Process-integrated molding material management

With its new Online-Sandlab, Michenfelder Elektrotechnik GmbH & Co. KG (based in Mainz, Germany) has optimized the monitoring and control of important molding material parameters, supplementing its modular molding sand management system FoMaSys. For the first time, the measurement of gas permeability has been shifted to the preparation stage.

Numerous supplementary values of relevance to the quality of sand preparation can be determined with a testing machine suitable for belt-mounting (Figure 1). For the first time, gas permeability testing has been moved from the laboratory to the preparation process – permitting real-time action and reaction to a very wide data basis generated directly at the molding machine (Figure 2). In addition, a targeted and almost delay-free optimization of sand quality at the molding machine can be achieved by integrating the results in the MiPro molding sand matrix and networking with the fully automatic control system integrated in the plant.

Deficits in the control of molding material quality

The control of molding material quality is oriented upon a pool of determined measurement values. This pool is not the same in every foundry; not every value is determined in every foundry. The level of importance assigned to the measurement values also varies from foundry to foundry. This is due to the differing experiences and preferences of those responsible, though often also simply because of the measurement technology available. Sometimes analysis is entirely outsourced to external service providers, sometimes the values come from the works laboratory. Samples are taken from a variety of locations. Different personnel carry out different tests on different samples on different laboratory equipment. Time lags and the ‘personnel’ factor...
Impair reaction speed and regulatory accuracy. Both are relics of an era in which there was still plenty of time for a batch and enormous bunker capacities were available in the circulatory system. Demands for automatic, rapid and precise control of sand quality in a modern foundry can hardly be met in this way. It is not unusual, therefore, to use automatic testing and measurement devices on the green-sand mixer, allowing improved reaction times. Very important factors that affect the molding sand on the transport route between the mixer and the molding machine, however, remain completely opaque — even with these systems. Despite improved constancy at the mixer it is thus impossible to register or prevent the sometimes major compactability fluctuations at the molding machine.

**Constancy at the mixer does not mean constancy at the molding machine**

The frequently unknown, but often dramatic and always differing, variations from sand preparation to sand preparation on the transport route — caused by still lasting bentonite saturation processes, evaporation and temperature effects, sand aerators and transport belt transfer stations — can be fully automatically registered and reliably compensated for by the special arrangement and networking of the system combination of the FoMaSys molding sand management system. By coupling a sand testing system to the molding machine with a moisture measurement and control module, integrated in the green-sand mixer and very finely corrected, an extremely low compactability fluctuation range of $s = 2\%$ can be ensured directly at the molding machine — fully automatically through all process stages. In everyday practice the system combination regularly achieves a standard deviation that, with $s = 0.8$ to $1.5\%$,

*A comprehensive state report without time loss*

Just in time for the tenth anniversary of the market introduction of FoMaSys, Michenfelder’s new Online-Sandlab is a system that provides a current and comprehensive report on the state of the molding materi-

---

**Figure 1:** Prototype of the Online-Sandlab. The multipurpose sleeve for testing compactability and gas permeability can be seen.
al at any time and directly from the molding machine – in effect, a process-integrated real-time laboratory. Its name says it all. While with the Vedimat sand testing system measurements were still limited to compactability and compressive strength, the Online-Sandlab – combined with the MiPro process evaluation and control system – allows determination of the following measurement values and the values derived or calculated from them.

**Measurement values/determinable values/options for use**

- compactability
- shear strength
- compressive strength
- gas permeability
- moisture and temperature

In combination with MiPro:
- shear strength with recording of the deformability curve
- compressive strength with recording of the pressure reduction curve
- fines content
- bentonite equivalent
- use of numerous monitoring, analysis and evaluation tools in MiPro
- remote maintenance of all systems connected to MiPro

When combined with moisture measurement and control system in the mixer:
- fully automatic regulation and maintenance of constancy of compactability directly at the molding machine
- use of the MiPro function molding sand matrix

Combining the Online-Sandlab with a moisture measurement and control system from the latest Micomp series integrated in the mixer consolidates core competences to create a combination from which users gain a threefold benefit: firstly in stand-alone operation from the perhaps most comprehensive process-integrated determination of measurement values. The possibility of fully automatically maintaining constant compactability directly at the molding plant is a second advantage enabled by such a system coupling. Thirdly, with two systems functioning independently of one another the user profits from the freedom of preparing the molding sand fully automatically either according to the desired molding material moisture or molding material compactability.

