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, control strategies etc.

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 as well as the control strategy solution fit together. ABB has the relevant experience, based on the experience and knowledge from more than 650 projects, plus the requisite products and solutions to design this type of equipment and to put it properly into operation.

**Customer Advantages**

- Scalable control concept depending on sensor and actuator solution
- Tight thickness and flatness tolerances over the whole strip length
- Optimized through-put rates
- In combination with OptimizeIT Pass scheduling and Set-up:
  - Minimized threading, tail-out and reversing times
  - Reduced off gauge length at strip head and tail
Key components for high-end thickness and flatness performance

Roll gap control
Two basic modes, either gap position or total roll force can be applied. Selection of mode 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 with a predictive model based option to improve the dynamic behavior of the thickness feedback controller significantly.

Thickness feed-forward control
If a thickness gauge at the entry side of the roll gap is available, 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 instant of rolling can be computed from the incoming strip thickness and the in- and out coming strip speeds.

By means of this mass flow control concept, high control accuracy can be achieved. Therefore it enhances clearly the concepts of thickness feedback and thickness feed forward concerning product quality.

Speed feed-forward control
With the speed feed forward control solution velocity depending process variations are compensated.

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 predominant sources of these variations are the backup rolls of the stand.

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.

Important sensors in a cold rolling mill
- Laser speed sensor
- Thickness gauge
- ABB Stressometer
- ABB Strip scanner
- ABB Tensionmeter
AGC for foil mills
Speed-tension optimization is used in foil mill applications, since the strip thickness depends very closely 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, fed into an algorithm, 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 or wrapped on a sleeve or 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. ABB uses adaptive controller to detect changes in the system and its disturbances 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 subsequent 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 demanded 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 best possible performance for a mill, ABB is able to simulate the rolling process based on a non-linear simulation model. Comparison of different control strategies based on various sensor and actuator concepts allows the selection of the best technological solution.

Example of a control concept for a single stand mill
Rolling Mills served by ABB’s technological solutions

For high-end performance in terms of material quality and productivity, ABB’s modular technological control solutions are available for all kind of materials and types of rolling mills:

- Break down mills
- Multi-roll mills
- Two-stand mills
- DCR mills
- Tandem mills
- Temper mills
- Foil mills

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

Technological control by ABB provides the tightest gauge tolerances