“Listening pays off” is true both in life and measurement technology

The acquisition of process control parameters is an important task during the continuous casting of steel. Due to the high temperatures of liquid steel, there are hardly any measurement methods that yield information about the liquid steel flow and are applicable in a production environment. A new acoustic approach, that makes use of the noises generated by the continuous casting process itself, is a first step to fill this gap.

A hot topic
The range of available materials was always an important factor in the possibilities of a civilization. This fundamental importance is emphasized by the terminology of time periods like “Bronze Age”. Today, steel is an important material and its quality is important for e.g., the safety of structural elements in buildings and bridges as well as the optical flawlessness of the surface of car sheet metal surfaces coated with car paint.

After the conversion from pig iron to steel in a converter and adjusting the amount of alloy components, the liquid steel must be solidified. Nowadays, the most common method for this task is the so-called continuous casting process: It allows the continuous solidification of the liquid steel into an endless block of steel. The block is then cut into smaller pieces for further processing.

To achieve high productivity and product quality, the correct steel flow pattern must be maintained in the submerged entry nozzle. It is thermally highly stressed and prone to clogging. Injecting argon gas into the submerged entry nozzle reduces the clogging problem and if the process parameters are correctly set, the gas bubbles escape from the mould before the steel solidifies.

Monitoring the clogging state and the fluid flow in the nozzle in general are thus highly desired goals in the steel industry. Unfortunately, because of the high temperatures of liquid steel of approximately 1600°C, it is very difficult to develop methods which can be applied during the regular production operation of a continuous casting plant.

Measurement technology is all ears
Most of the time, the measurement of continuous casting plant parameters must be done indirectly, using a wide range of different physical effects. Computer simulations and laboratory experiments are usually unable to completely reproduce their complex interdependence such that early testing on the real plant is important.
Some different approaches for characterization of the liquid steel flow were considered, but an acoustical method turned out to be the most promising one: Just like the flow in a water supply line or the bubbles in a hot tub cause audible noise, the same can be expected from the liquid steel and the argon bubbles injected into the nozzle. Since the noise changes with the flow and bubble properties, it should be possible to gain the desired information about the flow and bubbles.

Because there are optical methods that allow the noises to be measured without mechanical contact, it is not necessary to place sensors in the high temperature areas. However, the measurement locations must be visible, i.e., nothing is allowed to block the line of sight. Additionally, the noise propagates into adjacent cooler structures where special microphones can be mounted to capture the noise.

Altogether, only minor modifications are necessary to implement the proposed measurement methods in a production set-up, facilitating a quick utilization of the laboratory results.

![Fig. 1: The tip of the red-hot casting nozzle is immersed in the molten bath of a mould with rectangular cross-section. (Image courtesy of Primetals).](image1)

![Fig. 2: Simulation of acoustical properties for the analysis of gas bubbles.](image2)

**Impact and effects**

The described measurement method is not yet ready for a production environment, but the laboratory experiments suggest that it is possible to obtain information additional to the currently used one by recording the plant noise at carefully selected positions. This additional information can help to improve the long term quality and productivity.

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