Direct Pouring – An aid to efficiency

The Foundry Industry is heavily tied to automotive production and in 1998 the average light vehicle, of which 52 million were built, contained 80 kg of Aluminium. In 2001 the average weight of Aluminium in a light vehicle reached 100 kg and by 2009 the average light vehicle will contain 120 kg of Aluminium and the number of vehicles produced will be above 70 million. The amount of Aluminium castings produced globally will therefore continue to increase, they will also become thinner in wall section and lighter in weight.

Another important factor is that castings will be used for more sophisticated applications and all this will lead to ever greater demands for major improvements in metal quality.

In addition, to remain competitive foundries will have to become ever more cost conscious and continually investigate means of reducing production costs. This will necessitate the industry examining every facit of production and considering techniques thought inappropriate, or too revolutionary in the past, to maintain the progress made in recent years by the aluminium casting industry. One such technique is the use of DIRECT POURING.

There has been considerable research conducted in the recent past into the running and gating of aluminium castings and there is a much clearer understanding of the flow effects needed to create ingate velocities to produce good quality castings.

As castings become thinner in section, the die needs to be filled quickly and smoothly, the aluminium needs to be introduced as low as possible in the casting and risers to remain hot and effective in feeding.

Running systems have to be designed to ensure yields are high and keep sawing and dressing costs to a minimum, hence methods engineers are facing compromises continually.

DIRECT POURING is a concept introduced some 16 years ago to the industry where metal is poured directly into the casting cavity through a ceramic foam filter. This regulates and controls the flow of metal into the die or mould and has led to many benefits for many foundries as can be seen in the following examples.

Example 1

A gravity die cast radiator top tank (figure 1) is cast by gravity die in eutectic Aluminium - Silicon alloy. This sizable, thin-walled component was prone to cold shuts as well as pressure test failures. By changing to a simple running system where the casting was top poured through a 50 mm diameter foam filter the cold shut problem was completely cured while the filtered metal ensured the casting no longer suffered from oxide inclusions and pressure test failures. The 3.44 kg casting saw direct net savings of €2.5 per casting as a result of this change.

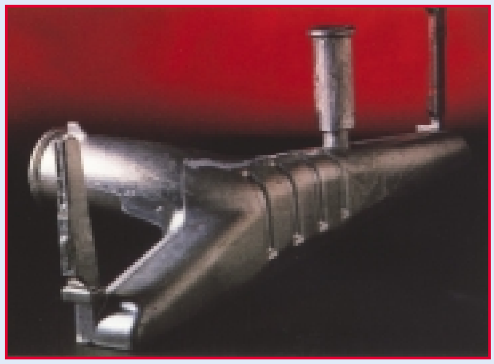

Figure 1: Radiator top tank

Example 2

In gravity die casting, the filter is printed directly into the die but in sand casting the foundry has the additional option of using a KALPUR* unit where the filter is contained inside an insulated sleeve to offer even better feeding characteristics. An engine sump (figure 2) is sand cast and is poured through a KALPUR unit placed on the top of the casting. This replaced the old running system which introduced metal through a series of ingates into the bottom flange. The poured weight was reduced from 11.5 kg to 7.5 kg, a saving of 4 kg and an overall saving in manufacturing cost to the foundry of over €5.00 per casting.

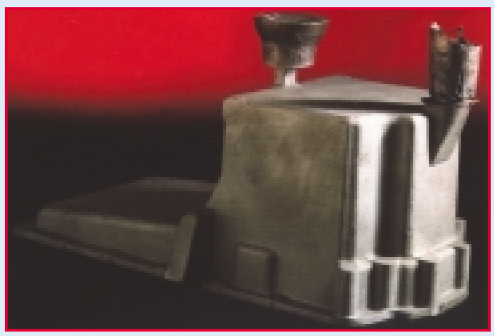

Figure 2: Sand cast engine sump

Many sand foundries have utilised this method of producing castings and seen that there is no need for complicated running systems and lengthy method development where jobbing work is involved.

Example 3

This 6 cylinder manifold (figure 3) is 17kg as cast and is poured through two KALPUR units. It has been sectioned to show the thin inner walls and the casting is subjected to pressure testing after machining. Being cast in eutectic Aluminium - Silicon alloy with Sodium modification this type of casting can be prone to pressure test failure but this particular method produces a very sound casting being free of both shrinkage and oxides.

