Digital technologies are transforming industry at all levels. Steel has the opportunity to lead all heavy industries as an early adopter of specific digital technologies to improve our sustainability and competitiveness.

This column is part of AIST’s strategy to become the epicenter for steel’s digital transformation, by providing a variety of platforms to showcase and disseminate Industry 4.0 knowledge specific for steel manufacturing, from big-picture concepts to specific processes.

Fully Automated In-Line Strand Condition Monitoring for Enhanced Roll Gap Measurement and Control in Continuous Casting

It is estimated that there are over 600 continuous steel casters worldwide. Measurement and control has typically been delivered by off-line strand condition monitors (SCMs) that are inserted manually into the caster periodically during downtime. In-chain calipers offer a robust roll gap measure that can be fitted onto the dummy bar head, automatically providing gap measurement data on every cast without impacting productivity.

Principles of Strand Condition Monitoring

SCMs are installed onto the dummy bar chain in place of the dummy bar. Measurements are then collated and recorded automatically from onboard sensors, which are then downloaded via a cable or Wi-Fi to a laptop for analysis and presentation.

The vast majority of SCMs in the market today are off-line. They are not permanent fixtures in the caster; rather they are manually inserted onto the dummy bar during periods of planned or unplanned downtime and once in place can provide a very comprehensive range of measures including roll gap, outer face roller and segment alignment, roller bearing and wear condition, and the efficacy of any water spray nozzles that have been fitted into the SCM.

Once the required measurements are obtained, the off-line SCM is removed from the chain. Casting recommences once the necessary adjustments (if any) to the caster setup are made and the SCM is stored for the next planned measurement date.

Experience shows that, of all the measurement parameters, it is the roll gap that most frequently demonstrates deviation from standard. An in-chain roll gap SCM that remains on the dummy bar during casting can provide measurement data after every cast sequence to trigger swifter rectification than would otherwise be the case and potentially ensure a higher prime slab percentage output as a consequence. This combination of off-line and on-line technology provides the end user with the complete quality assurance package.

The In-Chain Caliper

The in-chain caliper measurement system is semi-permanently attached to the dummy bar chain. It is recommended that each dummy bar is equipped with two or more assemblies that are fitted (with minimal change required) across the width of each strand to provide roll gap measurements at a fixed position from the centerline of the strand.

It is proposed that the measuring assemblies are located around the
top of the widest section of the dummy bar chain to aid measurement and stability particularly during insertion and extraction phases. Each assembly is designed to house a gap measurement mechanism (caliper) plus a combined datalogger and battery module.

Only one of the assemblies must have a datalogger and battery (the master). The other assemblies may be caliper only (slaves) depending upon the preference of the customer.

Measurement commences automatically every time the dummy bar chain is inserted into the casting machine, ensuring that the most up-to-date caster information is always available. Alternatively, the end user can select when the system will measure. Measurement will end automatically once the dummy bar exits the caster.

The system is robustly designed to endure the harsh environment in which it operates. All parts are nickel-plated or stainless steel to resist corrosion and are waterproof. Importantly, each caliper assembly is designed to fully retract behind the profile of the dummy bar chain to prevent damage from the drive rolls.

The caliper can measure slab thicknesses from a minimum of 170 mm as shown overleaf and has a current range of 85 mm to accommodate various thicknesses.

The measuring calipers assembly consists of two radius arms rotating around a common supporting shaft. Each arm can move independently of the other and is spring loaded and damped to provide smooth action. The radius of each arm is custom to the target gap of the caster, the midpoint of the measuring range, to aid measuring accuracy.

The common shaft is supported by sealed bearings and protected by a double rotary seal arrangement.
into the main housing body. On the end of the shaft is a rack-and-pinion arrangement that drives a rotary gap sensor. Attached to the pinion is a helical reduced-backlash pinion to eliminate measurement hysteresis.

Included on the measuring caliper is an inclinometer to measure the angle during the logging sequence. This angle is used to compensate for any measurement differences that might be caused by the caliper arms as they pass through each roller pair.

The combined datalogger and battery modules are also designed to be easily removed for service or battery charging. The batteries are designed to provide 8–10 hours of life, and with an ultimate timer built in, will be automatically switched off after a period of inactivity. Battery charging can be done off-line or on the caster itself.

Measurement of the gap is provided by a digital rotary encoder. This ensures noise-free, accurate gap measurement to ±0.15 mm via serial synchronous interface (SSI) protocol.

A dedicated Windows software program is provided for the in-chain caliper. This enables data transfer from the onboard computer for processing and display locally on the laptop PC or remotely via networked PCs. An example of an output screen is shown in Fig. 6.

**Market Development**

The first in-chain caliper was commissioned at a European steel mill in the first quarter of 2022.

**Conclusions**

The in-chain caliper fits semi-permanently into the caster to complement the off-line SCM technology. Combining the off-line and on-line measurement capability offers:

1. Total control of the continuous casting maintenance activities.
2. Minimized product downgrading and downtime.
3. Operating conditions for quality critical slab production.

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