

# Controlling Hot Sand to Ensure Mold, Casting Quality

*Understanding the effects of hot sand and utilizing the proper techniques to eliminate it are critical to producing consistent molding sand and defect-free components.*

*Scott M. Strobl and David V. Silsby  
Simpson Technologies Corp., Aurora, Illinois*

**H**ot molding sand has been described as the number one sand-related problem facing today's green sand metalcaster. Most foundries can show a direct relationship between hot sand and reduced casting quality. In fact, studies have shown that hot sand affects virtually every major operation within the foundry production line if not properly handled.

This article takes a look at what constitutes hot molding sand and describes the quality and production problems that can be encountered when molding with hot sand. In addition, techniques and key variables to consider in cooling hot sand will be explored along with the benefits derived by controlling sand temperature. The information presented in this article is a conglomeration of multiple technical studies on hot sand.

## What is Hot Sand?

Hot molding sand is defined as any high temperature sand that causes difficulties in sand preparation, molding and casting quality. Hot sand also can be described as one that requires additional raw materials to achieve usable molding properties. Specifically, a re-

turn sand with a temperature range of 120-160F (49-71C) is hot enough to demonstrate inconsistent mulling properties and control problems.

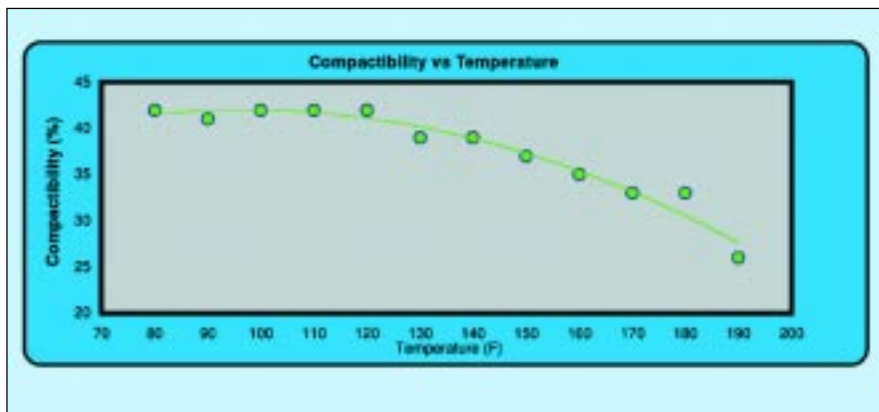
A study by A. Volkmar in 1979 indicates that temperatures above 120F result in a consistent loss of physical sand properties. In this study, a large sand sample was split into several sealable containers containing thermocouples, and, at various temperatures, the individual containers were quickly tested to ensure no heat loss. The study showed that a steady loss in compactibility occurred when sand temperatures exceeded 120F, however, there was virtually no change in compactibility between 80-120F (27-49C) (Fig. 1).

The 120F temperature figure was supported by another study, "The Problem of Hot Molding Sands" by J.S. Schumacher, which stated "sand over 160F (71C) does not mull to any consistency in physical properties, but sand below 120F develops uniformly when mulled. Between 120-160F, mulling produces sand that is inconsistent and difficult to control." The paper concluded that the best sand for molding was fully mulled, cool sand below 120F.

A series of technical articles titled "Why Does Hot Sand Cause Prob-

lems?" by J.S. Schumacher, R.A. Green, G.D. Hanson, D.A. Hentz and H.J. Schumacher evaluated the problems of hot sands using several unique laboratory testing techniques. First, laboratory evaluations of the viscosity of bentonite slurries were compared at various temperatures and times. The results indicated that bentonite disperses and gels differently in hot water than in cold water. The data also revealed an increase in viscosity as the temperature of the slurry was increased. It was hypothesized that when the slurry temperature was increased, the bentonite platelets arranged themselves edge-to-center, forming an open structure. This structure is vastly different than cold water slurry in which the bentonite platelets remained face-to-face, as the open structure at elevated temperatures results in several negative impacts on sand systems. Most importantly, water is held less efficiently by the bentonite resulting in a more rapid moisture loss and reduction in physical properties when compared to cool sand. According to the study, an interesting phenomenon could occur when using hot molding sands: "Pouring hot metal into a sand mold would yield a casting that could display those defects associated with a sand containing too high temper moisture. Pouring hot metal into a mold that is formed hot and allowed to cool would yield a casting that could display those defects associated with too low a temper water."

