Revolutionizing Cold Rolling: Elimination of 3rd Octave Chatter

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ABSTRACT

Cold rolling mills face significant challenges due to various vibration phenomena, particularly when processing high-strength steels at thin gauges and high speeds. Among these, third octave gauge chatter, occurring between 90 Hz and 150 Hz, stands out as the most destructive. This self-excited vibration can rapidly escalate, leading to unstable rolling conditions, reduced productivity, and substantial financial losses due to strip breaks, equipment damage, and production downtimes.

Primetals Technologies Austria, a leader in vibration consultancy services and solutions, has developed an innovative active chatter damping system, ChatterBlock Expert, to address this critical issue. Successfully tested on an industrial 5-stand tandem cold rolling mill, ChatterBlock Expert has proven its efficacy in suppressing third octave chatter. This breakthrough allows for significantly higher rolling speeds without compromising product quality, thereby enhancing productivity and ensuring superior product standards.

This paper will present the concept, challenges, and industrial implementation of ChatterBlock Expert, along with the impressive results from the test installation. Readers will gain insights into how this autonomous technology package can be seamlessly integrated into existing rolling mills, transforming them into chatter-free, high-efficiency production units. Join us to explore this revolutionary advancement in cold rolling technology and discover how Primetals is setting new benchmarks in the industry.

Keywords: Cold rolling, 3rd octave chatter, gauge chatter, vibrations, Anti-chatter, ChatterBlock

INTRODUCTION

Vibrations and the Special Case of 3rd Octave Chatter

Rolling mills are massive mechanical systems, constructed from tons of steel and operating under immense roll forces to reduce strip thickness. Due to the inherent elasticity of steel and the high forces involved, these systems naturally form oscillatory structures. Mechanical components such as gears introduce persistent excitations, while frictional effects add nonlinear dynamics. Fortunately, natural damping mechanisms typically ensure smooth rolling operations.

However, under certain conditions, such as machine wear, unfavorable parameter combinations, or specific rolling scenarios, vibrations may arise. These vibrations are consistently undesirable, often harmful, and occasionally damaging. While many types of vibrations can be externally or parametrically excited, they are often broadly referred to as “chatter.”

Among these, one particular type stands out: 3rd octave chatter (see Figure 1). This phenomenon is distinctive in that it represents a true physical instability. Unlike other vibrations, it is divergent—its amplitude increases rapidly within seconds, making it especially dangerous.

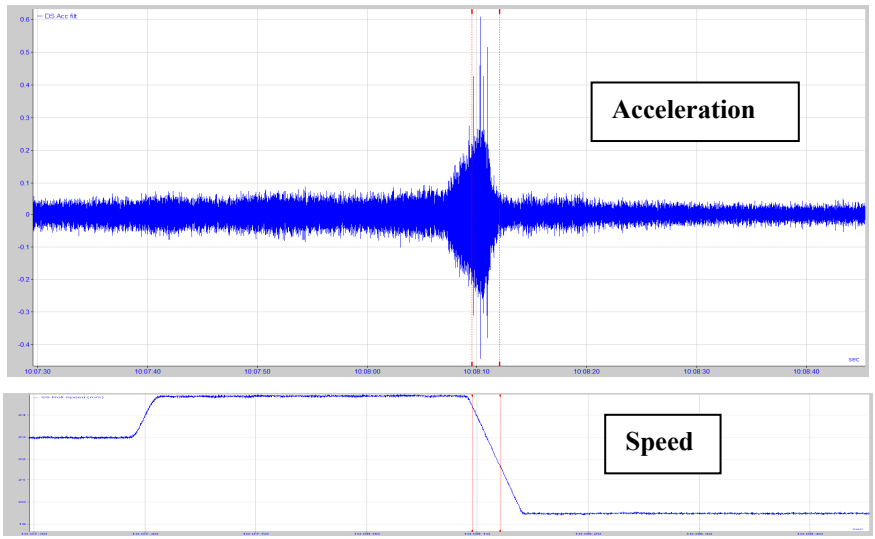

Fig. 1 Typical 3rd octave chatter – acceleration (above) and speed (below).
As chatter occurs, the speed is immediately reduced

When 3rd octave chatter occurs, operators must immediately reduce rolling speed to prevent damage.

