Control of rebonding sand mixing as a condition for optimisation of the sand feeding system in the casting line

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Abstract

In order to ensure the effective operation of the casting line, synthetic sand containing bentonite has to be fed in a precisely controlled quality and quantity. The required quantity is ensured by mixing stations outfitted with turbine mixers. The quality of sand mix, defined by its technological parameters, depends on the available measurement and control equipment and the system controlling the mixers’ operation. These issues are investigated at the Department of Foundry Engineering AGH-UST in collaboration with the PPP Technical Company in Now Sól (Poland), a major manufacturer of turbine mixers.

This study outlines the scope and results of research work aimed to improve the control equipment to enhance the performance of turbine mixers.

Keywords: Mechanisation And Automation, System For Controlling the Mixer Operation, Sand Mixing

1. Characteristics of the sand feeding systems

Moulding sand, used and rebonded at the mixing station, has to be fed to the casting line throughout the process. It is required that each process line should be supplied individually in order to adjust the sand parameters to the requirements of the thickening strategy implemented by the moulding machine.

Typically, mixing stations are outfitted with various types of turbine mixers.

Turbine mixers feature high efficiency, large pan capacity and short mixing cycles. The capacity range of turbine mixers is shown in Fig 1. It is worthwhile to mention that sand mix prepared in a turbine mixer exhibits a certain degree of aeration and hence permeability, vastly exceeding the parameters allowed by roller mixers. Selected relationships are shown in Fig 2. This aspect is of key importance since the recommended thickening methods require the aeration of the sand mix. The degree of thickening in the impulse and continuous process becomes more favourable when the sand mix is better aerated.

The research program undertaken for the benefit of manufacturers and operators of mixers involves the evaluation of the sand preparation and rebonding processes. Major determinants of the process efficiency include [5, 9]:
- pan position (horizontal, inclined) and its rotational speed,
- shaping of the turbine and blade assembly,
- rotational speed of the turbine assembly and the direction of its rotation,
shaping of the turbine blades, their number, position and inclination angles,
mixing time,
operating parameters of the turbine mixer.
Schematic diagrams of turbine mixers and dedicated equipment are shown in Fig. 3 and 4 [6]. These are mnemotechnical diagrams, available on the operator’s display. Preparation of the sand mix to be sent for rebonding mixing consists mainly of cooling and removal of contaminants. Sand is typically cooled by vibro-airslide coolers.

2. System for controlling the mixer operation and its key equipment

The operations of the whole station are monitored by a control system equipped with a state-of-the-art. PLC controller. The dedicated software provides for the control of all drives and mechanisms, allowing the defects or disturbances to be detected immediately [1]. The integrated remote access module enables the diagnostics and servicing of the control system using the Internet.

A configured controller incorporates the following elements:
- a central processing unit (CPU)- a processor,
digital input module,
digital and binary output module,
communications module interacting with two weight meters.
Input signals include the signals from:
- position and state control elements in particular system components fed to the inputs of the controller’s input modules,
- manually-controlled elements (keys, connectors) provided in the operator’s pulpit,
strain bridges in electronic scales converted by weight meters and transmitted to the communications module. All signals are analysed and processed accordingly by the CPU unit in accordance with the logic of the control program, which handles the mixer drives and mechanisms as well as the dosing systems. The program generates signals that trigger the output circuits of the control system (contact coils, valves, signalling elements). The circuit testing system is an integral part of the control system.

The amounts of particular components of sand mix to be rebonded are controlled by the dosing units, comprising containers of specified capacity and feeders. Because of major differences in the amount of main components (used mix, sand) and of additives (bentonite, coal dust) two independent units are employed differing in design, capacity and weighing precision. The return mix and rebonding sand are transported to the mixers via belt feeders, powdered products are handled by worm feeders. Application of two-gear drives allows the two-stage feeding: preliminary stage- feeding large amounts, final stage- feeding the twice smaller amount in order to reach the predetermined value [6].

