KALPUR *For Steel* direct pouring system improves yield, productivity, and quality.

Conventional gating systems are designed to allow externally generated oxide macro-inclusions to float out and adhere to the tops of runner surfaces. However, these systems are often inadequate for critical castings where surface and subsurface defects cannot be tolerated. In addition, turbulence within the gating system and erosion of the runner walls are often sources of inclusions. Heat loss in the initial metal passing through the runners can contribute to the formation of cold lap, cold shut, and cold shot defects. Finally, conventional gating comprises 10 to 50% of the total pouring weight and occupies much of the pattern plate area.

Foseco's KALPUR *For Steel* direct pouring system replaces conventional running and gating with a refractory insulating feeder sleeve that incorporates a ceramic foam filter to trap ladle slags and other inclusions - figure. 1. In addition, it reduces metal turbulence and reoxidation inside the mold and replaces a sleeve or sand riser that may have been required. The KALPUR system also improves temperature gradients within the filled casting, reducing shrinkage problems and possibly allowing the elimination of feeders that were required to accommodate gating hot spots.

Conventional molded gating system practice

A well designed gating system should supply inclusion free metal to the mold cavity and minimize the occurrence of entrained air and mold gases during pouring. It must also regulate metal flow without eroding mold surfaces.

The gating system should be long enough to allow inclusions time to float up and adhere to the top surfaces of the system. However, long gating systems are often not practical due to area constraints and their effect on yield. They also extract a large amount of heat from the first metal poured, often resulting in cold-metal defects or the need for higher pouring temperatures.

Short runner systems reduce heat loss but also reduce the opportunity for inclusion flotation and often result in high metal velocities and turbulent flow that leads to the formation of additional inclusions.

In recent years, ceramic filters, placed close to the casting cavity, have been used in conventional gating to mechanically trap both solid and liquid inclusions and decrease turbulent flow. However, since the first metal to reach the filter has already lost considerable heat, the additional heat needed to prime the filter often requires an undesirable increase in pouring temperature to avoid temperature related defects.

"Critical" and "Problem" castings

Oxide macro-inclusions are the most troublesome non-metallic inclusions encountered in critical steel castings. Reoxidation during pouring, slag, sand, and fluxed ladle refractories are primary sources. Also, at normal ladle temperature, some slags are very fluid and nearly impossible to skim from the ladle during pouring. While surface inclusions may be satisfactorily repaired with welding in many castings, they are not acceptable where machined sealing surfaces or rigorous radiographic inspection is required.

Fig. 1 KALPUR For Steel direct pour units, incorporating a ceramic foam filter within an insulated sleeve, are available in a range of sizes to accommodate a variety of mold weights and pouring practices.

Direct pouring should be considered for any "problem" casting where modification of conventional gating practice has failed to meet quality criteria or the foundry's internal and external scrap rate objectives.

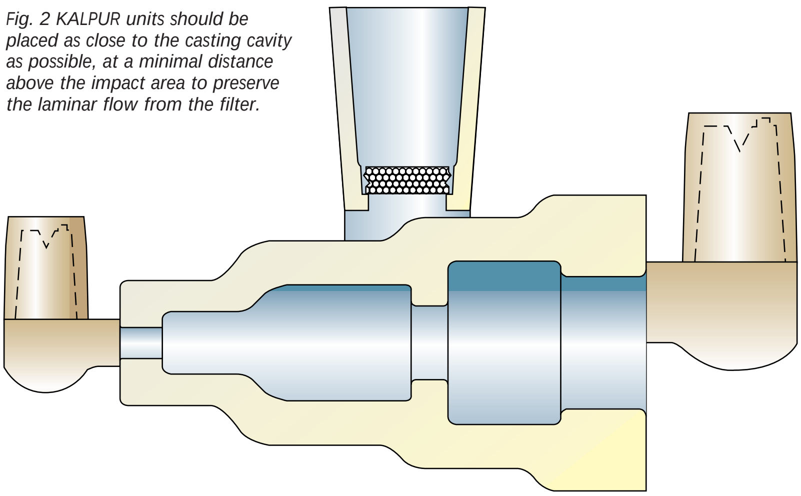
The KALPUR system

The KALPUR *For Steel* direct pouring system eliminates pour cups, sprues, runners, filter prints and ingates -figure 2. It builds upon direct pour technology originally developed for non-ferrous castings, where it has been successfully used since 1989.

The KALPUR unit combines the latest riser sleeve and filter-material technology in an insulating, low-density refractory sleeve unit. The filter is designed to optimize the degree of filtration and flow capacity for a wide range of pouring weights and foundry practices.

Filtration is accomplished by interception of larger inclusions at the filter face and smaller inclusions as they travel the tortuous path within the foam filter. Foam filters can trap inclusions significantly smaller than the open areas of the pores and can trap liquid inclusions as well.

Fig. 2 KALPUR units should be placed as close to the casting cavity as possible, at a minimal distance above the impact area to preserve the laminar flow from the filter.



