NEW ADVANCED THICKNESS CONTROL TECHNOLOGIES[1]

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Abstract

Operating authorities of cold rolling mills face steadily increasing requirements regarding product quality from their customers: thickness and flatness tolerances are decreasing while surface quality must improve further. In addition, mill flexibility will have to increase to be able to match growing product variety while high mill productivity (throughput and yield) is key to remaining competitive in the global economy. Therefore, to meet such demands a modern automation system is required with advanced technology products and solutions that can be seamlessly integrated into it. To help manufacturers meet their business and technical objectives, ABB has developed and launched the next generation cold rolling mill automation system and performance enhancing technology solutions. One main component from the new technology suite is the advanced thickness control solution. Today’s thickness controls do not fully take into account the decisive interaction between thickness, roll position and tension. ABB has developed a new technology, which considers this fact, and implemented it into a new controller concept. Initial tests at a customer's installation in Germany have shown significant improvements in thickness tolerance reduction as compared with state-of-the-art technology. This new technology is presented in the following and illustrated by examples of on-site measurements.

Key word: Advanced thickness control.

1 *Paper presented at 42th Rolling Processes, Rolled and Coated Products Seminar of ABM; Santos, SP, October 25 to 26, 2005.*
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1 INTRODUCTION

With ever-increasing demands for product quality and greater variety, mill productivity and flexibility are being pushed to the limit. Strip quality and mill throughput are influenced by various factors such as mechanical design, electrical equipment, auxiliary supplies and control strategy, and a multiplicity of associated variables has to be tightly controlled to meet product quality targets. In addition, pass schedules and set points must be optimally chosen to achieve the required productivity objectives. The entire control process enters into extreme parameter ranges, especially when one considers controlling up to 40 tons of moving parts to a precision of 1 µm.

