Whitepaper
Improving the Efficiency of the Blind Riser

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Abstract

Blind risers, or closed risers, are often selected by foundrymen to feed various sections of the casting. Although there is a general consensus in the industry that blind risers are less efficient than open risers, the complex configuration of the casting makes their usage indispensable in some cases. In general, blind risers are located in the lower sections of the casting or just hidden at a level below the top risers.

Just like open risers, blind risers act as reservoirs of molten metal capable of supplying liquid metal into the casting as the casting contracts on solidification. They also allow gases to escape the mould cavity as the metal rises into the mould. When compared to open risers, that break through the cope to the top of the mould and are entirely exposed to the outside atmosphere, blind risers are somewhat handicapped.

A vacuum pocket (depressurized zone) is sometimes created at the top of the blind riser due to the fact that their top front of metal is not exposed to the atmosphere. In order to prevent the formation of such depressurized zone it is of utmost importance that the liquid contained by the blind riser maintain a free communication with the outside atmosphere.

This paper describes a novel technique to vent risers and offers a simple and practical solution to this problem.

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Foundrymen from around the world are consistently confronted with challenges to improving their operations by producing higher quality castings, decreasing the delivery time while lowering costs.

One way towards achieving these expectations is to continuously be involved with the industry advancements and take advantage of the latest developments. The 3D printing technology has been around for more than three decades.

Initially adopted for the production of prototypes, this technology became increasingly embraced by manufactures for the mass production of goods.

In recent years the popularity of the 3D printing was extended to the foundry industry in the form of 3D sand printing technology.

Also known as Additive Manufacturing (AM) of sand moulds and cores, the technology enabled the direct production of cores and moulds without the need of a core box or a pattern. AM allows cores and moulds to be produced by selectively spraying binder over thin layers of foundry sand. The technology is quite amazing and it can offer substantial benefits when used selectively with a full understanding of its advantages and its limitations.

Previous Work

It has been well established that the vacuum pocket created at the top of the blind riser is the root cause for sporadic shrinkage observed sometimes in sections of castings even when blind risers are properly placed and sized.

Figure 1 shows the formation of such a cavity due to the fact that the metal is not flowing downward from the feeder head. It has been over twenty years since Williams cores have been designed and used in conjunction with blind risers in order to overcome this limitation. Their role is to aid feeding, firstly by creating an overheated zone at the top of the riser capable of preventing the metal from freezing and secondly by creating a passageway for the ingress of air and promoting a free downward flow.

Figures 2 and 3 show examples of Williams cores used on top of dome risers or in conjunction with sand covers for tube risers.

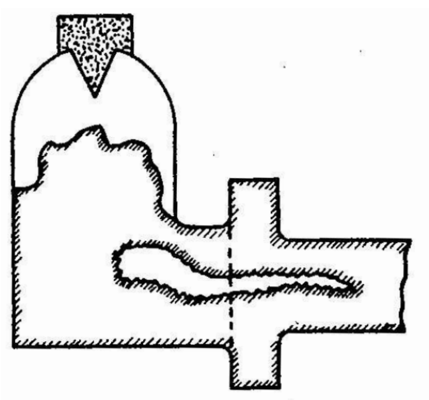

Figure 1 – Formation of a cavity in a casting due to lack of metal flow downward from the feeder head

