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# How to Improve Green Sands through More Effective Mulling

*Critical to proper sand preparation, mulling requires a careful understanding of the process' place in the entire sand system.*

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**P**roper mulling is fundamental to the success and profitability of a modern green sand metalcasting operation. Next to hot sand, inadequate mulling is one of the most common green sand problems in foundries.

Effective mulling can be defined as achieving the maximum amount of work on the sand during the time it stays in the machine. The muller's energy should be directed at homogenizing the sand and activating the clay, and shouldn't be hindered by factors that can be alleviated with proper maintenance—such as a dragging plow.

## Mulling Theory

The preparation of green molding sands involves homogenizing sand, water, clay and carbon to an average composition, and activating the clay.

The first step in mulling is to fully homogenize unlike particles. Ideally, molding sands discharged from a muller should have an equal composition. Commonly, sands that aren't fully mixed tend to form clusters of clay and moisture. Casting defects such as burn-on, burn-in, rough surface, porosity, blows and misruns are common when water isn't properly distributed.

As mulling proceeds and the sand mixture becomes uniform, clay activation begins. Without water, clay/sand mixtures can't achieve measurable strengths. When water combines with clay, the formulation develops a strong attraction to each other and sand grains. This electrochemical combination of water and clay is often referred to as activation.

While clay activation requires energy and time, higher activation results in greater molding sand strengths. For each type of machine,

sand, clay, sand mixture and mixing procedure, there is a mulling time that results in an adequate input of mulling energy. Generally, the development of green compressive strength at equal sand compositions is significant of high clay activation.

## Mulling Methods

Mulling is the application of energy to cause compression and shear. To homogenize and activate a green sand mixture, a great deal of energy is required. The amount of energy needed to mull a green sand increases as the activation of clay proceeds.

Activated clay has a texture similar to putty. The energy needed to equally spread this stiff material over the surface of all sand grains is substantial.

The typical muller currently seen in many foundries uses mulling wheels to perform three steps of intensive mixing. First, the sand, bentonite and water are kneaded between the face of the wheel and the pan of the machine. Second, the wide face of the wheel causes a smearing action, which helps to coat

the sand grains with clay. Third, as they rotate around the center axis, the wheels produce a rubbing or shearing action that further distributes the bentonite and water into the sand mass.

## A System Approach

If a foundry encounters difficulties achieving molding sand properties, evaluating the muller's performance may be required.

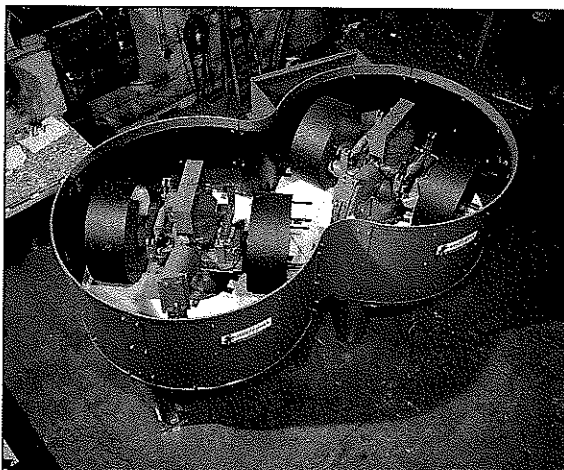
However, the slow deterioration of green strength and other important physical sand properties can be related to many areas in a foundry operation.

These include: hot molding sand; increased sand/metal ratios; poor bentonite control; variations in raw materials; gradual changes in sieve distribution; new molding machines; better shakeout systems; new and inexperienced workers; new core binders and coatings; new patterns; changing bentonite ratios; new base sands (AFS grain fineness number and distribution); chemical deterioration of bentonite; and an increase or decrease in any number of green sand additives.

It is important that the foundry review the entire sand system, not just the muller, when investigating sand strength problems. Changing components in a muller to overcome other system problems is certainly not the correct solution.

Because mulling is the method for sand strengthening, foundrymen generally look to the muller as the cause of the problem. Many foundries that experience a loss in their green compression strengths, however, may be looking in the wrong place.

