THE BENEFITS OF BOTTOM POUR TECHNOLOGIES IN STEEL FOUNDRIES

FOSECO

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

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

STEEL FOUNDRIES AND THEIR STOPPER TECHNOLOGY

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

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

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

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

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

There are two main criteria for this choice:

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

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

Figure 1. Casting in a steel foundry by monoblock stopper

Figure 2. Steel investment casting by a teapot ladle

Figure 3. Long assembled stopper in a 35 tonne ladle

Figure 4. Professional preheating station for large steel casting ladles

Figure 5. Monoblock stopper after preheating, ready for filling

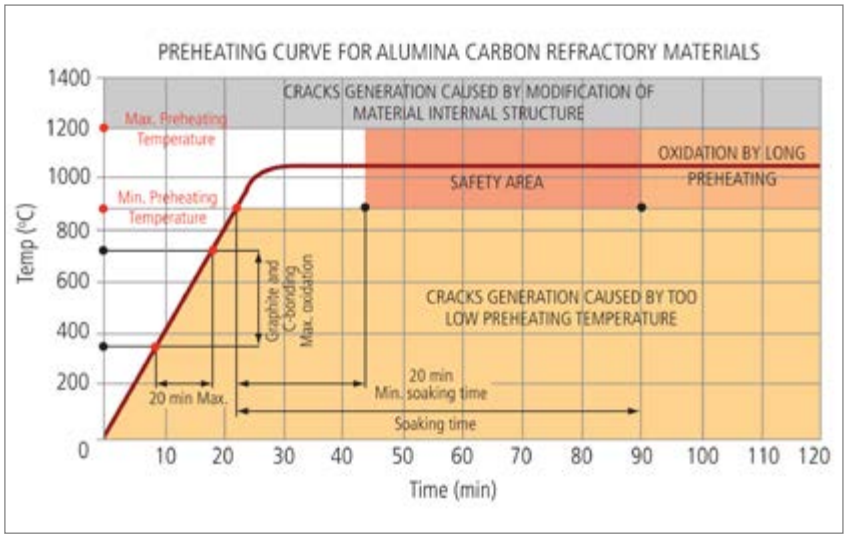

Figure 6. Preheating curve for alumina carbon refractory materials

Figure 7. Moisture migration through the vent hole

ASSEMBLED STOPPERS

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

THE IMPORTANCE OF PREHEATING

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

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

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

For tapping temperatures around 1600^{0}C or higher, using the recommended stopper preheating cycle is very important.

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

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

This is quite important in cases where the recommended preheating temperature cannot be reached. Here the stopper solid nose temperature should reach 1000^{0}C in 30 minutes, and the user should keep this temperature for 60 minutes.

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

MONOBLOCK STOPPER AND KALTEK* LADLE LINING

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

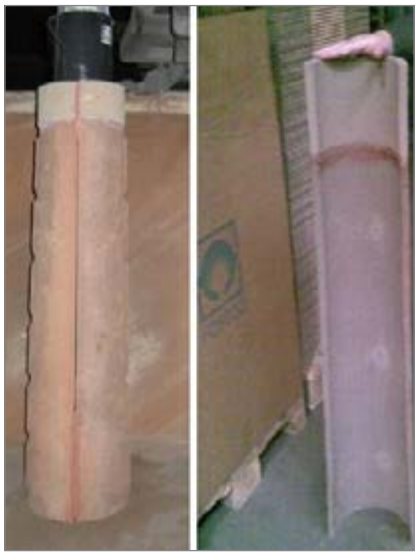

Figure 9. Preheating sheath for KALTEK ladles with small stopper sizes

Figure 10. Preheating construction for long monoblock stoppers

STOPPER SETTING PARAMETERS AND STEEL QUALITY OF THE STOPPER ARM

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

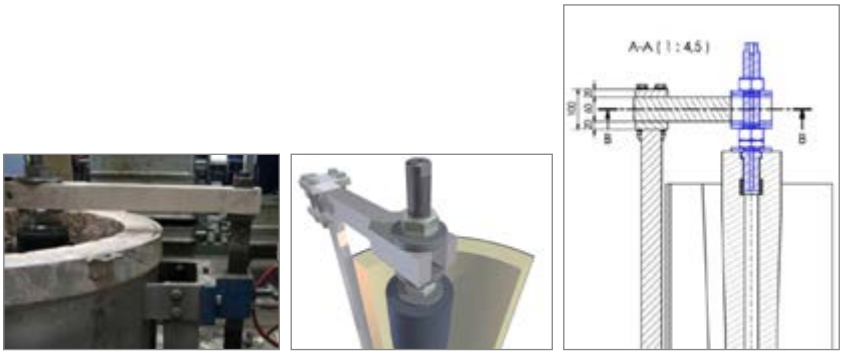

Figure 11. Crossarm for stopper ladle, all products out of heat resistant steel like SICROMAL 8. (Measurements not to scale)

Figure 12. Stopper arm protection by ceramic fibre

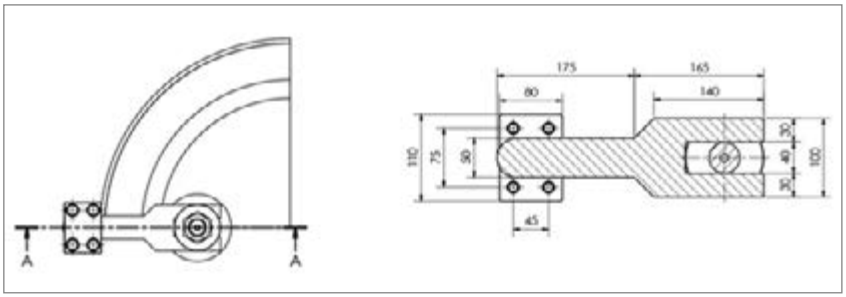

Figure 13. Cross arm details

NOZZLES

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

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

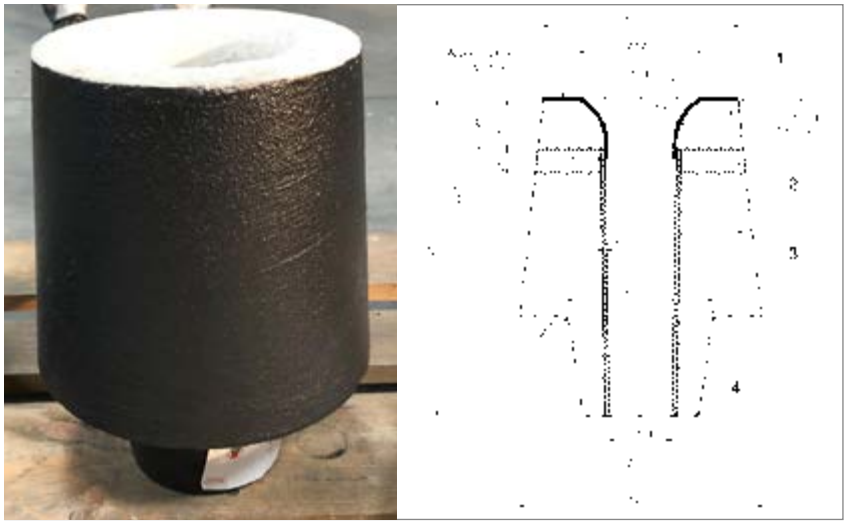

Figure 14. Zoned nozzle

Features of zoned nozzles:

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

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

CROSS-BORE NOZZLES

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

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

Figure 15. Cross-bore nozzle

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

THE FUTURE

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

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

CONCLUSION

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

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

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

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