The underestimated genius in sand conditioning

'Mouldingsandmanagement 2020' is a pioneering all-in-one concept for reclaiming used sand, as described here by Wolfgang Ernst from datec GmbH.

Sand casting involves a traditional production process which, by its readily implementable flexibility and cost structure, can even contend for the most challenging casting assignment. Yet, the pressure to substitute sand casting by other production processes and even by other materials, such as plastic, must not be ignored. Sand casting must assert itself or even regain lost terrain.

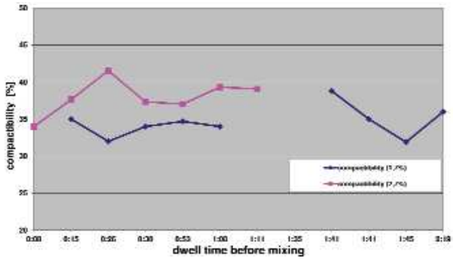

Figure 1. Development of compactibility over storage time in a used sand bunker.

An essential requirement, unavoidably at the top of the list, remains the possibility to drive the mouldable substance with its mechanical properties within tighter tolerance limits. However, certain methods are failing to predetermine the main effects of the Bentonite-based moulding material. Sand casting somehow escapes the technological approach designed by engineers. Although the electrical engineer may be able to calculate how the current following a resistor increases with an increased operating voltage, the foundry engineer is unable to determine in advance how, for example, the wet tensile strength will be altered when the extraction at the cooler changes. The individual reference values are too complex and too interrelated, preventing the formulation of tenable calculation equations applicable to a broad range of operations.

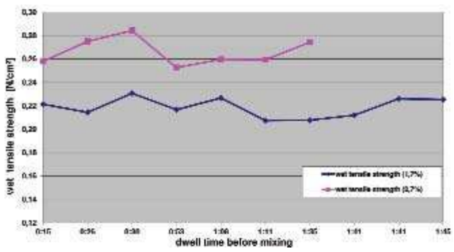

Figure 2. Development of wet tensile strength over storage time in a used sand bunker.

The global objective for development, particularly in the automotive industry, is the effort to achieve lower item weights and thereby also to achieve thin-wall casting. This requires a secure adherence to lower tolerances in the mechanical strength values of the form sand. An essential, fundamental objective of sand preparation is to achieve greater uniformity of sand composition. Sand composition properties must be such that untraceable surprises can be avoided. Moreover, there is the objective to tap hidden reserves, in order to achieve the same results using less Bentonite and water.

Time and again, the complex relationship between many processing steps and composition requirements has been convincingly demonstrated. Measurements, even at the location of unpacking, may affect the moulding system's properties.

'Mouldingsandmanagement 2020' is an objective and at the same time, an integral method to recognise and shape all steps and influences within the process. In particular, reciprocal effects must be detected and utilised to the desired extent. It is precisely the cooler's operation that affects the mixer's result. The following descriptions of results from our own analyses clearly demonstrate the correlation.

Research results

The research group, 'Bentonite-based form material', organised within the auspices of the BDG (Bundesverband der deutschen Gießereienindustrie – Federal Association of the German Foundry Industry) has run an experiment for 18 months called 'How long must the sand cure before it is good?' The experiment's result should make it possible to define a used sand bunker

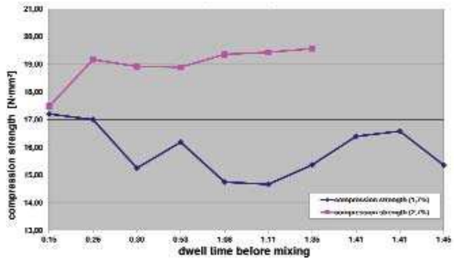

Figure 3. Development of compression strength over storage time in a used sand bunker.

capacity, in order to give the used sand sufficient time for curing before mixing.

Deliberately, the experiment was not carried out under laboratory conditions but in the course of the production process of a foundry. The selected foundry has a charge cooler. In this cooler, for an early equalisation the binding agent dosages are added according to the poured iron volume and the added core sand volumes. One of the four used sand bunkers was emptied in order to process the sand in the mixer at designated, previously determined intervals. Three mixings were turned on in intervals of 15 to 30 minutes over a two hour period.

The experiment was conducted two days in a row, whereby the essential difference was the cooler's discharge moisture. On the first day, the used sand with a low moisture content of 1.7% was taken into the empty bunker and thus to the mixer. On the next day, the used sand left the cooler with a 2.7% moisture content. On both days, an approximately similar casting programme was conducted to exclude any influences related to the difference between the casting programmes.

With a high personnel commitment, at various points of the cooler input and output, as well as at the mixer input and output, basic parameters were continuously monitored to discover aberrations at an early stage and then to exclude such measurement results. Figures 1, 2 and 3 show the compactibility, compression strength and wet tensile strength over both days.

Two significant findings were the outcome of this experiment. In this sand preparation, a slight improvement of the mechanical properties is detectable only for the first half hour of storage time on both days. Much clearer is the effect of used sand moisture through the cooler.

Compared to the low moisture content of 1.7%, used sand with a moisture content of 2.7% clearly achieves better strength values. In particular, the wet tensile strength values as well as the compression strength values within the broad average differ by approximately 25%. With the same Bentonite content of 8%, the wet tensile strength increased from approximately $0.22 N/m^2$ to $0.27 N/m^2$ and the compression strength increased from $15 N/m^2$ to $19 N/m^2$. However, the growth of the compactibility at the boundary is a plausible proof.

The first inferences provided the following two striking results:

- It is useful to run used sand with a high moisture content.
- This moisture content must be evenly distributed, since the results downstream from the mixer are affected by a possible moisture variation. This also explains the phenomenon that actual moisture and actual compactibility fluctuate one to another.