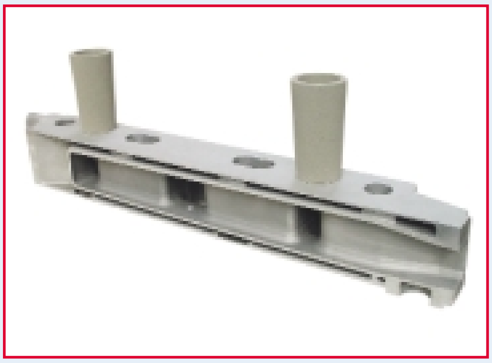

Figure 3: A six cylinder manifold

Example 4

Small and large castings can easily be poured with KALPUR and this further example (figures 4 & 5) is cast through 3 KALPUR units. The casting forms the chassis for a silicon wafer manipulating machine. There are 10 cores involved and the finished weight is 15.5 kg. There are some quite drastic changes in wall thickness requiring feeding of the heavy sections.

The casting is now poured through three KALPUR units and compared to the old traditional running system a saving of over 10 kg of feed metal is made. Taking into account the saving in melting cost, metal loss, sand binder usage, fettling , sawing and cleaning this would result in a reduction in manufacturing cost of over €15.00 per casting.

Figure 4: Chassis casting immediately after pouring, showing three KALPUR units

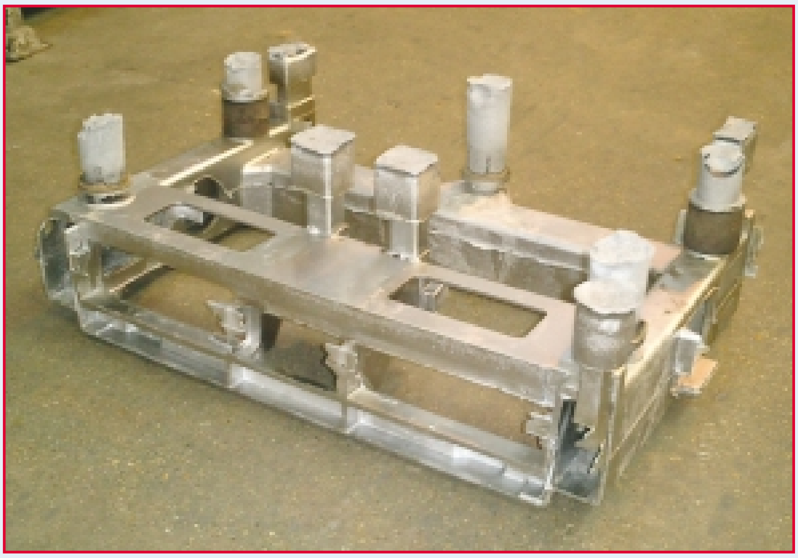

Figure 5: Chassis casting after knock out

KALMIN* 1000

As part of the continuing improvement programme, FOSECO has now developed a new product KALMIN 1000.

This insulating material can be supplied in numerous shapes and has the advantage of being formed and hardened in accurate tooling thus being a very dimensionally accurate and consistent product.

KALMIN 1000 is also free from organic materials and is therefore relatively fume free during casting.

When used in conjunction with ceramic foam filters the KALMIN 1000 sleeve can be formed around the filters during manufacture giving a precise fit and eliminating the possibility of metal by-pass.

Examples of these units can be seen in Figures 6 and 7.

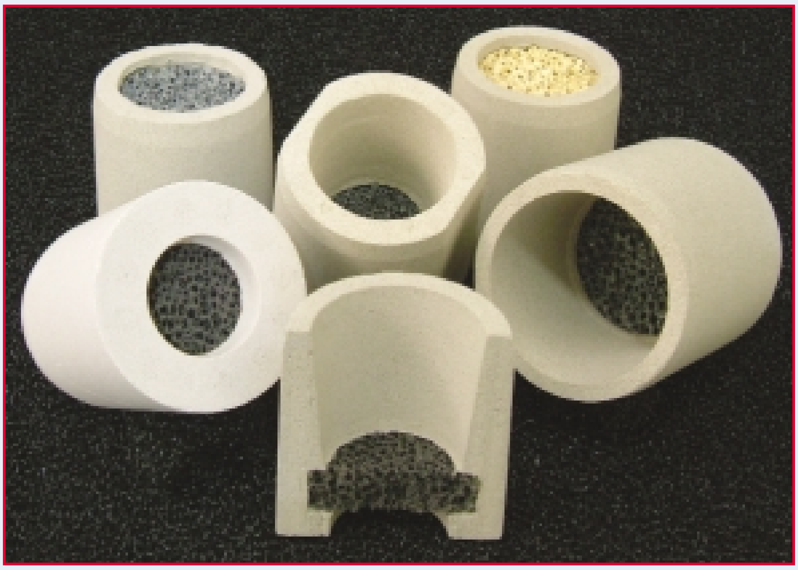

Figure 6: A range of KALPUR units in KALMIN 1000

Figure 7: Further pouring units in KALMIN 1000

In direct pour applications this feature is of great value in ensuring maximum performance in flow control. A reduction in flow rate of up to 30% can be experienced with the new KALPUR units offering even better flow control characteristics.

