Improved energy efficiency in the production of ferrous castings

Introduction

Energy costs to produce castings are constantly increasing and as a consequence are much more significant to the foundry. Energy is consumed in many areas and processes within the foundry, with the greatest consumption in melting, handling and metal treatment (figure 1).

Most foundries now have major initiatives to reduce energy consumption, however, in many countries increasing legislation is making this task very difficult. Such legislation is forcing foundries to fit cleaning equipment to furnaces, perform sand reclamation and reduce waste disposal, all themselves increasing overall energy consumption.

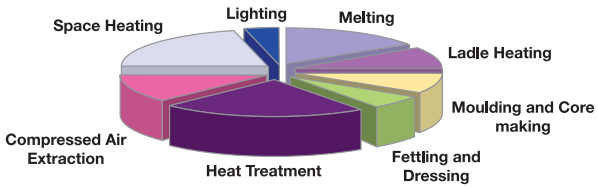

Figure 1 Typical energy consumption in steel foundries

Energy prices

In many countries energy costs are at an all time high. These costs are driven by a number of factors including deregulation of the supplies, rising world oil prices and environmental taxes. Some examples of recent increases in gas and electricity costs are shown in Table 1.

Country	Electricity	Gas
Denmark	39%	8%
Finland	42%	18%
France	48%	26%
Germany	8%	17%
Italy	15%	20%
Netherlands	27%	26%
Spain	15%	26%
Sweden	39%	28%
United Kingdom	41%	28%

Table 1 Typical energy price rises 2005 - 2006

It is now of increasing importance to Iron and Steel foundries to control and minimise their energy usage costs to ensure they remain competitive. As a major solutions provider to the industry, FOSECO understands the importance of supporting foundries in this area, many of the products and services have been designed and developed to optimise energy efficiency.

Melting furnace

The melting furnace is probably the major consumer of energy, therefore it is essential to ensure that the furnace is maintained in good order to guarantee its efficient running. Build up of slag not only reduces furnace capacity, it also affects the electrical characteristics by reducing the level of power that can be applied, limiting the output capacity of the furnace and reducing foundry productivity. Regular use of slag fluidisers such as FERROGEN* will keep the lining furnace clean, increase the crucible life, improve energy efficiency and maintain foundry productivity (figure 2).

Figure 2 FERROGEN and SLAX* application helps in the removal of slag

Ladles

There are many types and uses for ladles in the foundry. Depending on the type of foundry and the ladle process, the amount of time metal is held in the ladle, can be less than a minute to some hours, with ladles varying in size from a few kilograms to many tonnes.

While the metal is in the ladle it is desirable to minimise the rate of heat loss to the lowest level possible.

To increase energy efficiency FOSECO has developed a range of linings over the years i.e KALTEK* with the following benefits:

- ❑ Application is simple with no specialist equipment being required
- ❑ Water is not used In the application of the linings so there is no need for expensive drying operations

- All the linings are "Cold Start" so there is no need for expensive – and often uncontrolled – heating of the ladles before they are used, and the use of ladle preheaters can be eliminated. In steel foundries ladle preheating can account for almost 10% of the total energy required to produce the casting

- The linings are low density and provide higher insulation. The rate of heat loss from the ladle is lower than conventional systems giving greater control over pouring temperatures. Lower tapping temperatures (typically 30°C for large steel ladles) from the furnace can be achieved reducing the energy consumption in induction furnaces.

All the KALTEK systems can be considered "clean" ladle systems. The linings can be replaced very quickly, the time taken to knock out the used lining and replace it with a new lining so that the ladle is ready for use is usually less than one hour. This rapid re-lining means that the ladles can be re-lined when they need to be, old and dirty linings do not have to remain in service until there is time to re-line them. Indeed for optimum ladle cleanliness many steel foundries re-line the ladles after one heat, giving cleaner castings (figures 3 and 4). This can have a significant impact on the energy efficiency of the foundry. Cleaner castings mean less energy is used in rectification (gouging and welding of steel castings) and repeated heat treatment can be reduced.

Figure 3 Ladles from 2 tonnes to 20 tonnes are lined with KALTEK. Ladle drying and preheating has been eliminated. Lower tapping temperatures are achieved with large ladles

Figure 4 The ladle is not dried or preheated before use. The metal is poured at 1350 - 1380 °C with KALTEK.

Another major potential for energy loss is from the surface of the metal, this can be reduced by using PROCAL* ladle lids or various ladle topping materials such as KALDOX* and RADEX*.

Running systems and filters

The running system of a casting is most important in helping to improve the cleanliness and quality of the casting. A correctly designed running system will introduce the metal at the correct point of the casting cavity, with metal at the correct velocity and flow rate. It may also be designed to retain inclusions so that they do not reach the casting cavity. All of these functions can result in a running system that contains a lot of metal reducing yield.

