IMPROVEMENTS FOR CONTINUOUS CASTING
WITH EXAMPLES FROM voestalpine CASTERS IN LINZ

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Abstract
As much as vatron increases it’s know how in continuous casting as more products are
developed that help the operator to get information from his caster and to adjust the caster
properly.
Over the years vatron developed measurement and control devices for many parts of the
caster starting with the Taper Meter to adjust narrow face taper of the mold, the Mold
Guidance Checker to measure the 3d-oscillation of the mold, the MoldExpert, the mold
monitoring system with auto-adaptive breakout prediction algorithms, the Gap Tool to
manually measure the roll gap and the Roll Gap Checker to automatically calibrate roll gap
and measure segment alignment, roll rotation and the spray water.

1 MEASUREMENT DEVICES

Taper Meter
The exact taper of the mold narrow faces in continuous slab casters
is essential for optimized surface quality of the slab. The taper has a
substantial effect on the shrinkage process, shell growth and the
development of surface cracks. The slab size is also determined by
the geometrical measurement of the mold. The taper measuring
system allows checking and adjusting the mold within the required
tolerances before casting begins.
The taper is measured precisely with long-term stable inclinometers.
The measuring system is battery driven and designed such that
precision of the measurement is not affected by the rough operations
in the steel plant. The device is optionally equipped with a laser
distance measurement to determine the mold width.
The measurements can be performed simple, precisely and quickly.
The calibration device is delivered together with the taper meter and
it is integrated into the storage unit.

Mold Guidance Checker
Knowledge of oscillation movement of a slab casting mould provides plant operators with
important information about the slab surface quality to be expected.
The portable Mould Guidance Checker records and displays the movement of the mould in
three spatial axes during measurement. The operator can check the mechanical condition of
the entire oscillating equipment by means of evaluated data (bearing clearance, etc.).
The system comprises a sensor and battery-powered measurement PC (Notebook PC) which
enables oscillation amplitudes and movement deviations to be exactly recorded in each
works on a mould during casting conditions. Time dependent oscillation movements of the three axes are displayed during measurement. Other illustrations such as 2D and 3D graphs can be created by an evaluation program after measurement. Data transmission to the Quality Control Computer via a serial data line is also possible.

Previous experience has shown that abrupt changes of oscillation movement occur only after a major break-out. Periodical checkups (e.g. weekly) are considered to be fully adequate. Therefore it is not necessary to mount the sensor on the mould permanently.

**MoldExpert**

The MoldExpert is an advanced mold monitoring system that offers a unique auto adaptive breakout prevention system as well as a heat flux and friction monitoring package. This set of functions offers the operators and metallurgists a comprehensive mold monitoring tool for the virtual “look into the mold”

The MoldExpert collects all relevant data around the mold (thermocouples, hydraulic oscillator piston pressures and strokes, temperatures and flow of primary cooling water, mold level signal, etc.) in one system. This makes it easier to compare and combine data of different subsystems. The MoldExpert calculates relevant data characterizing the casting process.

The MoldExpert provides a detailed “look into the mold” and allows interpretation of the actual lubrication and solidification conditions. Critical situations are automatically realized and alarms are released.

Arranging a MoldExpert Client PC near the area of the mold allows the mold operators to constantly monitor the process condition and get direct feedback concerning their
actions.
The MoldExpert is made up of modular packages that can be installed individually.

**Breakout Prevention**
A reliable breakout prevention system is necessary to avoid costly repairs and to keep production available.
The MoldExpert uses three independent auto-adaptive algorithms to detect stickers.
- Each algorithm is specialized for different behaviors of stickers.
- Stickers in any part of the mold are detected.
- The algorithms automatically adapt to for example steel grade, casting powder, copper plate thickness.
- Limits automatically adapt to temperature behavior
- No tuning of algorithms for each steel grade is necessary, the algorithms adapt automatically.
- Automatic detection of open and bad thermocouples.
- The system works very well from the first cast on.

**Heat Flux Monitoring**
Heat flux through the copper plates is a measure for the heat exchange of the solidifying strand shell with the copper plates. The heat flux ratio between narrow and broad face can also be determined. It is also a good indicator of the performance of casting powder and correct narrow face taper.
These calculations are performed for all four copper plates, based on delta-T measurements of the mould cooling water flows within the mould cooling circuits.