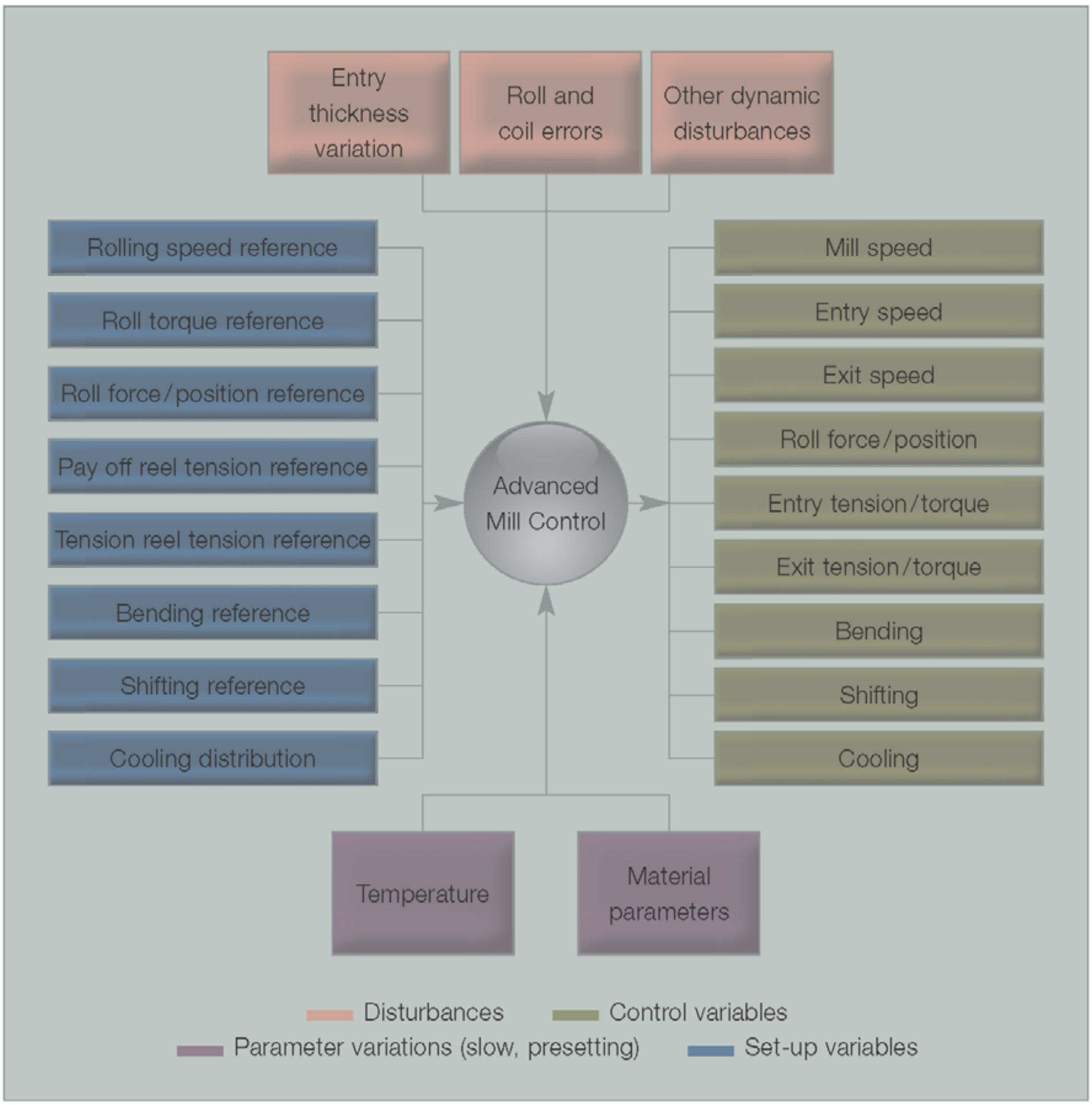

Figure 1. Cold rolling of flat metal products involves controlling a multivariable process with couplings, which is subject to significant disturbances and parameter drift.

Exploiting the full production potential of a rolling mill requires an overall and well-integrated approach to cold rolling mill automation, optimization, advanced control, and decision-support tools. This approach has to cover:

- Mechanical systems
- Drive train
- Material flow
- Visualization and control system
- Modeling and simulation
- Pass scheduling and set-up
- Technological control
- Supervision and diagnosis solutions

The design of such systems requires extensive knowledge and experience in the metal-processing industry and with more than 600 projects in the field of cold rolling, ABB has developed the next generation of cold rolling mill automation. This new system consists of:

- ABB's Industrial^{IT} automation platform with Aspect Object™ technology - the foundation.
- *Simulate^{IT} for Cold Rolling Mills*: for nonlinear dynamic mill simulation.
- *Optimize^{IT} for Cold Rolling Mills*: enables optimal pass scheduling and adaptive mill set-up.
- *Control^{IT} for technological control*: for advanced thickness, flatness and tension control.
- *Advise^{IT} for Cold Rolling Mills*: for monitoring and diagnosis of strip thickness, flatness and tension quality.

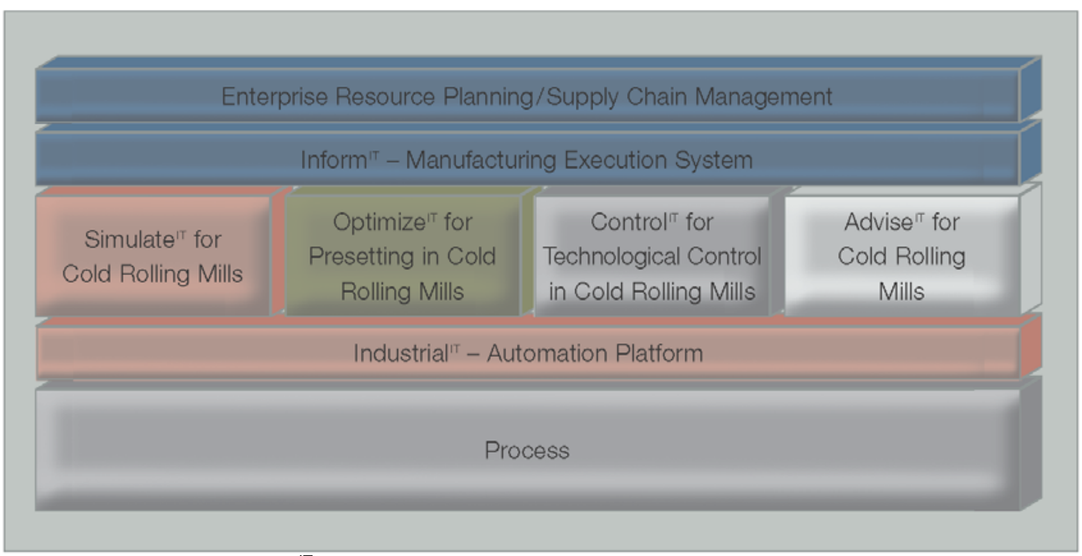

Figure 2. ABB's Industrial^{IT} automation platform, technology solutions and Manufacturing Execution System are all seamlessly integrated in the new ABB offering.

