As early as possible – as quickly as possible – as exactly as possible
Water dosage requirements for the complete used sand treatment

The level of rejects, or the chance of avoiding rejects and extensive cleaning work, depend very much on the quality of the moulding material, which is also reflected in the even composition of the sand system and the physical strength values (compactability, wet tensile strength, shear strength etc.).

The water content is of particular importance, and the investigations carried out by Levelink are still valid today. Water, bentonite and elutriating material are the sand constituents with the greatest influence on quality. The water content is subject to the highest level of variation during a cycle. [1] [2] While moisture measurement and control equipment used to be focussed on the mixer in order to obtain an equally moist sand for the moulding system, attention has now been shifted to other aspects. Due to an extension of the weekly work hours (multi-shift operation) and the greater output of cast iron, thermal stress has also grown over the years. The use of used sand coolers became necessary, not only to lower the used sand temperature, but particularly to increase preliminary moistening of the used sand to start the maturing process at an early point of time. The **akwa_mix** and **akwa_cool** are two water dosing systems manufactured by **datec GmbH** from Brunswick which are now used in foundries. Both are based on the same moisture measuring principle. This paper will explain the moisture measuring principle, its use in mixers as well as the two cooling processes in continuous coolers and batch coolers.

Moisture measurement as the core of precise automation

Currently, electrical processes such as conductive or capacitive measurement are dominant in the moisture measurement in mineral bulk materials. Microwave measurement which is frequently used for mineral bulk materials has not been applied in used foundry sands due to the measuring errors obviously caused by the CO_2 component. **Datec GmbH** uses both methods, depending on the material and the moisture range. Conductivity measurement (conductive measurement) has proved successful for used foundry sand since wet components can also be measured without problems.

None of the processes used imply a linear connection between the measuring signal and the actual moisture. Rather, the transmission function is a kind of hyperbola which must be compensated for by balancing. The shape of the hyperbola depends on the material quality and also the geometry of the measuring point. Density variations in the material, in particular, cause considerable indication deviations. This also explains why it is so difficult to measure moist moulding sand. Starting from a certain degree of moisture, the density becomes inhomogeneous due to lump and node formation, so that there is less material between the electrodes, and the indication may even go down.

Temperature exercises a particular influence, since increasing temperature values apparently lead to an increase in the moisture indication. This influence can be compensated for by parallel temperature measurement.

Another dominant factor of influence is the contamination of the electrode. The moisture electrode **FS 991** contains a self-cleaning mechanism based on a pneumatic cylinder inducing a lifting movement of the two measuring electrodes so that all adhering used sand particles can be removed by scraper rings **(Figure 1).** This self-cleaning is carried out at the end of each batch cycle.

Figure 1: Self-cleaning moisture electrode

Another important measure is the proper selection of the measuring point in order to avoid negative effects on the measuring accuracy. Installing the moisture and temperature measuring units on the discharge conveyor of the used sand bunkers ensures even densities for the measurement.
Temperature compensation, self-cleaning of the electrode as well as proper

selection of the measuring point on the discharge conveyor are the cornerstones of precise measurement in order to ensure reliable water dosage both for the mixer and the cooler.

Water dosage for the mixer

Water dosage requirements have not changed significantly in the past few years. The purpose of water dosage is to compensate for the moisture variations inherent in the used sand in order to wet the moulding sand to the target value specified in the formulation. This formulation target must be easily adaptable to the requirements of the moulding system. Possible evaporation as a result of temperature influences must be compensated as required. Water should be added as quickly as possible in order to prevent excessive cycle time extensions [3].

Two basic principles are used in the field of water dosage:

- Measurement before the mixer during dosage
- Measurement in the mixer

The **akwa_mix** measuring system measures the used sand moisture before the mixer on the discharge conveyor. Mean value formation of all values recorded every 100 ms will exactly detect and consider any variations. The measured moisture values are compared against the target moisture value, and the temperature values are used to determine evaporation. The final water addition value is determined directly at the end of dosage so that the entire final water amount can be fed into the mixer at any time. This enables the operator to make use of many advantages at once. The main task of the mixer is preparing the sand by adding water to the bentonite (dispersing). The entire water amount should be added as early as possible. If you add water at a later time, it would remain on the surface in an unbound state and can lead to typical defects in the casting **(Figure 2).**

Installing the unit outside the mixer will result in low wear of the measuring sensors as well as independence of the mixer type. Inspections can be easily carried out during production and do not require much effort. Integration in existing mixer control systems can be carried out without problems. The dosing computer used can even be extended to include scale dosing so that a compact measuring and dosing unit can be designed for mixing. In addition, the system is equipped with an efficient operational data logging system to document each charge with its relevant measuring values for quality documentation (ISO 9000).

The cooler as a particular challenge

Cast iron output has considerably increased in the past few years, while the sand quantity used has not grown to the same extent. The average iron : sand ratio has been enlarged. The higher thermal load made it necessary to use coolers in order to reduce the high loads by a more targeted sand conditioning. Two aims were especially relevant: Cooling the used sand to approx. 40°C and wetting to an even moisture of approx. 2.2 % and more. Especially the latter target has become increasingly important in order to use the retention time in the used sand bunkers for early maturing. Recent findings (..) have shown that the diffusion velocity of the water in the bentonite depends on the moisture. A used sand with a moisture content of 0.8 % absorbs the water in the mixer twenty times slower than a used sand with a moisture of 1.5 % [4], [5], [6].