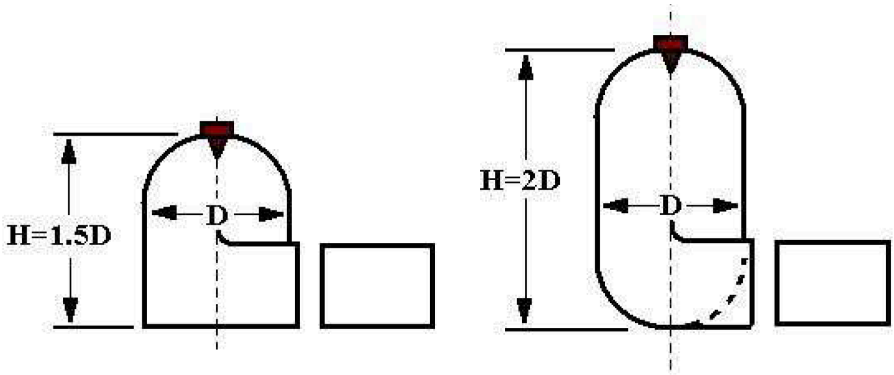

Figure 2 – Williams cores on simple and double spherical domes

Figure 3 – Examples of sand covers for cylindrical (tube) risers

Following the Williams core principle, in 1989 Foseco patented the Williams riser sleeve. The new riser sleeve incorporated an elongated member, in the shape of an inverted cone, extending from the top of the riser sleeve to a central point within the riser. Figure 4 shows the added feature as an "upside-down cone" located at the top of an insulating dome riser sleeve and extending downwards to the thermal centre of the riser.

The supporting theory for the new design was that the inverted cone, now an integral part of the riser sleeve, prevents the formation of a layer of frozen metal at the top of the riser and keeps an air passage open towards the solidifying riser assuring that the somewhat colder riser bottom still receives liquid metal from the top. Practical results and Magma simulations (Figure 5) confirmed that the inverted cone, when long enough to reach the thermal centre of the riser, does in fact create an overheated zone at the top of the riser.

Even in small risers, thermal currents bring hotter (less dense) liquid to the top, helping the top portion remain liquid. The second part of the theory, however, which claims the inverted cone creates a passage to atmospheric air was offered as a hypothesis rather than a proven theory. Variables, such as sand permeability and placement of blind riser within the mould, were not considered.

Depending on its position in relation with the top or the edge of the mould, the blind riser is subjected to an uneven and limited exposure to atmospheric pressure. Mould, core, mould wash and even sleeve permeability must also be considered when assessing the exposure of the liquid metal inside the riser sleeve to the atmospheric air.

It is not reasonable to assume that a blind riser covered by four or five feet of sand has the same exposure to atmospheric pressure, through sand permeability, as a riser placed close to the top of the mould and covered by just 2 or 3 inches of sand.

Figure 4 – Pre-shaped insulating blind riser sleeve

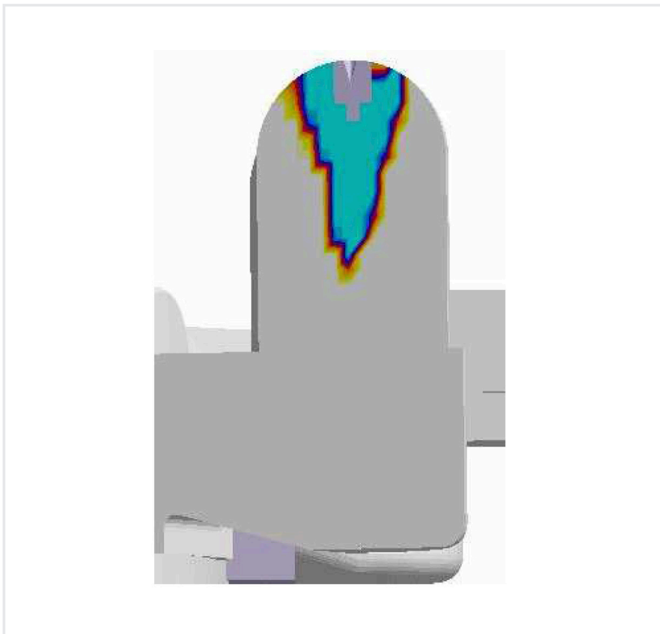

Figure 5 – Magma Simulation of Williams riser sleeve during solidification

Current Practice

Routinely, as a common foundry practice, blind risers are only provided with 1 or 2 vents, drilled or moulded from the closed end of the riser to the top of the mould. These vents, or pop-offs, only allow gasses to escape mould cavity as the metal rises into the mould.

The metal entering the pop-off passageway solidifies almost instantaneously blocking the communication between the metal in the riser, still in liquid state, and the atmospheric air. Often, the pop-off metal freezes even before reaching the top of the mould.

Pop-off vents are not to be regarded as a significant aid to feeding, as they do not offset the negative feeding pressure created at the top of the riser.