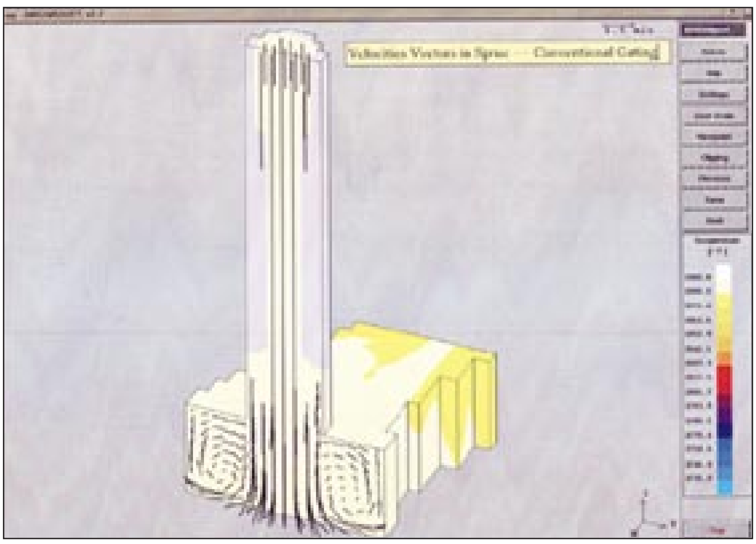


Fig. 3 Velocity vectors show the turbulent eddy patterns in the impact area directly beneath the sprue in a conventional gating system.

Benefits of KALPUR *For Steel* direct pouring

Extensive computer mold-filling and solidification simulation studies have been conducted to evaluate turbulence and thermal gradient differences between conventional systems and direct pour practice. The velocity vector and temperature distribution simulations in figures 3 through to 6 illustrate the benefits of using the KALPUR system over conventional gating on a "critical" valve casting.

Quality improvements.

Filtration more effectively removes external inclusions than gating system flotation, and the laminar flow created in the molten metal exiting the filter reduces metal reoxidation and the formation of internal inclusions. The KALPUR unit also provides a large pouring target, reducing the need to throttle bottom pour ladles, another cause of re-oxidation.

The elimination of the gating system prevents eroded sand and wash from entering the casting, and the calm, reduced-velocity flow within the casting cavity minimizes inclusions caused by impingement of turbulent metal on mold walls or cores.

Superheat is preserved, and faster metal rise rates and pour times are possible because of a larger metal entry area. These features lead to reduced thermal gradients, elimination of cold- metal defects, improved surface finish, improved surface details and better control of feeding.

Yield/economic improvements.

KALPUR filtration permits near-net-shape castings (lower machining allowance) to be produced, saving both metal and time.

Gating elimination reduces total pour weight, increasing yield and the number of molds that can be poured from a single heat. Also, with no gating, cleaning room time is reduced.

Grinding and welding repair are reduced on castings that are acceptable with such repairs. Internal and external scrap is reduced, along with the cost of returns and reprocessing.

A faster pour rate, made possible by the larger pouring target and increased entryway into the casting cavity, simplifies maintaining a constant metal head and can reduce pouring times.

The simplified pattern requires less time to produce and occupies less pattern plate area. This may accommodate another casting on the pattern plate or the use of a smaller mold box with less sand.

Use of the insulated direct pour sleeve as a riser reduces the size of the feeder (compared to a sand riser), further improving casting yield.

Selecting the proper size and positioning the KALPUR unit

The size of the unit for a given casting is determined by the type of metal, the casting weight, and foundry practice. Metal temperature, ladle practice (bottom versus lip pour), melting practice (cleanliness), metal deoxidation, and steel composition all determine the amount of metal that can be poured before filter blockage that would prevent proper pouring or adequate feeding after the mold is filled.

Capacities range up to 850 pounds of carbon steel and up to 1,400 pounds of stainless steel per unit when using lip pour ladle practice. Capacities can double with the cleaner metal normally produced by bottom pour ladle practice. Multiple units connected by a pouring box may be used for larger castings. Also, several units can be used in multiple-casting molds and poured consecutively.

Castings can be successfully poured at the same temperatures commonly used with conventional gating. When the KALPUR unit is used within the recommended pouring range, the filter does not affect the unit's function as a riser. In most applications, the unit will provide feed performance equal to an insulating sleeve of similar size.

To select the proper KALPUR *For steel* unit for a given application, two criteria must be met: feeding capacity and filtration performance. First, one must determine which unit sleeve is large enough to satisfy the feeding requirement. Next, the filter in that unit must be evaluated for filtration capacity and flow rate. If the filtration capacity or flow rate is inadequate for the mold weight, cleanliness of the metal, or maximum pour time, a bigger KALPUR unit having a larger filter should be selected.

The KALPUR unit is rammed into position. It should be placed as close to the casting as possible and ideally should be located no more than six inches above the impact area.

