Navigating the Ripples of Flow Coating

Two steel foundries detail the changes they made in equipment and coatings to implement this refractory coating technique.

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Coating spray nozzle clogged up? Having trouble keeping refractory coatings even on your molds? Looking for a way to spruce up a casting's finish?

Flow coating can solve all the various problems associated with other coating techniques such as spraying, dipping or brushing. Besides producing a higher quality finish than spraying, flow coating also can minimize casting cleaning costs due to burn-on and burn-in defects.

While flow coating can eliminate many problems a foundry may experience, it also poses challenges. Like any other coating method, flow coating has its benefits and drawbacks.

Southwest Steel Casting Co., (SWSCC), Longview, Texas, and West Michigan Steel (WMS) Foundry, Muskegon, Michigan, learned that first-hand when they decided to eliminate their green sand operations and expand their nobake lines.

Since flow coating is used in conjunction with nobake molding, the molding line change prompted the foundries to consider the refractory application technique as a way to further automate their operations. In this article, the two foundries describe what they had to do to implement the flow coating method and compensate for its disadvantages.

Flow Coating

Flow coating offers the benefits of both spraying and dipping coating techniques—mechanized methods that provide a uniform refractory coat on molds and cores. For flow coating to be effective, it must create a surface and sub-surface coating. Surface coating provides a barrier to the metal and improves surface finish. The sub-surface coating penetrates the surface of a mold or core to fill the voids between the sand grains. This lessens the possibility of metal penetration and veining. Flow coating also allows enough coating to gel to the mold/core surface while any excess drains off. Part of this is accomplished through the composition of the refractory wash.

The coating (or wash) consists of two parts: a refractory material (usually zircon in the steel foundry industry) and a carrier, which is the liquid media used to apply the refractory, bond it to the mold and preserve the wash itself. SWSCC and WMS use water and alcohol-based carriers.

The basic equipment for flow coating includes:

- *a tank or reservoir*—to hold, mix and dispense the coating. Usually it consists of an air-driven mixer coupled with a diaphragm-type pump;
- *automated mold-handling equipment*—like overhead hoists and mold manipulators to move the mold to and from the operator. The operator can manually manipulate the mold to some degree to coat the appropriate areas;
- *an application wand*—it allows the operator to apply the coating;
- *a drying unit or areas*—where the coating's carrier can be burned off or the coating can air dry;
- *re-circulation pumps and a reclamation basin*—to catch the excess coating as it flows off and return it into the mixing/dispensing unit;
- *filters/screens*—to prevent contaminants like sand from mixing in with the coating during reclamation.
- *testing equipment*—to maintain the quality of the coating. The two basic pieces of testing equipment are a mud balance to measure the specific gravity of the coating and an adaptive pressure iteration funnel to measure the coating's viscosity.

Flow coating is a method of applying a refractory coating that can be described as "wetting the mold with a garden hose at low pressure." With the flow coating method, the mold/core is maneuvered so it is at an angle in front of the operator. Even under low pressure, the coating can penetrate the sand and let the excess run-off.

Experimentation Leads to Smooth Transition

SWSCC is a medium-sized jobbing foundry that pours castings from 1-700 lb. Mold sizes range from 24 x 6 x 6 to 48 x 18 x 18 in. with a production rate of 30/hr. SWSCC's decision to switch from spraying to flow coating coincided with its plan to eliminate green sand molding operations.

Before installation, SWSCC built an experimental flow coating station, separate from the molding line, to test equipment and coating mixtures. Because the spray process ran simultaneously with flow coating testing, downtime was virtually nonexistent when the switch was made.

The flow coating station required 450 sq ft. The flow coating station was incorporated into the nobake molding line with the rollover machine (Fig.1) already installed. Molding lines were rearranged minimally.

As for training, the operator required little. Training stressed that the operator might have to manipulate the mold several ways to ensure coating of all exposed areas. Ensuring proper coverage is simple because the coating used by SWSCC is pink and any missed areas are obvious on a brown/black mold.

SWSCC continued to use the

same zirconium silicate wash, as with the spray process, only the baumé was different. The wash is mixed with an isopropyl alcohol carrier to reduce viscosity until a range of 46-49 baumé is reached.

During experimentation, SWSCC encountered three concerns. First, flow coating proved to be slower than spray coating, dropping mold production by 25%. Also, compared to spray coating, wash consumption increased by 38% and alcohol consumption increased by 63% in average gal/day. To maintain a production rate of 30 molds/hr, a second flow coating station was added to the mold finishing line.

The additional wash/alcohol cost dropped slightly as the operator became more proficient in flow coating. But the additional cost was offset primarily by a reduction in scrap (16.76%).

Although not all of the reduction was attributed to flow coating, the new process did significantly contribute. Since the excess refractory wash drained off of the mold, fewer incidents of wash build-up resulted. Reduced build-up meant reduced surface defects. At SWSCC, welding is performed to repair surface defects. With reduced surface defects, weld rod consumption lowered, as did the man-hours required to perform the task. Tied to that, the overall reduction of rework resulted in a cost savings.

