

## Featured Articles

# Operation Support and Remote Maintenance Techniques for Steel Industry Control Systems

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*OVERVIEW: Steel industry control systems tend to be large, comprising motors, drives, PLCs, and process computers among other components. In addition to reliability, they require the speed of response to perform realtime electrical and mechanical control. To achieve this, Hitachi uses the latest computing and information technology. Hitachi is also working on innovations in control and system technologies to improve the efficiency of equipment operation and the quality of steel strip. Hitachi has supplied numerous control systems to steel companies in Japan and overseas since the era in which steel was considered the mainstay of industry. In addition to making extensive use of universal technologies in recent years to facilitate expansion into global markets, Hitachi has also been developing both operations technology and remote maintenance techniques for delivering added-value after-sales services to meet the needs of emerging economies where new rolling mills continue to be constructed.*

## INTRODUCTION

ALTHOUGH the market for steel has been subdued in recent years as a result of the global economic downturn, steady growth continues. To succeed in a steel market characterized by intense competition on both technology and cost, Hitachi has been incorporating the latest technologies into the products it supplies for steel industry control systems, which include motors, drives, programmable logic controllers (PLCs), and process computers.

In addition to the conventional requirements for reliable and responsive control systems that can produce high-quality steel products, the shift in the market away from Japan and toward emerging economies in particular has brought with it growing demand for incorporating process know-how into systems to help ensure stable operation. There is also a demand for after-sales operation and maintenance services to assist with the control performance enhancements and troubleshooting required after a rolling mill enters operation.

This article describes new products and technologies that have been incorporated into steel industry control systems in recent years, together with case studies of improvements in operational efficiency, maintenance, and standardization that were developed in response to an increasingly global market.

## FEATURES OF STEEL INDUSTRY CONTROL SYSTEMS

### System Configuration

Hitachi's steel industry control systems are used in hot rolling mills, cold rolling mills, and processing lines. Steel plant equipment includes mechanical parts (rolling mills and their associated auxiliary systems) and the motors and other electrical systems that drive them. A continuous pickling line and tandem cold mill (PL-TCM), for example, is 300 to 400 m in length and has more than 1,000 actuators and 2,000 sensors. Furthermore, the steel strip, which exits the mill at speeds up to 100 km/h or more, needs to be produced to a thickness accuracy in the order of microns ( $\mu\text{m}$ ).

To produce high-quality steel strip through high-speed and reliable control of this large process, Hitachi's steel industry control systems use the industrial controllers capable of high-speed computation and the RS90 series process computer running the Linux\*<sup>1</sup> operating system. These are connected together by a 1,000-Mbit/s backbone network designed for high-speed control applications. Other equipment, including process input/output (PI/O) stations and insulated-gate bipolar transistor (IGBT) drives, are connected via a universal field

\*1 Linux is a registered trademark of Linus Torvalds.

