METALS

Improving quality and cost-efficiency in cold rolling

Technological controls for cold rolling processes

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for cold rolling processes

Rolling of flat metal products is a complex process where the quality of the product is influenced by various factors like incoming material, mechanical and electrical equipment, lubrication and control strategies.

For high-end performance in terms of material quality and productivity, ABB's modular technological control solutions are proven and tested in praxis.

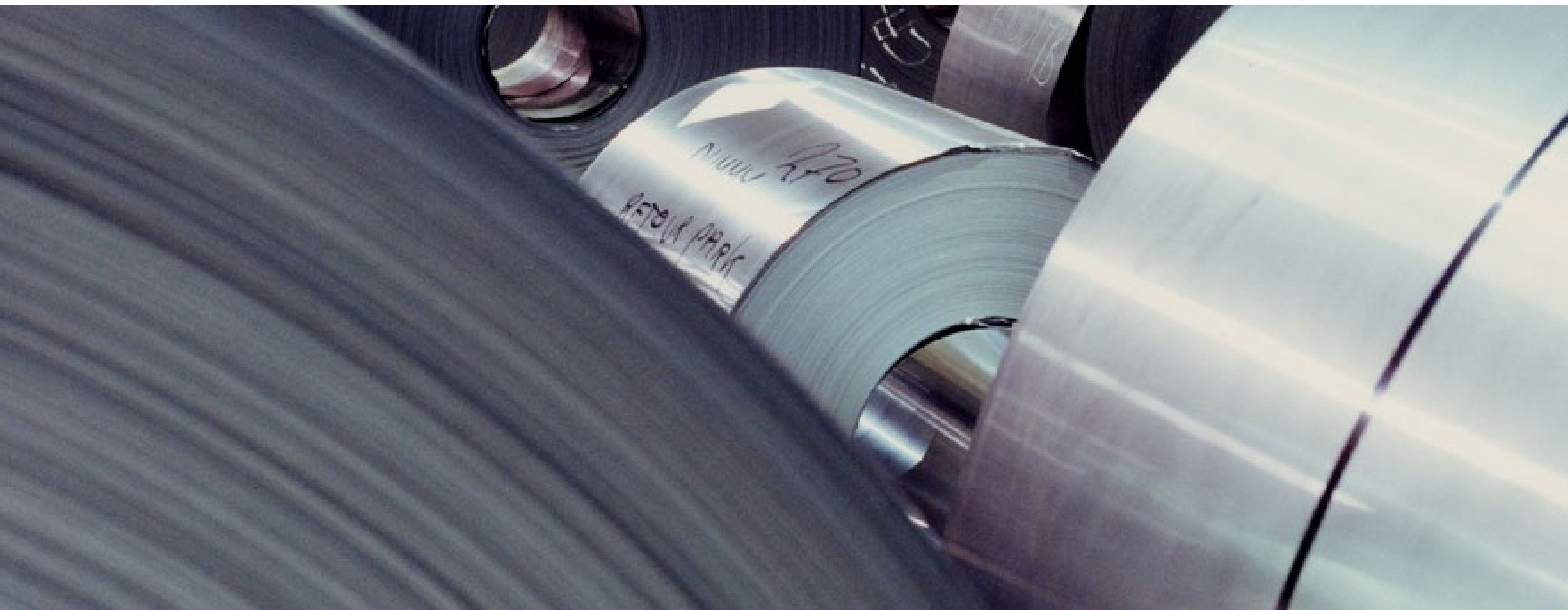
Available for all material and rolling mill types:
- Break down mills
- Multi-roll mills
- Two-stand mills
- DCR mills
- Tandem mills
- Temper mills
- Foil mills