The greatest benefit in switching to flow coating that SWSCC experienced has been in customer satisfaction. More on-time deliveries were achieved with the reduced lead-time and rework. The faster cleaning room processes allowed for better response for "rush" orders. The better-looking as-cast surface finish (Fig. 2) also met or exceeded customer expectation.

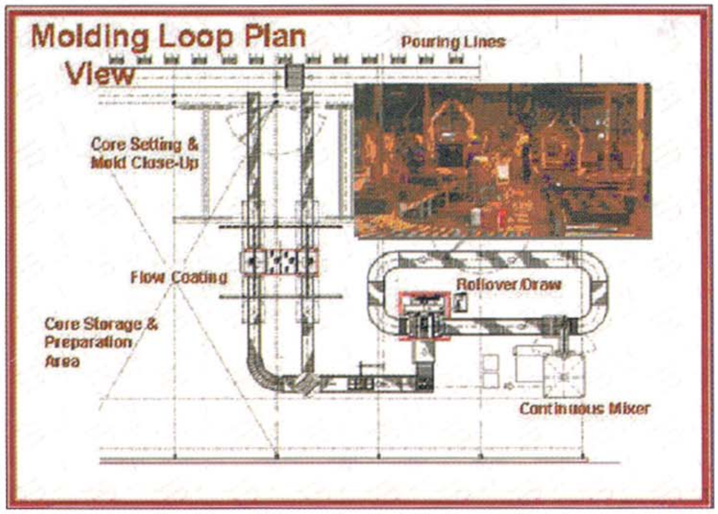

Fig. 1. This is Southwest Steel Casting Co.'s molding loop plan that incorporated a flow coating station. No extra space was needed and minimal changes in the molding line direction were made to accommodate the new coating station.

Equipment and Coating Changes

WMS is a jobbing steel foundry that produces castings up to 3000 lb, with the average casting weighing 22 lb. When WMS decided to eliminate its green sand operation, it bought a new nobake molding system that could produce 42 x 42-in. molds with a maximum cope/drag height of 17 in. at 30 molds/hr. To meet the productivity requirement, each mold half would need to be handled and coated in less than 1 min. WMS's method of spray coating the mold and burning off the carrier proved to be too slow and inefficient to meet that type of production. Other problems like clogged spray nozzles, insufficient mold coverage and variations in coating by operators also prompted WMS to explore flow coating.

Initially, the equipment specified for the flow coating operation included two infrared ovens with a slat conveyor, a hydraulic flow coating mold manipulator and a flow coat station to catch, mix and dispense the coating. The equipment required 320 sq ft.

As with SWSCC, the space needed for the flow coating station became available when the automated nobake molding line was installed.

At a very early point of production, two issues needed to be addressed: the inability of the infrared ovens to dry the coating to keep up with mold production and the refractory wash contamination by loose sand in the tank during mold manipulation.

Initially, the coating required 1 min to drain off the mold and needed 7-8 min in the oven to dry properly. To reduce downtime, the short-term solution to the first problem was to switch to an alcohol-based coating until the drying issues could be resolved. Eventually, a gas-fired oven was installed in place of the first core setting belt adding an additional 140 sq. ft. At full production speed, this would allow a coated mold to spend 1 min in the infrared drying oven and 4 min in the gas-fired oven for the coat to dry. This provided sufficient drying time.

The contamination issue stemmed from an open flow coating tank that exposed a large surface of the wash, allowing contamination of the wash and unacceptable levels of the carrier evaporation. To eliminate these problems, a second enclosed mixing and dispensing tank had to be purchased and installed. The original tank then was used to collect run-off. The excess coating was pumped into the second enclosed unit. An Y-shaped strainer was installed between the two tanks to filter contaminants with an automatic compressed air blowing station incorporated to remove any loose sand that remained as the molds were stripped.

Another problem arose during trials with the gas-fired oven and water-based coatings, initiating yet another change. The gas-fired oven dried the coating, but the surface finish was unacceptable. The resin system for molding was changed several times to improve surface finish. WMS continued to use phenolic urethane, but changed its formulation.

The foundry began testing to develop a coating to meet quality and productivity expectations. In order for flow coating to provide the most flexibility and productivity, molds were required to be poured as early as 15 min after stripping. The key to affect changes was the reaction between the original coating and the resin solvents. After several trials, WMS found a supplier who could formulate a water-based coating specifically to its requirements.

With the correct formula, the mold could be

Fig. 2. Flow coating results in a smoother looking surface finish as shown on this as-cast steel casting (l) as compared to the casting (r) that was spray coated. Flow coating also eliminates burn-in and burn-on sand defects, which in turn reduces machining costs.

coated and drained in less than one min without additional operations like brushing or swabbing. The coating would gel quickly, provide adequate sub-surface penetration, dry sufficiently in the ovens during the necessary timeframe and leave a surface finish equal or superior to that of the alcohol-based coating.

As a result, WMS can handle and coat each mold half in less than 1 min. A second unit produces smaller molds of 60 molds/hr. Molds on this unit are coated with the alcohol-based coating at a rate of one mold half/30 sec. WMS plans to convert the second unit to a water-based coating.