All components are seamlessly integrated with each other and with the Manufacturing Execution System (MES).
The paper will concentrate on the new advanced thickness control solution.

2 METHODOLOGY

Keeping the strip thickness within a tight tolerance band is one of the most crucial jobs in cold rolling. Deep drawing of aluminium and steel sheets for cans or car body sheets sets the benchmark. The more the thickness variation can be reduced, the closer the minimum permissible thickness the mill can be operated at. In return, material usage is reduced and overall cost-efficiency is improved. To achieve effective control of the rolling process, mechanical, electrical and hydraulic systems, instrumentation, as well as the lubrication and the control strategy must all fit together.
State-of-the-art thickness control algorithms are composed of single control loops and feed-forwards. They are limited in their achievable thickness performance because these algorithms do not take the connection between thickness, roll position and tension fully into account.

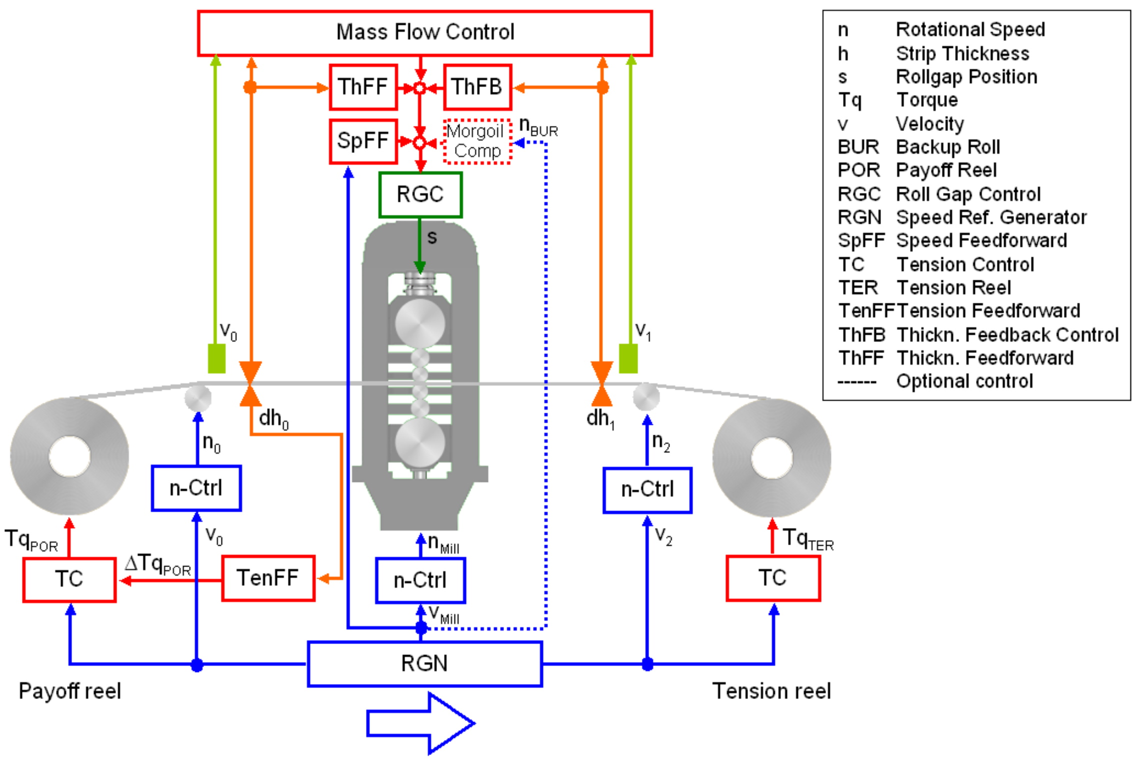

Figure 3. Classic control concept.

