

Sophisticated models supply control with microstructure information.



Laminar cooling headers give the maximum cooling power on short distances with a wide range of cooling capacity.



Microstructure target-cooling model saves costs in hot-strip mills

Hitchless Switch-Over and High Revamp Efficiency

Siemens VAI successfully implemented microstructure target cooling in the framework of hot-strip-mill revamps for facilities in Germany belonging to TKS Hoesch Hohenlimburg and ThyssenKrupp Steel (TKS), and for the ArcelorMittal Vanderbijlpark Works in South Africa. The advantage of minimized switch-over losses could already be realized in the mills that have implemented the shadow-mode strategy.

Requirements on steel, especially for very thin high-strength steel, are still increasing, both from the automotive and other industrial sectors. In addition to the alloying elements, the cooling section is decisive for the properties of these steels. Siemens VAI developed a new cooling-section control system that uses the so-called Gibbs' free enthalpy to calculate the steel transformation very precisely on the basis of a thermodynamic model. The new developments in the physical modeling of the steel transformation allow computation of temperature and phase fractions along the entire cooling section in real time.

By means of a model-predictive control function, the stipulated time curve of cooling in the cooling section is optimally adhered to for the whole strip within the limits of the plant. This not only ensures constant quality along the whole strip, but also enables efficient and reliable manufacture of multiphase steels. Specific properties of the material, for example in the case of deep-drawing steel grades, can also be specified precisely. Moreover, the strip-cooling model increases the flexibility of the rolling mill: it is possible to switch over production between different types of steel whenever the situation demands and new steel grades can be included in production without altering software or model parameters. This

makes the new cooling models from Siemens VAI the best choice either for the revamp of an old plant or as a must-have for each new plant.

Revamp strategy using shadow mode with parallel observer

Siemens VAI applied the shadow mode with switch-over concepts that proved successful in previous revamps. In the shadow mode it is possible to establish a new automation in parallel to the old one, supplied with all necessary data. A stand-alone Simatic S7 for the basic automation control (valve actuation, measured value sampling and communication) is prepared in advance and the interfaces are installed during normal scheduled maintenance shutdowns. After that, the real-time observer of the new automation and model calculates what happens on the plant based on the data measured by the old automation that is still in control. The operator can now check, whether:

- the model computations are accurate enough, i.e., that the observer computations show similar deviations from the desired temperature in comparison to the real temperature measurement;
- the monitor computation shows that the new automation system is able to improve the coiling temperature; and

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- >> • the new system is able to handle the entire product mix.

When this is the case, it is the time to switch over to the new system.

Direct control of the phase transformation during cooling high-carbon steel at TKS Hoesch Hohenlimburg

The first plant to implement the new microstructure target cooling was the hot-strip mill at TKS Hoesch Hohenlimburg in Germany. At this plant, Hoesch produces a wide range of products with many challenging steel grades in regard to cooling. A significant percentage of the production shows steel grades with more than 0.3 percent carbon and more than 50 percent of the production is single-coil orders. Hence, there are many material changes during production. Since there have always been difficulties to handle the high carbon grades, Hoesch decided to be the first to adopt the new cooling system. Furthermore, the operators are very familiar with the metallurgical needs of the material. Thanks to the new cooling approach, they gain a display of the calculated phase fractions at the coiler as well as online measurement of the coiler temperature.

After establishing the shadow mode, the first tests with the new cooling section took place in 2007. Over a period lasting several months, the models and cooling strategies were optimized, and microstructure target cooling was introduced and applied for all high-carbon steel grades, so that the full product spectrum could be run through and checked. Final acceptance was in May 2008.

Since the operators had the tools available to control the cooling section not only in regards to water amount and temperature, but also phase transformation and transformation degree, the amount of high carbon steel that doesn't meet specification has been significantly reduced. The possibility to switch back and forward between the new and the old automation also led to a high acceptance and confidence of the operators, which resulted in a smooth switch-over with low production losses (see Figure 1).

Minimum switch-over time and losses in a high capacity mill at TKS Duisburg

With the experience of the first plant's ability to deal with a very wide range of the product spectrum, the next plant was a very big challenge in respect to the production throughput and hence required minimum switch-over losses. The Hot Strip Mill 2 of TKS at Duisburg-Beeckerwerth in Germany is a two-meter-wide hot strip mill with six furnaces and a yearly production of up to 5.8 million metric tons.

A special revamp strategy with duplicated mode computation (observer computing with valve feedback from plant, monitor computing with desired valve states from the new automation system) and full adaptation during listener mode was developed for this plant. Here the switch-over concept proved its advantages regarding cost and time savings with fast availability of the new automation after the shadow mode had been established, and a quick phaseout of the old automation.