In addition, WMS replaced its manual silicate and oil sand cores with two PC-controlled, automatic, phenolic urethane amine coldbox machines. These cores are either flow coated or dipped, with the majority being flow coated.

WMS found that an effective flow coating application improves the dimensional accuracy of castings to meet customer demand. Flow coating reduces the void between sand grains by 28%. This also reduces the size of the pores by a factor of 20. In addition to improving the as-cast finish of a casting, closer dimensional accuracy can be achieved because flow coating produces a subsurface deposit (0.040-0.060 in.) that can replace a thicker surface coating.

West Michigan Steel Offers Tips for Flow Coating

- Coating is most effective on a warm mold surface.
- Coatings should be applied from mold/core top to bottom.
- Deep pockets such as flanges should be perpendicular to the container that collects the excess coating.
- Testing must be performed with suppliers to develop a coating to best fit a foundry's production requirements.
- The coating application must fall within the requirements of the existing or planned molding system. It must not dictate mold/core productivity. ▼

Beyond the Case Studies

Both foundries used what is considered manual means for the flow coating process, but a completely mechanical alternative exists. In mechanical flow coating, a mold or core is fed by a motor-driven supply system, like a conveyor belt, through an enclosed flow coating station. The coating is gravity fed or applied through a pump.

The advantage of a mechanized unit is reduced labor costs. The disadvantage is that a malfunction may not be immediately detected.

Also, flow coating is not limited to steel. It may be applied with any metal that uses a nobake molding system and is in need of uniform coating to reduce burn-in/burn-on defects. The foundry must decide if the required changes are worth the cost/effort.

The drying process can be air dry for chlorinated or flammable solvents; light-off (the burning off of a carrier) for flammable solvents; torch (usually) for water-based coatings; or oven dry whether it be microwave, radiant/infrared and/or gas-fired, fan-forced air heat. ▼

This article was adapted from two papers presented at the 1999 Steel Founders' Society of America T&O Conference.

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For More Information

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"Flow Coating: The Process and Its Control," J.P. Dietl and S.J. Wilson, pp. 337-340, AFS Transactions, Vol. 102, American Foundry Society, Des Plaines, IL (1994).

Survey Shows Popularity of Coating Techniques

The National T&O Committee of the Steel Founders' Society of America surveyed the steel foundry industry in 1999 to determine how often refractory coating is used and which coating methods were used.

Of the 21 foundries that responded, those that used a nobake system applied wash. On the other hand, half of those that used green sand or shell never applied wash.

According to the survey, the method for applying the coating varied greatly with no relationship to the mold/core system. Spraying (air), dipping and brushing were used approximately twice as much for the first coat as compared to spraying (airless), swabbing and flow coating (Fig. 3). Additional coats typically are applied by brushing.

The majority of the foundries either applied one or two coats. Only four foundries applied three coats and no foundries apply more than that.

Other results gathered from the survey showed that:
- nobake mold/core systems had the highest use of wash;
- zircon was the most popular type of wash;
- water was the most common carrier for zircon;
- gas flame was used most commonly to dry the coating. ▼

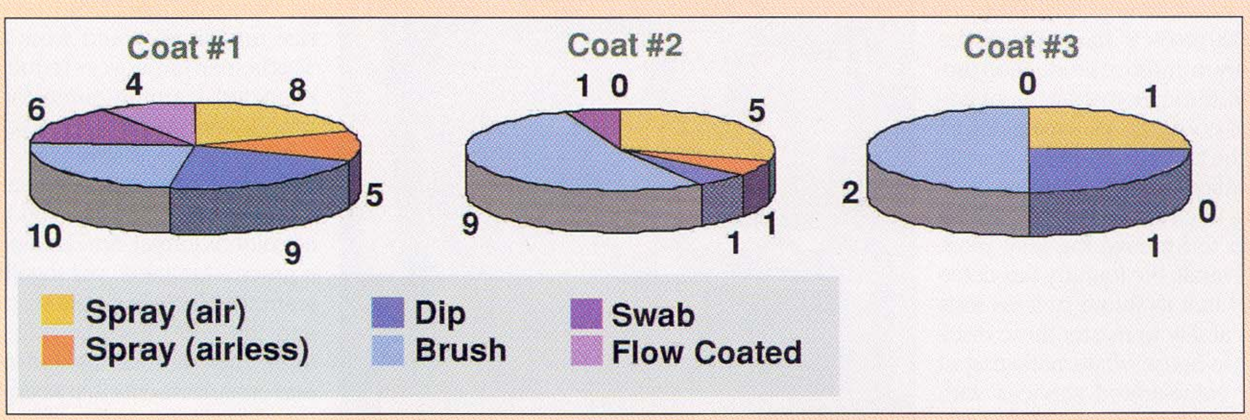

Fig. 3. Although no reason was given—the 1999 survey showed that steel foundries preferred brushing and spraying refractory coatings onto molds. These pie charts show that flow coating was the least likely to be used for the first coating application. For subsequent coatings, flow coating was not used at all.