The amount of water fed to the mixer and cooler determines the quality of mixing and cooling. Technological parameters of the sand mix depend on the moisture content [2, 3, 7]. The amount of water to be supplied is determined basing on the amount of the used sand mix, its moisture and temperature. The amount of used sand mix is determined using an electronic scales whilst its temperature and moisture contents are handled by the measurement system. Moisture measurements are taken with sensors in the form of rod condensers submersed in the used sand mix and incorporated inside the weight container whilst temperature measurements are effected using sensors fixed on the container’s walls and submersed in the used sand. Measurement data are transferred to the central device (a moisture meter system) which computes the required amount of water to be fed to the mixer throughout the entire mixing process in order to get the mix with the predetermined moisture content. The moisture control system is an integral part of the system controlling the entire mixing plant. Depending on particular requirements, water dosing is implemented by a single- or double-valve system. The first dose of water is fed during the preliminary stage of the rebonding mixing process.

Mixers and coolers manufactured in Poland are equipped with the measurement and control systems Michenfelder [6, 7]. The available MICOMP UNI systems include several solutions and types, including those interacting with mixers, coolers or combined mixers and coolers. The currently available moisture control system RWM is used for measuring moisture content by the capacitance method based on the dielectric constant.

Control systems which can be provided as an extra equipment in turbine mixers include MICOMP UNI G-VM and MICOMP UNI G-CH.

The control system MICOMP UNI G-CM is used for measuring moisture upstream of the mixer throughout the entire sand preparation process. Hence, the mixing dynamics can be precisely monitored for each batch of the sand mix being prepared.

Supported by the master system MiPro, the process can be visualised and vital parameters archived: temperature of the return sand prior to feeding, moisture content throughout the entire mixing cycle, temperature of the sand mix on leaving the mixer and the amount of supplied water.

Apart from fully automatic moisture measurement and control systems, the available equipment includes online sand testing systems where the amounts of the rebonding agents are obtained basing on the online measurement data.

The Michenfelder system for measurement and control of sand compactibility (Vedimat) allows for maintaining the constant level of sand compaction upstream of the moulding machines, which improves the quality of the manufactured moulds. Application of sand testing systems integrated with the master system MiPro allows for process visualisation and archiving of the following parameters: sand compactibility, compression strength and active bentonite contents to help reduce the demand for bentonite or bentonite-carbon mixture.

The mixing cycle time and time required for downstream processes (dry mixing time, the total mixing time after water feeding, time required for regular operations) can be controlled by controlling the power consumption by the mixing unit. Power consumption tends to increase during the mixing cycle with an increase of the surface area of grains covered with clay-water slurry, accompanied by improved mix resistance. Leaving aside the idle run, the mixing cycle involves: I- charging of mix components; II- homogenisation; III- water dosing; IV- mixing of wet sand; V-emptying the mixer [9, 10].

The characteristics of power demand by the mixer’s drive can be also based on current intensity patterns. In the case of electric-powered devices, current intensity is the key parameter quoted alongside their power ratings. Current intensity in drive of a turbine mixer is shown in Fig. 5 [9].

![Fig. 5. Current intensity by a mixer drive [9]](image)

### 3. Conclusions

Main equipment of the sand processing lines includes turbine mixers and vibro-airslide coolers, also available from domestic manufacturers. It is shown that turbine mixers are widely recommended for use in preparation of sand mix because of their favourable operating parameters. Rebonded sand prepared in
a turbine mixer has the required technological parameters, such as permeability. It is well aerated, which is of key importance in the context of currently applied thickening strategies.

It is worthwhile to mention that we are now able to easily control major parameters of mixing process through regulation of process parameters, such as cycle time, rotational speed of the pan and rotor and other mixing assemblies and the design of the mixing unit. Constructional parameters that affect the mixing performance include the blade spacing, shape and inclination angle. Obviously, the engineering and design is the sole responsibility of the manufacturer, yet the operators and use are still given an opportunity of changing the settings through the control of the cycle parameters.

This study briefly outlines the moisture and sand control systems operated during the mixing and before sand feeding into the moulds.

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References