**Comprehensive is not the same as informative**

A broad data basis is only valuable when it is rapidly usable – because it offers easily comprehensible preparation of the data quantity generated. Data preparation must quickly provide knowledge and conclusions as a basis for rapid decision-making or automated process interventions. Processing of the data from the Online-Sandlab takes place methodically in the MiPro process evaluation and control system, where user-friendly analyzers and the molding sand matrix act as a navigation system for molding sand preparation – in the form of a patented display format for monitoring forming-sand-specific quality parameters in the production process. It autonomously generates prompts so that appropriate counter-measures can be taken when the quality moves out of a previously defined quality window. Thereby the user receives clear instructions on the appropriate ‘adjusting screw’ that requires attention in the process in order to restore sand quality to the desired range. The eco-

---

**Figure 2:** Gas permeability of a running batch directly at the molding machine (visualization via the MiPro process evaluation and control system)

**Figure 3:** Shear strength with outline angle as information on deformability of a batch directly at the molding machine (visualization via the MiPro process evaluation and control system)
nomic advantage for the foundry lies in the time gained through the valuable knowledge on process interactions provided in real time, and the subsequent instructions for action. No long speculation on the causes, effects and counter-measures is required. Suitable counter-measures can be undertaken immediately.

A change of awareness in molding material preparation
The fully automatic systems that will master preparation in modern foundries in future also have historically evolved roots. Capacity and speed aspects dominated the new designs and modernizations of sand preparation plants for decades. Modern molding plants transported more sand so that more rapid green-sand mixers were required. This permitted more throughputs per time unit and bunker capacities could be reduced. The rising thermic stresses suffered by the sand, combined with reduced regeneration times caused by this development, were countered with the introduction of sand coolers. Aggregates that could also mix and cool simultaneously were developed.

The quality of the molding sand comes to light at the molding plant
The molding plants have always been the relentless pacesetter – and still are today. This is where the sand is needed; this is where the money is earned. This is also where the defects that cost money are produced when the molding sand quality is wrong – despite sufficient capacity and rapid mixers. As if under a magnifying glass, one can see there exactly how good the sand preparation, the machines and the monitoring and control of the sand quality works. No consistent casting quality can be achieved when there are fluctuations in the sand quality at the molding plant, whatever the cause. And it is precisely here that a slow rethink started about 15 years ago. Despite good equipment in sand preparation there are still too many casting defects due to the sand. Particularly in the case of complex castings, sand-related casting defects come to light late and are thus especially expensive. A feeling for the relevance of sufficient pre-moistening of the sand in the used sand area is beginning to develop. There is a stronger focus on the molding sand and the complexity of its correlating and mutually interdependent quality factors.

The loss of expertise is a heavy burden
For a long time, no questions were asked regarding the effects of known, and sometimes unknown or even completely hidden, processes on the quality of the molding material. This was also because the interactions were unclear. Until now the topic was often limited to a rather theoretical scientific approach. But asking questions is one thing. What should one do, however, when the corresponding expertise hardly exists any more in the company? Now it becomes clear that the 'old hands' for whom molding sand preparation was a matter of touch, who could determine the quality of a molding sand with their hands, are no longer available. Who still knows all the subtleties of the process-, product-, mixer-, cooler-, bunker- and employee-specific reactions and behaviors of the molding sand? Who knows and recognizes the consequences of doing or not doing something along the entire sand preparation chain? Who knows what it means when, for example, mixer cycle times are simply reduced under the pressure of demanding molding machines; when molding sand is not sufficiently pre-moistened in the used sand bunker and then lands up in the mixer; or when ultra-fine particles are continuously removed but discontinuously inserted?

Figure 4: Regulator results, using the example of a FoMaSys installation: Day 1

As in other industrial sectors, a particular employee structure has formed in response to the high level of automation in the foundries – and particularly in sand preparation. A few highly educated specialists (mostly engineers and technicians with a background in mechanical engineering, electrical engineering or process technology), a few plant operators, and the maintenance staff set the tone. They generally have the machines well under control and maintain the processes. The same generally cannot be said regarding the mastering of molding sand quality. In the meantime, there is widespread agreement that this special subsection of foundry technology has been given insufficient attention for decades, even in foundry-relevant specialist training. It is also becoming increasingly clear that it is no longer modern to control molding sand quality exclusively with laboratory support: it can no longer keep pace with the run-out numbers and product-related changes of direction and cycles – so vital for the sur-
vival of foundries – and will in future only play an accompanying role.