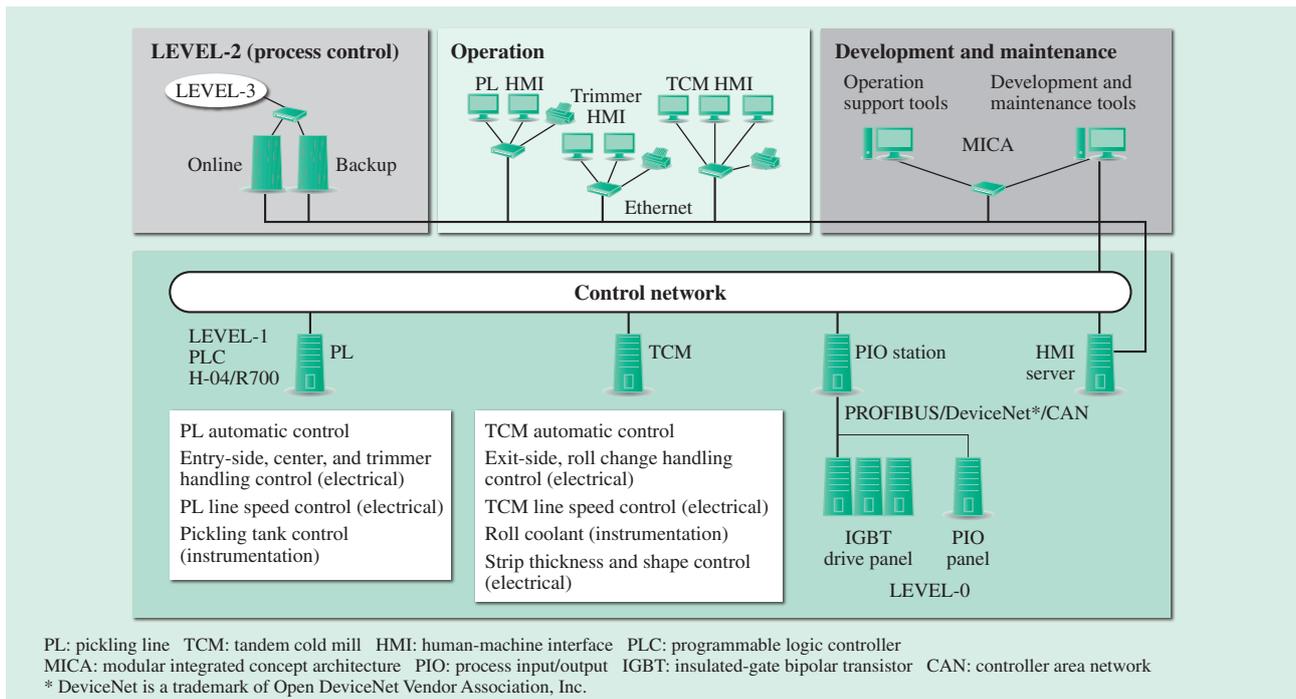


Fig. 1—System Block Diagram of PL-TCM.

A PL-TCM is a common type of steel finishing line. The control system shown here performs reliable and responsive control of a large and complex process.

bus such as PROFIBUS\*<sup>2</sup>. This configuration enables responsive control of the rolling mills and auxiliary equipment (see Fig. 1).

### Use of Latest Products in System

The latest model in Hitachi's range of PLCs is the R900 central high-speed processing unit (CHPU) released in February 2014. It has more than 10 times the processing performance of the previous R700 model and features more efficient use of space, and allows up to five central processing unit (CPU), network, or other cards to be installed with each CHPU card. To maintain compatibility and improvements in engineering efficiency, the existing Modular Integrated Concept Architecture (MICA), Process Data Analysis (PDA), and other utility tools for tasks such as programming and data analysis can still be used with the R900 CHPU as easily as before.

The second generation of large-capacity 3.3-kV IGBT inverter drives for the main motors were released in September 2013. Use of global-standard IGBTs not only allows for greater output, but also ensures long-term product availability, a simpler circuit design, and smaller drive size (55% of the previous model). Hitachi has also developed an auto-tuning function for

its small-capacity drives that can determine control parameters automatically, facilitating their use with motors for which the specifications are unavailable.

## LATEST TECHNOLOGY FOR STEEL INDUSTRY CONTROL SYSTEMS

### Hot Rolling

In the hot rolling field, Hitachi has strengthened its collaboration with Mitsubishi-Hitachi Metals Machinery, Inc., and has completed a large number of projects in recent years that involved the supply of both mechanical and electrical control equipment. In addition to conventional hot rolling mills, this has included supplying overseas customers with control systems for a variety of different types of hot rolling plants, including compact hot strip mills that produce coils by rolling thin slabs or transfer bars directly from a continuous caster, Steckel mills (reverse finishing mills), and aluminum hot rolling mills.

Hitachi has a long history of working on developments that anticipate customer needs. At an aluminum hot rolling mill supplied to a Taiwanese site in 2013, for example, Hitachi achieved more reliable operation and better strip thickness accuracy through the sophisticated mathematical modeling of rolling for a wide variety of product grades, ranging

\*<sup>2</sup> PROFIBUS is a registered trademark of the PROFIBUS Nutzerorganisation e.V.