The Venting Chamber

The innovative aspect of the project described in this paper consists of a venting chamber moulded on top of a riser sleeve (Figure 6). Chambers can be made of sand using either the no bake or the isocure process.

They have the shape of cups with 2"– 3" diameter and a wall thickness of approximate 3/8". Before the sand is packed into the mould the chamber is placed on top of the blind riser sleeve. A 3/8" diameter dowel penetrates the top of the chamber but does not penetrate the riser sleeve.

After the sand is cured the dowel is removed leaving an unobstructed passage between the cavity of the chamber and the top of the mould. With the chamber-vent system in place, the only remaining obstruction between the liquid metal inside the blind riser and the atmosphere is the actual riser sleeve, but the high permeability of the sleeve together with the hot zone at the top of the feeder make this obstruction negligible.

Practical results showed that the downward movement of the liquid metal from the feeder head is significantly improved when the venting chamber is used.

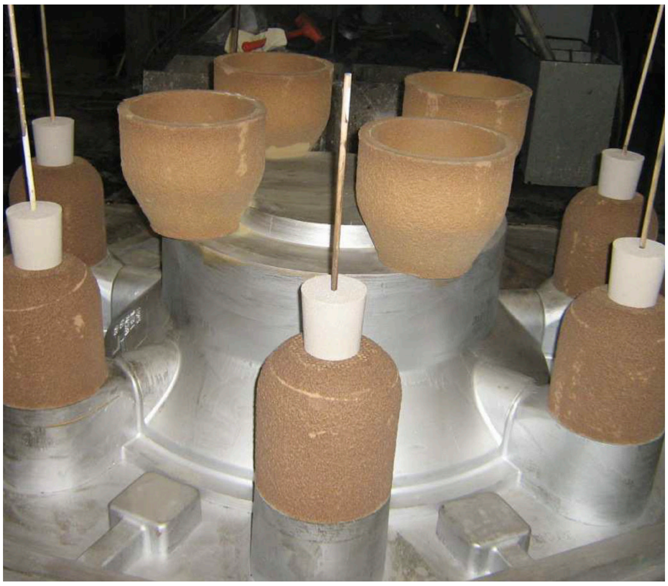

Figure 6 – Venting chambers moulded on top of blind riser sleeves

At Bradken (Formerly AG Anderson Ltd), venting chambers are made in a multiple cavity box using the isocure process. Figure 7.

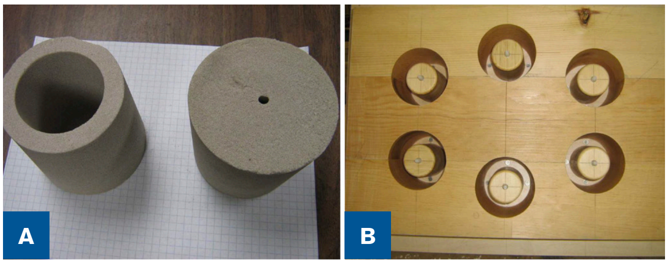

Figure 7 – (A) 3" dia. venting chambers made using the isocure process in a six cavity core box (B) Core box

In order to offset the potential backpressure caused by an air pocket entrapped at the top of the riser sleeve, after the removal of the pattern a 3/8" dia. pop-off passage is drilled from the inside of the riser sleeve through the cope making sure that the drill doesn't wander into the cavity of the venting chamber. Figure 8.

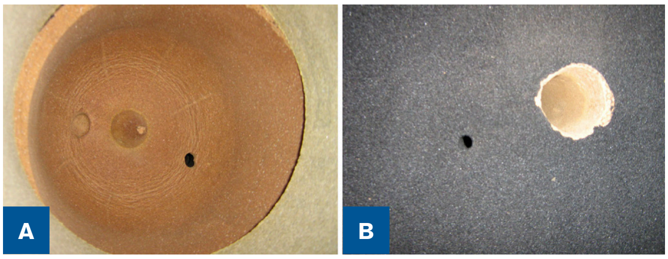

Figure 8 – (A) Pop-off hole drilled through sleeve and cope (B) Top of the mould. Pop off hole and chamber vent

Experimental and Practical Results

In order to validate this process, an extensive comparison study was carried out and the results showed significant improvement of feeding when venting chambers were used on blind risers. Figures 9 and 10 show some of the results.