Irrespective of the type of cooler – mixing cooler or fluidized bed cooler – all used sand coolers (even the vacuum coolers) are based on the principle of evaporation cooling. The thermal energy present in the used sand is consumed by the energy-intensive process in the phase shift of the water from liquid into aqueous state [7], [8]. Air plays a particular role in this process since its water absorption capacity is not in a linear relationship with temperature. The air can absorb more water with increasing temperature. Temperature development in the exhaust air is essentially dependent on the cooler design; a good cooling effect can be achieved by a large cooler volume and a long retention time. The proper dimensioning of the air and water quantities also plays an important role. Generally the following can be assumed: 1 % water is required to achieve cooling down by 27 K, while approx. 3 – 4 kg of used sand can be cooled with 1 m^3 of air.

Cooling, however, is not only achieved by evaporation, but also by the effect of heat dissipation to a colder environment, like in the case of a heating radiator [9]. This process also results in a cooling by several degrees. Ground floor locations are particularly suitable since they are characterized by good air exchange with the environment. Rooms in the basement are not suitable due to the minimal air movement. In the case of tower units, the upper floors should not be used because the hot air accumulates there.

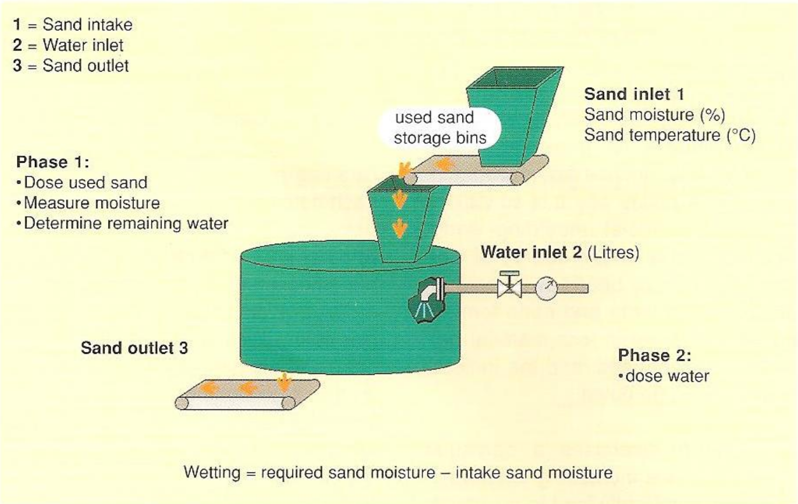

Figure 2: Water dosage diagram for a mixer

The water balance for cooling water dosage

The actual water consumption can be determined at any time by measuring water inflow and outflow. Water is generated in the cooler due to the existing moisture in the used sand flow and the air humidity in the air fed into the cooler by a fan. Finally also the water pipeline itself adds water to the unit based on the dosing in accordance with demand. Water is discharged out of the cooler via the air humidity of the exhaust air and with the cooled and wetted sand. A suitable measuring arrangement can be used to measure the five water flows; dominant effects are generated by the moisture variations

a) in the used sand fed into the unit and
b) the exhaust air discharged out of the unit. **Figure 3** shows the measuring points and the use of the results obtained in a conditional equation. All measuring points are outside the cooler so that the water cooling system can be used for any cooler type. The method presented can be used both for mixing coolers and for fluidized bed coolers, additional features can be installed at a later point of time without much effort.

Measurement is carried out continuously so that the water quantity required is constantly fed in via a proportional valve. Tests have shown that the temperature developing in the used sand is only affected by the evaporated water quantity. The water absorption capacity of the air determines the final temperature. Addition of more water will not lead to an increase in evaporation, but only to excessive wetting of the used sand. The air absorbs as much water as it can so that insufficient water addition will generate the effect that the used sand leaves the cooler in an extremely dry state.

The batch cooler as a further development of the continuous cooler and sand conditioning

Developments especially in the casting program of jobbing foundries have resulted in increased stress on the mould material. In particular the short changes between load stages in the iron: steel ratio as well as the core sand inflow have shown the limits of classic sand conditioning. In 1996 the German foundry Harzguss in Zorge installed a mixer behind the fluidized bed cooler where binding agents were added depending on the shaken out mould type. Based on a close coupling between the box tracking program of the moulding plant and the dosing computer for the scales, the principle of mould material balancing is used to determine the binding agent required, thus keeping the sand system on a balanced level [10]. A lot of effort has been invested in apparatus to achieve considerable improvement of sand conditions. To reduce the effort required in the area of machinery, the idea of the batch cooler was born. The decisive disadvantage of feeding the binding agents into a continuous cooler is the immediate exhaustion of these fine particles by the exhaust air. Thus they will end up in the filter system and not in the used sand. For this reason the batch cooler works sequentially in several steps. After filling the cooler with the used sand to be cooled and the required water quantity, the air supply is switched on and the sand cooled. Then the air supply is switched off. The binding agents and the filtered dust components are added to the cooler in this quiet atmosphere and mixed with the sand.

