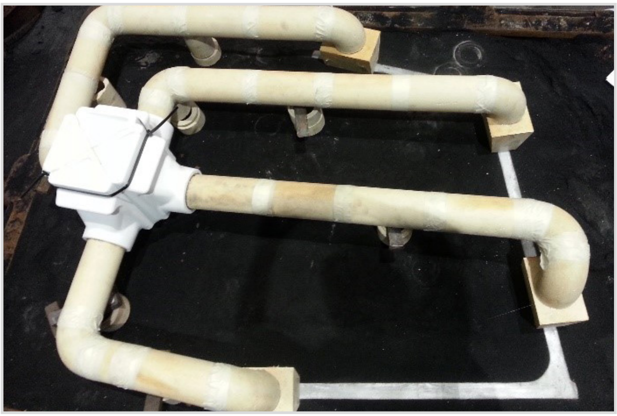

Fig. 15a: Gating system with HOLLOTEX Shroud filter box installed

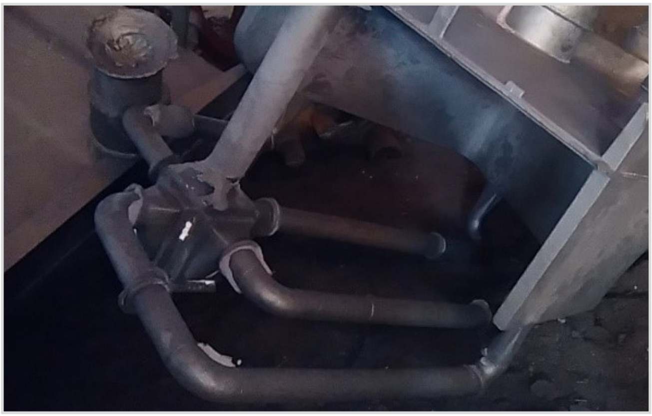

Fig. 15b: Casting with HOLLOTEX Shroud - shot blasted

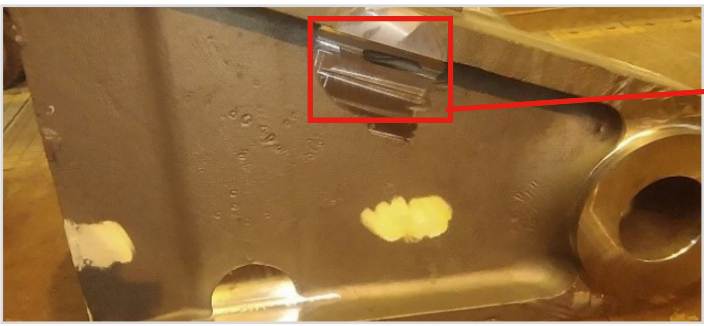

Fig. 16a: Upper surface with HOLLOTEX Shroud

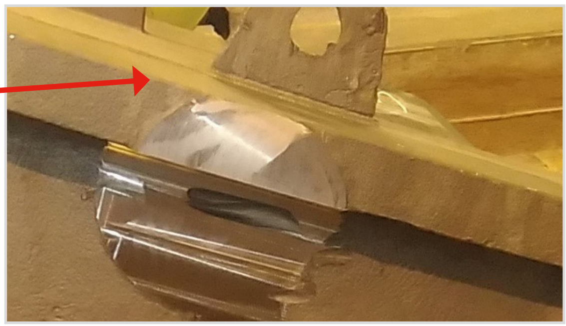

Fig. 16b: No sand inclusions or gas bubbles present

SUMMARY

The HOLLOTEX Shroud is an innovative technology for metal stream protection enabling foundries to meet and exceed latest casting quality expectations and significantly increase the mechanical properties. Defect free castings flow through the fettling process much faster and final delivery dates are predictable. This can give the foundry a competitive advantage being recognised as a reliable supplier, or preferably partner, winning more contracts.

Major benefits of the HOLLOTEX Shroud include:

- No air entrainment
- Reduced unacceptable X-ray and MPI defects
- Reduced repair requirements
- Process repeatability (consistent casting quality)
- Faster delivery of castings
- Pouring temperature reduction
- Improvement in mechanical properties
- Health and safety through reduced exposure to molten metal during the casting process
- Environmental improvements

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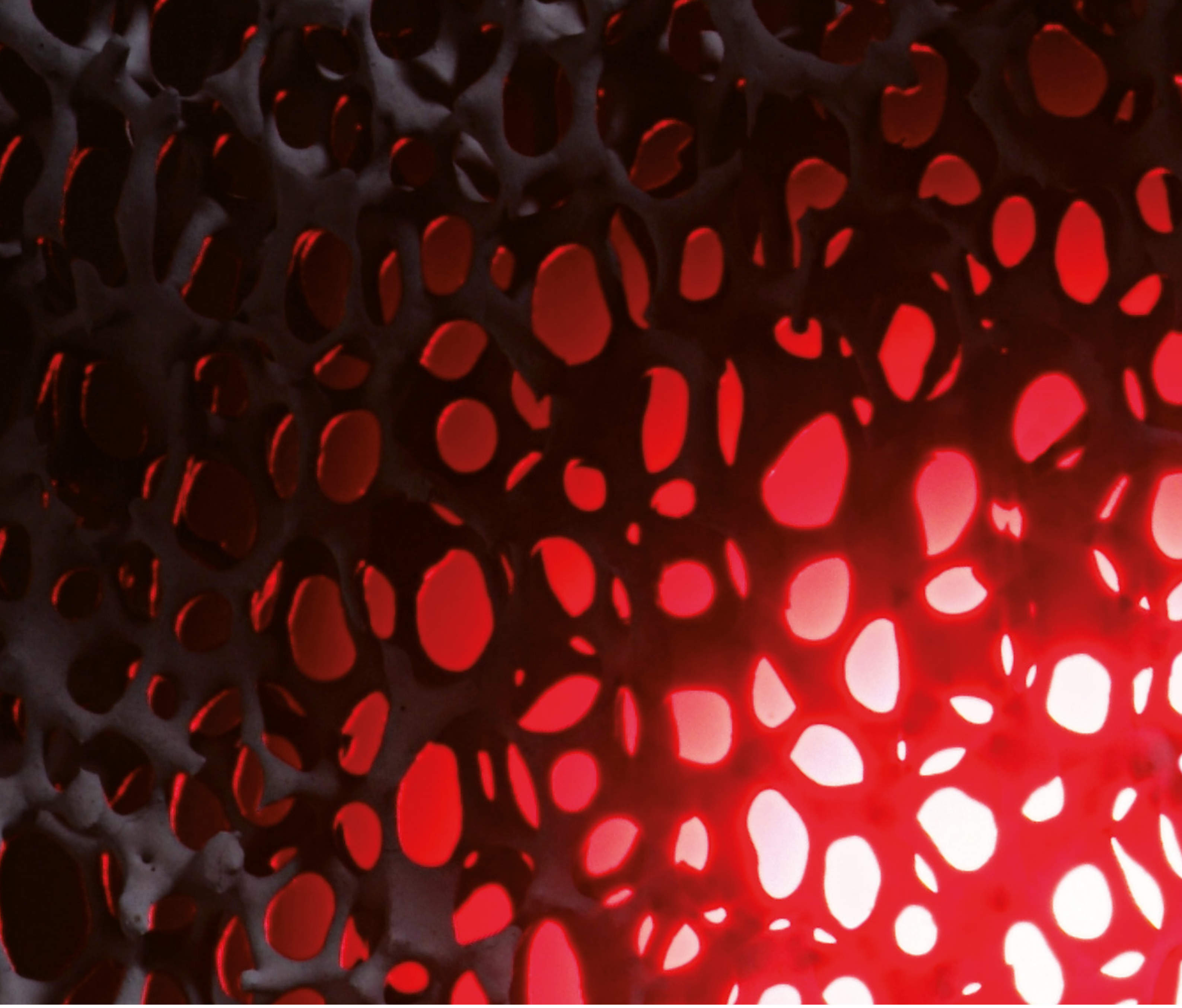
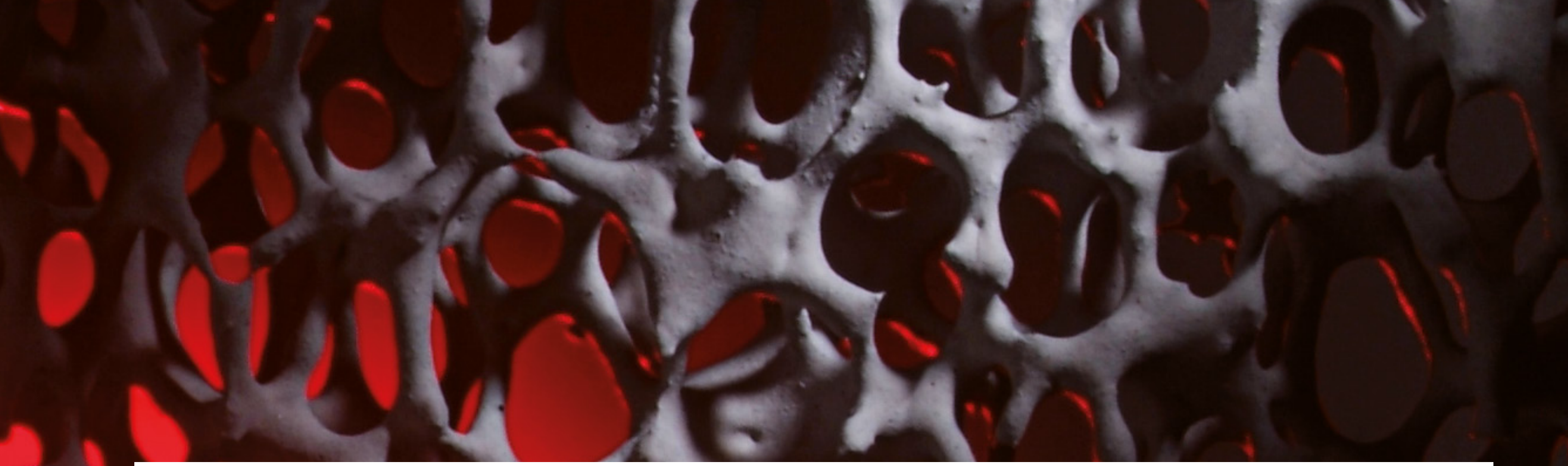


SEDEX - ONE PRODUCT FAMILY: VARIOUS PRODUCT CHARACTERISTICS FOR DIFFERENT REQUIREMENTS

Authors: Stephan Giebing and Andreas Baier

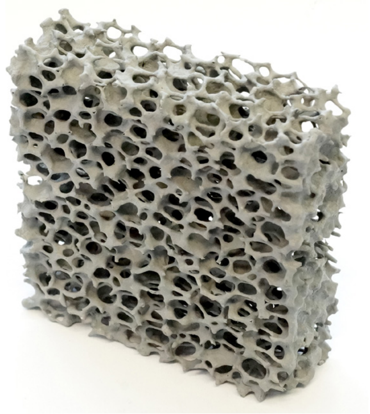
In the industrial production of cast iron products, the use of SEDEX filters has established itself as the recognised "state-of-the-art" standard over the last few decades. The removal of non-metallic inclusions, and turbulence reduction achieved by SEDEX filters, are of great importance for economical casting production.