Figure 9a shows how the riser that was not assisted by a venting chamber failed to feed properly, as a skin of metal formed prematurely on its surface. The riser moulded with a venting chamber (Figure 9b), remained open at the top allowing the atmospheric pressure to act through the chamber-vent system against the liquid front of metal at the top of the riser. To better understand the behaviour of the liquid metal and the extent of the feeding improvement, the two risers were RT-ed and then sectioned longitudinally (Figure 10).

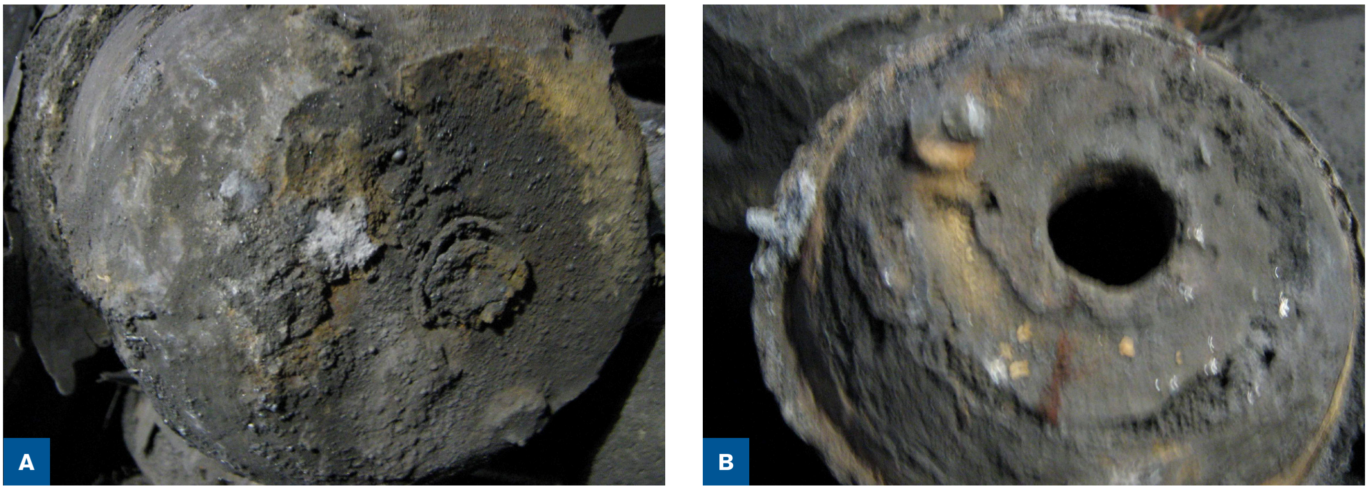

Figure 9 – (A) Blind riser moulded without a venting chamber (B) Blind riser moulded with a venting chamber

Figure 10 – The riser unassisted by a venting chamber (left) has a skin of metal formed at the top and shows an insignificant amount of metal loss. The riser assisted by a venting chamber (right) is open at the top and shows significant metal loss.

Effect of the New System on Casting Yield and Quality

The major metal loss that occurred in the properly vented riser demonstrates the effectiveness of the venting chamber in improving the efficiency of a blind riser when properly provided with an unobstructed passage to the atmospheric air.

The results of this study and the obvious improvements noticed on castings made with properly vented blind risers made the use of the venting chamber system a common practice at Bradken (Formerly AG Anderson Ltd). Since the initiation of the process, the methoding on some jobs was reviewed and many of the risers, now assisted with a venting chamber, were reduced in size. As a result, the overall casting yield was significantly improved.

Concurrently, the more efficient blind riser resulted in a considerable reduction of riser removal and upgrade hours. Before the implementation of the new venting system a 8,000 lb. steel diffuser had a pouring weight of 15,500 lbs. After the addition of a venting chamber to each blind riser and the complete method reconfiguration, some risers were reduced in size and others completely eliminated.

