Experiences with VFD's and Simpson Batch Mix-Mullers®

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Introduction

Mechanical and control improvements incorporated onto installed molding machines can lead to dramatic improvements in molding rates. The ability to fully utilize the positive impact of these productivity improvements can be limited by the capability of the sand plant. Any increase in mold rate may result in a sand demand that is greater than the original sand system was designed to produce. In many cases, the options were limited to large capital expenses for new mullers to produce larger tonnages or a dreadful reduction in sand properties as a result of shortening a mullers cycle time. A third option would be to incorporate a VFD (variable frequency drive) to an existing Simpson Mix-Muller®. By incorporating a VFD to a Mix-Muller® it is possible to obtain an increase in production without sacrificing molding sand quality.

The Project

The project objective was to increase the production of prepared green sand from a standard Simpson 6G Mix-Muller® (see figure 1). To increase production, an adjustable frequency AC drive (VFD) was installed on the production 6G, 200 Horsepower, Mix-Muller® located at Grede Foundry, St. Cloud, Minnesota.

Figure 1 – Simpson Mix-Muller

Prior to installing the VFD, the muller produced molding sand at the rate of 92 tons per hour with a constant vertical shaft speed of 25 RPM. The prepared and was delivered to a BMD impact-molding machine. Return sand is cooled and pre-blended in a Simpson Multi-Cooler®. The return sand and a new sand addition are added to the muller using a weigh system. The muller is set up to prepare an 8200-LB batch in 158 seconds door close to door close. A Hartley AutoLab automatically controls the compactability and clay addition.

After making several modifications the molding machine, Grede was able to increase the BMD sand requirements to approximately 115 tons per hour. At this production rate, the molding machine was reported out of production waiting for sand over 25 minutes a shift.

Design of Study

A mulling cycle in a Simpson Mix-Muller® can be divided into four unique phases: material charge, water addition (dry mix), mulling and material discharge. The hypothesis of this study assumed that an increase in vertical shaft speed would enhance the effectiveness of each phase. An increase in vertical shaft speed would allow the mulling wheels to process a greater sand area in a fixed mulling cycle. This enhancement may allow for a time reduction in the mulling cycle without sacrificing the integrity of the mulled sand.

A muller performance baseline was prepared before changing any production parameters (see figure 2). The baseline was determined one month prior to beginning the study using sand laboratory data.

Grede Foundry, Inc. – St. Cloud

Statistical Analysis of Sand Properties – June 1997 – Before VFD

Property	Mean	UCL	LCL	6 Sigma
Green Compression Strength (PSI)	21.9	25.1	18.7	6.4
Compactability	41	46	36	10
Methylene Blue Clay (%)	9.2	9.7	8.8	0.9
Moisture (%)	3.5	3.8	3.1	0.7
Working Bond (%)	3.7	4.2	3.2	1

Figure 2 – Baseline Data

Green compression strength was considered the primary quantitative method of determining the effect of changes in vertical shaft speed. Working bond was used as a secondary measurement technique.

The major limitation associated with both the primary and secondary measurement indexes is the vast number of independent variables that influence their magnitude. It is not valid to simply state that a variation in green compression strength was dependent on a change in the effectiveness of mulling. The cause of such variation could be a result of a compositional change in the sand and have no relationship to the muller's performance.

A method of isolating the muller performance from all other process variables was developed. The baseline laboratory data was used as a template to help pinpoint whether a change in green compression strength was dependent on a variation in mulling. The model is valid assuming that the primary compositional changes effecting green compression strength are compactability, methylene blue clay and moisture. It was assumed that all other changes in the physical properties of sand should be reflected in the results of these three indicators.

Using standard statistical techniques, the pre-VFD compactability, methylene blue clay and moisture data were analyzed to determine the mean, upper control limit, lower control limit and 6-sigma variation using an X-Moving R chart. After determining the control limits, all data points falling outside the control limits were eliminated from the population of data used to determine the control limits for green compression strength. The baseline control limits are shown on the attached table of this report.