In addition to this particular process advantage of intelligent sand conditioning, batch cooling is a profitable cooling process since its efficiency is much higher than in other processes. In the Danish foundry V. Birn, two batch coolers were installed with a total throughput capacity of 400 to/h, which can cool down the approx. 7 to of batch weight from 120°C to 40°C in 120 sec. [11], [12]. Again, the water dosage system supplied by datec GmbH plays an essential role. The water demand is determined in two stages: temperature measurement of the sand fed into the scales enables the operator to exactly calculate the water quantity to be evaporated. Moisture measurement indicates how much water is still required to reach the target moisture of the formulation. **Figure 4** once more visualizes the cooler setup and the measuring equipment required around the batch cooler.

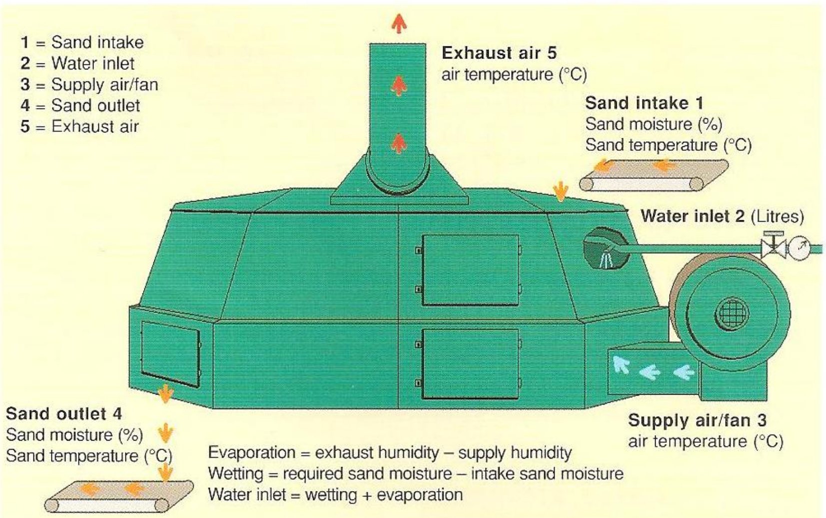

Figure 3: Water dosage diagram for a mixing cooler

Summary

The examples given above for mixers and coolers demonstrate that water addition should be based on the motto: as early as possible – as quickly as possible – as exactly as possible. A moisture measuring and control facility must be equipped with intelligent moisture measuring equipment in order to be able to indicate correct moisture values for all conditions in the used sand.

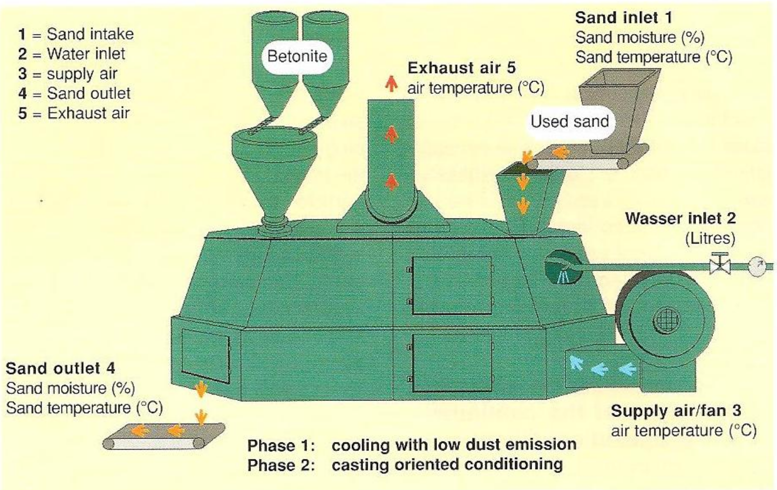

Figure 4: Water dosage diagram for a batch cooler

The higher requirements due to greater thermal loads and the inflow of increased core sand quantities require improved sand conditioning. The tendency of working with a constantly dry moulding material makes conditioning more difficult [13]. Special attention is directed to the currently very topical question as to where the water is actually located in the bentonite and what effect it causes. Clay and bentonite are among the minerals with very complex phenomena which can cause many different effects at the same time as a result of various treatment measures. For sand conditioning in a foundry we have to find out how the rather slow maturing process (several hours [15]) can be accelerated. Drying out as a result of evaporation is a very fast process. The question is whether wetting could proceed in an equally fast way so that maturing can be accelerated. Sand behaviour under vacuum suggests that new treatment methods in sand conditioning could achieve new effects [16]. The batch cooler, with a longer wetting period before evaporation, could possible lead to much faster maturing [12]. A principle which we could call "used sand into the sauna" might help us achieve a more efficient conditioning behaviour. Water dosage plays an essential role in all cases – i.e. the capabilities offered by water dosage will enable intelligent conditioning management.

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