Chinese rolling mill for extra high grade aluminium strip

ABB Industrietechnik supplied all of the electrical equipment, including the measuring systems and controls, for Southwest Aluminium's new four-high cold rolling mill in Chongqing-Xipeng, China. Just three months were needed to start up and optimize the mill. All of the guarantee values for the strip flatness and thickness tolerances could be verified in this short time, although there was no access to a higher-order process computer for modelling or for adaptation of the preset data and controller parameters. Various ABB companies from different countries contributed to the successful completion of the project.

ABB Industrietechnik AG, Mannheim, received the contract to supply the electrical equipment for the Chongqing 2 cold rolling mill in China at the end of November, 1992. The order for the mechanical equipment for the mill went to Schloemann Siemag AG (SMS) of Germany.

The mill operator, *Southwest Aluminium Fabrication Plant* (SAFP), is an independent company belonging to *China National Nonferrous Import & Export Corp.* SAFP, with an annual output of more than 200,000 t, is China's largest aluminium producer. The company's range of products also includes pressed parts, a large proportion of which are exported, for example to the US aircraft company Boeing.

The cold rolling stand **1** for which ABB supplied the electrical equipment is the centrepiece of the second stage of expansion of the new mill. It is designed to produce approximately 110,000 t/year of thin aluminium strip in a range of alloys.

Production will concentrate mainly on the base material for foil as well as on high-grade strip for making cans for the beverage and foodstuff industry.

Table 1 gives the main technical data of the installed CVC[1)] four-high stand. With the new equipment, 3-mm thick aluminium strip on coils weighing up to 11 t can be rolled at a maximum speed of 1,500 m/min to achieve gauges down to 0.15 mm.

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Distributed control with ABB Master

To ensure that the narrow tolerances specified for the strip thickness and flatness are not exceeded, ABB installed its digital multiprocessor control system ABB Master. The extensive automation of the cold rolling mill is based on this system, which unites loop and logic control in the same hardware and software [1, 2].

Although many different types of drive are used in the mill, the same interface – a so-called Master Fieldbus – can be used to couple them all to the higher-order ABB Master control system. As far as users on the Master side of the interface are concerned, it is irrelevant whether a synchronous, induction or DC machine is being driven. This is because those parts of the software responsible for the coupling are the same for every type of drive.

New DC technology from ABB ensures constant strip tension

The 1,000-kW DC motors that drive the reels have their own power supply units. As high tension accuracy is essential for optimum strip thickness control, especially during acceleration and deceleration, fully digital converter units from the PAD8 family were chosen for stepless speed control of the DC machines. A 16-bit microprocessor controls both the basic and special functions as well as monitoring and signalling.

Synchronous machine ensures high speed accuracy of the main drive

A 4-MW cycloconverter-fed three-phase synchronous motor is used as the main

[1)] CVC = Continuously Variable Crown

The new CVC four-high cold rolling stand of Southwest Aluminium in Chongqing-Xipeng, China. The stand was placed in operation by ABB in record time. **1**

drive. The complete drive unit, with motor and converter, was supplied by ABB Large Drives of Helsinki, Finland. A constant strip thickness depends to a large degree on accurate control of the speed of the main drive. Since every change in speed (eg, as a result of disturbances) influences the strip thickness direct, fast dynamic response, with precise speed and torque control of the main drive, is essential for cold rolling mills.

The required fast dynamic response is ensured by the PSR programmable high-speed controller [3], which is based on Risc processors. Modules from the PSR family are configured to form a non-application-specific control and monitoring system that ensures very fast processing and easy, user-friendly programming.

For commissioning and diagnostics, ABB has installed the new 'DriveWin' tool – an application program based on Windows **2**. This system is run on an industrial PC with high-speed processing capability. It is integrated in the switchpanel direct and is linked to the PSR system. More than 50 predefined pictures representing the hardware and software and showing the actual operating statuses of the drives can be displayed on a colour monitor. Modifications to the software and parameters can be carried out directly on the screen. Lists of faults simplify troubleshooting and help to identify their origins. Corrective action is also suggested. A transient event recorder registers and stores real-time and historical data for displaying on monitors as trend curves, etc.