As part of the continuous improvement of SEDEX filters, various product features have been examined in detail. This resulted in the introduction of two new ceramic foam filters: SEDEX SUPER FLOW and SEDEX *ULTRA*, whose properties and potentials are discussed here in comparison to the well-established SEDEX filter.



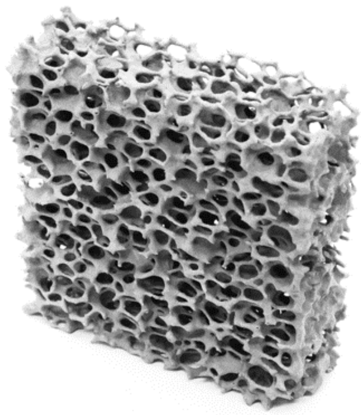
SEDEX FILTER

SEDEX filters have been used by the foundry industry for more than 25 years. During this time, the filter and its application have been continuously improved in co-operation with leading foundries around the world. The use of SEDEX foundry filters is a guaranteed way to produce quality, cost effective castings.



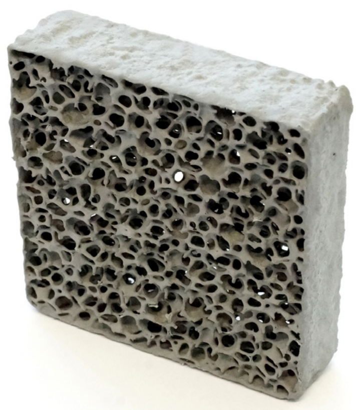
SEDEX SUPER FLOW FILTER

A new generation of SEDEX filter with a consistent open pore ceramic foam structure to remove slag / dross and other non-metallic inclusions from molten iron. Super SEDEX has improved foam structure which results in higher metal flow rates that allows use of higher porosity filters thus resulting in better filtration efficiency.



SEDEX *ULTRA* FILTER

SEDEX *ULTRA* filters represent the state of the art amongst filters for iron casting. There is a frame around the filter which significantly impro-ves the handling and performance characteristics of the filter.



SOME BACKGROUND ON GATING AND FLUID DYNAMICS

The removal of non-metallic inclusions and molten metal turbulence reduction represent the two main features of ceramic foam filters within a gating system. However, these two features represent only a part of the success story of SEDEX filters. An additional, often underestimated, aspect is related to the concept of gating system design developed by Foseco. In contrast to conventional systems, these are downsprue controlled gating systems which reduce the metal velocity and thus minimise turbulence during mould filling. The control of the mould filling in terms of metal velocity and pouring time is performed by the flow determining cross-section usually placed in the downsprue. Based on well-established principles, the size of the filter must be selected so that the filter never becomes the controlling factor during the mould filling process which would then affect pouring time and flow rate.

There are some considerations in terms of pressure drop caused by different gating system components, including filters, and how they affect flow rate. These analysis are also used to characterise filters but clogging of the filters by the segregation of non-metallic inclusions is not taken into account.

Fig. 1 shows some of the components commonly used in the design of gating systems including tube, extension or reducer, elbow and L-piece. The respective effect on fluid dynamics can be calculated in terms of pressure drop caused by them.

Any change in flow results in a pressure drop; the pressure drop is caused by friction of the respective component and depends on its geometry, but also on the density and velocity of the flowing medium. The pressure drop leads to a reduction of the flow rate.

This also applies to wire screens. **Fig. 2** shows the pressure drop caused by wire screens as a function of wire diameter and mesh size [1]. At constant mesh size, the pressure drop increases with increasing wire diameter, the pressure drop increases with constant wire thickness and decreasing mesh size.

Considering ceramic foam filters, the characteristics wire diameter and mesh size of wire screens can be qualitatively transferred. The mesh size corresponds to the porosity and wire diameter to the strand thickness. This explains why at constant strand thickness, and increasing porosity, the pressure drop increases and the flow rate decreases. On the other hand, at the same porosity, a reduction in the strand thickness results in a decrease in the pressure drop, which results in an increase in the flow rate.

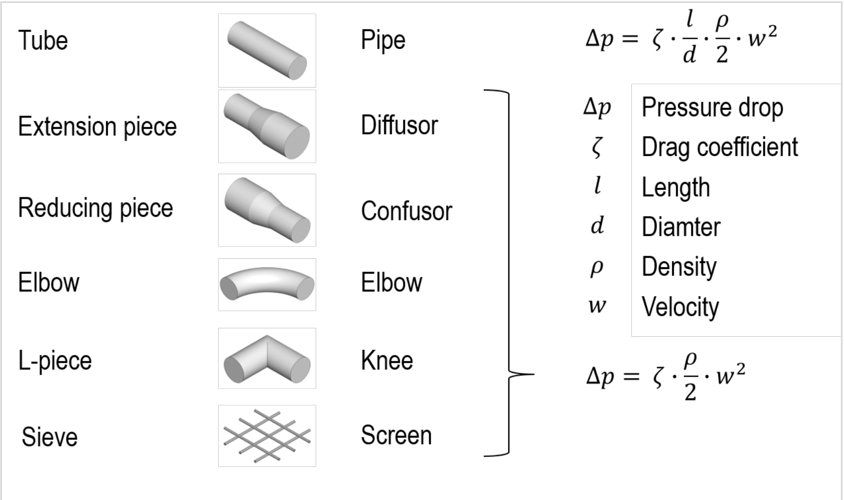


Figure 1: Pressure drop due to various gating system and fluid dynamic components

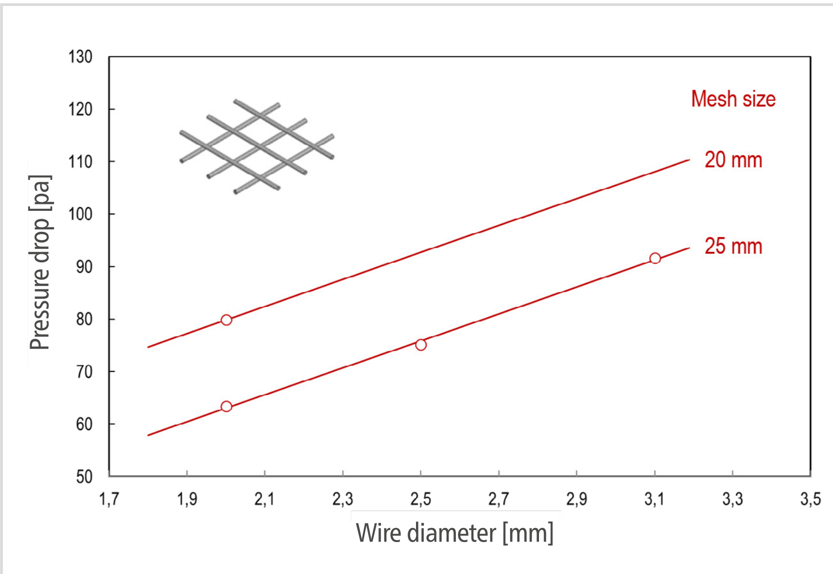


Figure 2: Pressure drop caused by wire screens as a function of wire diameter and mesh size [1]

IMPLICATIONS ON USE IN FOUNDRY PRACTICE

How does this affect SEDEX SUPER FLOW and SEDEX *ULTRA*, compared to the standard SEDEX? Both products represent weight-optimised developments of the SEDEX filter. Due to the lower filter weight, a lower strand thickness is achieved, which results in a reduction of the pressure drop and an increase of the flow rate at constant porosity.

With SEDEX *ULTRA*, however, the situation is somewhat more complex. In addition to the weight reduction, the frame formation leads to a redistribution of the ceramic within the filter structure. As a result, the SEDEX *ULTRA* shows an even smaller strand thickness compared to the SEDEX SUPER FLOW providing a further reduction in the pressure drop and increase in the flow rate. The mechanical integrity of the filter structure is maintained by the frame.

The influence of weight reduction and frame formation on strand thickness, pressure drop, and flow capacity is shown schematically in **Fig. 3. Fig. 4** compares the water flow characteristics of the various products in different porosity ranges.

Figure 4 shows the flow rate decreasing with increasing porosity for standard SEDEX. In addition, the finer porosities 20 and 30 ppi, can be used to illustrate how the reduction of the strand thickness of the further developed SEDEX filters affects the flow rate. At the same porosity, the SEDEX SUPER FLOW shows on average a flow rate approx. 8 % higher than standard SEDEX.

With SEDEX *ULTRA*, this is even more pronounced. Compared to standard SEDEX, the SEDEX *ULTRA* provides on average a 15 % higher flow rate at the same porosity.