The second portion of this study evaluated the effect of sand temperature on the development of the sand's physical properties. A sand lab was enclosed in a temperature- and humidity-controlled chamber and sand tests were carried out at 70F (21C) and 140F (60C). When all other conditions besides sand temperature were held constant, the



*Fig. 1. This chart of compactibility vs. temperature indicates a steady loss in compactibility occurs with green sand with an increase in temperature above 120F (Volkmar 1979).*

results showed a considerable reduction of sand properties by the sand tested at 140F (Fig. 2).

As shown by these studies, the technical research and data collected to date clearly defines a threshold sand temperature for green sand molding of 120F. Sand temperatures entering a muller above 120F are considered hot molding sands.

### Hot Sand-Related Problems

Hot sand affects every aspect of a green sand molding operation and can result in higher scrap rates, increased consumption of bentonite and/or a complete loss of system control.

In terms of scrap, a wide variety of sand-related defects show a strong correlation to excessive sand temperature, including sand inclusions, rough surface finish, metal penetration, swells, sand erosion, gas-related pinholes, blows, stickers and broken molds. Many of these defects are caused by the tendency for rapid moisture loss on the mold surface.

In terms of sand system operation, hot molding sand has many adverse effects. Hot sand normally returns to the muller in a widely fluctuating temperature and moisture. A test conducted at an iron foundry indicated a temperature range of 90-380F in various locations within a batch hopper (Fig. 3). During sand preparation, this large variation in temperature causes the evaporation of various quantities of water. This variability makes accurate moisture additions and compactibility control at the muller difficult, if not impossible. The prepared sand's inconsistent discharge temperature will increase the batch-to-batch variation of the physical properties. Uncontrollable sand drying also is a concern when conveying hot prepared sand long distances to multiple molding machines.

The tendency for moisture condensation from hot sand onto cold surfaces also gives rise to several unique problems in and out of the sand system. First, there is a tendency for hot sand to stick to cooler hopper and bin walls and result in "bin funneling" or "rat holing" in which hot sand enters the top of the bin and passes directly through the center of the bin. This results in frequent usage of a smaller portion of the available system sand, which compounds to a rapid turnover rate of sand (due to less active sand in the system), increased sand temperatures and aggravated hot sand problems.

A second serious problem caused

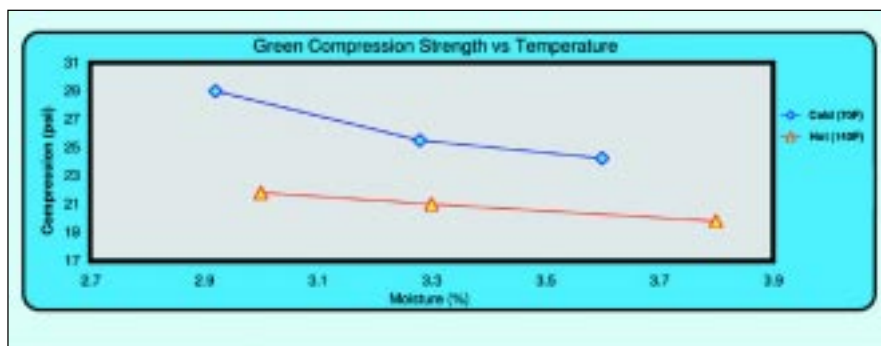


Fig. 2. This chart illustrates the decrease in green compression strength of hot molding sand vs. that of cold molding sand.

by moisture condensation is with cold cores placed in warm molds. The excessive moisture on the surface of the cores can result in weakened cores and casting defects such as gas-related blows and pinholes. Metalcasters also may encounter problems of prepared molding sands sticking to patterns due to condensation.