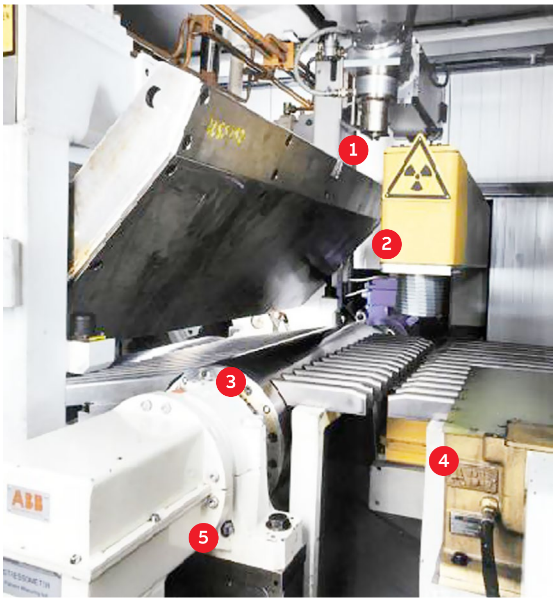
Significant quality parameters
The significant quality parameters are: material thickness, material shape and surface, and the homogeneity of stress distribution. For optimized cost-efficiency and to maximize material usage, tight tolerances for the thickness are vital, to enable the strip to be rolled down as closely as possible to the minimum permissible thickness.

Product quality can only be effectively optimized if the mechanical, electrical and instrumentation equipment and control strategy solution fit together.

Comprehensive know-how cold rolling
With experience from over 800 cold rolling projects ABB has the in-depth knowledge, skills and offerings required to design and implement solutions that allow for tangible, long-term process improvements.

Customer advantages
- Scalable control concept depending on sensor and actuator concepts
- Tight thickness and flatness tolerances over the whole strip length
- Optimized throughput rates
- In combination with pass scheduling and set-up generation:
  - Minimized threading, tail-out and reversing times
  - Reduced off gauge length at strip head and tail





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02 Important sensors in a cold rolling mill

1 Speed sensor
2 Thickness gauge
3 ABB Stressometer for flatness measurement
4 ABB strip scanner
5 ABB tension measurement

Roll gap control
Two basic modes, either gap position or total roll force can be applied. Mode selection depends on the type of superimposed Automatic Gauge Control (AGC) and the threading strategy.

To ensure a constant response time over the whole working range various process related adaptations and supervisions are included.

AGC for break down mills
Depending on the sensor concept based on customer needs different thickness control strategies are possible:
- Thickness feedback control
- Thickness feed-forward control
- Mass flow control
- Speed feed-forward control
- Roll eccentricity control
- Tension feed-forward control

Thickness feedback control
The basic control strategy is thickness feedback (monitor control) based on the measured thickness deviation at the exit side of the mill.

The delay time, transport of the strip from the roll gap to the thickness gauge, essentially determines the control system's dynamic response, particular at low rolling speed. The software package provides a predictive model based option to significantly improve the dynamic behavior of the thickness feedback controller.

Thickness feed-forward control
With a thickness gauge at the entry side of the roll gap, the thickness feed-forward control can be applied. It is able to compensate any thickness deviation caused by changing entry thickness. A correction value is calculated according to a stored entry thickness deviation and forwarded to the roll gap control for interaction when the strip section reaches the roll gap.

Mass flow control
Using the mass flow principle, the outgoing strip thickness at the moment of rolling can be calculated based on incoming strip thickness, incoming and outgoing strip speeds. By means of this mass flow control concept, high control accuracy can be achieved, clearly enhancing concepts of thickness feedback and thickness feed forward relating to product quality.