If the flow rates of the porosity 10, 20 and 30 ppi shown in **Fig 4** are compared across the board, it can be seen that 20 ppi SEDEX SUPER FLOW and SEDEX *ULTRA* filters show values at the same or higher level than 10 ppi SEDEX filters.

The same situation is established when comparing 30 ppi SEDEX SUPER FLOW and SEDEX *ULTRA* with 20 ppi SEDEX. Due to the formation of the frame and the associated lower strand thickness, SEDEX *ULTRA* filters show higher flow rates than SEDEX SUPER FLOW filters at equivalent porosity.

These flow characteristics enable the use of finer filters in foundry practice resulting in an improved filtration efficiency and thus a reduction of reject rate. In the case of SEDEX SUPER FLOW, the aim is to apply a finer filter of the same size and flow capacity compared to SEDEX filters.

The special flow characteristics of the SEDEX *ULTRA* also enable the use of smaller filters, which reduce the level of rejects and thus the cost of casting production. In addition, the SEDEX *ULTRA* filter has particularly favourable properties for the automated insertion of filters into the mould due to its closed frame.

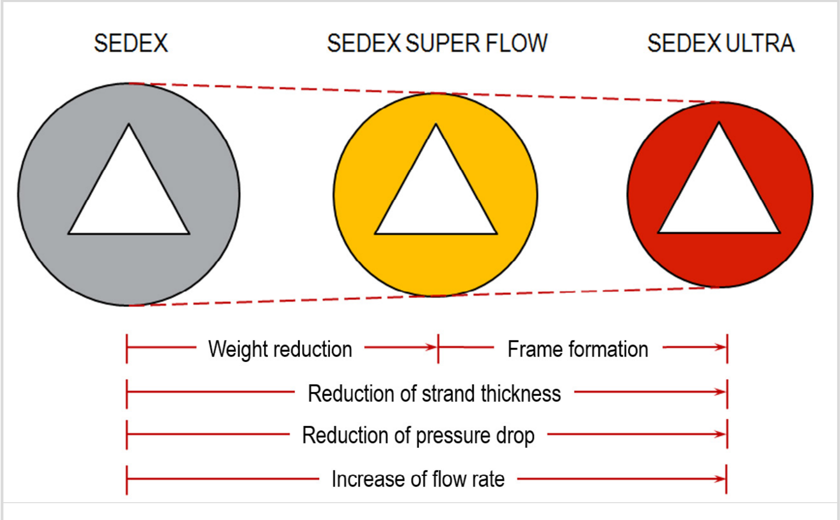


Figure 3: Reduction of the strand thickness of ceramic foam filters by weight reduction and frame formation, and their influence on pressure drop and flow rate (schematically)

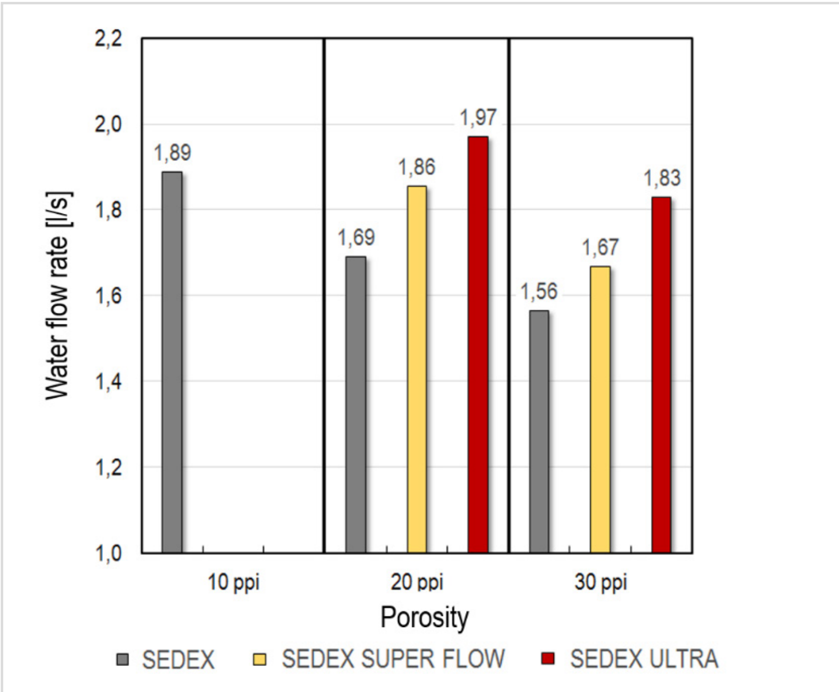


Figure 4: Water flow rate of the different SEDEX products at 10, 20 and 30 ppi (50x50x22 mm)

The advantages of the further developed SEDEX SUPER FLOW and SEDEX *ULTRA* filters can be summarised as follows:

SEDEX SUPER FLOW Filters:

- More open filter structure due to reduced strand thickness
- The ability to use finer filters of the same size
- Reduction of the reject rate through improved filtration efficiency

SEDEX *ULTRA* filters:

- Particularly open filter structure due to reduced strand thickness
- The ability to use smaller and finer filters
- Reduction of casting reject rate due to improved filtration efficiency
- Reduction of returns due to the use of smaller filters
- Increased productivity due to improved handling

Within the scope of this article, the flow characteristics of the various products and their possible applications are discussed. An essential requirement for such development work is to ensure other important product characteristics such as dimensional accuracy, cold compressive strength and the thermal shock resistance (as determined by the Impingement test) are not negatively affected. The basics of quality assurance for SEDEX filters have already been reported in the past [2]. In addition, the requirements for ceramic foam filters are defined by the BDG directive P100 [3].

APPLICATION EXAMPLES

SEDEX SUPER FLOW - REDUCTION OF REJECT RATE THROUGH THE USE OF FINER FILTERS

The use of finer SEDEX SUPER FLOW filters, and the resulting improved filtration efficiency, can be demonstrated in an example of steering knuckles made from ductile iron **(Fig. 5)**.

Originally, these components with a poured weight of 43.0 kg were manufactured using two SEDEX 50x50x22/10 ppi (specific through flow 0.86 kg/cm^2) at a pouring time of 8 s. On this application, the magnesium treatment process used is of particular importance. The treatment is carried out by the in-mould process, which can be problematic due to possible filter blockages. In this application a maximum specific flow capacity of 1.0 kg/cm^2 is recommended for SEDEX filters. Under these circumstances, 10 ppi SEDEX filters with a thickness of 15 or 22 mm are commonly used.

Despite these critical application conditions, when switching to SEDEX SUPER FLOW 50x50x15/20 ppi, the pouring time of 8 s was maintained, and the castings were manufactured reliably. The reject rate was reduced by approx. 40 % of the original level. As a result of these very positive experiences, the entire casting programme of the foundry was converted to the use of SEDEX SUPER FLOW filters.

SEDEX *ULTRA* - REDUCTION OF RETURNS BY USING SMALLER FILTERS

Practical experience has shown, due to the special flow characteristics of SEDEX *ULTRA* filters, a higher filter capacity can be achieved. Depending on the application, this allows a reduction in filter area by up to 20 %. At the same time finer porosity filters can be used compared to the original application of SEDEX filters (for example 20 ppi filters instead of 10 ppi).

The example of a flywheel made from ductile iron, shown in **Figs. 6 to 8**, demonstrates how the use of SEDEX *ULTRA* filters can improve yield by reducing filter area. **Fig. 6** shows the initial situation with a conventional gating system without a filter. The pouring time for this casting layout was 15.5 s with a poured weight of 25.0 kg.

Initially, a SEDEX 50x50x15/20 ppi filter was used, since SEDEX *ULTRA* filters were not yet available at that time **(Fig. 7)**. Due to the introduction of SEDEX the scrap rate reduced significantly. Furthermore, the poured weight was decreased to 23.7 kg (0.95 kg/cm^2) and the pouring time was reduced to 10.5 s increasing productivity significantly. The savings achieved in terms of rejects, pouring time and the resulting massive increase in productivity are only few examples demonstrating the benefits of ceramic foam filters and the success story of SEDEX filters.

A few years later, SEDEX *ULTRA* 40x40x15/20 ppi (**Fig. 8**) was introduced, this equates to a reduction of filter area by 36 %. Apart from the modification to the filter print for the new filter size, the gating system was unchanged. This measure resulted in a further reduction in poured weight by 0.2 kg (1.47 kg/cm^2) at the same pouring time. Based on an annual production of 50,000 flywheels, the reduction of the poured weight by 0.2 kg resulted in a return reduction of 10,000 kg.

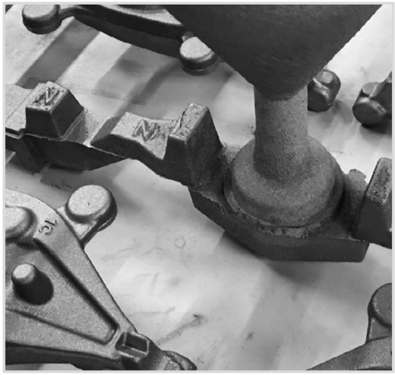


Figure 5: Steering knuckles made from ductile iron

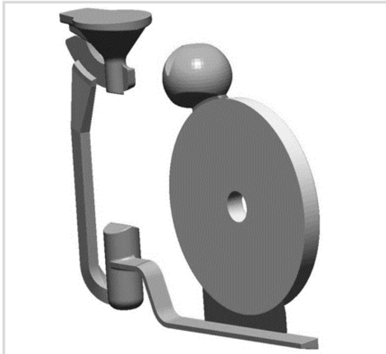


Figure 6: Flywheel made from ductile iron - Initial situation without filter

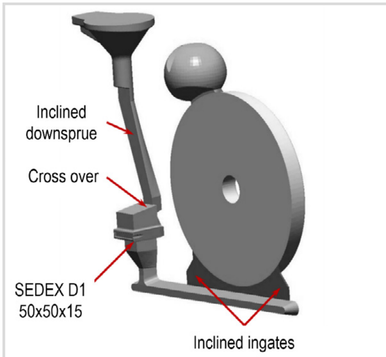


Figure 7: Flywheel made from ductile iron - Layout with filter using SEDEX 50x50x15/20 ppi

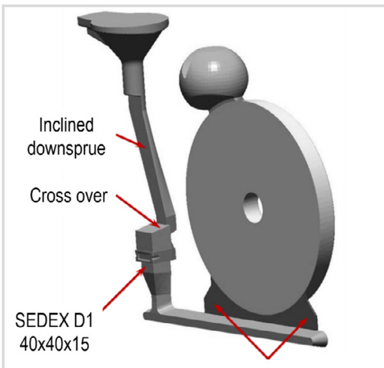


Figure 8: Flywheel made from ductile iron - Layout with filter using SEDEX *ULTRA* 40x40x15/20 ppi

Depending on the size of the filter used and the filter print, the potential savings that can be achieved by using SEDEX *ULTRA* filters can vary. **Table 1** shows the possible savings in terms of weight and cost for different filter sizes based on the widely-used filter print SEDEX FP4.