A range of pouring sleeves are also produced where the filter is a separate item, this enables the foundry to mould the cup in place and insert the filter later. Other sleeves are designed for inserting after moulding having the filter formed in situ.

Conclusions

The use of DIRECT POURING therefore offers the foundry:

- ❑ Simple running system design.
- ❑ Excellent yield.
- ❑ Limited temperature loss.
- ❑ Good directional solidification.
- ❑ Smaller moulds.
- ❑ Reduced sawing and cleaning.
- ❑ Faster processing of castings.
- ❑ Filtered quality Aluminium at reduced cost.

Resulting in:

- ❑ Ease of methoding design.
- ❑ Improved metal utilisation.
- ❑ Shrinkage free castings.
- ❑ Reduced binder spend.
- ❑ Lower finishing costs.
- ❑ Better casting quality with fewer rejects and less repairs.

DIRECT POURING can be carried out in sand casting through an insulating KALPUR unit or in gravity die through a SIVEX filter printed into the die. The KALMIN 1000 route also offers a more dimensionally accurate product which further reduces the flow rate through the pouring device.

Foundries are continuously searching for methods of improving casting consistency while controlling their production costs. DIRECT POURING is one proven method of achieving this aim.

Reference

Case study 282.; Use of molten metal filters in Non Ferrous Foundries: Department of the Environment's Energy Efficiency Best Practice Programme.

The XSR Rotor: A new development in FDU degassing technology

Introduction

Aluminium and its alloys are now regarded as indispensable materials for most industrial applications and are used extensively in building, engineering, transport and particularly the automotive sector where it's use has increased rapidly over the last few years.

In the casting sector the products are almost exclusively produced by sand, die or high pressure die-casting methods and as the range of applications has increased so has the quality requirements placed upon them.

The properties and quality of the castings is greatly influenced by the metal treatment of the molten metal including such treatments as fluxing, degassing, grain refinement, etc.

Accordingly as requirements have become more demanding, development work by FOSECO has concentrated in particular areas to produce the products necessary to keep pace with the demands of the end user.

Theoretical principles

Hydrogen has a high solubility in liquid aluminium which increases with melt temperature (figure 1), but the solubility in solid aluminium is very low so as the alloy freezes, hydrogen gas is expelled forming porosity in the casting. [1]

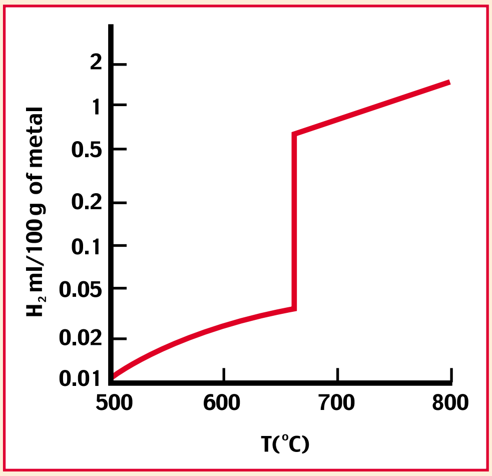

Figure 1: Solubility of hydrogen in aluminium

In aluminium there is a reaction with water vapour as follows;

(a) $2\ Al_{(l)} + 3\ H_2O \longleftrightarrow Al_2O_{3\ (s)} + 3\ H_{2\ (g)}$

Molecular hydrogen then dissociates in the molten metal:

(b) $3\ H_{2\ (g)} \longleftrightarrow 6\ H_{(dissolved)}$

The molten aluminium also interacts with atmospheric oxygen thus in addition to the oxidation reaction seen in equation (a), the following reaction also occurs;

(c) $4\ Al_{(l)} + 3\ O_{2\ (g)} \longleftrightarrow 2\ Al_2O_{3\ (s)}$

This reaction results in oxide skin formation on the surface of the molten metal during the melting process and any subsequent transfer of the molten metal. The oxides produced become trapped in the bulk of the molten material, and are then transferred to the finished cast component. Further non-metallic inclusions such as carbides, nitrides or borides can come from sources such as the crucible material or other refractory materials.

Any inclusions produced can lead to defects in the structure of the casting and therefore can have a detrimental effect on mechanical properties, also they lead to machining difficulties and possible damage to machine tools. It is therefore essential to remove dissolved hydrogen and non-metallic inclusions from the molten metal prior to casting to achieve optimum quality.

The treatment that has been developed to clean the metal is a physical process involving flushing with an inert gas. The hydrogen, which is dissolved in the molten material, diffuses into the rising bubbles of flushing gas and is transported to the surface of the molten material, this process is dependent on two major steps [2]:

- Speed of diffusion of hydrogen through the Nernst diffusion boundary layer into the inert gas bubbles – a diffusion-controlled degassing stage,
- Concentration of hydrogen in the inert gas bubbles – the equilibrium-controlled stage of degassing.