A telephone modem provides direct external access to the system. This remote diagnostics option helps customers to quickly identify faults. An added advantage is that the stored drive data can be read on-line and all of the drive signals can be accessed. On-line modification of the parameters and software is also possible.

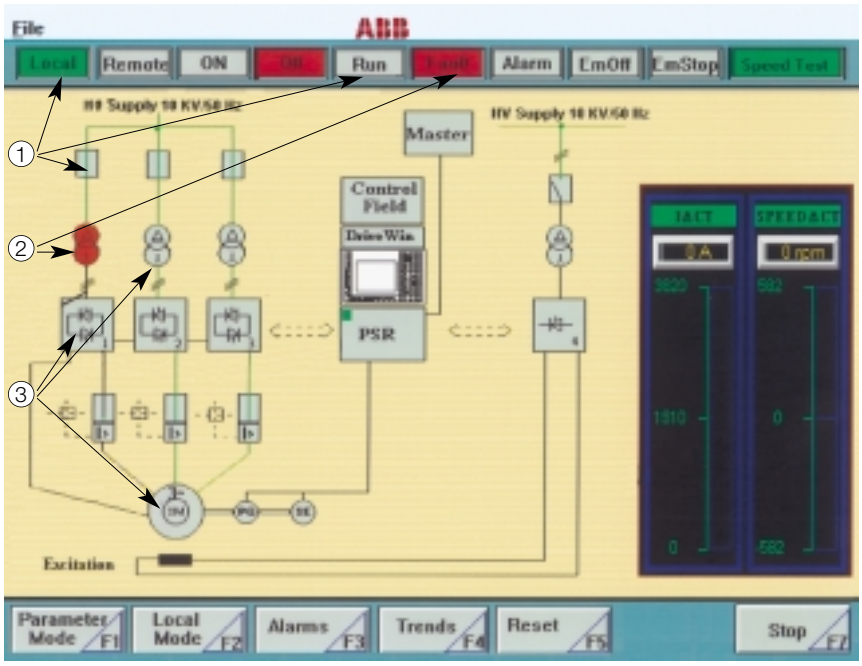
Precise positioning of the coils with AC drive technology

Multi-motor sectional drives from the new ACV700 series [4] position the

Table 1:
The main technical data of the CVC four-high cold rolling stand of Southwest Aluminium in Chongqing-Xipeng, China

Product data	
Strip width	900 – 1,700 mm
Strip thickness, entry	max. 3.0 mm
Strip thickness, exit	min. 0.15 mm
Coil weight	11,000 kg
Coil diameter	1,920 mm
Strip tension	
Pay-off reel	4.3 – 77 kN
Coiler	3.2 – 77 kN
Roll stand	
Rolling speed	max. 1,500 m/min
Diameter of work rolls	400 – 440 mm
Diameter of back-up rolls	1,150 – 1,250 mm
Roll force	max. 16,000 kN
Main drives	
Pay-off reel, DC	1,000 kW; 1,065 rev/min
Stand, AC	4,000 kW; 582 rev/min
Coiler, DC	2 x 1,000 kW; 1,065 rev/min

coil lift cars with high precision in the pre-rolling and entry/exit zones. The ACV700 series covers a wide power range and is an optimum solution for medium-size and small-scale AC drive systems. Designed to meet the requirements of different applications, the drives feature modern power semiconductor devices and digital control and can be hooked up to a range of automation and PC-based systems. The high-performance application controllers have subordinate system controls, such as flexible local and remote I/O control, integrated in them.



Overview of the ABB DriveWin diagnostics facility. This new tool for commissioning three-phase AC synchronous motors allows more than 50 predefined images to be displayed on the screen. **2**

1 *Switching statuses*
2 *Fault signalling*
3 *Equipment display (click-on function)*

Thickness measurement with ABB Accuray

Southwest Aluminium's new mill is also the first project to have ABB Industrietechnik's own thickness measurement system, ABB Accuray, installed. A measuring device with two different emitters fitted to it is installed in the entry and in the exit zone of the rolling mill. Thicknesses of 2 mm and more are measured with an ameritium (gamma emitter) source that operates with an intensity of three curies. A strontium-90 source with an intensity of 300 millicuries measures the thinner strip down to 0.15 mm [5].