Higher mixer moisture content for same compactability

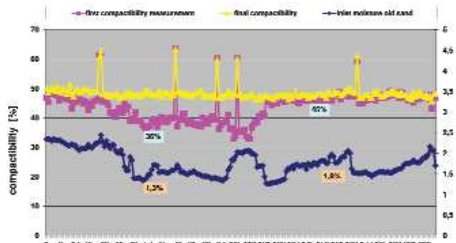

Figure 4. Mixer input moisture content and compactibility.

A second investigation result from another foundry confirms that dry sand must be used with a higher mixer moisture content for the same compactibility.

Because of a cooler defect in another foundry, the used sand had to be processed without sufficient water supply. Figure 4 shows that the input moisture content at the mixer dropped from the

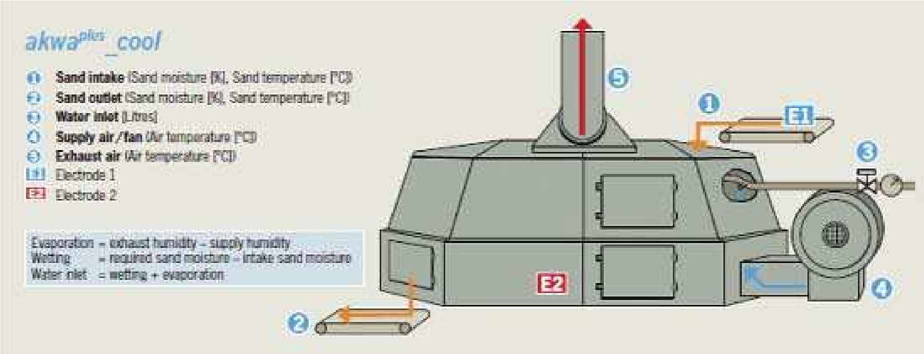

Figure 5. Cool water dosage.

usual 2.0% to 1.3% and that a couple of hours later, the moisture content increased to approximately 2%. In this foundry, the mixer is equipped with Rotocontrol RTC 106 sand testing automaton which, for every charge takes at least one sand sample from the mixer to detect the compactibility. In case of a deviation from the target value, an additional water quantity dosage is added subsequently.

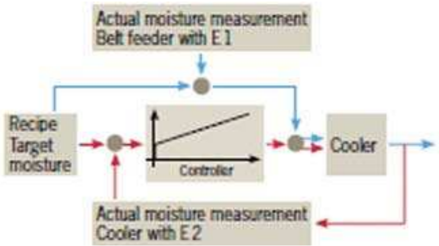

Figure 6. The controller for both moisture sampling systems.

A final sample is taken before the mixer is discharged. The pre-water is determined by the sample of the used sand moisture content and the recipe requirements of a target moisture content, so that the used sand in the mixer always has the same moisture content at the time the sample is taken. The violet line in Figure 4 clearly shows how the compactibility initially reaches the 45% target value at a 2% moisture content. When the input moisture breaks down at 1.3%, the compactibility also decreases by almost 9%, although the moisture content in the mixer does not decrease. Only by a further addition of water of up to 0.2% could the target value of compactibility be achieved.

As became clear during the first attempt, the mixer cannot compensate for the failures of the cooler. When the sand is discharged out of the cooler in dry form, it must be run with a greater moisture content in the mixer to achieve the same mechanical strength values.

Water dosage must be precise

Traditional considerations assumed that a variation width of the moisture content downstream from the cooler of +/- 0.3% is quite sufficient, provided that it does not drop below 2%. Yet the proposed results have forced a further development towards higher precision. Based on many years of experience, evidence shows that every measurement and dosage process has its strengths and weaknesses. The idea was conceived to link the two methods in such a way that they reciprocally balance their disadvantages.

In the one process, after the water balance process of the cooler, the used sand moisture content and temperature of the incoming sand are measured, in order to determine the supplied water dosage up to the target moisture content. Additionally, air temperatures in the intake air and exhaust air are measured to detect the evaporated water content. In the other process, moisture is sent over rotating electrodes inside the cooler.

In the first approach with the 'akwaplus_cool' system, the ground water volume dosage is prepared and the moisture content measurement in the cooler serves as the control measurement spot, connected to a traditional PI-controller, compensating the differences with the target moisture content value. Figure 5 illustrates a cooler with individual sampling points for moisture and temperature. Figure 6 shows the controller and also illustrates the division of duties between the individual moisture measurement systems. Figures 7 and 8 show both electrode types on the dosage belt as well as in the cooler.

This methodical approach of the control measurement position connected to a controller can also be applied to the flow bed cooler. The results are uniform since the even moisture content, all the way to the mixer, results only in minimal variations in the strength values downstream from the mixer.

Conclusions

In many foundries, the used sand cooler is a noisy machine, creating high volumes of dust. Its operation is insufficiently understood and its available potential is not recognised. Moreover, there is not much involved in finding its optimal point of operation.

The most significant cause for optimisation is the water supply. Submitted research has clearly shown that a high discharge moisture content substantially affects the form sand quality of the form system. The mixer is unable to compensate for all variations not caught within the cooler.

Technically, bunkers must be designed for higher moisture content. Many bunkers have an unfavourable shape, since from a certain moisture content, form sand is no longer sensibly discharged.

The akwaplus_cool water dosage process, with the double sampling system as a monitoring and control function, facilitates the achievement of higher accuracies of discharge moisture content at the cooler. This also reduces the variations in the characteristic form sand values, downstream from the mixer.

The draft of 'Mouldingsandmanagement 2020' considers the integral sand cycle in order to detect and control the more elusive interactions.

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Figure 7. Moisture electrode on the dosage belt to the cooler.

Figure 8. Rotating moisture electrode in cooler.