After communication had been established and the shadow mode started in July 2007, the first test strips could already be produced in August 2007 with the new automation, and a first quality evaluation showed some tighter tolerances compared to a similar campaign made with the existing automation system. Until October 2007 the whole product spectrum was rolled, typically during the day. During the other hours the old automation was running the system. Then the ramp-up phase started and by December 2007 the whole range of steel grades had been run with the new system, without using any extra downtime and thus without any production loss. By June 2008, only results of very rarely rolled thick material (between 16 mm and 25 mm) had been improved. Figure 2 provides an overview of the production times with the different systems and the according usage and switch-over times. Due to the pre-optimized model, the quality was inside the range or even better than with the old automation, right from the start. With the excellent results in quality, the final acceptance was issued in August 2008. The achieved quality parameters exceeded expectations and performance was improved regarding cooling quality in all aspects. The savings that materialized in this plant due to the new cooling section include fewer rejected coils due to missed or inconsistent material properties because a cooling course was missed, and fewer coiling problems due to sagging coils. The latter is a problem when the phase transformation happens on the coiler. Due to the different expansion coefficients of austenite steel and ferrite steel, the windings of the tightly coiled austenite coils loosen after the phase transformation due to the leap in the expansion coefficients. If the phase transformation can be calculated and therefore the location of it can be controlled, this can be avoided as long as there is enough cooling capacity left. This also leads to savings in recoiling costs due to the reduction of such coils.

Revamp without additional switch-over time and production losses at ArcelorMittal Vanderbijlpark Works

After this success, the third customer – ArcelorMittal

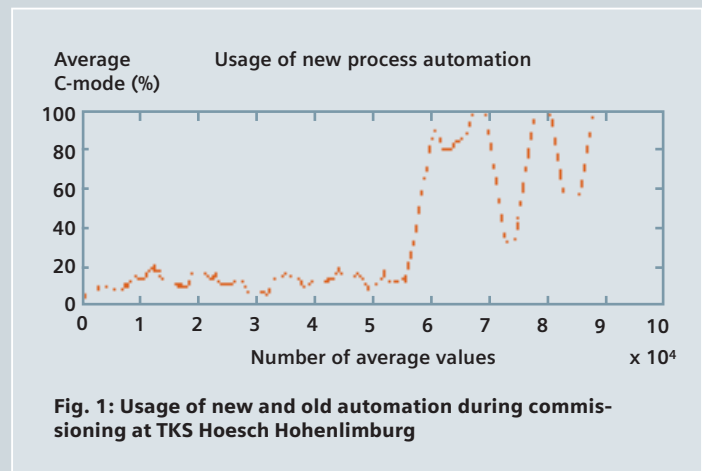


Fig. 1: Usage of new and old automation during commissioning at TKS Hoesch Hohenlimburg

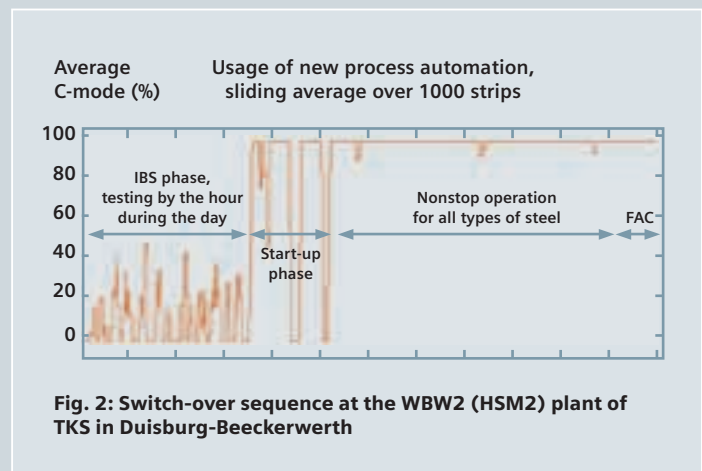


Fig. 2: Switch-over sequence at the WBW2 (HSM2) plant of TKS in Duisburg-Beeckerwerth

Vanderbijlpark Works – was looking for better cooling results and decided to go with the low-loss switch-over method. The ArcelorMittal Vanderbijlpark Works plant is a 2.05-meter-wide hot-strip mill with a production of approximately 3.5 million metric tons per year. The former automation from General Electric was quite old and unable to provide the flexibility that a modern plant needs for more complex steel grades and more demanding customers. In order to improve the cooling quality, reduce the number of out-of-tolerance coils, avoid egged coils and be more flexible to produce enhanced steel grades, ArcelorMittal decided to revamp the cooling section’s automation. The listening mode was implemented during a maintenance shutdown. The communication, including also the old GE system, was implemented in cooperation with the customer in a very short time frame. After restart, the cooling section could be easily switched back and forth and the data supply for the shadow mode started in September 2008. To save

costs, a shadow mode with an offline optimization was established again to ensure that the quality after the switch was as good as possible.

The first switch-over was made on October 22. Just a few months later, at the end of January 2009, the acceptance certificate was issued. The first strip was already within the required tolerances and the performance from the start was better than before. The number of out-of-tolerance strips could be significantly reduced, especially for thick material up to 25 mm and for thin material with deep finishing-temperature skid marks. In addition, the cooling system is now able to observe the cooling quality also for higher mill speeds – a big advantage in regard to the mill’s potential throughput. ■

Authors

Dr. Klaus Weinzierl, Rainer Burger, Udo Borgmann

Contact

hotrollingmill.metals@siemens.com