Taming the vibration behavior of rolling mills

For Good Vibrations

Unwanted vibrations are a major concern in rolling mills. The constant demand for higher productivity leads to ever-higher rolling speeds, and this results in increased vibrations and the associated problems. The Siroll ChatterBlock family of tools and solutions from Siemens VAI helps to get mill vibrations under control.

Rolling mills are complex mechanical assemblies. Thousands of structural components interact with each other through various interfaces such as hydraulic fluids or friction. Some components move in rotation (rolls, spindles, shafts) or in various directions (chocks, strip), some are large (housings) and others are extremely small (springs and screws). Rolling mill eigenmodes thus cover a wide range of frequencies — typically from a few Hertz up to over a few thousand Hertz. It is therefore inevitable that some resonant modes are excited during strip accelerations and decelerations, causing large vibrations in the system. Vibrations typically become more critical with increasing rolling speed and may lead to unwanted strip thickness variations and, in the worst case, to strip and equipment damage (Figures 1 and 2). Consequently, for certain products some mills must run at a significantly lower speed than the mill design would allow.

Mill chatter is a self-exciting vibration phenomenon that occurs in hot- and cold-rolling mills — and especially in tandem cold-rolling mills. It is characterized by a divergent in-phase vertical vibration of the work and backup rolls with a frequency of about 90–150 Hz for third-octave chatter, and 600–800 Hz for fifth-octave chatter. Mill chatter can be physically understood as intrinsic system instability (parameter-excited vibration) caused by both the equipment and the strip.

Vibrations create numerous problems in rolling mill operation, which can be divided into three categories: productivity, safety and efficiency. Vibrations may be detrimental to productivity because they increase the difficulty to control strip thickness, which therefore lowers the quality of the output material. If strip quality is below standard, it is a net loss for the producer since the metal must be re-melted or at least downgraded. Vibrations may also lead to significant safety risks: excessive oscillations commonly result in strip breakage with potentially dire consequences for the operators and the mill itself. Attempts to control vibrations place a heavy burden on automation, requiring better and more sophisticated systems. Finally, component wear is accelerated, for example on seals or bearings, and overall energy consumption is increased. This lowers the efficiency of the mill in terms of both investment and energy per ton of steel produced.

It is thus highly important to control vibrations in the mill either actively with tailored automation solutions, or with sophisticated mechanical design solutions – or a combination of both. The Siemens VAI ChatterBlock family of tools and solutions address the problems associated with vibrations.

The Siroll ChatterBlock family of solutions

Over the last decades, Siemens VAI has proven to be a reliable partner for assessing rolling mill dynamics. The services provided to customers are illustrated in the Siroll ChatterBlock family of solutions (Figure 3). The name ChatterBlock is derived from the need to deal with or "block" mill chatter and it also refers to the mechatronic equipment “block” that actively suppresses mill chatter (Figure 4). Siemens VAI addresses all kinds of vibrations that occur in a steel or aluminum rolling facility.
The Siroll ChatterBlock family of tools and solutions from Siemens VAI helps to get mill vibrations under control.
After a customer contacts Siemens VAI to provide assistance in connection with mill-vibration matters, the first step is to complete a problem-description questionnaire about the vibration behavior. All related mechanical and process data is taken into consideration to obtain a general picture of the existing situation. The acquired information is analyzed, open questions are clarified and the phase of problem-solving activities is started. The correct and full understanding of the problem generally requires an on-site inspection of the facility, which allows a clear picture of the dynamic behavior of the mill to be obtained. Wear parts, mechanical components, the roll shop, process-data recording and more are inspected by Siemens VAI specialists. Possible causes of the vibratory problems are discussed in detail with the maintenance personnel, operators and production management.

Measurements are usually performed to detect the source of vibrations. Either data from the already-installed measuring systems or data gathered from additional sensors mounted on suspicious components are recorded. A thorough data analysis of the relevant time and frequency domains is carried out. In addition, customized, in-house simulations tools, such as the Siemens VAI Virtual Mill Stand, are applied in order to evaluate and better understand the prevailing conditions. A detailed report that includes an explanation of the root cause of vibration and proposed solution measures is then presented to the customer. With the results of these investigations, an offer is submitted by Siemens VAI that contains one or more of the following: upgrades of mechanical components or the installation of vibration-control tools such as ChatterBlock Control and ChatterBlock Monitoring, which are described below.

**ChatterBlock Control**

Mill chatter vibrations can be clearly distinguished from other vibration phenomena in the rolling process by their vibration frequency and the fact that mill chatter vibrations quickly diverge. A new mechatronic system, the so-called active chatter damper, was developed in order to actively suppress and cancel third-octave chatter. This system uses new, exclusive servo valves developed in a cooperation between Siemens VAI and Moog Industrial. The first pilot installation at a tandem cold mill in Russia shows satisfying results and confirms the correct approach of this technological solution.

**ChatterBlock Monitoring**

This ChatterBlock tool, which was previously referred to as Siroll ChatterMon, has already been implemented in numerous plants. Vibration signals from sensors installed at each mill stand are transferred together with the rotational velocity data of the spindles to a central processing unit. The vibration levels for third-octave or fifth-octave chatter for each stand are derived from analyses of this real-time data. When critical vibration levels are exceeded, the mill is slowed.
Siemens VAI addresses all kinds of vibrations that occur in a steel or aluminum rolling facility. Down to sub-critical speeds, the online customer software provides bar-graph indicators for every vibration level as well as online trending. ChatterBlock Consultancy services reflect Siemens VAI’s competence to assess and analyze all types of dynamical effects and vibration problems of rolling mills. This comprises detailed modeling of the dynamic system, consideration of linear or non-linear phenomena, and non-linear phenomena, and the performance of static and dynamic calculations. Vibration consultancy services also include run-up simulations of the coupled mill stand and drive and vibration problems of rolling mills. The system algorithms can detect fifth-octave chatter or defects of work, intermediate and backup rolls, such as roll eccentricity and flat spots. The system algorithms can detect fifth-octave chatter or defects of work, intermediate and backup rolls, such as roll eccentricity and flat spots. In summarizing, any type of problem associated with or originating from vibration can be fully dealt with.

Fig. 4: The Siroll ChatterBlock family of solutions to cope with vibration problems in rolling mills.

Siemens VAI offers a whole range of solutions and know-how to keep vibrations under control.

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Keep vibrations under control.

Dynamic mill behavior during rolling operations.

Siemens offers a whole range of solutions and know-how to keep vibrations under control.

Fig. 3: The Siroll ChatterBlock family of solutions to cope with vibration problems in rolling mills.