

CAST IRON RISER DESIGN



DAVID C. SCHMIDT
Vice President
Finite Solutions, Inc.



ARTICLE TAKEAWAYS:

- Risers are designed to feed initial metal shrinkage
- Gates and contacts should freeze off as graphite expansion begins
- One riser per feeding zone – too many risers cause shrinkage in graphitic irons

A fundamental difference between gray and ductile cast iron and other alloys is the expansion that occurs as graphite precipitates during solidification. In most situations, the casting can become “self-feeding” after the onset of expansion and no further risering is required. Risering is designed to provide feed metal for the contraction of the liquid metal and the solidifying iron prior to the start of expansion. Once the expansion begins, the risering system should contain the expansion pressure to ensure that the casting is self-feeding for the rest of solidification. This differs from shrinking alloys such as steel, where feed metal must be supplied to the casting during the entire solidification process.

Another major difference between graphitic cast irons and other alloys has to do with the mechanism involved in “piping”, or the onset of feeding behavior in the riser. In practice, only one riser should be used on each “feeding zone” in an iron casting; if multiple risers are placed on the same zone then typically one riser will begin piping while the other will not. Often, porosity is seen at the contact point of non-piping riser(s).

One riser per feeding zone is probably the design rule most often violated in iron foundries. We see designs where two or more risers are attached to the same feeding zone, resulting in casting porosity. The tendency of many foundry engineers is to add more risers to try and resolve the porosity issue; this is exactly the wrong approach and will worsen the situation.

To correctly design a risering system, we need to determine the location and size of feeding zones. Feeding zones are defined by knowing it is possible for liquid metal to flow from one point to another in response to expansion pressures. If there is no possibility of metal flowing from one area of the casting to another as expansion begins, then each area forms a separate feeding zone and will require its own correctly-designed riser (but no more than one).

Casting analysis begins with calculation of the Casting Modulus(Mc). This is the volume:surface area ratio of each part of the casting and has been used for many years to estimate the order of solidification through the casting. In steel castings, this information is immediately useful to show where risers should be placed and what size they should be (the Modulus of the riser should be greater than the Modulus of the casting). In iron castings, the Mc is used to estimate when expansion will begin, expressed as a percentage of complete solidification.

Prior to computers, calculation of Mc was time-consuming; you had to estimate volumes and surface areas by approximating parts of the casting with simple shapes. With modern casting simulation software, solidification of an unriggered casting can be predicted in a matter of minutes. Data from this simulation can be converted to Mc values throughout the casting. This data is more accurate than the V/SA calculation, as effects such as local superheating of the mold material are taken into account by the simulation, which was not possible with manual methods.

With the Mc data for the casting, along with chemistry and temperature data, the point of expansion onset can be calculated. Heavy section castings will begin to expand earlier and will undergo

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more expansion than castings with light sections. This transition point is expressed as a percentage of full solidification time and is called the Shrinkage Time (ST) point.

The ST point can be converted to an equivalent Modulus known as the Transfer Modulus (MTR), and it defines the areas of the casting where liquid metal transfer is possible. The calculation of MTR is as follows:

$$\text{MTR} = \text{SQR} (\text{ST}/100) * \text{Mc}$$

By plotting the Transfer Modulus we can visualize the feeding zone(s) in the casting. We can determine the number of required risers, using the rule of one riser per zone.

MTR is the point at which feeding of the casting from risers is no longer needed as the iron becomes self-feeding due to graphite expansion. This is critical in designing the risering system since expansion pressure must be controlled. Assuming the mold is rigid enough, all contacts with the casting (gates and riser contacts) must be solid enough to ensure that the expansion pressure is contained in the casting after the onset of graphite expansion. This leads to another simple rule: The Modulus of the feeder contact neck should be equal to MTR. This ensures that feeding of liquid contraction will occur, and that the expansion pressure will be contained in the casting due to freezing of the feeder contact at just the right time during solidification.

CASE STUDY

As an example of both the incorrect and correct approach to feeding cast irons, we examine a 3070 Kg gray iron casting, shown in **Figure 1**.

The foundry making this casting approached riser design as a steel casting rather than an iron casting. **Figure 2** shows the test casting, which was the 7th trial. Every area with chalk showed shrinkage, which was pervasive in the casting, even with 36 risers.