In contrast, the new ABB technology control solution uses a model based Multi-Input Multi-Output (MIMO) control concept, whereby the existing mechanical/metallurgical couplings at a mill stand are dynamically decoupled. The decoupled loops are controlled with Single-Input Single-Output PID control algorithms. Dynamic feed-forward strategies support disturbance rejection.

The MIMO controller is adapted online to the actual process state to ensure constant strip quality and robust control performance for different materials and operation points. Suitable adaptation parameters are calculated online using a process model. A supervision component monitors and tracks the quality of the changing parameters.

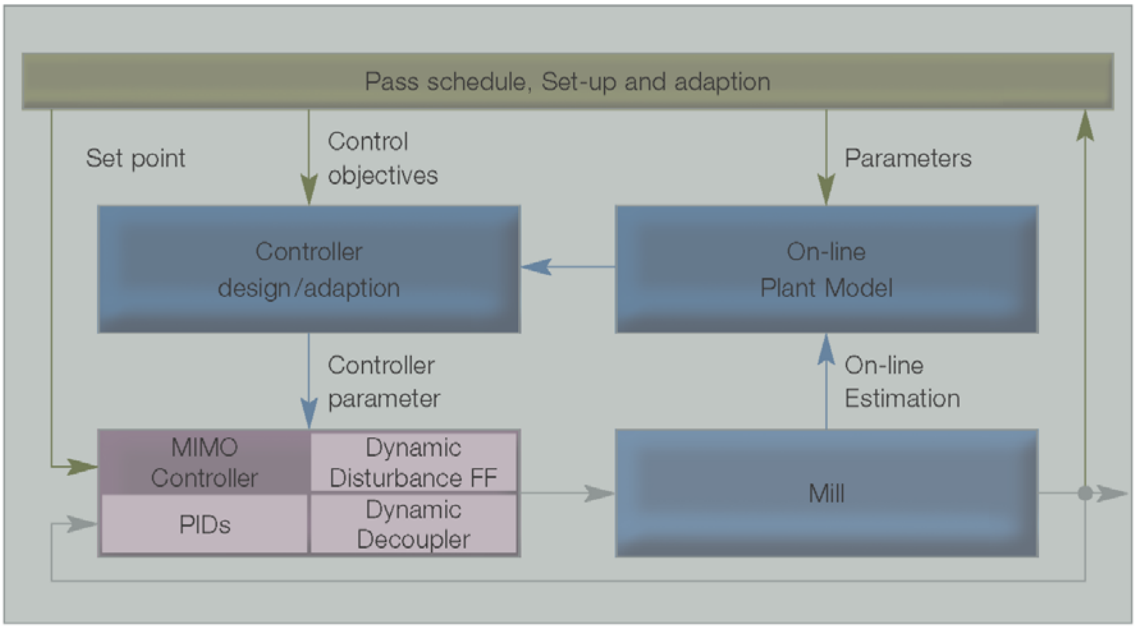

Figure 4. MIMO control concept with dynamically decoupled PID controllers, dynamic feed-forward and online parameter adaptation.

3 RESULTS

On-site measurements (Fig. 5) have shown significant improvements for thickness tolerance reduction with ABB's new control concept compared to state-of-the-art technology.
The improved bandwidth of the new thickness control method ensures that tolerances during acceleration and deceleration can also be significantly improved.
Better disturbance rejection at constant speed and during acceleration/deceleration provides improved strip tolerance over the whole strip length.
Control allows an increase in speed within specified tolerances reducing scrap length and allows for smooth ramp-up increasing throughput.
First tests at customer installations show an improvement in thickness deviation of up to 50% (product dependent).