This type of chatter is most observed in multi-stand cold rolling mills, whether processing steel or aluminum. The industry trend toward higher-strength steels and higher rolling speed intensifies the issue.

Traditionally, the only effective countermeasure has been to reduce rolling speed—either reactively when chatter is detected or proactively when processing critical materials. This inevitably leads to reduced productivity. For example, thin-gauge high grade electrical steel may be limited to rolling speeds of maximum 600–700 m/min, despite mills being capable of operating at much higher speeds.

Over the decades, numerous countermeasures have been proposed and extensively analyzed, ranging from specialized equipment and predictive models to friction control techniques. Yet, a robust and universally effective solution has remained elusive.

PRIMETALS TECHNOLOGIES' APPROACH – FROM INSTABILITY TO INTELLIGENT CONTROL

Primetals Technologies approached the 3rd octave chatter problem by targeting its root cause: instability. From a control engineering perspective, any instability can be mitigated through appropriate feedback control. This insight led to the development of a beneficial solution: augmenting the damping characteristics of the mill stand to stabilize the system dynamically.

The core idea is to introduce active damping—not by altering the mechanical structure, but by using a smart control system that counteracts the vibration in real time. The system measures the acceleration of the hydraulic gap control (HGC) cylinder piston and processes this signal through a sophisticated controller. The controller then actuates a high-dynamic servo valve, generating a pressure response that directly opposes the vibration, effectively increasing the system's damping (see Figure 2).

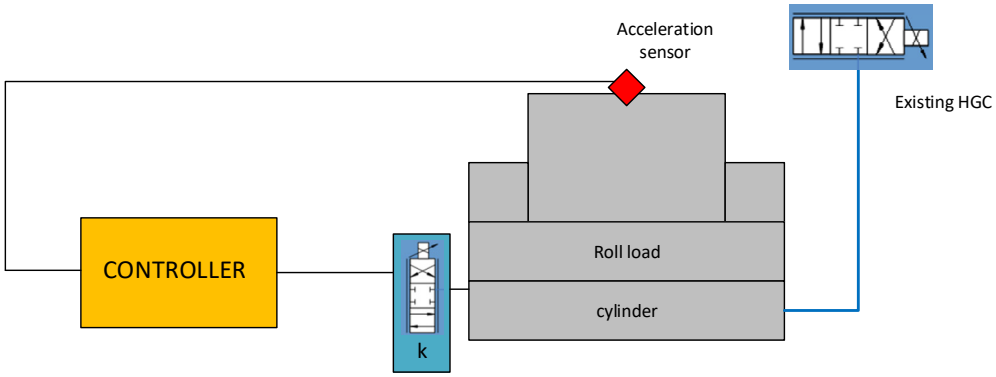

Fig. 2 Basic schematics

This solution is designed as a fully independent add-on system. It does not interfere with the existing HGC thickness control loop, ensuring seamless integration into existing mill architectures.

Given that 3rd octave chatter typically occurs in the 90–150 Hz range, the system requires a servo valve with extremely fast response and minimal phase shift. Even small oil volumes (e.g., 40 ml) can generate significant pressure differentials within a single vibration cycle (e.g., 6.7 ms at 150 Hz), necessitating a nominal flow rate of 400 l/min. Conventional large servo valves, often multistage, exhibit excessive phase lag at high frequencies. To overcome this, Primetals Technologies developed – with development partner MOOG - a custom-optimized servo valve (see Figure 3), tailored for high-frequency performance and reliability.