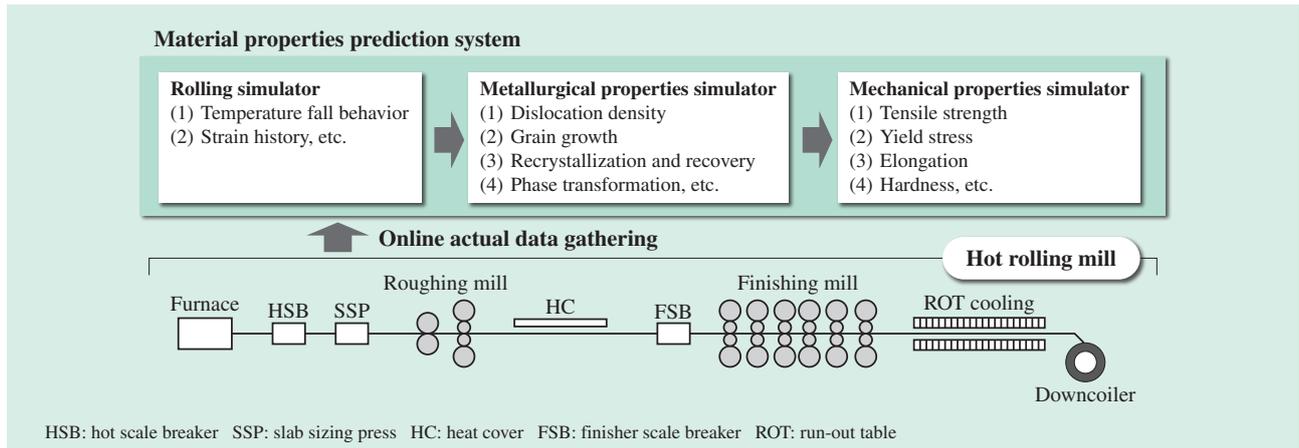


Fig. 2—Hot Rolling Mill and Material Properties Prediction System for Steel Strip. The system uses actual rolling data to estimate changes in the metallurgical properties of hot-rolled coils, and then predicts the mechanical properties to ensure coils are produced with the required strength and formability.

from soft pure aluminum to aluminum alloys that are several times harder, and by using this to optimize control signals such as the rolling load, roll gap, and rolling speed.

Because of the need to produce steel strip with strength, formability, and other material properties within the required range, there is strong demand from hot rolling plants in emerging economies for the means to predict these properties. To meet this demand, Hitachi has commercialized a material property prediction system (MPPS) for steel strip (see Fig. 2)<sup>(1)</sup>. MPPS uses an online simulator to calculate the temperature and strain history of the steel strip from the temperature and rolling data collected from the plant. This information is provided to a metallurgical properties simulator to estimate the changes in metallurgical properties (crystalline grain size, volume fraction of each crystalline structure, and dislocation density, etc.) from the time the slab is charged into the furnace until the strip is coiled on the downcoiler. These results are then used by a mechanical properties simulator to predict the mechanical properties (strength, hardness, and elongation, etc.) of the hot-rolled coil (see Fig. 3). A human-machine interface (HMI) is also provided to simulate how varying the parameters for a designated coil, such as its temperature changes and working history or its chemical composition including alloying elements, will change its metallurgical and mechanical properties.

The MPPS is a useful tool for producing quality reports after rolling, for assisting with the production of rolling schedules, and for simplifying steel strip quality inspection.

### Cold Rolling

Hot rolling provides the feedstock for cold rolling. Hitachi has for many years maintained a high level of competitiveness in the field of cold rolling, with a large share of the international market for PL-TCMs for the mass production of high-quality steel strip in particular. Recently, Hitachi has been working on improving the quality of steel strip rolled on single-stand mills, and has developed a hybrid automatic gauge control (AGC) for the production of high quality steel strip.

When thin steel strip is rolled at high speed on a single-stand mill, long-period fluctuations in the exit thickness (with a period from several seconds

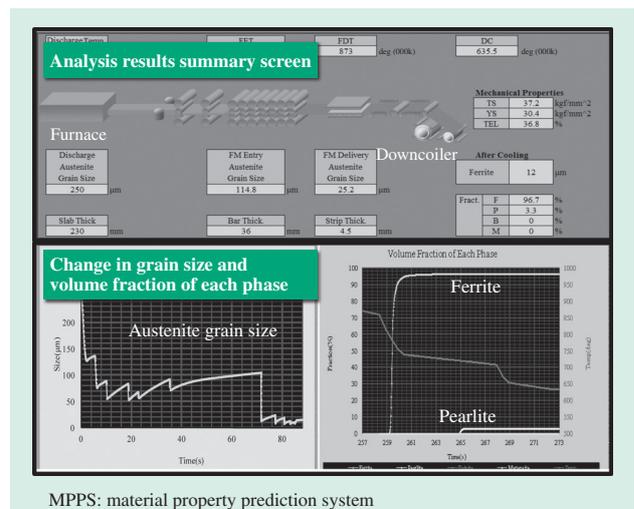


Fig. 3—Screen Showing Results of MPPS Analysis. The MPPS uses actual rolling data to estimate changes in the metallurgical properties of hot-rolled coils and predict the mechanical properties.

