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Use of Large Mini-Risers for Yield Increase and Cost Savings

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ABSTRACT

The use of insulating or exothermic riser sleeves over natural risers has been established as good foundry practice as a source of extra metal to combat metal shrink defects and improve casting yield. Mini-risers have been developed to further increase the yield and reduce casting contact. Mini-risers were typically limited in size to displace risers under 6 inches in width. A new subset of XL “mini-risers” have been developed to reduce large riser size by up to 50% . Significant weight can be removed from the riser portion of ductile iron and steel castings. Made via a cold box resin process, they have high dimensional accuracy with exceptional breakdown during shakeout. This paper reviews the methodology and offers examples of casting improvement/cost savings with XL technology.

Keywords: risers, mini-risers, exothermic, sleeves, yield improvement, cost in use, iron, steel

INTRODUCTION

Risers are necessary to feed relatively heavy sections of a casting to account for the liquid contraction of the metal as it cools. Nonferrous and ferrous alloys have different levels of contraction thus affecting how much demand will be placed on a riser. The risers feed metal into the casting after pouring to ensure the casting does not have shrink voids. The size of the riser is typically based on the modulus of the area that needs the feed metal. Modulus is defined as the volume of the casting divided by the surface area of the casting. The modulus of the feeder is typically at least 20% greater than the modulus of the area of the casting to be fed.
The first risers used were natural/sand risers. Natural risers are made during the molding process with a mandrel on the pattern to create a void in the sand over the area that needs to be fed with metal during solidification.

Later, riser sleeves using fiber formulations(insulating or exothermic), sand exothermic, and lightweight insulating material risers (insulating or exothermic) were developed to help reduce the size of the riser. The riser to casting ratio of 1.2:1, riser to casting was still important but these other formulations can use a smaller riser because of their ability to keep metal in a liquid state for a longer period of time. This is referred to as an effective modulus. An extension factor is applied to a material which is then multiplied by the geometric modulus of the shape. These riser sleeves formulations could reduce the size of a riser by 10–20% when compared to a natural riser.

For decades, the shape of risers was cylindrical, cylindrical with a tapered end to contact the casting (neckdown), or a truncated cone. For the open type risers, both cylindrical and neckdown, hot toppings, cover lids, and floating cover lids have been used with success to ensure maximum performance of these risers. In recent times, metalcasters are putting greater emphasis on throughput, casting yield, and reduction of time in the cleaning room. With regard to riser sleeves, this meant a new type of riser needed to be developed, particularly for larger castings with large risers which have relatively large casting contacts.

THEORY OF MINI-RISERS AND TESTING METHODOLOGY

Like the insulation in the walls of a building, the thickness and quality of the insulation will determine the dissipation of heat from the metal in a riser. Exothermic, thermite-based, packages aid the effectiveness of a riser sleeve as well. A hotter exothermic package can help prevent skinning over while keeping in mind for ductile castings that excess exothermic material can cause flake graphite.[1] By this same line of thinking, increasing the wall thickness of a riser sleeve will increase the sleeve’s ability to keep metal liquid. In terms of casting mathematics, the multiplier to determine the effective feeding modulus is then increased. For example, if an exothermic cylindrical sleeve has a modulus extension factor of 1.5, a mini-riser with 2–3 times the sleeve wall thickness might have an extension factor of 2.2.

Referring to the 1.2:1, riser to casting modulus ratio, the focus was placed on creating riser sleeve sizes that have an effective modulus sufficient to displace larger risers on castings. These XL mini-risers were primarily developed to displace risers with a 6 in. (152.4 mm) internal diameter and larger. In doing so, the internal shape or volume, as it were, of the riser sleeve could be reduced by 50% compared to traditional riser sleeve shapes. Verification of the effective feeding modulus was confirmed by thermocouple testing of various shapes and formulations on shrink cube test castings.

Practical experiments of the final riser designs have been conducted at several foundries. The riser selection methodology focused on effective modulus first compared to casting needs. Riser volume could be reduced by at least 50% if the original casting design with traditional risers had not been optimized. In the cases where available tooling where the XL mini-riser selection fell between two sizes based on the feed requirements of the casting, the larger XL mini-riser was selected. In order to avoid alloy segregation in steel castings[2] and to mitigate the effects of variations in pouring temperature with any alloy, the user should strive for a 30% safety margin in the riser. Meaning, the lowest point of shrink in the riser as it relates to the casting surface should be no lower than 30% of the original riser height relative to the casting surface.

IN PRACTICE

"Foundry A" produces a 1474 lb. net weight manganese steel rotor casting. It was rigged using six 10" x 12" (254 mm x 304.8 mm) fiber insulating sleeves. The castings were sound with each riser weighing 305 lb (138.6 kg). There was also evidence of decent riser efficiency (Figure 1). Based on riser weight alone(1830 lb; 832 kg), the rotor casting had a 44.5% yield.

Figure 1. Six (10 in. x 12 in.) risers are shown as cast. (Artwork courtesy of Ebacero Foundry.)

After a modulus review of the casting, 4.2 cm (1.65 in.) it was determined that a modulus of at least 2.0 in. (5.08 cm) is necessary to feed the casting. The six (10 in. x 12 in.) risers were replaced by XL 2565 (ml) riser sleeves. XL 2565 risers have an effective modulus of 5.2 cm (2.04 in.). The metal in these risers weighs 45.3 lb (20.5 kg) when the riser is full. The casting yield would increase to 84% (Figure 2). Sound castings were made. The 40% yield reduction would also allow the foundry to pour one extra casting out of every heat.