Filtration systems using SEDEX* and STELEX* are designed not only to trap inclusions such as oxides and particles of sand, but also to control speed and avoid turbulence of the molten metal. The use of foam filters is not only efficient in trapping unwanted inclusions, but will often simplify and shorten the running system improving yield.

SEDEX and STELEX foam filters will assist in the production of clean castings reducing the amount of scrap and the associated energy costs in, rectifying castings. The metal yield of a casting can be improved by reducing the size of the running system; this can give other energy efficient benefits such as increasing the number of castings per moulding box or reducing the size of the box and therefore, the amount of sand required (figures 5 and 6).

The very high efficiency of filters in cleaning the casting will result in an improved surface finish. This improvement enables the machining tolerance on castings to be minimised, reducing the amount of time and energy required for machining.

Figure 5 Original 4 cavity spray with double sand feeders and the improved 8 cavity spray with castings turned through 90°, doubling productivity

Figure 6 Casting spray with SEDEX filter (green), KALMINEX 2000 insert sleeves and FEEDEX VS spot feeding technology

Feeding systems

A reduction in the amount of molten metal that is required to adequately feed a casting has a major impact on reducing the amount of energy required to make the casting. Insulation of the feeder head by using feeder sleeves and anti-piping compounds on open heads ensures the metal in the feeder head stays liquid longer. The effective application of feeding systems provides the foundry with many advantages in that an insulating or exothermic feeder has a smaller diameter and reduced height, compared to an equivalent sand lined feeder. The energy benefit is the improvement in yield (figures 7 and 8).

A reduction in feeder size can also give other benefits:

- A reduction in the cost and energy consumed to remove the feeder
- The possibility of an increased number of impressions on a pattern plate or reduction in pattern plate size saving energy in mould production
- The use of smaller moulding boxes
- Melting smaller quantities of metal to produce the casting.

Figure 7 Casting with VS spot feeding on a twin flange section

Figure 8 Finished casting: 86% yield

The KALPUR* – Direct Pour system combines the benefits of feeding and filtration into a unit that functions as a pouring cup, filtration system and feeding system. Correct application of KALPUR will allow for the complete removal of a conventional running and gating system and in many cases provides optimised directional solidification of the casting (figure 9).

Figure 9 Using KALPUR the yield is 56%

Computer simulation

Advances in computer simulation now allow the foundryman to evaluate the effect of different applications of filters and feeding systems without having to make a single casting; this in itself is a major energy saving. The various methods for producing the casting can be evaluated and optimised before any metal is cast (figure 10).

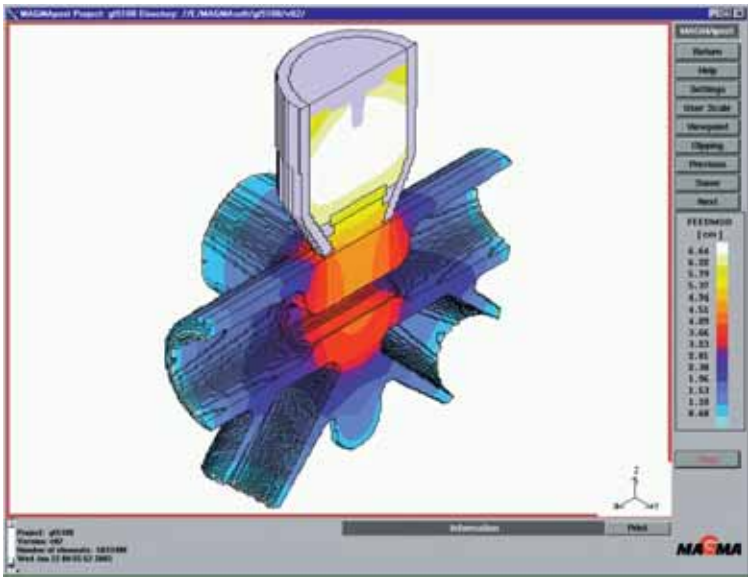

Figure 10 Computer modelling shows the ideal thermal gradients for solidification that can be achieved for optimisation of the feeding system

Conclusion

Clearly energy and related costs due to legislation and health and safety will continue to rise.

There are, however, many ways in which this can be controlled as follows:

- ❑ Efficient melting and cleaning of furnaces to prevent slag build up leading to increased power requirements
- ❑ Attention to ladle practice, using high insulating linings and systems that negate the need for constant pre-heating such as KALTEK
- ❑ The use of ceramic foam filters to markedly reduce running systems and improve yield
- ❑ Replacement of sand feeders by insulating or exothermic feeder sleeves grossly reducing the amount of feed metal required
- ❑ Computer simulation ensuring the casting is produced most efficiently.

By using best practice, incorporating the factors listed above, considerable savings in energy can be made to offset increases and assist profitability.