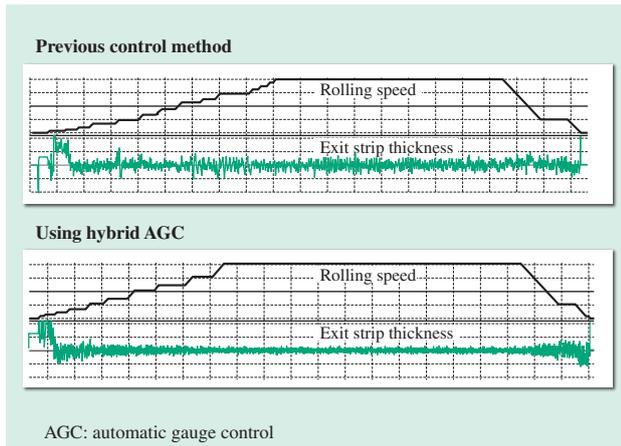


Fig. 4—Improvement in Strip Thickness Accuracy from Use of Hybrid AGC.

A significant improvement in exit strip thickness accuracy was achieved by controlling the roll gap of the rolling mill and the tension reel current based on actual rolling data.

up to 10 or more seconds) can occur for system-related reasons. This has made it difficult in the past to combine improvements in both productivity and quality. The hybrid AGC suppresses these fluctuations by controlling the roll gap and tension reel current based on actual rolling data and the operating point for rolling. This has succeeded in improving the exit thickness accuracy during high-speed rolling (see Fig. 4).

### Portable Remote Control

Because the control panels used by operators to operate machinery are positioned at specific locations to suit each item of equipment, they need to be installed at many different places around the plant. The problem is that they can be cumbersome to use because of the restrictions on where they can be located. This means that a number of operators may be required to observe the machinery and operate the controls, or that the operator, having observed the steel strip from up close, then has to walk back to use the operating panel.

In response to this problem, Hitachi has developed a portable remote control in collaboration with Mitsubishi-Hitachi Metals Machinery, Inc. that operates via a local area network (LAN) to make work more efficient and to simplify the equipment. By adopting a number of different approaches to deal with issues of responsiveness, reliability, and ease-of-use, Mitsubishi-Hitachi Metals Machinery, Inc. has been able to eliminate all of the control panels installed at its experimental mill, and is using the remote control units to operate the rolling mill instead (see Fig. 5).

## GLOBALIZATION AND UNIVERSALITY IN STEEL INDUSTRY CONTROL SYSTEMS

### Remote Maintenance Services

Because many emerging economies lack experience in plant operation, there is strong demand for operations technology and operational support services after systems are installed. To achieve this, data is shared between the customer site and the remote maintenance system at Hitachi, and used to provide after-sales services that include troubleshooting or parameter tuning for the rolling control systems. The maintenance support system with playback simulator is useful for services like these.

The maintenance support system with playback simulator has multimedia analysis functions for simultaneously replaying process and video data to give the user a sense of what was happening in the plant when they perform analysis. This requires the transmission of process data and large amounts of video data from a server at the plant to the maintenance system (client). For this reason, data is downloaded rather than streamed in order to avoid problems with buffering delays caused by inadequate communications infrastructure. Also included is a function whereby, when the user enters an analysis key (coil number, time, analysis data or segment, etc.) at