Figure 2. Six XL 2565 mini-risers on the rotor casting are shown. (Artwork courtesy of Ebacero Foundry.)

In addition to the 40% increase in yield and production increase, the riser casting contact shrunk from 10 in. to 4.3 in. This represented a 50% time savings for riser removal in the cleaning room.

"Foundry B" produces a 6400 lb class 40 gray iron casting with a modulus of 3.954 inches(10 cm). The casting was fed effectively with a 16 x 8 x 30 in. (40.6 x 20.3 x 76.2 cm) fiber exothermic riser fitted with a breaker core made from chromite sand. The opening of the breaker core was 5.6 in. (14.22 cm). The riser weight was ~1275 lb (580 kg). The foundry attributes the burn-in sand on the casting to the excess heat and solidification time from the large neckdown riser (Figure 3). Riser removal time was not an issue for the foundry, but excessive time was being spent removing the burn in sand before the casting could be sent for machining.

Figure 3. The casting with a large neck riser as cast showing burn-in from excess heat from the riser. (Artwork courtesy of The C.A. Lawton Co.)

Both a XL 18000(ml) and a XL 26000(ml) mini-riser were proposed to reduce riser size and potentially combat the burn in sand defect. The effective modulus of these risers is 4.73 in. (12 cm) and 5.73 in. (14.55 cm), respectively. Foundry B used the same 5.6 in. (14.22 cm) chromite breaker core above as part of the simulation model to reduce casting contact. In simulation, the XL 18000 showed some minor porosity just below the feeder in the casting. The riser being 1.19 times the casting modulus, just short of our theorized best ratio (1.2:1). The porosity simulation of XL 26000 against the incumbent (Figure 4) showed porosity only in the riser and above the breaker core area. The riser to casting modulus ratio was 1.44:1.

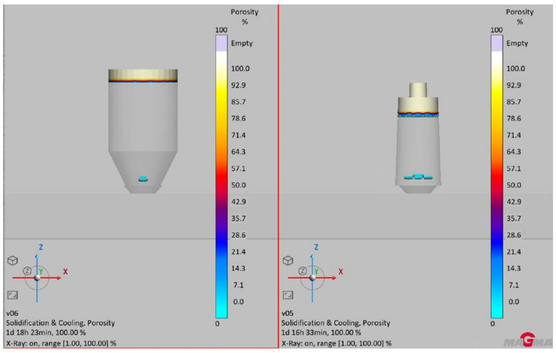

Figure 4. Prediction of casting porosity fiber – fiber exothermic riser (left) vs. exothermic XL 26000 mini-riser (right). (Artwork courtesy of The C.A. Lawton Co.)

Another simulation area that was reviewed was the hot spot created by the riser. The XL 26000 riser contains 800 pounds less feed metal when full. Which means the riser and casting solidified two hours sooner based on simulation data. The predicted hotspot for the XL 26000 riser was smaller at the time of solidification (Figure 5). In theory, this would help lessen the burn in sand issue the foundry was contending with in the cleaning room.

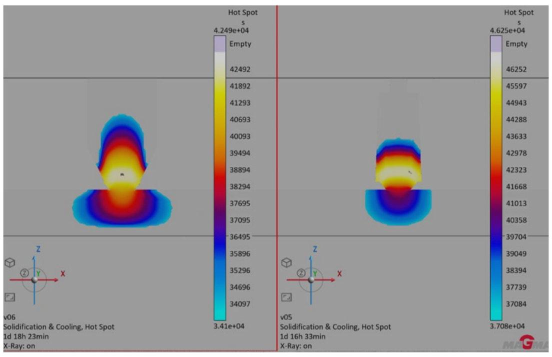

Figure 5. This is the MAGMA hotspot prediction showing a fiber exothermic riser (left) vs. an exothermic XL 26000 mini-riser (right). (Artwork courtesy of The C.A. Lawton Co.)

Following the simulation proof of concept, the foundry placed a XL 26000 mini-riser on a casting with the same breaker core set up as above. The casting was sound with minimal burn in near the riser neck. Figure 6 shows the riser removed from the casting. The flashing around the bottom of the riser is the burn in/burn on sand. The time in the cleaning room related to the riser was reduced by 75%.

Total poured weight was reduced by approximately 800 lb. (364 kg) per casting. The burn-in reduction resulted in three fewer hours per casting in the cleaning room.

Figure 6. The resulting XL 26000 riser after removal from the casting which shows comparatively minimal burn in under the riser. (Artwork courtesy of The C.A. Lawton Co.)

CONCLUSION

Advancements in riser shapes and materials over time have led to casting improvements over natural risers. Evaluation of riser size to improve casting yield, with improved knock off potential in the cleaning room, is a worthwhile exercise for any foundry.

Use of XL mini-risers can lead to large casting yield improvements. The methodology for implementing XL mini-risers in the foundry can vary. But the user should ensure the modulus of the proposed riser is at least 20% greater than the modulus of the area of the casting to fed by the riser. Simulation software tools can be used to give a high degree of confidence before a casting is poured. Or published manufacturers' data for sleeves can be relied upon to change casting rigging to these highly efficient risers. The XL mini-risers can help reduce the size of a riser by 50% or more. Time in the cleaning room can be saved in significant amounts.

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