The same diffuser is now poured using 12,000 lbs. of metal. Casting yield improved from 51% to 66.7%. This example is of a particular importance at Bradken (Formerly AG Anderson Ltd) since the foundry makes two of these diffusers a week. For this casting alone, the metal saving over one-year period is 364,000 lbs., which represents the weight equivalent of 30 diffusers. The overall benefit of the new venting system becomes even more substantial when considering energy savings and savings incurred as a result of the reduction of upgrade and riser removal hours as well as the significant savings generated by the pour weight reduction.

Table 1 and Figure 11 illustrate the reduction of upgrade and riser removal hours in the case of the above mentioned diffuser.

Table 1 – Moulding, riser removal, cleaning and upgrading hours

	Shop Order #	Cores & Moulding	Riser Removal	Cleaning	Weld Repair
Castings made before the new riser venting	36560	35.50	20.50	16.50	78.82
	36224	44.00	32.00	12.25	216.50
	36561	41.75	29.75	12.75	157.80
	36462	16.00	27.75	11.25	43.00
	36465	32.25	31.75	17.50	181.40
	36692	38.25	33.50	12.00	56.16
	36289	39.00	39.00	17.75	93.16
	36693	36.25	25.00	19.50	41.00
	36956	35.00	28.50	20.50	64.50
	36957	35.25	26.50	23.25	89.00
	Average	35.33	29.43	16.33	102.13
Castings made using the new venting system	37612	48.50	17.25	21.00	24.75
	37703	28.66	17.00	17.25	44.75
	37702	34.25	19.25	24.75	25.75
	38077	32.25	20.25	12.00	47.50
	38078	26.75	19.25	18.00	23.00
	38147	29.25	32.50	11.75	6.50
	38148	46.75	18.00	20.50	35.75
	38149	35.75	10.25	15.25	40.50
	38150	28.00	23.50	14.25	58.25
	38796	30.75	12.75	15.00	21.25
	Average	34.09	19.00	16.98	32.80

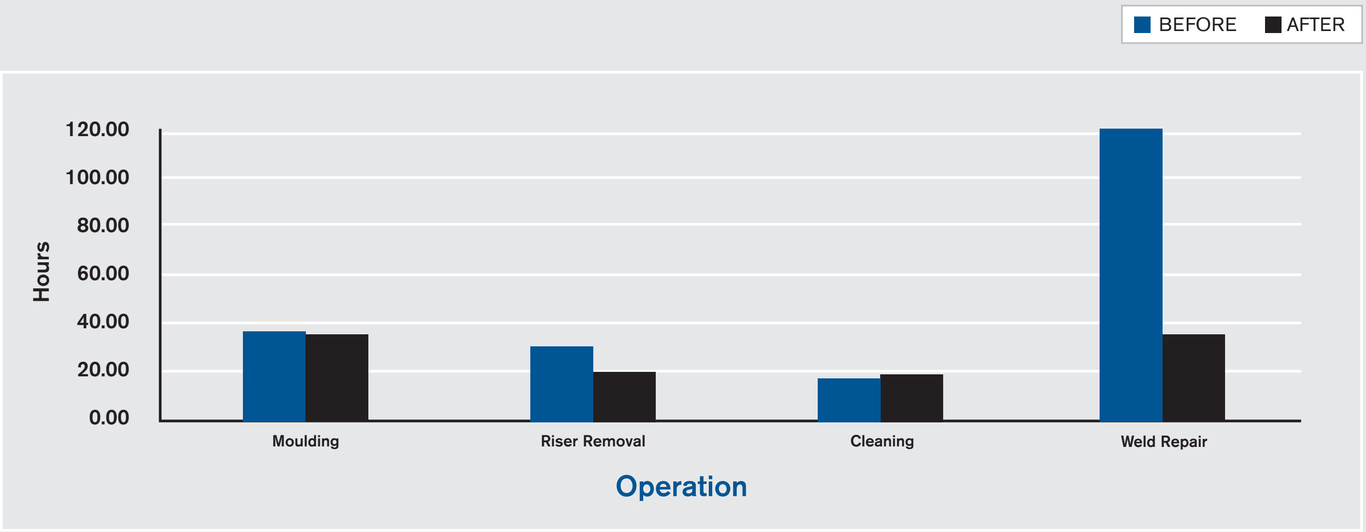

Figure 11 – Average of moulding, riser removal, cleaning and upgrading hours

Venting Chamber – A More Advanced Approach.