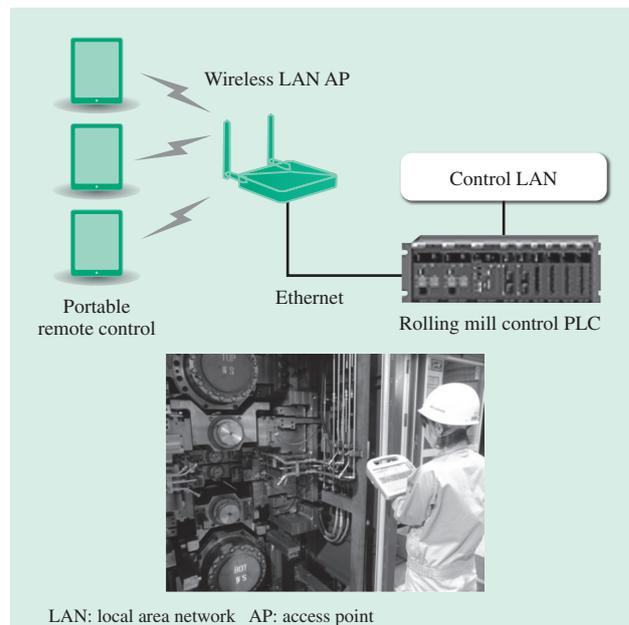


Fig. 5—Block Diagram of Portable Remote Control System, and System in Use.

Instead of being tied to the location of the control panel, the portable remote controls allow operators to view machinery as they operate it.

the client, the system uses predefined relational data to automatically send the client only the data that is required for analysis (see Fig. 6). Remote maintenance services have already been introduced at some sites in China and South Korea<sup>(3)</sup>.

### HMI Standardization

The trend in steel industry systems overseas has been toward the use of standardized software to improve maintenance. It is particularly common for customers to specify the use of standardized graphics software for HMIs.

The object linking and embedding for process control (OPC)<sup>\*3</sup> standard is used to integrate process data with standardized graphics software. Furthermore, Hitachi has developed Human Interface Generator for Web (HumInG-W), a web-based graphics package for operator screens that allows screens to be viewed from a standardized personal computer in an office or other remote location. To ensure the responsiveness of these screens, the package uses a server-controlled realtime push-based technique for updating data. Also, the ability to perform client system configuration from a web browser provides flexibility during upgrades, and facilitates integration with off-the-shelf software<sup>(3)</sup>.

### Process Computer Standardization

A common requirement overseas is for process computers to use the open-source Linux operating system (OS) running on standardized server hardware. To overcome the problem that standard Linux implementations cannot run Hitachi's proprietary realtime technology, a virtual machine system is used for virtualization to facilitate the migration of existing applications. This reduces the cost of application software upgrades and ensures that future system upgrades can be performed at low cost and with high quality.

## CONCLUSIONS

This article has described the characteristics of steel industry control systems; the latest new technology for product quality, operational efficiency, and other improvements; and remote maintenance services and the use of standardized technology designed to keep pace with ongoing globalization.

The further installation of rolling equipment is anticipated in emerging economies such as India.

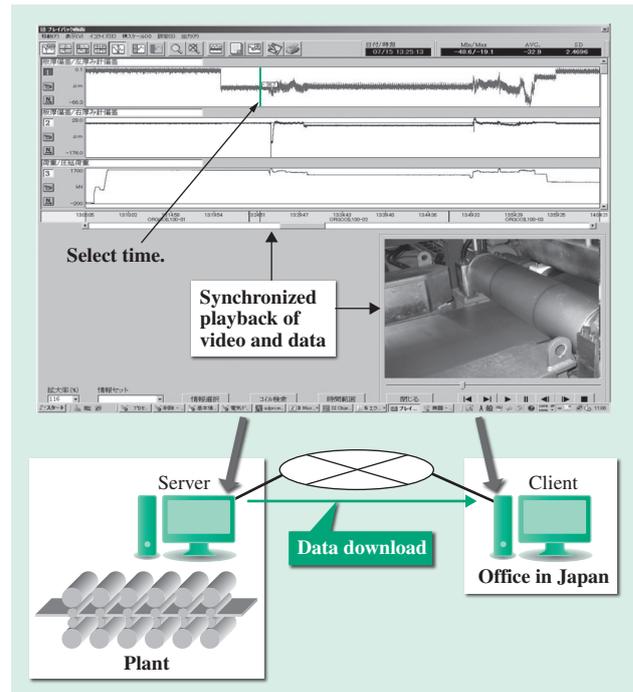


Fig. 6—Maintenance Support System with Playback Simulator Screen.

The system assists with plant analysis by enabling synchronized playback of charts and video.

Along with adding value to after-sales services and developing operations technology that makes this possible, Hitachi intends to continue supplying advanced steel industry control systems that satisfy the ideas and requests of customers around the world.

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\*3 OPC is a registered trademark of the OPC Foundation of the USA.

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