

# Q-LEVEL+

## Accurate mold level control system for continuous slab casters

### BENEFITS

- Possibility of installing it on existing slab casters
- Increased mold level stability
- Suppression of standing waves
- Suppression of dynamic bulging effect on the mold level
- Suppression of roll eccentricity effect on the mold level
- Maximization of operational performance and productivity at steady-state conditions
- Enhanced slab surface quality
- ROI < 6 months

### PROCESS

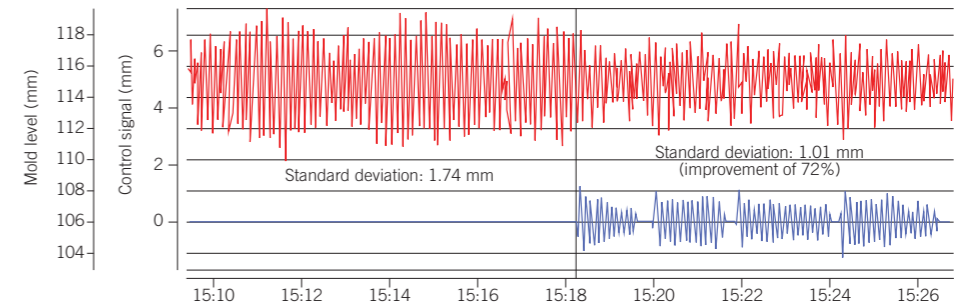
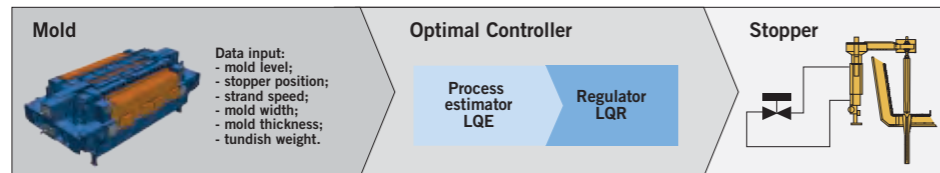
Q-LEVEL+ is a tool specifically developed to improve the steady-state condition of liquid steel flow into the mold by counteracting any mold level disturbances. It is well known that an unstable mold level may contribute to a number of quality issues, affecting both surface and internal quality. One of the main innovations of Q-LEVEL+ is the capability to analyze and process the level fluctuation due to a multitude of periodical disturbances, such as dynamic bulging, roll eccentricity or mold natural waves. Q-LEVEL+ is able to analyze the level behavior and can therefore anticipate the disturbance and take the proper preventative action, which guarantees a highly dynamic control of the process, as it can react faster - even in advance of quick variations in the parameters, thus guaranteeing higher stability for the mold level.

### EQUIPMENT

Q-LEVEL+ is comprised of three modules that each have a specific and dedicated functionality. The modules have the function of receiving control signals and process signals from the sensor; then, these signals are processed according to setup parameters from the PCS (Process Control Station). After processing, the system is able to counteract any mold level anomalies.

- The three modules are:
- > Optimal Controller: response speed;
  - > Supervision and Control Strategies: decides best strategy to keep mold level at target;
  - > Filter System: to counteract phenomena like dynamic bulging.

Q-LEVEL+ can be applied on all existing caster plants, utilizing both stopper rod or slide gate equipment controlled by eddy current or radioactive sensors.



— Mold level (mm)  
— Feed forward stopper control signal (mm)

Danieli Automation HMI:  
1 FFT mold level  
2 System ON/OFF  
3 Stopper trend.



### PROCESS CONTROL

Q-LEVEL+ Optimal Controller is mainly composed of two different parts:

- > LQE (Linear Quadratic Estimator), a special module used to estimate the real time process data;
- > LQR (Linear Quadratic Regulator) Matrix, a proportional vector from Estimated States to actuator reference.

By varying the matrix values it is possible to change the mode of controller and to increase or decrease the speed response. The supervisory module is always active during casting operations and it decides the best strategies to keep the level at the target and fix the anomalies. The filters module is comprised of special filters to counteract the phenomena like

bulging waves, or rolls eccentricity waves or standing waves.

One of the main innovations of Q-LEVEL+ is its ability to analyze and process the level oscillation due to a multitude of periodical disturbances such as dynamic bulging, rolls eccentricity and mold natural waves. Process control sequencing is as follows:

- > FFT analysis of the level oscillation.
- > Identification of a specific disturbance frequency that can be correlated to roll pitch, diameter and/or natural wave.
- > Evaluation of the relevant disturbance amplitude.
- > Counteraction by anticipating flow control correction acting on stopper rod / slide gate mechanism.

### PERFORMANCE ACHIEVEMENTS

Q-LEVEL+ has been proven to reduce the standard deviation in mold level control by 72%, as shown in the chart above.