After changing the vertical shaft speed the muller was allowed to operate at these parameters for three weeks while laboratory samples were routinely taken and tested. These results were then analyzed for data points falling outside baseline upper and lower control limits for compactability, methylene blue clay and moisture. Data points found outside these defined ranges were dropped from the population and the remaining data sets were used to generate modified green compression strength data. It was assumed that an out of control condition in the compactability, methylene blue clay or moisture properties could result in a positive or negative skew in green compression strength data that more than likely is not associated with a change in the effectiveness of the mulling process.

After removing out of control data points, the mean, lower control limit, upper control limit, X-Moving R chart, Cp and Cpk were calculated from the modified green compression strength and modified working bond data.

The project goal was to reduce the mulling cycle as short as possible while maintaining sand physical properties equal to those achieved by the baseline muller and process. A change in vertical shaft speed was gauged by process capability calculations. An acceptable change would result in a reduced mulling cycle and result in a modified green compression strength and modified working bond Cp of >1.0 and Cpk of >1.0.

Results and Conclusions

After experimenting with several vertical shaft speeds for various duration times and start and stop points, the following batch cycle was determined to be the most effective in reducing cycle times (see figure 3):

Mulling Phase	RPM	Time (in seconds)
Material Charge	25	5
Water Addition	25	21
Mulling – Stage 1	30	Approx. 26
Mulling – Stage 2	25	Approx. 36
Discharge – Stage 1	32	18
Discharge – Stage 2	27	28

Figure 3 – VFD optimal batch cycle

Using these RPM's we were able to reduce the discharge time 10 seconds and the mulling time was reduced 13 seconds. This resulted in a 26% reduction in discharge time and 17% reduction in mulling time. The total cycle time was reduced 23 seconds, resulting in a 14.5% improvement in cycle time. The muller has been set at these experimental parameters for 3 weeks to determine if any loss in accumulative mulling would result.

The first three weeks of data are tabulated in the following table (see figure 4). As stated earlier in this report, an acceptable RPM change would result in a reduced mulling cycle and modified green compression strength Cp of >1.0 and Cpk of >1.0. The initial data appears to show a very slight reduction in the green compression strength falling below the minimum specification as set by the baseline data.

Grede Foundry, Inc. – St. Cloud
Statistical Analysis of Green Compression Strength
After VFD Installation

Property	Mean	UCL	LCL	6 Sigma	Cp	Cpk
Green Compression Strength (PSI)	20.8	23.6	18	5.6	1.152	0.766
Working Bond (%)	3.6	4	3.1	0.9	1.18	0.8646

Figure 4

Grede reports no adverse effects from mulling changes during weekly phone conversations between Simpson and Grede. The VFD modifications have been utilized in full production since 1998 with no adverse effects to the sand quality or muller performance.

A project summary chart (see figure 5) clearly indicates the success of this research. By adjusting the vertical shaft speed during a standard mulling cycle a 20% improvement in sand production was achieved. The chart shows both the before and after VFD times for each phase of the mulling process. It clearly indicates the increased effectiveness of changing the vertical shaft speed during the mixing cycle. By increasing and decreasing the RPM, the customer experienced a reduction in both the mulling and discharge phase of the mulling cycle. This reduction in cycle time was accomplished without a loss in the physical properties of the molding sand as measured by green compression strength.

Mulling Phase	RPM	Time – After VFD	Time – Before VFD	% Improve
Material Charge	25	8 Seconds	8 Seconds	0 %
Water Addition	25	27 Seconds	27 Seconds	0 %
Mulling – Stage 1	30	Approx. 26 Seconds	67 Seconds	19 %
Mulling – Stage 2	25	Approx. 28 Seconds		
Discharge – Stage 1	32	18 Seconds	56 Seconds	18 %
Discharge – Stage 2	27	28 Seconds		
	Totals	135 Seconds	158 Seconds	15 %
	TPH	110	92	20 %

Figure 5 – Project Summary Chart

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- Flaskless, Matchplate Mold Making Equipment
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- Core Making Equipment
- Sand Reclamation Equipment
- Pollution Control Equipment
- Sand Laboratory Testing Instrumentation
- OEM Spare Parts and Field Service
- Laboratory Testing and Rental Equipment

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