The situation shown in **Table 1** is visualised in **Fig. 9.** The original SEDEX 60x60x22/10 ppi is replaced by a SEDEX *ULTRA* 55x55x15/20 ppi. In this case, the filter area is reduced by 16 %. The corresponding filter print shows a by 0.5 kg lower weight, which corresponds to a cost reduction of approx. 0.13 € (melting and treatment costs 0.25 €/kg). Assuming an annual consumption of 200,000 filters, this equates to a savings for the foundry of 100,000 kg returns worth 25,000 €.

SEDEX		SEDEX *ULTRA*		Reduction	
FP4	Weight [kg]	FP4	Weight [kg]	Weight [kg]	Costs [€]
50x50x22	1.53	45x45x15	1.15	0.37	0.09
50x75x22	2.38	55x55x15	1.52	0.86	0.22
60x60x22	2.02	55x55x15	1.52	0.50	0.13
50x100x22	3.2	67x67x15	2.55	0.66	0.17
100x50x22	2.89	67x67x15	2.55	0.35	0.09
75x75x22	3.46	67x67x15	2.55	0.91	0.23

Table 1: Weight and cost savings on ductile iron by using smaller SEDEX *ULTRA* filters based on the filter print SEDEX FP4 (melting and treatment costs 0.25 €/kg)

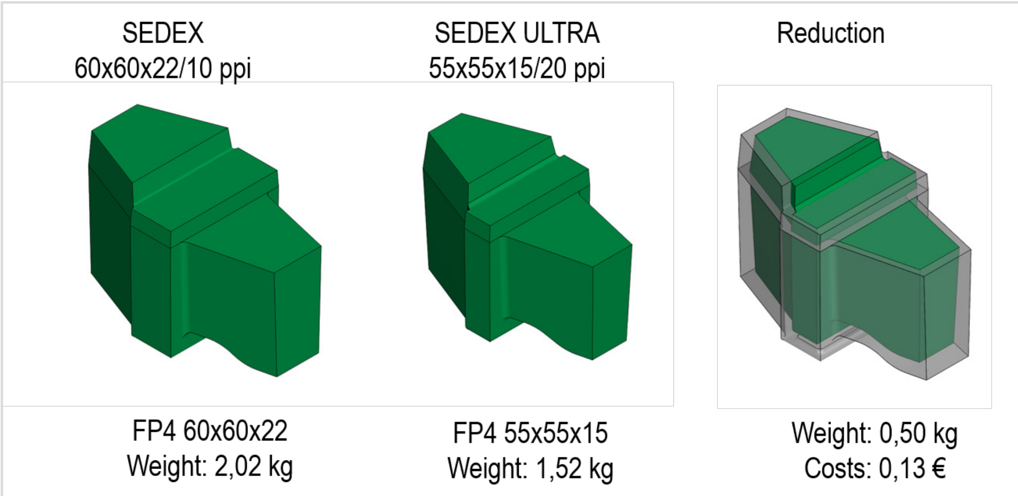


Figure 9: Saving of returns and costs by using smaller and finer SEDEX *ULTRA* filters

SEDEX *ULTRA* - IMPROVED HANDLING CHARACTERISTICS

The following example of a carrier made from ductile iron at a poured weight of 11.4 kg illustrates the favourable handling characteristics of the SEDEX *ULTRA* filter due to the four-sided closed frame.

Originally, the carrier shown in **Fig. 10** was manufactured using a SEDEX 40x40x15/10 ppi with a pouring time of 5 s (0.71 kg/cm^2). By changing to SEDEX *ULTRA* 40x40x15/10 ppi, the insertion of the filter in the mould by the core setter was more reliable. As a result, the number of moulds produced was increased from 300 to 330 pieces/h improving productivity by 10 %.

In addition, this carrier also demonstrated a reduction of the reject rate by the use of finer SEDEX *ULTRA* filters. During the project, the filter was converted to the finer SEDEX *ULTRA* 40x40x15/20 ppi. Despite the finer porosity of 20 ppi, the desired pouring time of 5 s was maintained. The use of the finer 20 ppi SEDEX *ULTRA* filter resulted in a 50 % reduction of the reject rate.

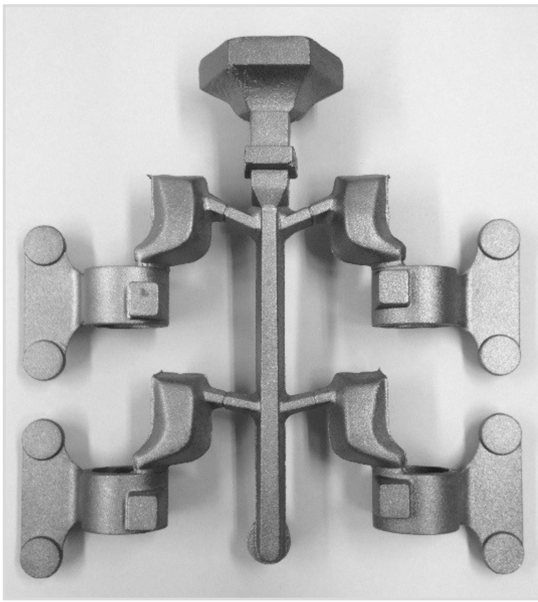


Figure 10: Carrier made from ductile iron - Improved handling by use of finer SEDEX *ULTRA* filters

SUMMARY

The use of SEDEX filters, which has been well established for many years, has made a significant contribution to the economical and reliable production of cast iron products. The further developments presented reveal further possibilities with regards to filtration efficiency and return reductions. The physical background has been discussed with the help of fluid dynamics and flow rate data. SEDEX SUPER FLOW filters allow the use of finer filters of the same size. In addition to improved handling properties, SEDEX *ULTRA* filters allow the use of smaller and finer filters.

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NEW FEEDEX K TECHNOLOGY - VAK

Author: Christof Volks

The requirement for cast parts with thinner wall sections and a more complex design is a continuous trend in the foundry market. This leads to castings with more isolated sections and as a result the requirement for spot feeding.

This article describes the incremental development and optimisation of the ram-up sleeve application technology using a patented collapsible metal breaker core design. The latest development is the result of a consequent implementation of experiences made in the area of spot feeding on high pressure moulding lines.

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INTRODUCTION

In the last 40 years the development of spot feeding concepts was driven by the individual technical requirements of foundries. Changes in the production process of foundries resulting for example in higher moulding pressures had to be covered with adapted spot feeder sleeve designs.

Process cost pressure and increasingly complex casting designs demanded by the end customers influenced the market for reduced feeder contact and footprint areas. As a result, solutions which gave the lowest fettling and cleaning costs, in combination with optimised yield were developed.

Figure 1: Product range of spot feeders with collapsible breaker core

DEVELOPMENT OF COLLAPSIBLE BREAKER CORES

In 2004 a new generation of spot feeders was launched, which addressed the foundry demands (Fig. 1).

The concept of a collapsible metal breaker core provides two key advantages:

- The moulding pressure is partly absorbed by the collapse of the metal breaker core and compaction of the moulding sand beneath it, enabling this concept to withstand higher moulding pressures than other conventional solutions.
- The feeder neck height is reduced during moulding, this helps to ensure that the feeder neck remains open until after the casting solidifies (Fig. 2 – Right).

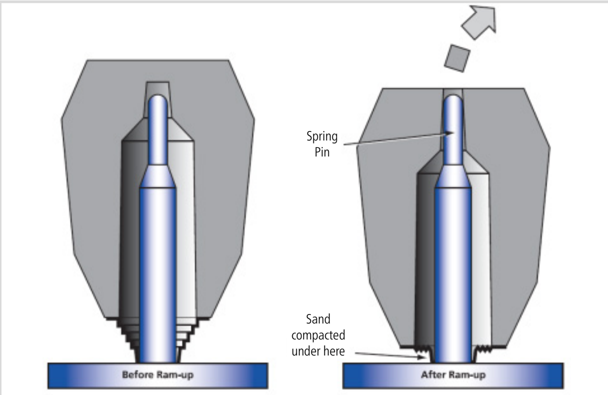

Figure 2: Sleeve and metal breaker core before and after compaction

Figure 3: Application of FEEDEX VAK utilising the benefit of the smallest footprint area

IN THE LAST 15 YEARS THIS FEEDER SLEEVE PRODUCT RANGE PROVED TO BE A ROBUST SOLUTION FOR MANY DIFFERENT FOUNDRIES.

LATEST SPOT FEEDER DEVELOPMENT

A further development, which started in 2015, adopted the advantages of spot feeders with collapsible metal breaker cores such as consistent knock-off areas, constant feeder volume and excellent moulding results. The new design allowed the reduction of the breaker core metal wall section whereas these were still suitable for the use in high pressure moulding applications. The design has been modified from a stepped to a grooved design (Fig. 4).