Key design optimizations include:

- High-stiffness motor-to-valve transmission
- Enhanced cooling for thermal stability
- Low-friction spool design with specialized lubrication
- Cavitation prevention via optimized accumulators
- Custom bearings for high-cycle durability
- Proven reliability through >100 million test cycles

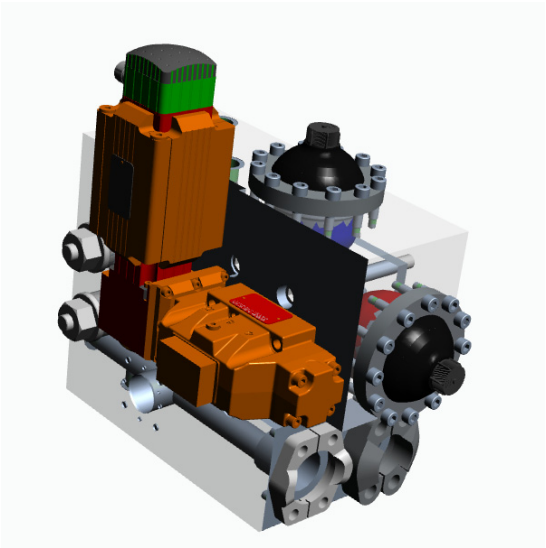

Fig. 3 The unique servo valve, mounted on the valve block

A major advantage of using a controller-based system is the ability to precisely shape its frequency response. To avoid interference with the gauge control system (typically active below 20 Hz, see Figure 4), the ChatterBlock Expert employs digital filters that isolate the chatter frequency band (e.g., around 120 Hz).

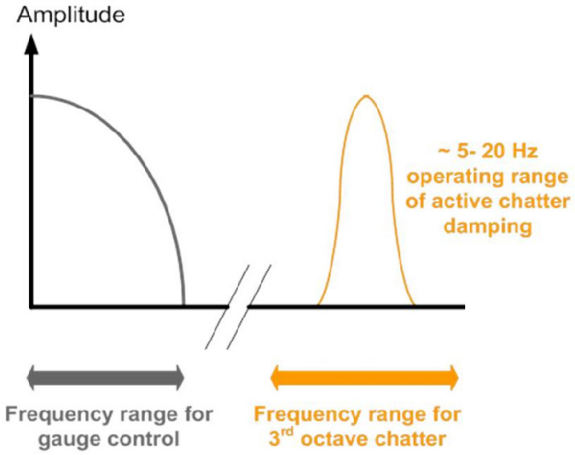

Fig. 4 Frequency separation

To achieve optimal performance, Primetals Technologies collaborated with Johannes Kepler University Linz to develop a custom digital filter algorithm. This filter exhibits a sharp bandpass characteristic with ideal phase behavior at the target frequency—far exceeding the capabilities of classical filter designs (see Figure 5).

Additionally, an algorithm was developed to shift the bandpass frequency of the filter to every desired frequency, while maintaining the characteristics of the original filter. Thus, the ChatterBlock Expert system can be tuned to dampen the mill chatter in a broad frequency range.

Moreover, the system includes a real-time frequency detection algorithm. Within milliseconds, it can identify the current chatter frequency and automatically re-tune the bandpass filter, ensuring maximum damping efficiency across a broad frequency range.