So far it has been illustrated how the venting chamber assists the blind riser by providing free passage between the liquid metal in the riser and atmospheric air at the top of the mould. The chamber, however, cannot always prevent the premature freezing of the surface of the feeder head.

The solid skin formed on the surface of the riser can lead to the formation of secondary cavities often penetrating into the casting. The venting chamber method can be slightly modified in order to further increase the temperature gradient of the feeder towards the top. By simply filling the chamber with ordinary exotherminc hot topping the venting chamber becomes a "hot venting chamber".

Figure 12 shows that shortly after the metal reaches the top of the riser, the sleeve below the chamber collapses under the superheat allowing the exothermic material to flow into the riser and float over the top of the liquid metal. The hot topping initiates an additional exothermic reaction that encourages the metal at the top of the riser to remain in a liquid phase even longer.

This exothermic reaction contributes to the caloric exchange between the molten metal and the riser sleeve making the blind riser act as an open riser, well covered with hot toping and exposed to atmospheric pressure, while still retaining the practical convenience of the blind riser. The hot chamber method can be successfully adopted when casting yield is of significant importance or when casting configuration imposes the use of smaller risers.

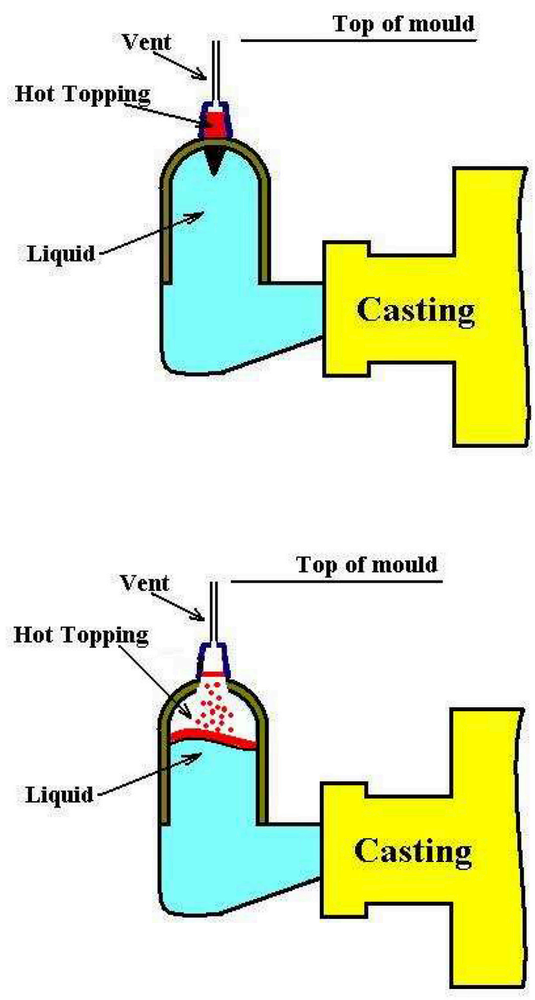

Figure 12 – Hot venting chamberhours

Venting Chamber and Core Venting

Venting chambers can also be used for core venting. When moulded on top of core prints, the chambers capture high amounts of core-generated gases allowing them to escape unobstructedly (Figure 13a). The ends of the nylon vents, often used inside cores for core venting, can be captured under the venting chamber placed on the core print (Figure 13b).

Core venting through a venting chamber is highly recommended in situations where large cores (mainly split and glued cores) are surrounded by heavy walls of metal. Proper core venting is an important step in producing a gas-free casting and the use of the venting chamber method for core venting becomes a key to success particularly when dealing with heavy walled castings.