For instance, specimen tube wear in the sand laboratory is a common cause for the gradual decrease in green compression strength. The simple but often neglected practice



*Just as important as maintaining the muller's wheels, plows, crib liners, springs and wear plates, foundrymen need a good background in sand system control for proper sand preparation.*

of swabbing and lubricating a specimen tube prior to every use can prevent a slow, downward trend in green strength, as well as increased permeability.

According to a study by the American Foundrymen's Society Green Sand Test Committee (4-D), failure to lubricate a specimen tube could result in a 3 psi reduction in green compression strength because the density of the sample is changed. If lab equipment isn't calibrated, a slow deterioration in properties could result.

Focusing on rebuilding a muller at this point would be ridiculous, but many foundrymen immediately target the muller as the source of the problem. Therefore, a foundry must strive to consider the entire sand system before jumping to any rash decisions about the muller.

### Green Sands of the '90s

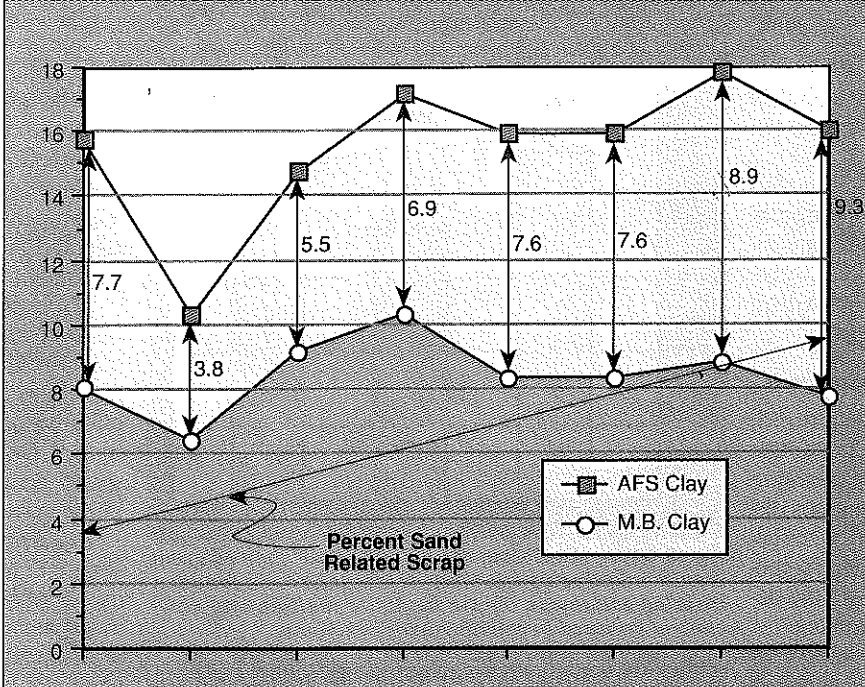
Many mullers in foundries today have been in service for more than 45 years. After mixing billions of tons of molding sand, muller wear should be recognized.

Today's molding sands have undergone many changes compared to the sands mulled 45 years ago. The industry has switched from naturally bonded molding sands to nearly 100% synthetic sands bonded primarily with bentonite clays. There are also many new process variables in a modern foundry that dictate an increased awareness of how a muller operates.

Today, foundries require more work from mullers primarily because of new core sand binders and faster molding machines. Merely changing a worn plow may not be sufficient to achieve the maximum benefit from the machine. A predictive maintenance program must replace reactive maintenance. Educating employees to understand proper mulling procedures and sand control techniques will also help ensure optimum work performance from a muller.

### Core Sand

Over the past 20 years, new core sand binders with improved shakeout charac-



**Fig. 1. A medium-sized cast iron foundry discovered that as the difference between AFS clay and methylene blue clay rose, so did its percentage of sand related scrap. While sand additions should be kept to a minimum, this problem occurred because additions were too small.**

teristics have been introduced to the foundry industry. As these binders have grown in popularity, the amount of spent core sand entering the system has substantially increased. Furthermore, new high-efficiency shakeout systems have increased and compounded the amount of core sand merging into the system. This increased core sand infiltration greatly magnifies mulling deficiencies.