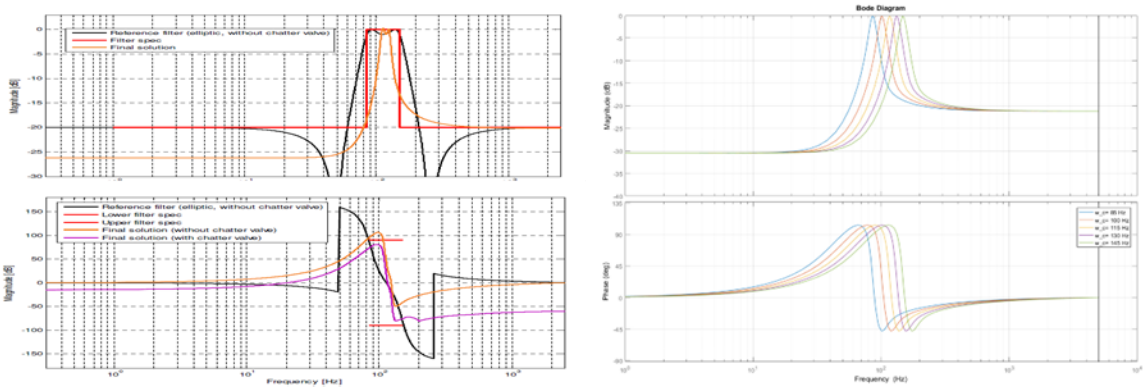

Fig. 5 Special tunable filter algorithm with bandpass characteristics

THE INDUSTRIAL SOLUTION - AN EASY ADD-ON

A key design objective of the ChatterBlock Expert system was to ensure maximum compatibility with existing mill infrastructure. The result is a modular, mechatronic add-on package that can be integrated into virtually any tandem cold rolling mill or reversing cold mills with minimal disruption.

The system is engineered to operate independently of the existing HGC control, requiring only minor mechanical and electrical modifications. This makes it ideal for retrofitting during planned maintenance shutdowns.

TYPICAL INSTALLATION REQUIREMENTS

To implement the ChatterBlock Expert system, the following adaptations are typically necessary (customizations are possible based on mill-specific conditions), see Figure 6:

- Modification of HGC cylinders to accommodate the new valve block
- Connection to the existing hydraulic pump system(Since the ChatterBlock Expert operates only during rolling, the energy demand is well within the capacity of standard hydraulic systems designed for rapid roll changes)
- Installation of acceleration sensors(Primarily on the HGC piston; optionally on the HGC housing and mill stand for diagnostics and monitoring)
- Deployment of electrical cabinets:
    - One cabinet near the stand for the valve drive converter
    - A second cabinet for sensor interfaces and signal conditioning (IBA PDA system)
    - A main cabinet in the automation room housing the ChatterBlock Expert PLC
- Minimal interface to existing automation systems(At a minimum: emergency stop integration and a configurable on/off signal; more advanced data exchange is possible as needed)

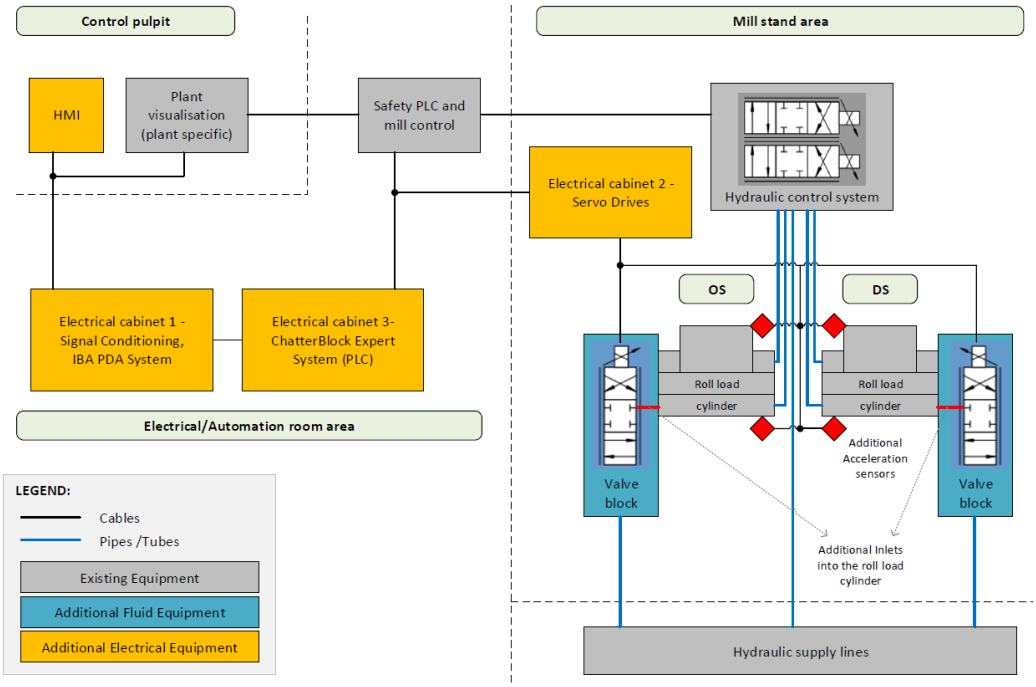

Fig. 6 Implementation solution

HUMAN-MACHINE INTERFACE (HMI)

An integrated HMI (see Figure 7) is provided for commissioning, diagnostics, and optional operator interaction. It displays real-time vibration data, including frequency and amplitude, and interfaces with the IBA system for deeper analysis and optimization.