The new sleeve concept allowed the combination of the metal breaker core with the feeder sleeve, without application of hot glue in a press fit operation. The breaker core itself rests on a small socket in the opening of the feeder sleeve. During moulding the grooved part of the metal core is compacted and the main feeder sleeve body is moving down towards the pattern plate, compacting the mould sand between sleeve and pattern plate (Fig. 5).

After full compaction the major part of the metal breaker core is super-heated by the high exothermic sleeve material. As a result, the metal neck surface in direct contact to the mould sand is reduced by 50% compared to the prior stepped design (Fig. 6).

Several field trials proved an equivalent or even better feeder neck pass-through performance compared to the existing concept with similar knock-off results (Fig 7).

Today FEEDEX VAK is a solution which is utilized in a high number of applications in the iron foundry industry.

CONCLUSION

The concept of collapsible metal breaker cores provides several key advantages such as consistent moulding results even with highest moulding pressures as well as reduced footprint and neck contact areas. Further developments resulted into an improved design providing excellent feeder neck pass-through characteristics. An extensive test program and field trials proved the technical validity of this concept.

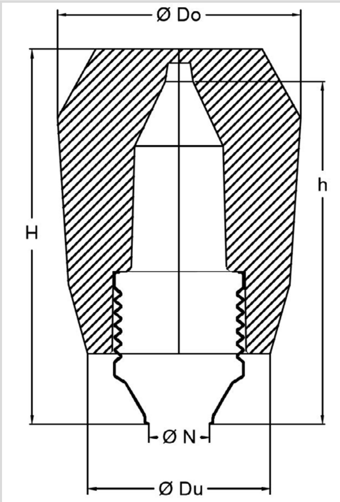

Figure 4: Principle sketch of new generation of collapsible metal breaker core together with spot feeder

Figure 5: New sleeve concept before and after compaction – typically 8 to 15mm distance between sleeve main body and casting

Fig. 6 : Comparison of new and conventional design after application

Figure 7: Knock off result with new spot feeder concept – sound casting with virtually no further fettling work required

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VIRTUAL EXPERIMENTATION WITH THE FOSECO PRO MODULE

New Sleeve Shapes, recipe formulations, applications and supporting thermophysical data for improved casting quality.

Author: Máirtín Burns

Foseco is a leading supplier of consumables to the global foundry industry. With sales and technical personnel in all key markets, Foseco application engineers work in partnership with foundry customers to develop customised solutions. This combined effort involves adapting and fine tuning Foseco product and process-control technology to each foundry's unique circumstances.

CONTINUOUS TECHNOLOGICAL EVOLUTION

Continuous technological evolution drives innovation in casting design and foundries must find solutions to the various challenges that these innovations present. When new challenges emerge, Foseco's strength is its ability to combine expertise from global technical networks with local knowledge to help deliver new solutions.

The casting engineering skills to bring high quality castings to market requires an ever-evolving blend of technical knowledge, practical experience, problem-solving skills and "human" intelligence along with an ongoing investment in engineering and production technology. An important part of this know-how is the successful exploitation of computer technology to tackle and address the complexities of making castings commercially. This is also in constant evolution.

Simulation engineering is therefore a key technical element behind efforts to gain competitive advantage. The "method", and choice of consumables used in that method, plays a significant role in final casting quality and production costs. For either new or existing castings, computer modelling with simulation tools such as MAGMASOFT® provide invaluable insights to help manage these factors before committing to making pattern or process changes. This visual analysis tool helps reach a common understanding of a problem or opportunity and then how best to address it.

FOSECO and MAGMA work in close cooperation to create real value for the foundryman through their joint activities in areas of technology development and know-how. Together both partners seek to advance foundry knowledge in the areas of improved gating and risering design, robust production practices and improved consciousness of cost and quality trade-offs, thus helping to deliver enhanced solutions and even more competitive cast-parts.

The basis for this approach is the ability to quantify and effectively model FOSECO products. This requires the determination of key material properties using advanced measurement techniques and then validating it in MAGMA. The resultant information is provided to the foundryman via the FOSECO Pro Module for MAGMASOFT®.

Foseco works continuously to develop new product technology and application techniques to meet the ever-changing needs of customers. Simulation with MAGMA plays an important role in virtual experimentation and new sleeve development. New additions to the Foseco sleeve product range are made available in the Pro Module database so that MAGMA simulation engineers can integrate them for their daily methoding analysis and optimisation work.

The Foseco Pro Module is a parametric 3D library of sleeve and filter products, combined with proprietary thermo-physical data, which has been integrated directly into MAGMASOFT®.

The key benefit is that it reduces the time to set up, model and simulate the performance of Foseco products. The consequence for the foundry is enhanced casting quality and more robust production processes through better correlation between real and simulated casting results.

Figure 1: Foseco's collective competence in methoding is a complex mixture of foundry engineering, product and recipe development, gating and risering design and casting process simulation expertise

EXAMPLES

Examples of such recent developments include the FEEDEX VAK and the FEEDEX SCK (Sleeve Construction Kit) product ranges shown below as they will appear in the latest release of MAGMASOFT® 5.4 autonomous engineering.

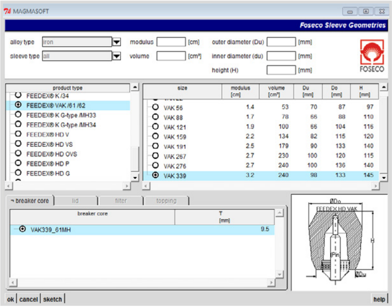


Figure 2a. FEEDEX VAK in the Foseco Pro Module interface

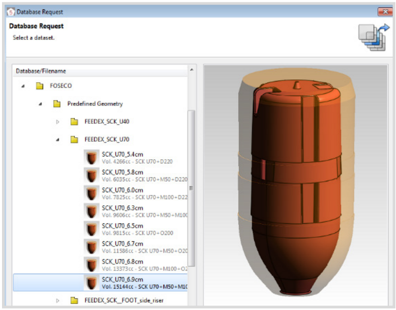


Figure 2b. FEEDEX SCK ranges in the Geometry Database

FEEDEX VAK is a further development of the well-proven Kompressor spot feeder technology for grey, ductile and CGI castings. FEEDEX VAK sleeves are fitted with a patented collapsible metal core, which allows precise spot feeding on the smallest casting section. The VAK /61 series is designed for moulding machines with standard moulding pressure and the VAK /62 series for extreme moulding pressures. The cores are designed to ensure a reliable feeder neck pass-through and an optimum feeder knock-off after casting

The FEEDEX SCK Sleeve system is an innovative, hybrid insulating/exothermic, modular sleeve construction kit for Iron and Steel jobbing foundries. The glue-free, interlocking and easy-to-assemble range of 8 elements provides 31 options (23 iron and 8 steel) with modulus values between 5.4cm to 6.9 cm for precision feeding in large castings. SCK provides flexibility, feeding efficiency and small contact areas, thereby optimising yield and casting cleaning costs.

In order to include the SCK range in the Pro Module, a material dataset which describes the thermal properties of the C6_SCK insulating neck material had to be developed. Using a procedure previously described in the joint Foseco-MAGMA technical paper "Advanced thermo-physical data for casting process simulation – the importance of accurate sleeve properties", the process to develop a material dataset began at Foseco's global Foundry R&D centre located in Enschede, Holland. The material properties were first measured in the analytics laboratory thereby giving a base dataset.

A pattern was specially designed to allow measurement of the temperatures in the casting and sleeve material inside the mould. The mould was subsequently poured, and the temperature history was recorded. The real-life physical setup was modelled, and the actual boundary conditions were applied to the virtual twin modelled in MAGMA. Using the Inverse functionality to match measured and calculated curves, a series of simulation experiments were run, allowing the refinement of the final material properties for use in MAGMA.

MAGMA is a world leader in the development of casting process simulation software who first introduced fully integrated Optimisation and virtual **Design of Experiments (D.O.E.)** methodology into MAGMASOFT® v5.3 in 2015.

The current release MAGMASOFT® 5.4 further advances the ability to comprehensively model and simulate all stages of a wide range of casting making and foundry related processes.

Figure 3. Sleeve Thermo-physical data development at Foseco's Global R&D centre in Enschede

This new generation of tools gives the user the ability to both visually analyse and statistically evaluate the simulation results. The statistical evaluation tools give a relative numerical value for the specific chosen criteria which allows the user to quantifiably compare competing methods that would be otherwise very difficult or impossible to do. An example of such would be to quantify the relative quality differences between multiple gating system or Feeding system proposals.

The goal of all simulation modelling is to correctly predict the final casting properties. In all cases, having accurate thermo-physical properties are critical to the final quality of the simulation results. With the new generation of modern simulation software and computer hardware, the foundryman can leverage these new sleeve, recipe and simulation technologies to optimise their casting production method.

CASTING OPTIMISATION STUDY OF A DUCTILE IRON ROLLER CASTING

The following analysis is a typical example on how the Foseco Pro Module and MAGMASOFT® 5.4 Autonomous Engineering can be used to study and optimise a casting method. The simulation analysis provides essential input for decision making processes in the foundry and provides insights that may be pertinent to future casting simulation analyses.

Using this new generation of simulation technology tools, specifically the methodology of virtual Design of Experiments, requires a slightly different approach in how a casting is to be studied. Having the ability to vary and analyse a potentially infinite number of potential variables, simulation engineers have to take a efficient approach to setting up and running Optimisation and virtual Design of Experiment studies. Having first considered and defined the objectives and variables, the model has to be correctly prepared and the D.O.E. defined.

In the example pictured, a 1700 kg roller casting, the challenge is to feed the chunky centre of the casting when there is very limited space on which to place sleeves. Similar casting are extensively chilled to help with the directional solidification of the casting towards the risers. The aim of the study was to see if it was possible to reduce casting costs either through use of fewer chills, smaller risers, or less padding (machining) in the centre of the casting whilst still maintaining casting quality.