**Mold Friction Monitoring**
One of the most important tasks in continuous casting is a reliable lubrication of the casting powder on the meniscus and between the strand shell and mold coppers. The so-called “mold friction force” is caused by the interaction between the strand shell surface and the mold copper plates. It is calculated online from pressure measurements on the mold oscillator cylinders and oscillation strokes.
By knowing this mold friction force, a quantitative insight into the behavior of casting powder during operation is possible. This metallurgical information reflects operating conditions as well as quality features. Mold friction is an important parameter to optimize casting and oscillation practices.
Additionally, hardware problems of the oscillator can be seen due to the visualization.

**Data Storage**
If an alarm is issues, a 15 min snapshot of this data is stored automatically. So each alarm situation can be analyzed later.
Additionally, the operator has the possibility to store an interesting situation, even if it occurred up to 3 days ago.
Parallel, the MoldExpert stores process data like friction work, mold level and thermocouple temperature in a cyclic buffer. This buffer typically holds data of the last 3 or 4 months. The long term viewer is used to view that data in synchronous subplots. The time scale allows zooming from hours to
seconds and the corresponding casting length is displayed as well. Mold casting conditions of slabs with irregularities and defects can easily be traced back.

**Gap Tool**

The gap tool is used to manually measure the distance between opposing rolls (in continuous casters). The guidance rolls that support the gap tool ensured that the measurement is done perpendicular to the surface of the roll. The dial gauge can easily be adjusted to different roll gaps.

**Roll Gap Checker**

The Roll Gap Checker was developed by voestalpine mechatronics GmbH, Linz to measure the roll gap, the alignment and the rotatability of the rolls of a continuous caster. Additionally, a spray water tester can perform a test of the nozzles of the secondary cooling.

To perform a measurement, the Roll Gap Checker is mounted to the dummy bar, replacing the dummy bar head. The Roll Gap Checker can be guided through the strand guidance in both directions, from top to bottom or reverse, with speeds up to 5 m/min, what enables short measurement times.

For all measurements it is important that the bearing clearance is eliminated. This is done by pneumatic springs that have the following advantages:

- The supplied force is very high and is nearly constant with stroke
- The possible stroke is very high compared to other springs
- Lifetime is high
- Force can be shut on and off
If the caster is equipped with the VAI ASTC system (automatic strand taper control), then the results of the Roll Gap Checker can be sent, after inspection by the operator, directly to the ASTC master controller which uses these values as calibration values for the segment controllers.

Main advantages of the direct ASTC connection are:
- No human errors by typing wrong numbers
- No human errors during measurement
- Bearing clearance is always eliminated
- Quick transfer of calibration data

Data is transferred automatically when the Roll Gap Checker exits the last roll of the strand guidance. From the measurement PC (within the Roll Gap Checker) it is sent via W-LAN (wireless LAN) to the evaluation PC that is connected to the plant Ethernet.

Calibration of the Roll Gap Checker can be done under the same conditions that there are during measurement (means springs are under pressure) in the storage and calibration device. No disassembly of the Roll Gap Checker is necessary to calibrate the sensors and the operator gets an online instruction, how to do the steps of calibration. This means that the operator does not need to have special electrical knowledge and calibration is done very quickly.

2 OPERATOR EXPERIENCES

Roll Gap Measurement

Measurements are necessary because the gap between the rolls changes with casting, caused by wear of rolls and defects in the bearings.

A non proper adjusted roll gap leads to a bad inner quality of the slab, like half way cracks, a bad segregation index or it may lead even to center line cracks. Especially on heavy plates a high segregation index or half way cracks may be detected by the ultra sonic inspection and downgrade the slab quality, or even worse it may lead to a customer complaint.

A measurement of the roll gap is usually done every 6 weeks at each caster of VA-Stahl.
Taper Measurement
The adjustment of the taper has severe effects on longitudinal and corner cracks. Therefore a measurement of the taper is done before each start of cast.

Mold Oscillation
If the guidance of the oscillator is not correct this may also lead to corner cracks.

MoldExpert
Only the costs for the repair of the caster after a breakout are on an average of about 57.000.- Euro. Additionally the plant cannot cast for 8 to 24 hours. This emphasizes the importance of a reliable breakout prediction system.
The MoldExpert is also a valuable tool for the development of casting practices and the evaluation of casting powders for new steel grades.

3 SUMMARY AND OUTLOOK
Through the close contact with our customers our products are continuously improved. In this case we want to highlight voestalpine Stahl Linz. Their demand on producing highest quality steel, especially for automotive industries, is a challenge for us, to provide them with the best measurement and control devices available. In this way new measurement tasks leads to new measurement devices.
An example of that cooperation is a Segment Checker that is developed now. It will be an automatic measurement device that measures the position of the rolls of unassembled segments in the maintenance shop.