Now, however, one gets the feeling that there is increased interest in this complex of topics on many levels – at the specialist associations, the educational establishments, in course syllabuses, at suppliers and at the foundries themselves.

The trend was recognized over 20 years ago
To the same extent that specialized knowledge on the subtleties of molding material preparation beyond the functionalizing of machines has been lost, attempts have been made to counteract this through the introduction of automated systems. The age of data acquisition arrived. Michenfelder already reacted to this emerging development over twenty years ago, with its first fully automatic sand testing and control system. Despite its functionality, the time was not yet ripe for the reliable and comprehensive – for its time: with compactability, compressive strength, shear strength (Figure 3), and deformability – but cost-intensive system. Looking back, the quantity and variety of data was problematic. What did the data mean? How could the data be evaluated? What consequences did the data have? Users were frequently overtaxed by these questions. Only with the development of comprehensive graphic monitoring and analysis systems was the new flood of data tamed and made applicable for users in everyday operation.

Meaningfully and comprehensively processed data as a basis for decision-making
With the development of the MiPro process control system there now existed numerous and new types of monitoring, analytical and evaluation possibilities for the assessment of any system. From the shake-out grid to the sand cooler, from the used sand silo to the green sand mixer and from there to the molding machine. From station to station the networked FoMaSys modules reduce fluctuations in sand quality step-by-step until reaching the molding machine. This process is called ‘quality funneling’. FoMaSys fully automatically ensures a constant compactability with a fluctuation range reduced to a minimum precisely where maximum performance and best possible flow properties are demanded from the molding sand. Not just anywhere in the sand circulatory system, not just anytime during preparation, but directly at the molding plant. With the producer’s continuous moisture measurement and control system, perfected over decades, output moisture levels downstream from the coolers and mixers are guaranteed with minimal fluctuation ranges in the tens or hundreds. The producer is a pioneer in this area. The performance and concept of FoMaSys is based on this competence. The ability of the Vedimat or the Online Sandlab to keep compactability constant directly at the molding plant is based on the FoMaSys and sophisticated process-related system integration. The measurement of mechanical sand parameters at the molding plant is by no means too late. This is sometimes wrongly claimed, but is only true if no highly precise continuous moisture measurement and control system is used in the green-sand mixer.

Figure 5: Regulator results, using the example of a FoMaSys installation: Days 2 and 3

FoMaSys installation in Brazil
Day 1: Regulation by sand moisture
The target value for sand quality is a predefined moisture level. The output moisture was kept very constant at 3.02 % H₂O with an accuracy of ±0.05 % (red curve, Figure 4). The compactability before the molding machine (at this point in time still unregulated – yellow curve) fluctuated by ±3.07 % around an average of 41.92 despite constant moisture at the mixer. Because the regulation of compactability was not yet activated there was also not yet any adaptation of the water requirement (target moisture: green line) to keep the compactability automatically constant.
Despite highly precise output moisture at the mixer, the compactability at the molding plant fluctuated. This was caused by:

- creeping percentage changes in the proportions of bentonite, c-carriers, clay matter, core sand, new sand and used sand,
- differing bentonite saturation levels due to varying material input moisture in the mixer, and
- evaporation on the path to the molding machine.

Days 2 + 3: regulation by compactability
The target value for sand preparation is now a predefined compactability of 40%.

The compactability was kept constant directly at the molding plant at 40.1% with an accuracy of ±1.6% over 2,000 batches (yellow curve, Figure 5). The fluctuation range of compactability therefore halved after activation of the system (back-coupling of the Vedimat to the Micomp Uni); accuracy thus doubled. This compactability accuracy was achieved directly at the molding plant through continuous fine adaptation of the water requirement of the batch in the mixer in the hundredths range. Here, in the practical example: ±0.04% around an average of 2.92% H₂O (red curve).

The finest of adaptations and the corresponding accuracies can only be achieved as a result of the particular installation position of the Vedimat linked with a moisture measurement and control system that can measure and regulate in the hundredths range (only possible in the mixer).

Summary
Technological and process-related details, as well as the comprehensive approach of the FoMaSys molding sand management system, have become successfully established during the past ten years. The introduction of the Online-Sandlab may set a new standard for molding material management.