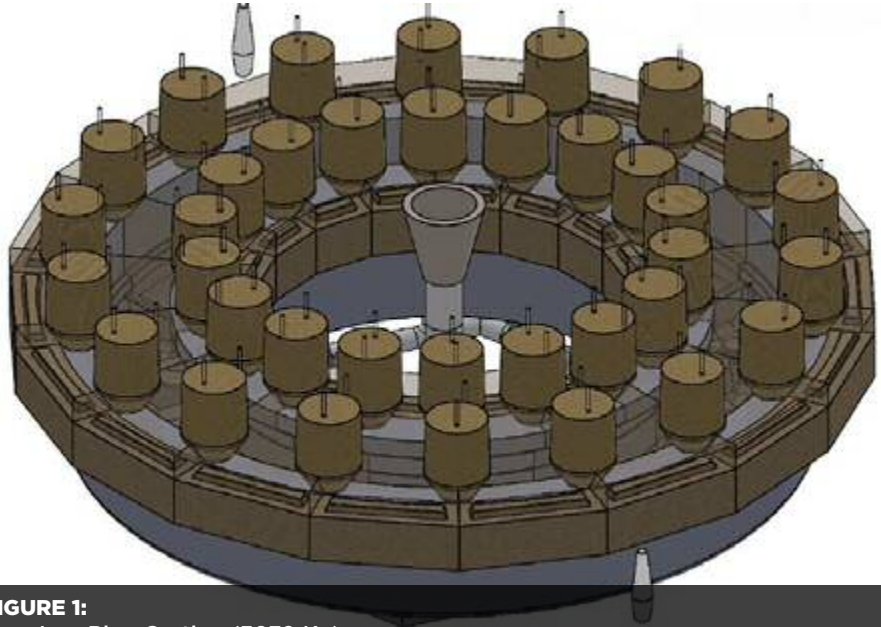


FIGURE 1:
Gray Iron Ring Casting (3070 Kg)

This is typical of the approach to design and problem solving that one might find in a steel foundry; if a casting cannot be successfully produced with a given set of risers, the typical decision is to add more risers. This approach did not resolve the problem, instead the quality of the casting was worse.



FIGURE 2:
7th design with 36 risers still shows extensive shrinkage



FIGURE 3:
Plot of MTR at a value of 1.7cm

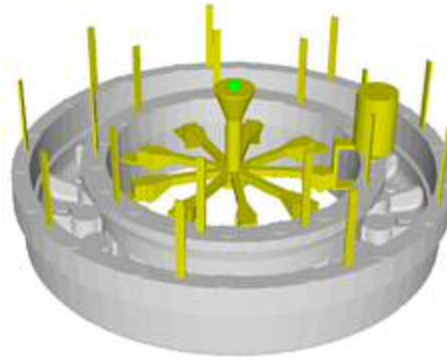


FIGURE 4:
Single riser design. Casting Model (left), Shop Floor (right)

A very strong clue to the cause of this porosity is that these defective areas were found at the location of the risers on top of the casting (which were removed after casting shakeout). This suggests the phenomenon which has been discussed earlier in this paper, that multiple risers are being used on a single common feed zone and only one riser is showing piping behavior with shrinkage formation under the non-piping risers.

An analysis of this casting was performed, involving a solidification simulation and calculation of the MTR. The value of MTR was determined to be 1.7 cm. A plot of MTR in the casting is seen in **Figure 3**.

This image shows very clearly that the entire casting consists of a single feed zone, and that only a single riser should be used on this casting. The final rigging design is shown in **Figure 4**, both as a CAD model and the test casting after shakeout.

When this design was adopted in the foundry and the riser and contact were sized correctly, the result was a shrinkage-free casting, while dramatically increasing process yield by reducing the number of risers from 36 to 1! See **Figure 5**.

The analysis of this casting to produce the correct riser design required 15 minutes of time. The foundry could have saved considerable costs over a long period of time had they performed this quick and simple analysis before finalizing the production design for the casting.



FIGURE 5:
Totally sound casting, including test bore

SUMMARY

Understanding the solidification mechanisms of graphitic iron alloys in terms of expansion/contraction behavior, feeding mechanisms and control of expansion pressure is critical to correct design of risering systems. Quick and simple analysis is available which will help the foundry engineer to design the production process correctly at the beginning of production, thereby avoiding major costs involved in producing defective castings.



Contact:
DAVID C. SCHMIDT
dave@finitesolutions.com

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