In general, hot sand problems only become worse due to the natural tendency for a reduction of usable sand capacity.

### Cooling Hot Green Sand

Maintaining a sand system involves the reduction of fluctuations and variations. This requires not only a balance of incoming and outgoing materials but also a balance of energy. Additions of new raw materials must be made to offset losses due to thermal destruction, dust collection, etc. The energy required to activate the clay in the muller also must be maintained. The heat energy induced by the solidification of the casting must be removed from the sand to allow it to remain constant and balanced.

Sand returning from shakeout will vary in consistency in terms of tempera-

ture, moisture, grain size, clay content and other critical physical properties. This inconsistency is a problem for sand preparation equipment, whether it has automatic or manual controls. Ideally, the sand cooling system should blend the erratic temperature swings and all other inconsistencies into a homogeneous sand mass. By employing the proper form of homogenization after

casting shakeout, the system sand (due to the averaging effect) would tend to gradually change over time rather than exhibiting sudden large violent swings. However, just adding water onto hot molding sand will not efficiently cool the sand and aid in

creating the homogenous mass. For efficient cooling to take place, the water must make contact with all sand grains for a critical amount of time and the steam generated from the conversion of water from liquid to gas must be removed. For these two reasons, the practice of adding water to sand on a belt conveyor does not effectively cool sand below 120F.

It is important to stress the fact that no evaporation will take place if the air

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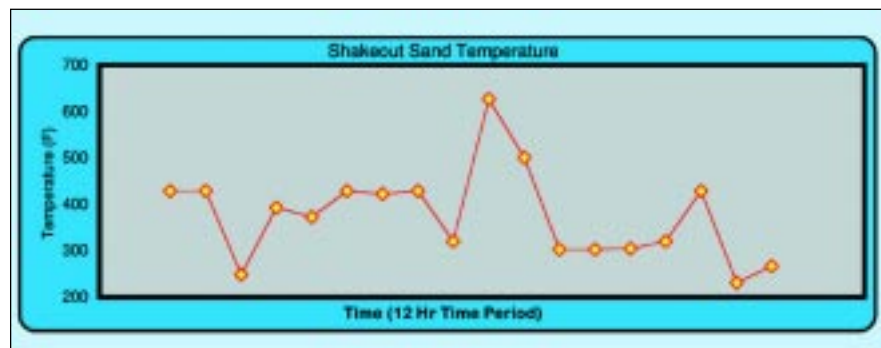


Fig. 3. This chart shows the variation in temperature of the shakeout sand for a large iron foundry. This wide fluctuation is almost impossible to control without mechanization to produce a homogenous molding sand.

surrounding the hot sand and water mixture is fully saturated with moisture. An influx of unsaturated air capable of absorbing moisture is required for a sand cooling system to effectively cool sand using evaporation. It is best to pass this unsaturated air through the sand mass since passing unsaturated air over the top of a moistened sand mass is ineffective.

Retention time within the cooling vessel is another important consideration regarding the cooling of molding sands. It is easy to cool sand to 212F (100C) through water vaporization, which occurs instantaneously if unsaturated air is available to remove the steam. To achieve sand temperatures below the 212F, the cooling time increases and this process is no longer instantaneous. An effective sand cooling system has an adequate supply of unsaturated air and enough retention

time within the cooling vessel to take full advantage of water vaporization and evaporation.