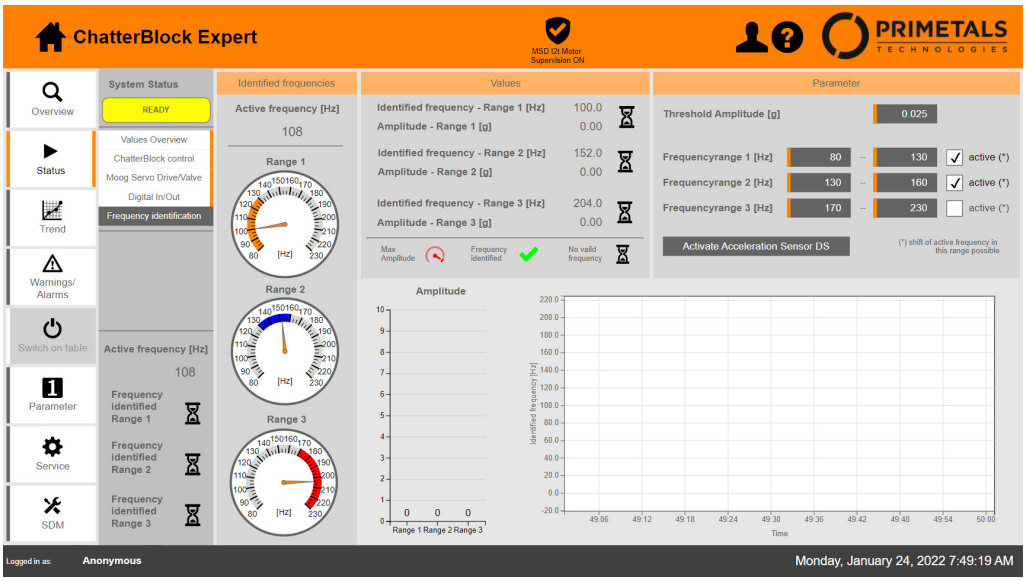

Fig. 7 HMI for supervision, parameterization und service functions

The system's frequency identification algorithm continuously monitors vibration signals. When chatter is detected (i.e., amplitude exceeds a defined threshold), the system automatically identifies the dominant frequency and adjusts the digital filter accordingly. This ensures optimal damping performance across varying operating conditions.

RESULTS – DEMONSTRATED PERFORMANCE IN INDUSTRIAL OPERATION

The effectiveness of the ChatterBlock Expert system has been validated through extensive prototype tests on an industrial tandem cold rolling mill. The most compelling way to demonstrate its capabilities is by comparing rolling performance with and without the system activated—under identical conditions and on the same strip.

The general test procedure involves starting from a stable rolling speed and gradually accelerating the mill until either the maximum speed is reached, or chatter occurs, triggering an automatic speed reduction. This process is repeated to confirm the critical speed threshold for chatter onset.

Example 1 – Maximum Achievable Speed
In this prototype test (see Figure 8), the strip was rolled (1) with deactivated ChatterBlock Expert and (2) with activated.

- ChatterBlock OFF: The mill was accelerated until chatter occurred, triggering an automatic slowdown. After reacceleration, chatter reappeared, and the system stabilized at a reduced speed of 21.2 m/s.
- ChatterBlock ON: The mill was accelerated without any chatter events, reaching a maximum speed of 27.7 m/s.