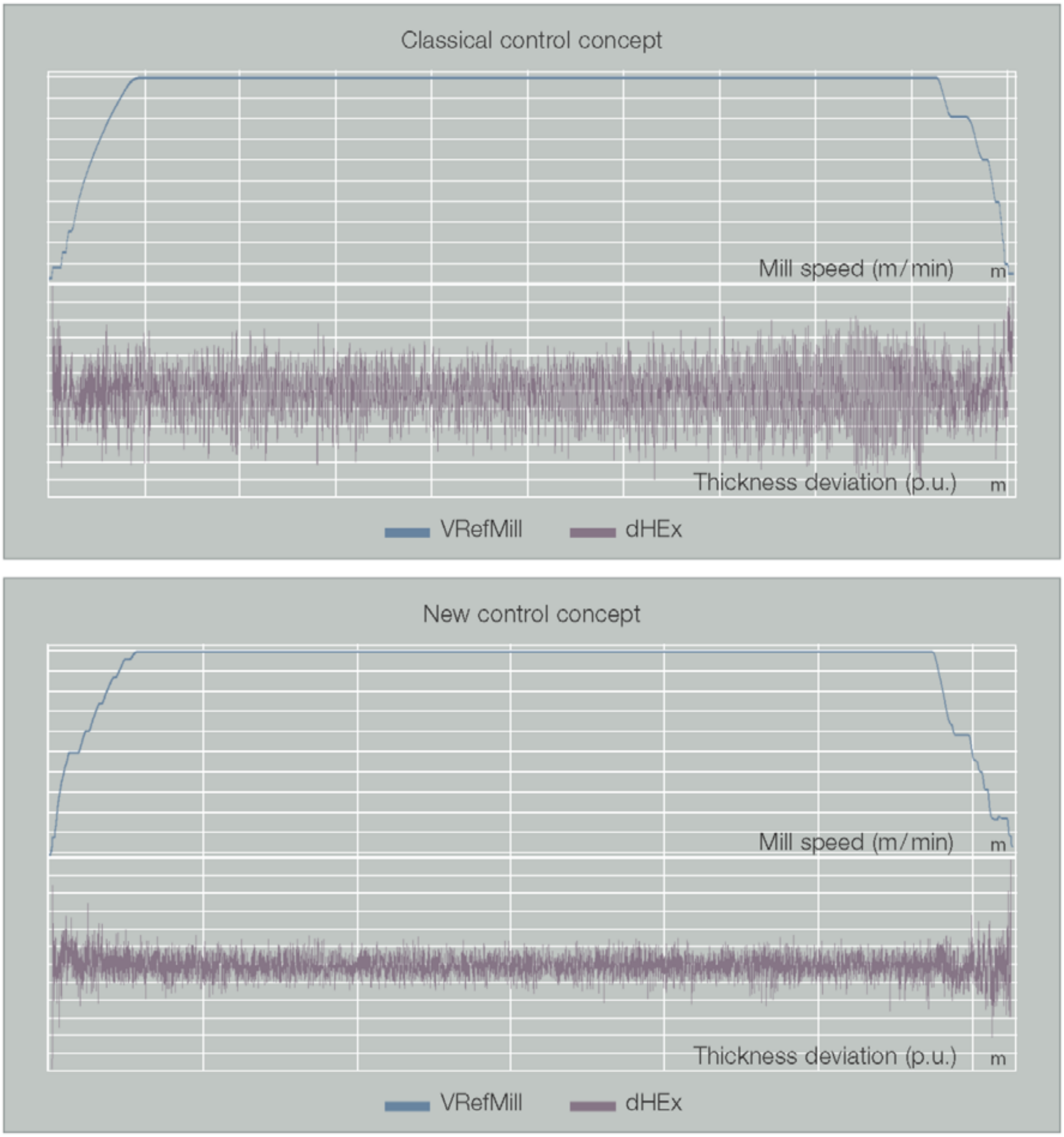

Figure 5. Results from the 4th full pass under normal operating conditions: Length series of thickness deviation for the classic control concept (top) and the new control concept (bottom); 3Sigma improved from 1.3% classic thickness control (top) down to 0.7% for the new advanced thickness control (bottom).

4 CONCLUSION

When using a new model-based and on-line adaptive MIMO controller in connection with the new ABB process controller AC800PEC the thickness deviation could be reduced by up to 50% after the last pass in an aluminium cold rolling mill. Due to its design and the demonstrated performance, it sets the standard for automation in the metal-processing industry.

The use of this new MIMO control concept for the improvement of thickness tolerance is not only an attractive option for new installations but also for plant modernization.

As a next step, the MIMO concept is presently adapted to and extended for other materials and multi-stand cold rolling mills.

REFERENCES

1 ABB Review 4/2004, "Industrial^{IT} for Cold Rolling Mills", Andreas Kroll, Andreas, Vollmer

2 Project Development Guidelines and Documentation ABB