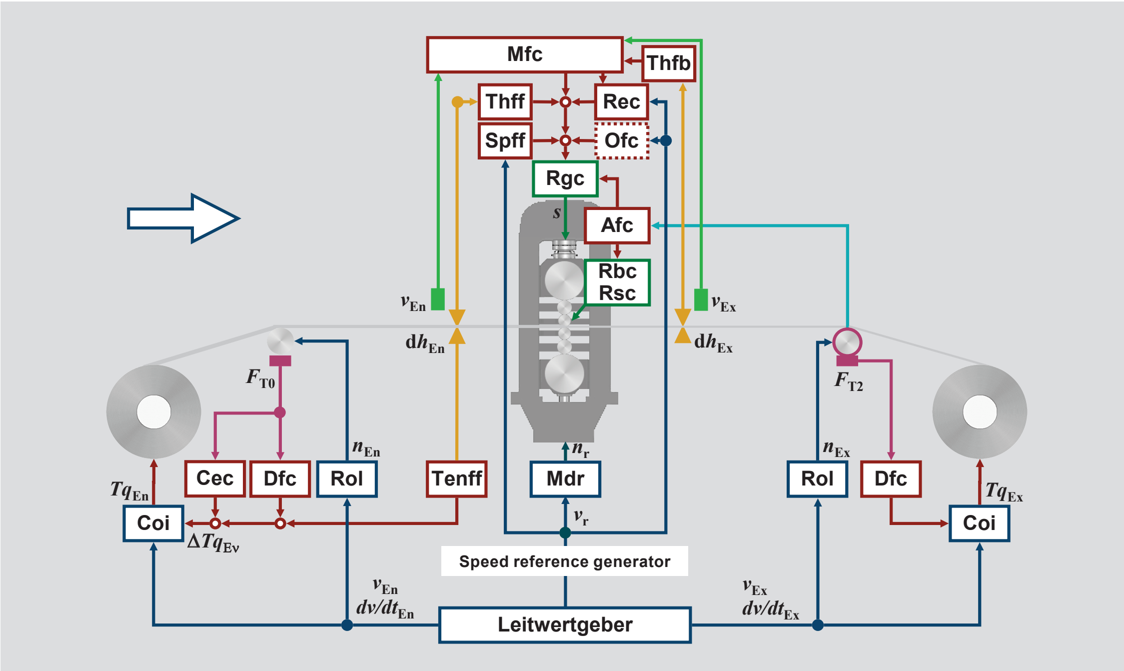
Speed feed-forward control
With the speed feed forward control solution velocity-related process variations are compensated, in particular in the acceleration and deceleration phases.

Roll eccentricity control
Irregularities in roll geometry cause periodic variations in the roll gap, which can lead to variations in thickness of the rolled product. The function compensates for periodic disturbance from geometric asymmetries on the backup rolls. An automatic adaptation to compensate changes during rolling, e.g. due to thermal effects, wear, loading, etc. is implemented.

Tension feed-forward control
The tension feed-forward control responds to entry thickness deviations and applies a suitable adjustment to the coiler torque in order to consider the interactions between roll gap and tension.

Thickness control strategy

v	Velocity
dv/dt	Acceleration
n	Rotation speed
FT	Strip tension
Tq	Torque
dh	Strip thickness deviation
s	Roll gap position
En	Entry
Ex	Exit
Mdr	Mill drive control
Coi	Coiler control
Rol	Roll control
Dfc	Tension control
Cec	Coil eccentricity compensation
Rgc	Roll gap control
Rbc	Roll bending control
Rsc	Roll shift control
Ofc	Oil film compensation
Afc	Automatic flatness control
Rec	Roll eccentricity control
Thfb	Thickness feedback control
Thff	Thickness feed-forward control
Spff	Speed feed-forward control
Mfc	Mass flow control
Tenff	Tension feed-forward control



AGC for foil mills

Speed-tension optimization is used in foil mill applications, since the strip thickness depends very heavily on tension and rolling speed. In order to achieve maximized material throughput, the speed of the stand is increased until the strip tension has reached its control limit or the speed has reached a pre-selected technological limit value.

AGC for temper mills

Based on the measured elongation and the actual strip dimensions, the elongation control module calculates a correction for the reference value of total roll force and/or tensions.

Coil eccentricity control

The coil eccentricity compensation minimizes periodic tension oscillations generated by changes in the circularity of the coil. A major reason for it is the strip head pressed in the slot of the mandrel. Tension torque corrections are applied at each rotation when the diameter change passes the contact zone of the strip on the coil.