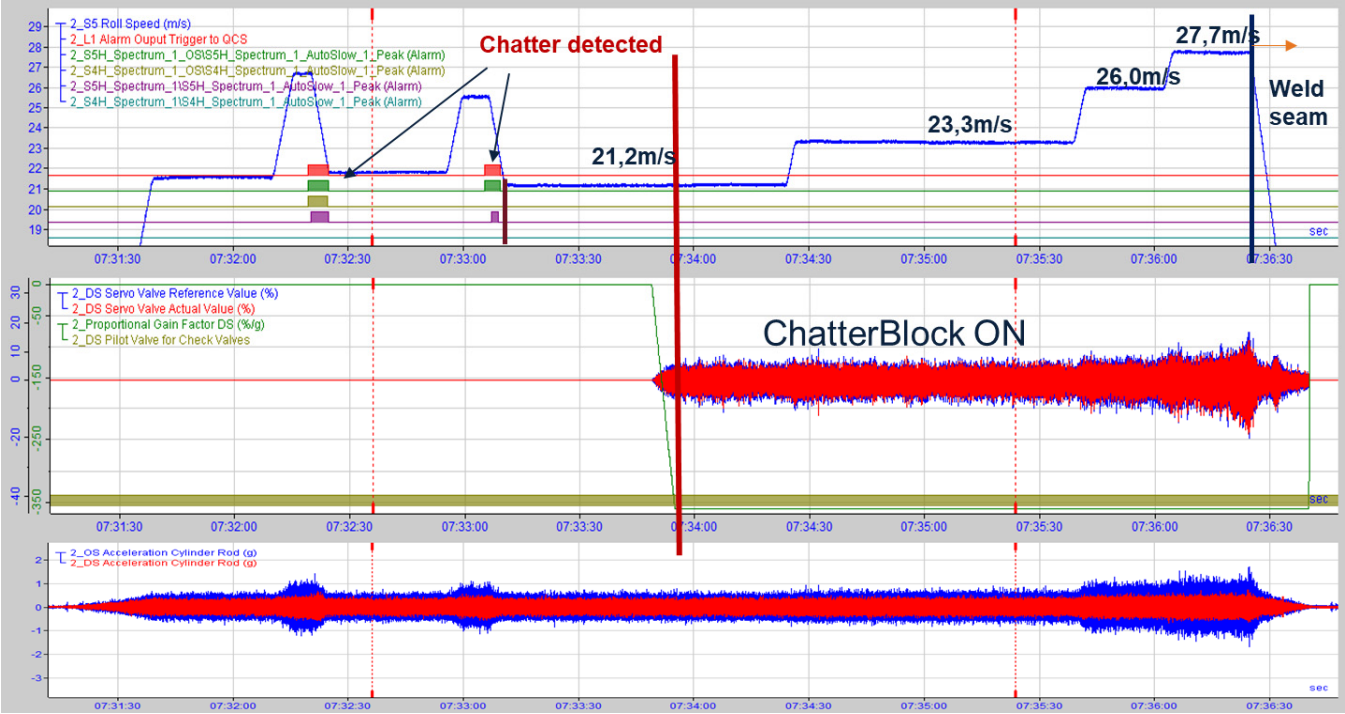

Fig. 8 Evaluation of achievable production speeds with and without ChatterBlock Expert

Example 2 – Dynamic Activation and Deactivation
This prototype test (see Figure 9) illustrates the system's responsiveness and repeatability. The strip was rolled continuously, with the ChatterBlock Expert toggled on and off during the process.

- ChatterBlock ON: The mill reached a maximum speed of 27.95 m/s without chatter.
- ChatterBlock OFF: Upon deactivation, chatter occurred again, forcing a slowdown. The stable speed without the system was 23.1 m/s.
- ChatterBlock ON (again): After reactivation, the mill once again reached 27.95 m/s without chatter.