Compare the quality improvements and total cost of direct pouring using the KALPUR unit to conventional gating. It will be found that the KALPUR *For Steel* direct pouring system is the clear choice for producing clean critical castings.

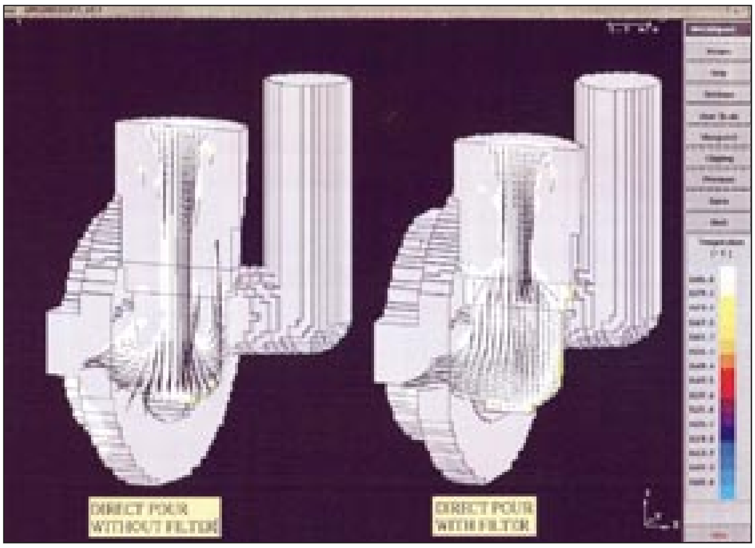


Fig. 4 Velocity vectors beneath the KALPUR unit illustrate the effect of the filter on metal flow as it enters the casting. The left-hand image shows the turbulence that results when no filter is used and the metal impacts directly on the casting wall. The right-hand image shows the calming effect of the filter as the metal passes through it.

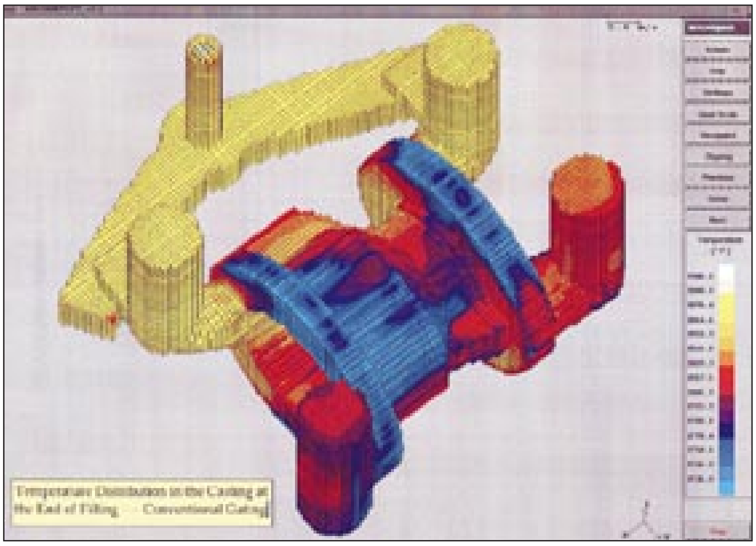


Fig. 5 Temperature distribution within a valve casting immediately after filling through conventional gating shows that large areas are much colder than the last metal poured.

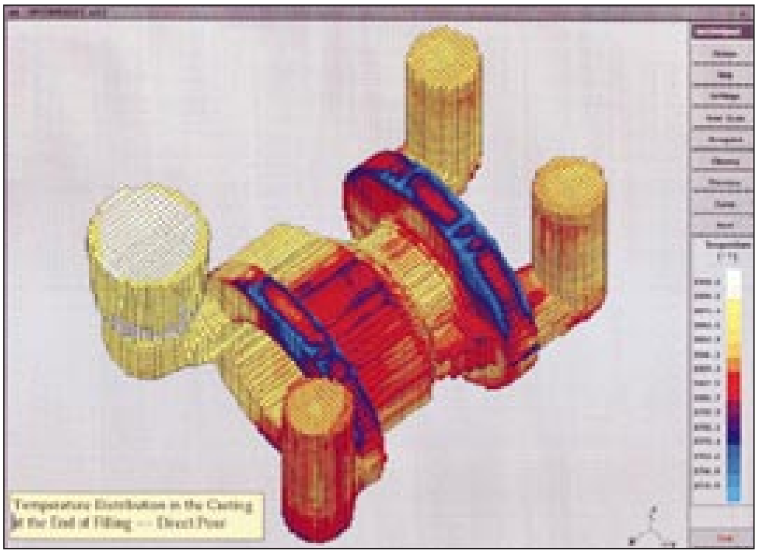


Fig. 6 Temperature distribution within a valve casting immediately after filling through a KALPUR unit shows higher overall temperatures, illustrating reduced heat loss when direct pour units are used.