Water must be added to hot sand to have evaporation, but it must be controlled within a narrow working range. The quantity of water added should be adequate to facilitate cooling and maintain a tight control of the sand's discharge moisture. It is desirable to achieve discharge moisture as close to the molding percentage as possible. The ability of the sand cooling system and any other components after it to transport the moistened sand will determine the maximum discharge moisture percentage. In addition, when possible, it is beneficial to make a portion or all of the required bentonite addition at the sand cooling system. The benefits of adding water and bentonite at this stage increase the system efficiency due to the tempering effect in the sand silos.

Tight control of the discharge moisture from the system and effective homogenization of sand has an extremely positive effect on the consistency of the prepared sand delivered to the molding operation. Effective blending and control of both temperature and moisture of the shakeout sand prior to the muller also enhances the capability of online compactibility controllers. ▼

#### References—

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## Performance Gains Through Cooling Equipment

Whether a foundry operates a single shakeout or multiple shakeout lines feeding to a central storage point, the return sand naturally exhibits wide variations in return sand temperature and moisture. These wide swings in temperature are the result of changing sand-to-metal ratios, casting cooling times and poured vs. unpoured molds. These factors make return sand temperature inconsistent, unpredictable and difficult to control.

A properly designed, sized and installed sand cooling system will provide the foundry with an additional point of control in the sand preparation process. In a well-designed layout, the cooler becomes the initial point for correcting elevated sand temperatures and inconsistent moisture levels by cooling and blending the return sand prior to the muller. This approach to sand preparation allows the muller to perform its primary function of coating and activating clay onto sand grains. The result is a more consistent molding sand.

### Reducing Casting Defects

A reduction of sand-related scrap is one of the best measures of sand consistency. An example of this is a gray and ductile iron engine block and head foundry that was looking to improve sand consistency on one of its cope and drag lines. The molding line was utilizing 200 tons of sand/hr.

The foundry performed a study that tracked sand inclusion rates in its cast-

ings for the 9 months before and after the installation of a sand cooler. Over the course of this study, the equipment reduced sand inclusion scrap by 34.5% and reduced the scrap variation, significantly improving the foundry's productivity on the molding line.

A second example of a foundry improving productivity through sand cooling is a 100-employee gray iron foundry producing piston rings that was experiencing swell, inclusion and run-out defects in its castings. The foundry ran several stack molding lines using 100 tons of sand/hr.

To confirm the benefits of operating the molding system with cool sand, the foundry embarked on a series of casting trials utilizing specific jobs that exhibited unacceptable scrap rates. For a five-day period, 12,000 study castings were produced in the morning when the sand temperature measured less than 95F (35C). The same parts were poured in the afternoon after the sand increased in temperature and had stabilized between 130-140F (54-60C). The 24,000 study castings produced were evaluated after rough inspection and being processed through the cleaning room.

The study concluded that scrap was 2 times higher with the castings produced in hot sand. It appeared that more effective sand cooling could provide significant improvement in the plant's molding sand practice. The foundry installed a cooler and has seen a significant reduction in scrap, improving its bottom line.

### Increased Productivity

Beyond the reduction in casting defects associated with sand cooling, foundries have been able to increase muller capacity and reduce bentonite usage through the effective use of a sand cooling system. For a 125-employee ductile iron foundry in the Eastern U.S., these added benefits of sand cooling helped eliminate two problems.

The foundry had hot sand returning to the muller from shakeout and marginal muller production that wasn't meeting the capacity of its two vertically parted molding machines requiring approximately 100 tons of sand/hr. The foundry installed a sand cooler that incorporated pre-blending and a bentonite addition. After installation, however, the foundry eliminated the bentonite addition at the muller and began introducing it into the cooler beneath the bed of sand, leaving only trim water added at the muller to stabilize the final compactibility value.

The cooler solved the hot sand dilemma. After cooling, the sand, water and bentonite mixture is charged into a sand storage silo to allow time for the bentonite to temper prior to mulling. This tempering time (in addition to the cooling) has reduced the required mulling cycle by 20%. The ultimate results are an increased feed rate of sand to the molding line, increased molding capacity and elimination of the need to install additional mulling equipment. ▼