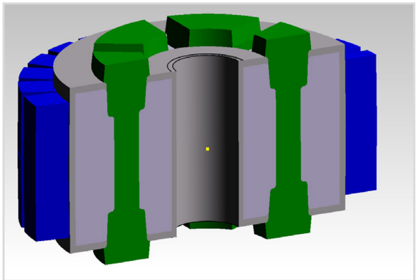


Figure 4: 1700 kg roller casting

Figures 5a and 5b illustrate the competing trade offs between increasing padding at the cost of increasing thermal modulus and feeding requirements, combined with influence of whether chills are used in the top/bottom rings. The Chills do not remove shrinkage but help move it into another location.

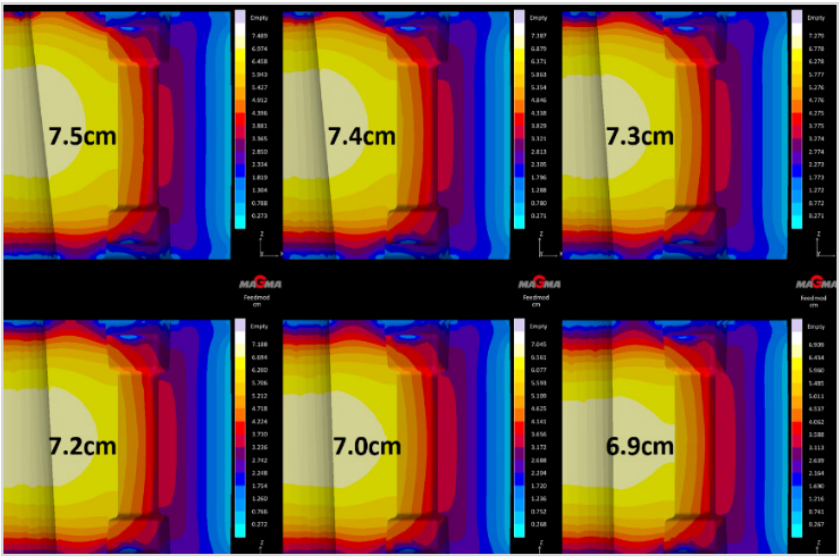


Figure 5a: Influence of Feeding Taper on peak FEEDMOD result (Casting without Feeder, all chills active)

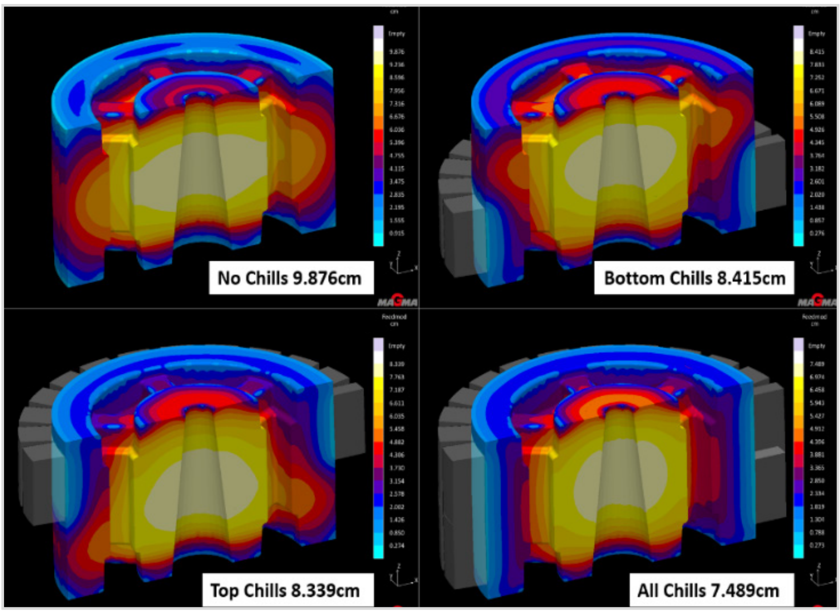


Figure 5b: Influence of Chill activation on peak FEEDMOD result

VARIABLES

A DOE was setup to try to identify the best possible compromise between the competing factors. These are illustrated in figure 5. The total number of designs was 96.

For efficiency, this D.O.E. with 96 designs was run with a relatively coarse MESH, without a gating system, and therefore solidification only. It was simulated overnight on an 8-core workstation.

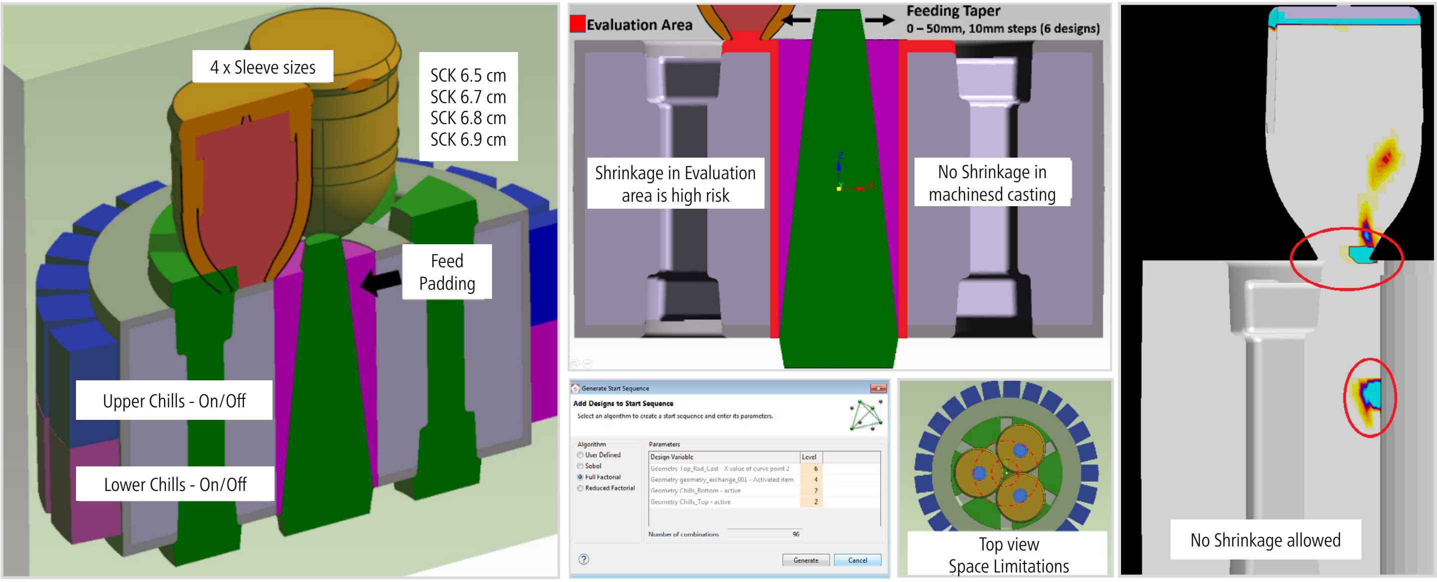
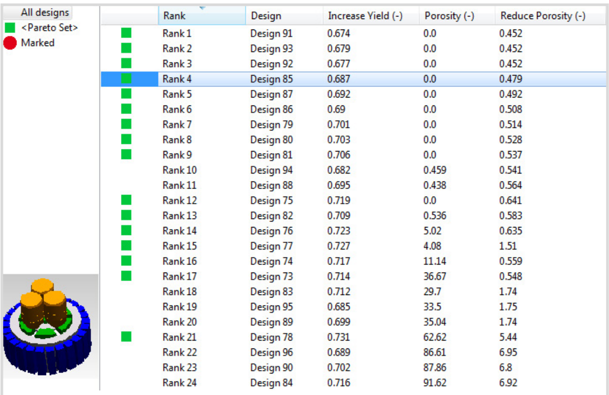


Figure 6: Overview of variables, sleeve positioning constraints and the size of the D.O.E.

SUMMARY OF RESULTS AND ANALYSIS



	Rank	Design	Increase Yield (-)	Porosity (-)	Reduce Porosity (-)
■	Rank 1	Design 91	0.674	0.0	0.452
■	Rank 2	Design 93	0.679	0.0	0.452
■	Rank 3	Design 92	0.677	0.0	0.452
■	Rank 4	Design 85	0.687	0.0	0.479
■	Rank 5	Design 87	0.692	0.0	0.492
■	Rank 6	Design 86	0.69	0.0	0.508
■	Rank 7	Design 79	0.701	0.0	0.514
■	Rank 8	Design 80	0.703	0.0	0.528
■	Rank 9	Design 81	0.706	0.0	0.537
	Rank 10	Design 94	0.682	0.459	0.541
	Rank 11	Design 88	0.695	0.438	0.564
■	Rank 12	Design 75	0.719	0.0	0.641
■	Rank 13	Design 82	0.709	0.536	0.583
■	Rank 14	Design 76	0.723	5.02	0.635
■	Rank 15	Design 77	0.727	4.08	1.51
■	Rank 16	Design 74	0.717	11.14	0.559
■	Rank 17	Design 73	0.714	36.67	0.548
	Rank 18	Design 83	0.712	29.7	1.74
	Rank 19	Design 95	0.685	33.5	1.75
	Rank 20	Design 89	0.699	35.04	1.74
■	Rank 21	Design 78	0.731	62.62	5.44
	Rank 22	Design 96	0.689	86.61	6.95
	Rank 23	Design 90	0.702	87.86	6.8
	Rank 24	Design 84	0.716	91.62	6.92

Figure 7a: Reduced list of ranked solutions

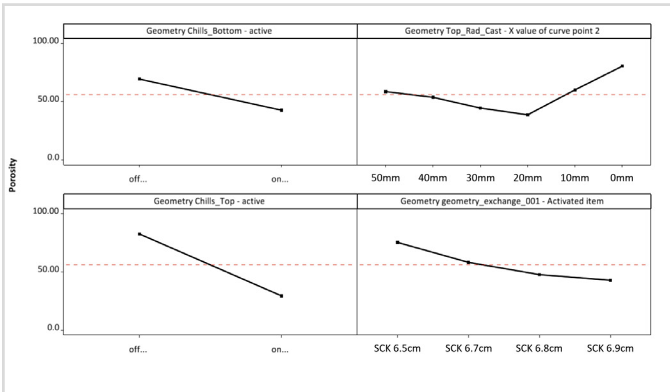


Figure 7b: Result Assessment: Main Effects Diagram

MAGMA produces a list of solutions which are ranked relative to the objectives, (in this case porosity, yield and total porosity), and given a relative numerical score. Figure 7b shows the Main Effects Diagram which summarises the influence of each of the parameters. Turning off top or bottom chills is negatively correlated with increased porosity. There is a distinct step change increase below 20mm padding radius, along with a general trend showing less porosity with bigger sleeves (which is competing with the maximise yield objective).