Adaptive control concepts

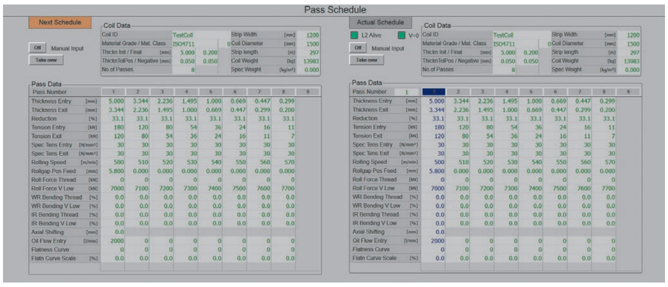
The phenomena in the roll gap during rolling process are largely non-linear and time-variant. In case of system changes or disturbances ABB uses adaptive controls to modify the parameters accordingly. This adaptation is achieved under consideration of quality and stability criteria for the entire control loop.

Flatness control

Correct strip flatness is essential to ensure an overall product quality, productivity and successful sub-sequent processing. Homogeneity of stress distribution and material shape is controlled by ABB's modular flatness software.
The flatness error, given as difference between the measured strip flatness and the target curve, can be minimized by modifying the roll gap with various control functions, such as roll-bending and -skewing, shifting of rolls, cooling patterns and eccentric positioning control for multi-roll stands.
The influence of each separate type of control action is defined by evaluated action curves. A least square fit of these action curves to the flatness error results in the most efficient combination of control actions needed to reduce the flatness deviation.

Coordinated control

Given the complexity involved in interaction of the final control elements and the required dynamics, the desired results can be assured only by automated coordination of all screw-down reference values and control commands for strip thickness, tension and shape.
At any time manual operation such as set-point changes or selection and de-selection of control loops can be performed with bump less transitions.
To ensure highest product quality, ABB is able to simulate the rolling process based on a non-linear process model. Comparison of different control strategies based on various sensor and actuator concepts allows the selection of the best technological control solution.



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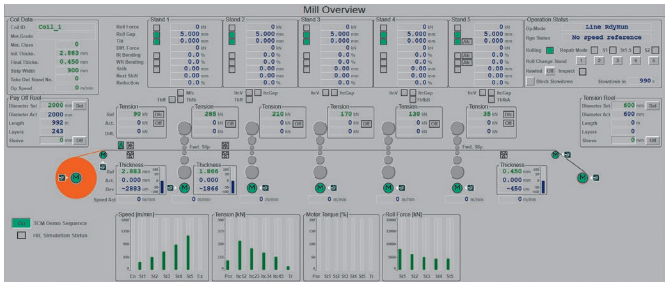
01 Pass schedule, actual and next



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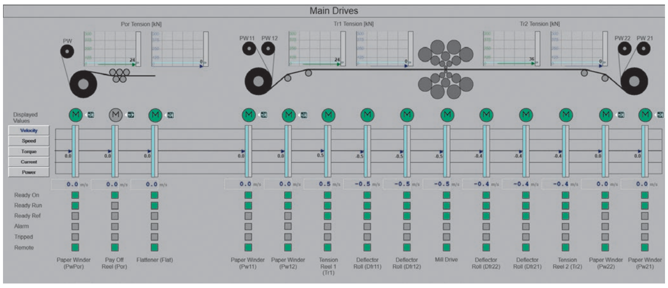
02 Overview tandem cold rolling mill



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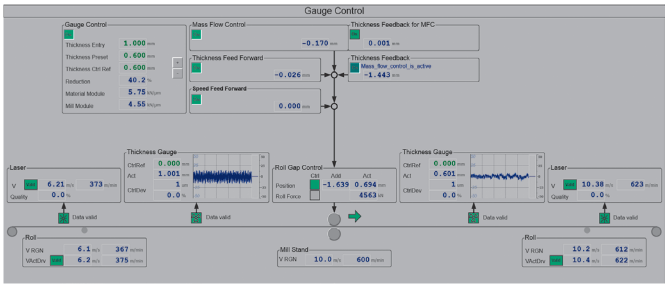
03 Main drives



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04 Gauge control

Superimposed strategies and solutions are available for:

- Pass scheduling and set-up model
- Threading and unthreading
- Tension, torque and/or roll force distribution in multi-stand mills
- Roll gap stabilization to run wedge strip

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