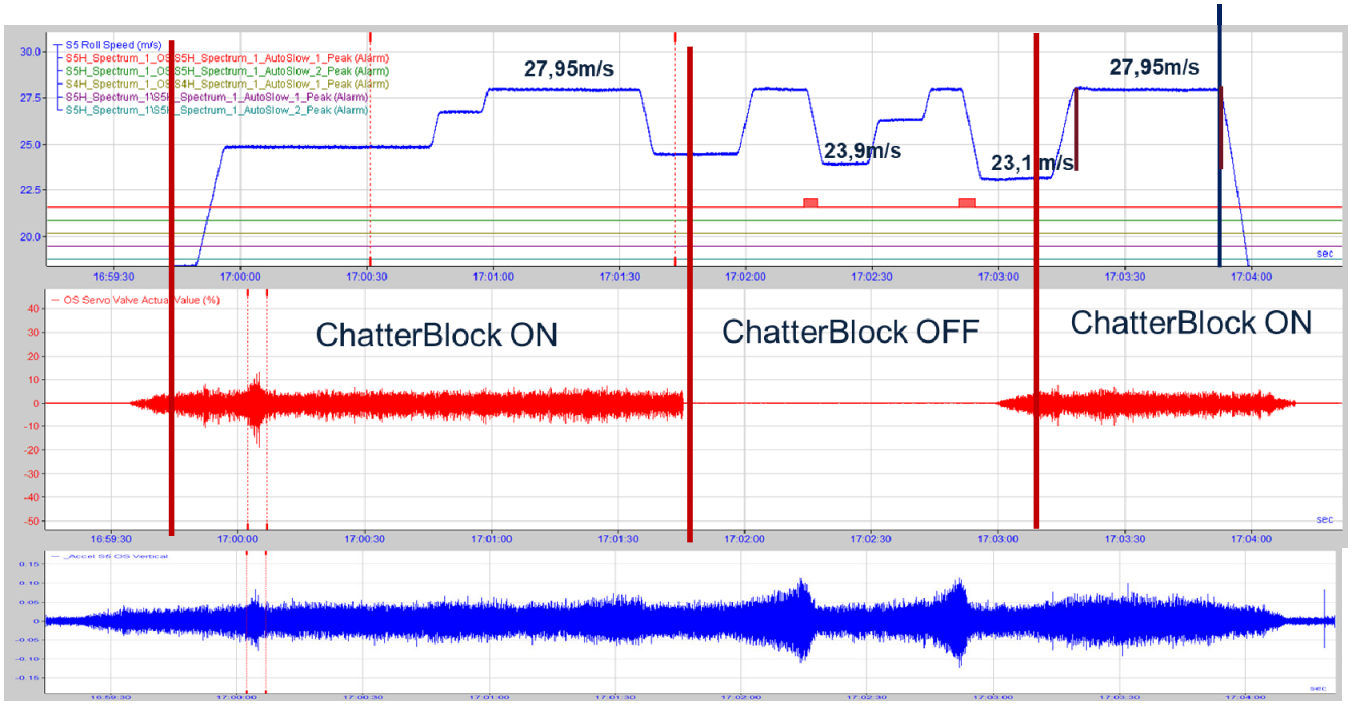

Fig. 9 Evaluation of speeds after switching off and switching on again

These results clearly demonstrate the robustness, repeatability, and industrial viability of the ChatterBlock Expert system. It enables mills to operate at significantly higher speeds without compromising stability or product quality.

SUMMARY

Recognizing that 3rd octave chatter is a true physical instability, Primetals Technologies developed a control-based solution that actively stabilizes the rolling process. At the heart of this innovation is a specially engineered hydraulic actuator—an advanced servo valve—combined with a high-speed control system that dynamically augments damping in real time.

Through a rigorous development process, the ChatterBlock Expert system was brought to industrial maturity. Prototype installations in industrial field have clearly confirmed its ability to suppress 3rd chatter effectively, enabling significantly higher rolling speeds without compromising product quality or operational safety.

Key advantages of the system include:

- Substantial productivity gains through increased rolling speeds
- Minimal integration effort thanks to its modular, non-intrusive design
- Autonomous operation with optional integration into existing automation systems
- Real-time adaptability via intelligent frequency detection and filter tuning
- Proven reliability in demanding industrial environments

The ChatterBlock Expert is now available as a ready-to-deploy solution for both new and existing mills. Designed for seamless retrofitting, it can be installed during standard maintenance intervals with manageable modification steps. Its independence from existing gauge control systems ensures compatibility, while its flexible interface options allow for tailored integration.

With ChatterBlock Expert, Primetals Technologies sets a new benchmark in cold rolling performance—delivering stability, speed, and superior product quality in one intelligent package.

