Advanced Tension Control in Steel Rolling Mills

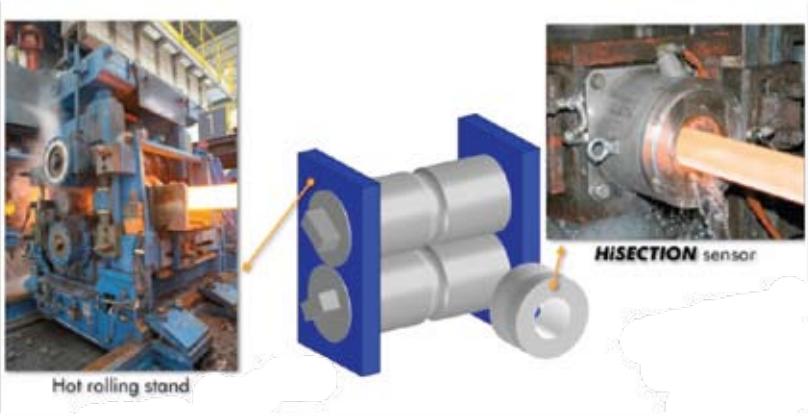
A rolling mill made of a sequence of rolling stands yielding the desired final steel bar section as the bar moves through the mill

Ever-increasing competition in the global steel market has led to the need for significant cost savings in terms of increased production, more stringent tolerances on final product dimensions, and less shop floor utilization. Tension control systems for rolling mills have been a specific target of development because of their cost and impact on product quality.

Traditional tension control systems for steel bars/billets (so-called "long products") involve using loopers between stands to avoid bar tension. Loopers deviate the hot steel trajectory, creating a "buffer" of material between stands to compensate for unanticipated speed fluctuations.

Loopers take valuable space and may cause cobbles; that is, sudden blocking of the hot steel flow leading to loss of production, safety issues, and possibly equipment damage.

HiTension is an innovative and effective architecture for accurately controlling the tension of the steel bar between the stands based on HiSection eddy-current section sensors. Accurate interstand section measurement paves the way to tension control, thus avoiding the need for loopers in rolling mills. Furthermore, improved section tolerances and increased yield are attained.



Schematic view of a rolling stand equipped with HiSection sensor

Enabling Sensing Technologies

- Key to bar/billet tension control is the availability of accurate interstand section measurements.
- Usually only the final downstream section is measured. With eddy-current section sensors, each intermediate section can be measured online.
- Section measurements on each stand allow for identification of an accurate mathematical model of the rolling process.
- This way, the bar/billet section fluctuations can be actively corrected by a model-based multiple-input, multiple-output advanced control system.

Inventions and Innovations

- First looperless multivariable feedback controller for steel bar/billet tension in hot rolling mills worldwide
- Direct feedback of interstand section measurements with eddy-current section sensors

HiTension and HiSection are products of Danieli Automation S.p.A.

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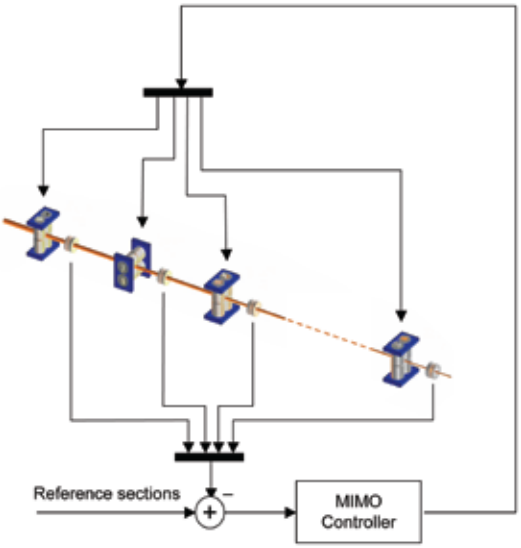
From: *The Impact of Control Technology*, T. Samad and A.M. Annaswamy (eds.), 2011. Available at www.ieeecss.org.



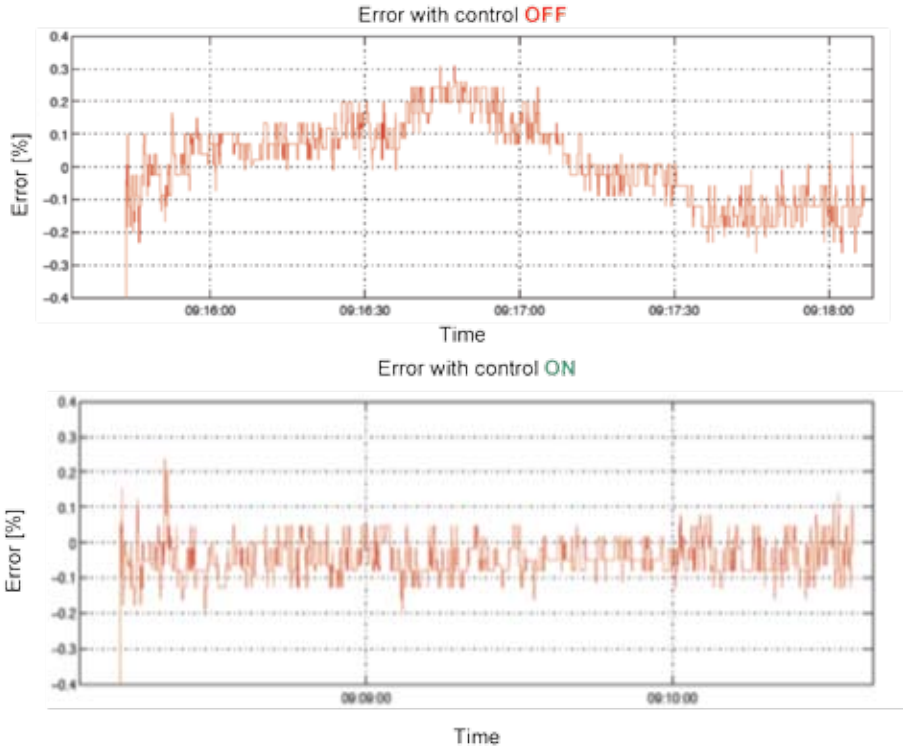
Control Architecture

- Each interstand section is measured in real time and compared to reference value. The error variables are fed to the controller that regulates the stand speed.
- Controller parameters are tuned online at the beginning of production based on the identified process model.

Left: Section control architecture for a bar/billet rolling mill. The interstand section is fed by the HiSection sensors to a multivariable controller acting on the stand rotation speeds.

Operational Results

- The HiTension architecture is now running during regular production at a steel plant in northeastern Italy.
- Use of the tension control leads to
  - Tighter tolerances on final section: <0.5% of nominal value;
  - 50% reduction of section error variance on the whole bar/billet.



Right: Comparison of the error on the diameter of a bar, at a fixed point, without (upper) and with (lower) HiTension control. The controller cancels out the low-frequency error component that is present when the controller is turned off.

Benefits

The HiTension bar/billet rolling mill control system has resulted in several very significant benefits:

- Major improvement in rolling quality
- More stable rolling conditions
- Major reduction in cobbles frequency
- Increased productivity through reduction of out-of-tolerance production
- Solution toward looperless rolling mills for long steel products