Individual inspection of the generated results images allows quick and focussed comparison between different versions. Figure 8a shows all results plotted on the Parallel Coordinates Diagram, a tool which allows the user to follow the parameter combination routes to give specific solutions. Clear tendencies were further revealed are summarised below and illustrated on figure 8b.

PARALLEL COORDINATES DIAGRAM

1. When both Top and bottom sets of chills were removed – Shrinkage in final casting.
2. Top Chill ON + Bottom chill OFF – Shrinkage in (high risk) evaluation area.
3. Top Chill OFF + Bottom Chill ON – Shrinkage in Feeder Neck.
4. Minimum taper – 0mm and 10mm – Shrinkage in final casting
5. 20mm and 30mm taper – critical Fraction liquid separation between feeders and casting.
6. Smallest riser – SCK 6.5cm – Isolated Hotspot – all discarded.
7. Largest Feeder SCK 6.9cm –no improvement with smaller tapers, worse yield - discarded.

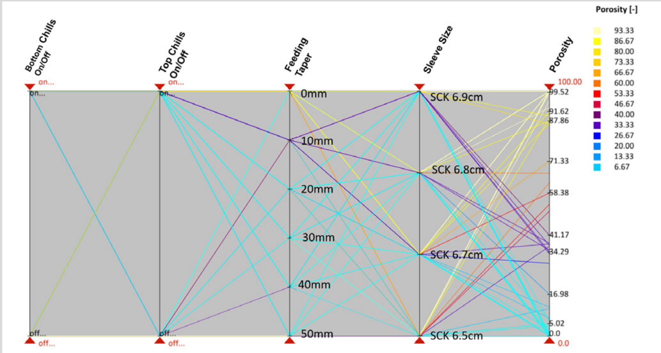


Fig 8a - MAGMA Parallel Coordinates diagram showing all options and porosity results

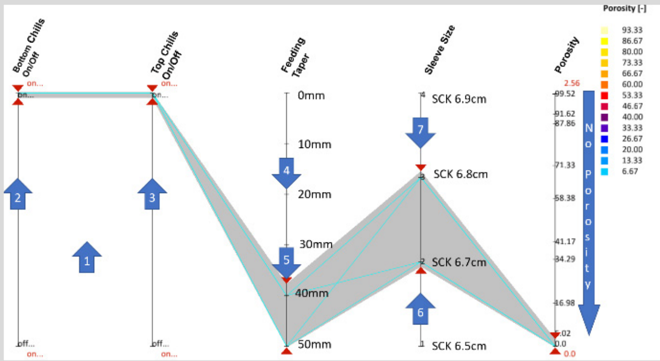


Fig 8b - After analysis, the workable options are narrowed down to 2 sizes and 2 feeding pad radii.

A second D.O.E. was run on the 4 best candidates. As this casting is bottom gated with a long filling time, it is important to correctly account for temperature distributions at the end of filling. The gating system was added, the mesh was refined, and filling was also calculated. The results of these are shown below in figure 8 and figure 9.

In each of the 4 designs above in figure 8, it can be seen in the fraction liquid results that there is a separation between the liquid metal in the feeder and the hotspot in the casting. There is some final porosity as-cast but this is moved into the machining allowance and the feeding taper, figure 9. There is no shrinkage in the final machined casting in any of the four designs. There is a clear tendency that reducing the taper increases the surface shrinkage (fig. 9b, 9d), and that the feed safety margin is lower with the SCK 6.7cm (fig. 9a, 9b). The relative depth of the hot spot zone is also deeper into the casting for the smaller SCK 6.7 cm (fig. 8a, 8b). In order to have a robust method which can potentially withstand variations in pouring temperature and iron quality, the prudent choice is to select the SCK 6.8 cm sleeve with the 50mm taper (fig. 9 c).

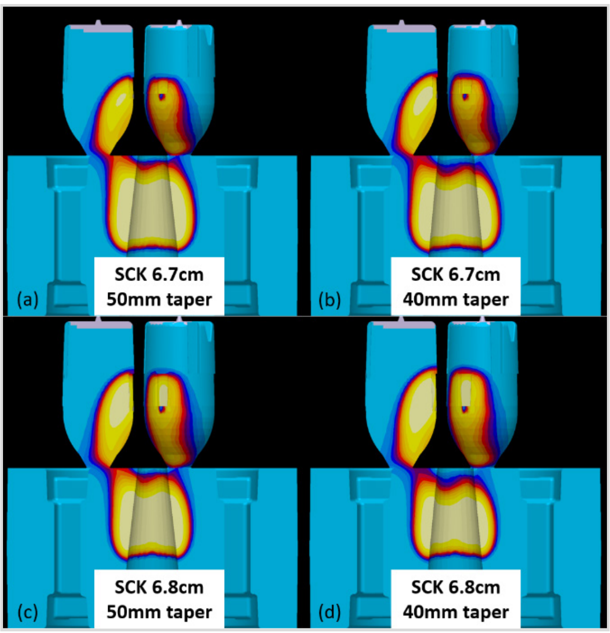


Figure 8: Fraction liquid results

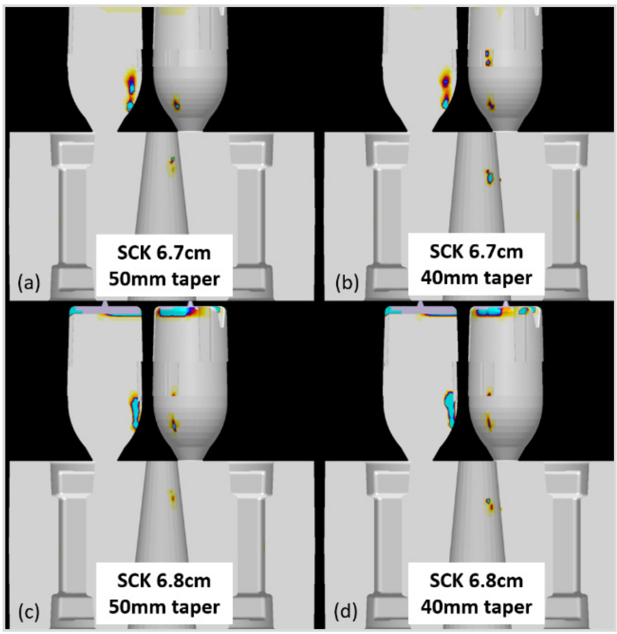


Figure 9: Casting soundness results.

CONCLUSION

In all walks of life, computers and information technology are being used more and more to analyse and make sense of big data. This new generation of autonomous engineering tools developed by MAGMA have greatly simplified the means to simulate and analyse casting projects from multiple viewpoints in parallel. It is very useful for virtual experimentation and learning. The continuous advancement in all foundry related technology requires similar developments by foundries, software companies and consumable suppliers.

Foseco continues to add new sleeve, filter and breaker core size updates to all the available regional databases. It is committed to working on developing new and improving existing thermo-physical datasets to support the technical advancements being made.

The latest Pro Module database, version 2.5.4, is distributed on the MAGMA installation DVD. It is necessary to Install the FosecoDB to update the database. For further information on the Foseco Pro Module for MAGMASOFT®, please contact your local Foseco company.

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PRECISION FEEDING IN LARGE CASTINGS

Author: Steffen Franke

Over recent years, the foundry industry has been increasingly challenged by constructional changes in the methods used to make castings in the drive to save material. This has made the task of ensuring efficient feeding of these castings more and more complex. While the focus in the past has been mainly on mass production in machine mould casting, this trend is now progressively finding its way into the hand-mould casting field. Ever-thinner wall thicknesses lead up to solid attachment points, which means that feeding material through areas with thinner wall thicknesses is becoming more difficult if not almost impossible. Nevertheless, the high-modulus areas in the component, in which the thermal centres lie, must be fed.

This can be accomplished with very small footprints using the legally-protected Sleeve Construction Kit (SCK) feeding system newly developed by Foseco.

THE CONCEPT

The SCK feeding system is based on a modular construction concept that makes it possible to cover the 5.4 cm to 6.9 cm modulus range using a small number of separate individual components. The use of larger feeders often involves enlarging the aperture and with that the footprint. This leads to increased fettling and cleaning costs.

If the aperture area is reduced, this runs the risk that the feeder neck becomes constricted. This in turn leads to secondary shrinkage pipes and the casting becomes unusable.

The SCK feeding system counteracts this effect without constricting the feeder neck. Fettling and cleaning costs are therefore reduced. The system is a hybrid system consisting of highly exothermic and insulating feeder components, which allows the requirements to be met by adopting the best possible balance of modulus and volume.

CONSTRUCTION

The system consists of various components that can be put together in individual arrangements according to modulus and volume requirements. This is done with a simple plug-in system, thus dispensing with the need to glue the components together.