Large influxes of spent core sand are often blamed for lowering sand properties. When large percentages of core sand enter a sand system, an equal amount of system sand must be removed to achieve a material balance. The sand removed from the system has a percentage of clay that remains slightly activated, depending on the sand/metal ratio and cooling time.

If this material stays in the system, then the foundry benefits from accumulative mulling, or extra mulling. Accumulative mulling helps maintain higher levels of activated clay and higher strengths. The longer sand is maintained within the system, the more fully the clay will develop.

### New Sand

Similar to core sand's effects, too much new sand will remove excessive amounts of mulled clay and fines. New sand should only be added to control sand fineness, distribution and reduce buildup of inert fines and oolitics.

Many guidelines exist to determine the amount of new sand required to maintain a sand system. Most are based on the

type of alloy and tons poured. When encountering high core sand influxes, no new sand is needed in some cases.

Ideally, only minimal levels of new sand should be added to achieve consistent properties. A minimum sand addition maintains activated clay within the system longer and increases the muller's effectiveness.

If the new or core sand additions are too small, however, the percentage between the AFS clay and methylene blue clay generally increases (Fig. 1). As

the AFS clay percentages increase at a constant or decreasing methylene blue clay level, more water is required to maintain a constant compactibility.

Without proper and consistent new sand additions, the percentage of sand-related defects increases, as experienced by a medium-sized cast iron foundry (Fig. 1.) A minimum sand addition maintains activated clay within the system longer and increases the effectiveness of the muller.

Since the influx of a majority of core sands is difficult—if not impossible—to control, the importance of mulling has substantially increased. With today's molding sands, it is crucial to ensure a maximum effort is imparted to the molding sand during a determined cycle or retention time to help offset increases in core sand entering the system.

### High-Production Issues

When encountering mulling inefficiencies in high-production molding systems, foundries often overcompensate bentonite levels to generate sand strengths needed to satisfy their requirements. There is also evidence that clay percentages are increased slightly to overcome chemical deterioration of bentonite caused by certain core sand binders.

High clay content will result in proportionally greater burnout rates and higher percentages of small particles with increased surface areas and water requirements, not to mention an increase in operating cost. To maintain water requirements within desired speci-

fications, an increase in new sand may be necessary. This solution can result in a further reduction in effective mulling.

Higher molding rates can also result in increased sand temperatures. As sand temperature increases beyond 120F, the amount of effective mulling greatly decreases.

### Component Maintenance

With these points in mind, today's foundries must maximize the mulling efficiency of their current machines. With machines displaying long service lives, metalcasters are faced with another somewhat hidden problem—a slow deterioration of effective mulling.

Effective mulling shouldn't be confused with cycle time or retention time. If a mulling cycle is fixed, then the mechanical and electrical components of the muller must maintain a constant mixing intensity to achieve consistent mulling over time.

A foundry must always be aware of the mechanical and electrical state of its mullers. As mullers age, the amount of effective mulling can significantly decrease. Coupled with increased core sand influxes, chemical deterioration of bentonite and increased tonnage requirements, a loss of effective mulling could lead to catastrophic quality problems.

### Cycle Times

As foundries add molding machines, many have pushed their prepared sand tonnage requirements beyond the muller's recommended production capacity. The results are mullers operating with reduced cycle times.

Molding departments that short-cycle or push mulling equipment beyond specifications will eventually suffer poor casting quality. This type of undermulling is common and easily recognized by all foundries.

The only solution to this problem of meeting higher molding demand is to purchase a muller with increased capacity. If a foundry reduces mulling cycle times to meet capacity of the molding machines, it will experience definite quality problems.

At the same time, however, some mullers are operating below maximum capacity and have decreasing strength properties and nonuniform water distribution.