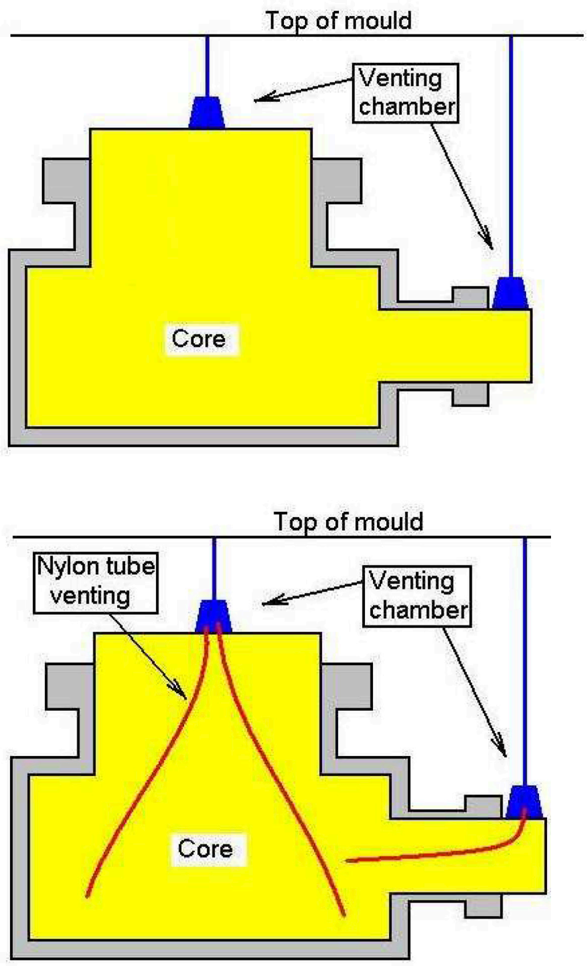

Figure 13 – Core venting through venting chambers

Further Work

The techniques described above are meant to increase casting yield and quality by improving the functionality and performance of the blind riser. The feeding distance, which is strictly controlled by the casting wall thickness, is not affected by the use of the venting chamber.

Previous studies have shown that by applying pressure over the liquid front of metal at the top of the riser, the amount of feed metal supplied through the solidifying wall will increase. The pressure improves the ability of the metal to flow through the partially solidified casting and reach areas away from the riser. The principle of increasing the feeding distance by the use of pressurized risers has been experimentally proven but it has never been adopted as an industrial solution due to its limited practicality. It was difficult to find a practical method to apply continuous and controlled pressure from a source through the mould and inside a riser sleeve right in the area where the metal is still liquid.

The use of a venting chamber with a slightly modified venting system can become a more practical approach to riser pressurization. The venting chamber could be connected to a source of nitrogen or compressed air by using copper or even flexible plastic tubing. In this case the venting chamber becomes a pressure chamber that receives the gas from the line and transfers it into the riser. A basic sketch of the proposed design is illustrated in Figure 14. This will make the subject of future work.

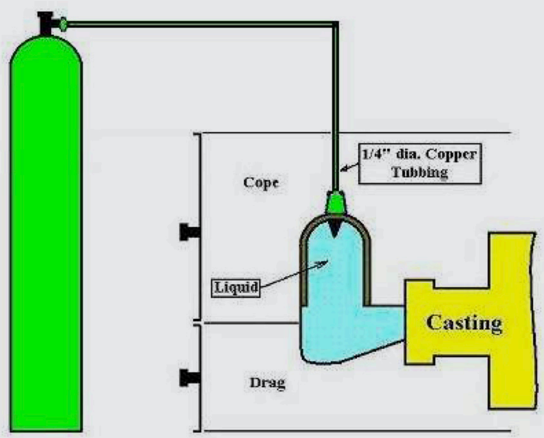

Figure 14 – Schematic of a proposed pressurized blind riser.

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Conclusions

The efficiency of blind risers becomes comparable to that of open risers when venting chambers are employed.

The casting yield increases significantly when risers are provided with an adequate air passage to atmospheric air and with a hotter top front of metal.

Whether the venting chamber is used to improve the communication with the atmospheric pressure, to increase the temperature gradient at the top of the riser sleeve or as an aid to core venting, the methods presented here are simple and relatively inexpensive solutions to limitations frequently encountered by foundries when conventional methods are applied.

Today, when the foundryman is confronted with escalating prices of raw material and increased energy costs, solutions like this aimed at improving yield and reducing labour and energy costs deserve full consideration. There is nothing wrong with going back to the basics every once in a while and re-evaluating sound and simple techniques such as "the lost art of venting".

References

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