The basic system consists of a highly insulating bottom part with an integrated breaker edge as well as a cover lid or a cap-shaped topping made from highly exothermic feeder material. When the feeder is filled with liquefied material, this creates the required energy in the upper part of the feeder and keeps the liquefied metal in the lower part hot. Foseco uses the proven FEEDEX HD material for the exothermic components and the highly insulating KALMIN 250 for the bottom part. Integrated Williams wedges keep the surface of the molten metal open and therefore ensure optimum feeding.

When casting ferrous metals, the outstanding insulating effect of the bottom part allows the aperture to be reduced to as little as 40 mm with a footprint of only 90 mm (Figure 3).

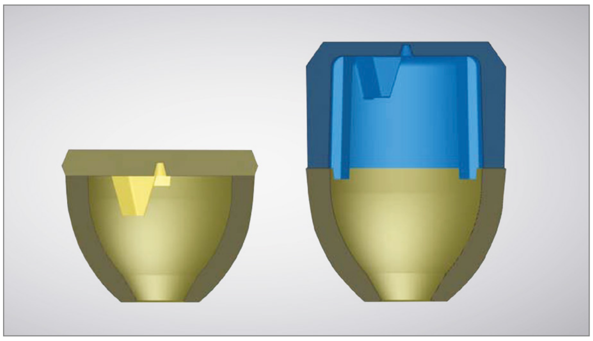

Figure 1.
Basic components:
5.4 cm modulus (left),
6.5 cm modulus (right)

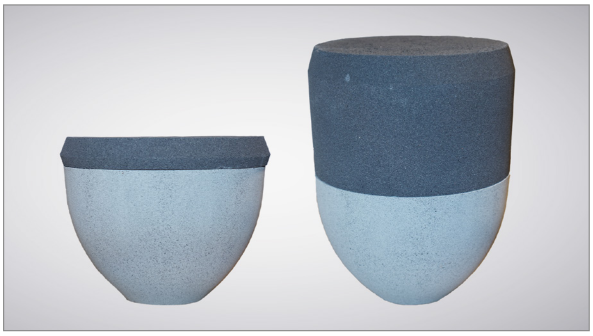

Figure 2.
Basic components:
5.4 cm modulus (left),
6.5 cm modulus (right)

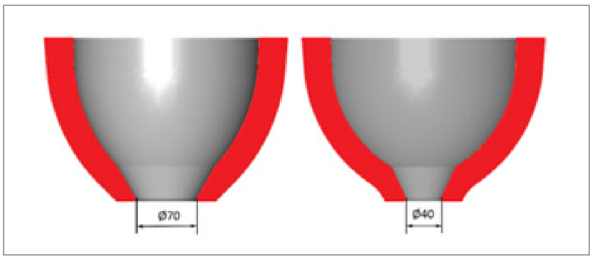

Figure 3.
Comparison of apertures:
70 mm aperture (left),
40 mm aperture (right)

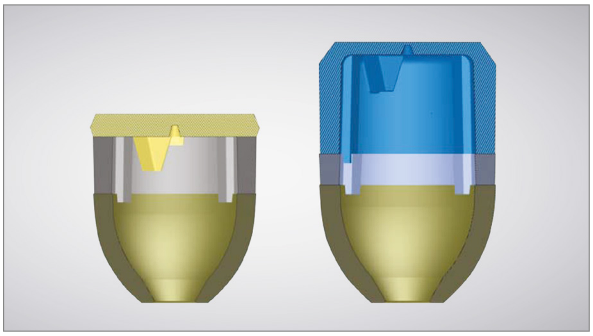

Figure 4.
Basic and add-on components:
6.0 cm modulus (left),
6.7 cm modulus (right)

COMPARED WITH CONVENTIONAL FEEDER TYPES, THE FEEDER NECK AND THEREFORE THE AREA TO BE FETTLED CAN BE REDUCED BY UP TO 75 %.

This allows the junctions for feeding to be positioned without problem.

The integrated breaking edge in the bottom part makes the feeder easier to knock off.

The highly insulating bottom part described above can be composed of various highly exothermic components according to need. It is therefore possible to feed castings with a 5.4 cm to 6.9 cm modulus with the smallest possible aperture and avoid forming cavities.

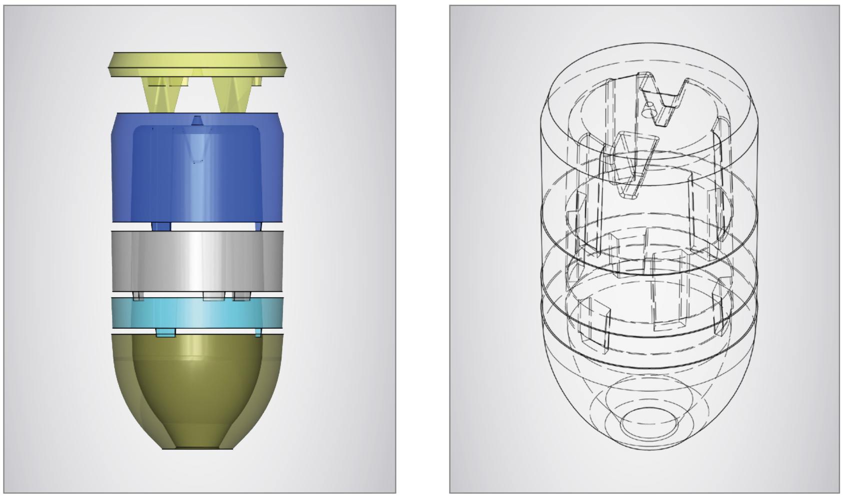

Figure 5: Modular construction – system diagram (left), wire model (right)

Figure 6: Cast feeder – 6.8 cm modulus

The necessary moduli and the required volume can be optimally achieved using various combinations of add-on components, which consist of two different rings with a height of 50 or 100 mm (Figure 5).

The modular construction of the SCK feeding system allows 16 different feeders to be assembled out of six components in the given modulus range. This system greatly reduces the diversity of types in conventional feeding systems and releases storage space. Figure 5 shows the various components. Exothermic cover lids are used for moduli up to 6.3 cm, while the cover lid is replaced by the top part for moduli of 6.5 cm or above.

The data sheet for the SCK feeding system also shows locating pins. Locating pins eliminate any invalid combinations, because they prevent the use of fewer or smaller add-on parts than specified.

Table 1 shows the combination matrix of the SCK feeding system with the corresponding basic and add-on components.

APPLICATION

Extensive test series were carried out at different foundries. Sample cubes were first cast and tested. The results were very satisfactory and confirmed the findings from the earlier Magma simulations.

Modulus [cm]	Vol. [dm³]	Bottom part SCK U			Middle part HD1 SCK M		Upper part HD1 SCK O 200	Lid HD1 SCK D 220
		Neck aperture			Hight			
		40	70	110 (for steel)	50	100		
5.4	4.4	x	x	x				x
5.8	6.2	x	x	x	x			x
6.0	8.0	x	x	x		x		x
6.3	9.8	x	x	x	x	x		x
6.5	9.7	x	x	x			x	
6.7	11.5	x	x	x	x		x	
6.8	13.3	x	x	x		x	x	
6.9	15.1	x	x	x	x	x	x	

Table 1: Combination matrix of the SCK feeding system consisting of basic and add-on components

Figure 7: Feeder arrangement – three 6.8 cm modulus feeders

Once the preliminary test series were completed, casting samples were taken from actual castings.
An aperture of 70 mm was used in the SCK feeding system for the first tests. The highly insulating material has already allowed the feeder aperture to be reduced to 40 mm on numerous applications. This dispenses with the need for laborious cutting off of the feeder neck during fettling. The amount of fettling of the castings required and the associated costs as well as the production throughput times are drastically reduced.

Figures 6 and 7 show a practical example. The roller casting made from GJS 600-3 with a casting weight of 1500 kg was cast using three 6.8 cm modulus SCK feeders (bottom part, 100 mm middle part, and top part), Figure 6. The bottom part had a breaking surface aperture of 70 mm.

The highly insulating effect of the bottom part in this system allows the feeder to be very narrow because there are no adverse thermal influences (Figure 7). The separate thermal centres positioned very centrally in the casting were advantageous in achieving optimum feeding.

Moreover, it is also possible to integrate the highly insulated bottom part in the form of a feeder base into the system to allow side feeding (Figure 8). Similar advantages also result for fettling and cleaning costs.

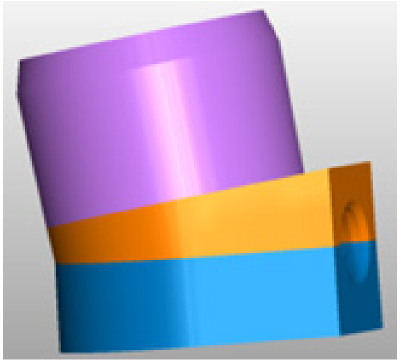

Figure 8. Feeder base with top part – 6.5 cm modulus

The highly insulating KALMIN 250 material used for the feeder base has the advantage that it can be easily shaped to achieve the casting contours. The material is very easy to remove using a file or similar abrasive tools.

A highly insulating bottom part capable of withstanding higher thermal loads is available for casting steel. In this case, the material is KALMIN 70. The diameter of the feeder neck was adapted to the steel application.

With a neck of 110 mm and a footprint of 160 mm, the feeder can be easily positioned on the corresponding model contours. The integrated breaking edge facilitates the separation of the riser from the casting.

For applications with an open riser, it is possible to position several rings on the lower part and cover the riser with covering powder after casting.

The add-on components discussed above can also be used here. An aspect not to be underestimated when dealing with high-modulus feeders is the weight, which increases rapidly with the modulus value. The modular construction of the SCK feeding system allows the components to be introduced into the mould separately and connected together there. From an ergonomic point of view, this makes the task of the foundry operatives considerably easier.

SUMMARY

Using the SCK feeding system has many advantages for foundries and their operatives. The lower need for storage space, reduced fettling, cleaning and grinding costs, ease of assembly and an improvement in working conditions mean this system represents a great step forward in cost minimisation in foundries.

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