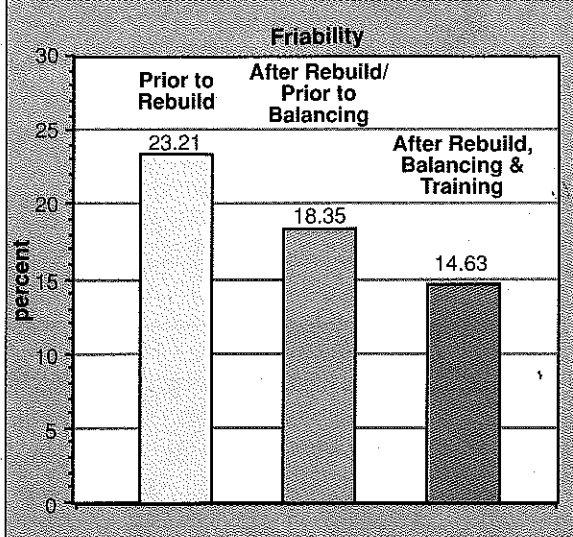


Fig. 2. While rebuilding the muller alone showed great results in reducing friability at this large iron foundry, training employees on the basics of mulling and sand control resulted in even further reductions.

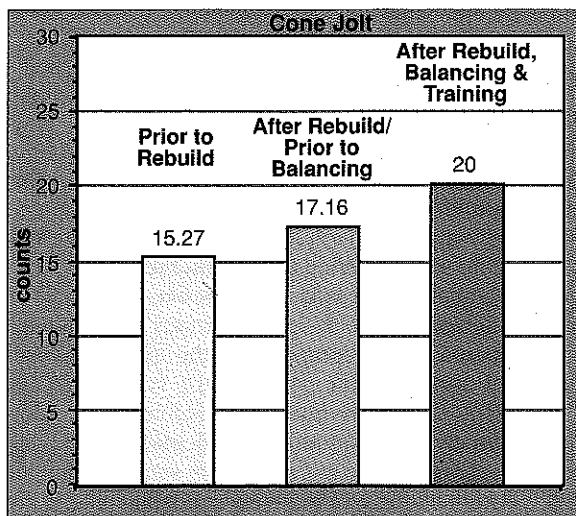


Fig. 3. This chart also shows the gains made in sand toughness after rebuilding and balancing, along with a training program.

### Case Study: Problem Complexity

An investigation of a muller's performance often goes beyond the obvious wear components, including wheels, plows, crib liners, springs and wear plates. While these are all important and must be considered, the root of a problem may lie within the machine itself.

For instance, a sand system using a continuous-type muller in a medium-sized iron foundry was suffering from a slow reduction in green compression strength. This muller relies on a percentage of the motor load to control the amount of material in the machine at any given time.

The percent motor load required to allow the machine to begin discharging prepared sand is preset by the foundry. Ideally, the set point should be at the correct motor load to achieve the proper bed depth and

the recommended retention time.

Following some adjustments to the machine made by foundry maintenance staff, however, the muller's shear pins were breaking if a set point greater than 75% was selected. Hence, the foundry never increased the set point beyond 75%.

About 32% of the motor load is needed to turn the mechanical elements of the machine. In theory, with a setting of only 75%, effective mulling was decreased by nearly 20%. This decrease resulted in a substantial drop in green compression strength.

Determining the cause of the shear pin failure was critical. After investigation, it was determined that the shear pin failure was due to wear of the vertical shaft bearings, which resulted in an increased gap between the hub and crosshead holding pin. This gap created a greater shear load on the pin and resulted in premature failure.

Once the problem was recognized, readjustments were made to the muller to get in-line with ideal operations.

### Case Study: Training and Understanding

After operating and tracking its muller performances over 20 years, a large iron foundry noticed a slow deterioration in sand properties. After consulting with its equipment manufacturer, the foundry decided to rebuild the muller.

Foundry management also felt that because of many new employees over this 20-year period, a great deal of operating knowledge had been lost. Therefore, shortly after completion of the rebuild, all employees associated with mullers—including maintenance, management and production personnel—attended muller operation and sand control training.

The result of mulling improvement is substantial. Shown in Fig. 2, the foundry cut its friability by 37% after rebuilding, balancing and training. Figure 3 shows a 31% increase in sand toughness. The foundry also gained about 18% more green compressive strength and better control of compactibility.

When evaluating a muller, it is extremely important that all aspects of the system are reviewed. This approach ensures that the appropriate corrections are made. ▼

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