The key benefit of the new measuring device lies in the simplicity of the alloy calibration and the fast processing speed of the computer. The maximum time between actual-value measurement and control is 1 ms **3**. The measuring source is calibrated the first time in the factory. Afterwards, all the customer has to do when adding a new product is carry out comparative measurements.

Control is based on a programmable MasterPiece 200 controller, thereby practically excluding problems with integration. Any software modifications which become necessary can be carried out easily thanks to the standardized function plan programming of the mill's control system.

Guaranteed flatness with ABB Stressometer

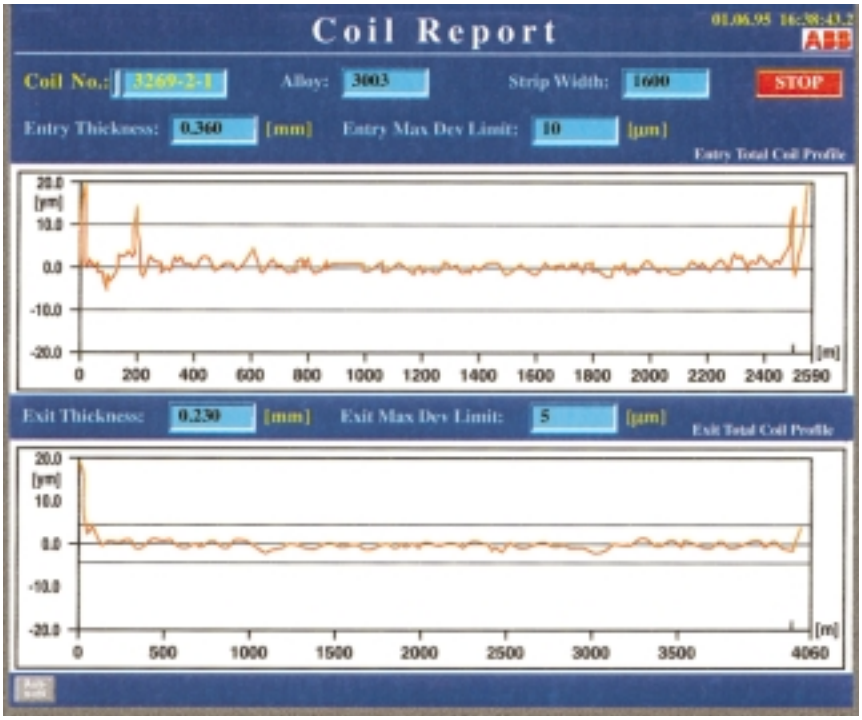
Strip flatness is ensured by an ABB Stressometer. Very high tensile stresses can be applied to the measuring roll of the Stressometer, which has a solid steel core. The high stresses, however, do not compromise the precision of the measurements, which are accurate to 0.1 N. The measuring roll installed in Chongqing has 34 zones, each with a pressductor force transducer for carrying out four measurements per revolution. This high rate ensures stable measurement, thereby allowing the flatness controller to be connected at speeds as low as 20 m per minute.

In the new four-high stand, the flatness is controlled by means of correction signals sent to the tilting, bending and cooling controllers and to the work roll displacement unit. Thus, the flatness controller serves four closed loops, allowing flatness values of five to seven I-units. A change in the flatness of one I-unit corresponds to a change in length of 10 µm/m.

The application programs are implemented in the ABB MasterPiece multiprocessor system, ie they are also programmed in the standard function plan language. Communication between the flatness controller and the technological control loops for hydraulic screw-down takes place over a high-speed bus link. The high-performance communication (HPC) bus from ABB can transmit data at speeds of up to ten megabits per second.

Control comparisons are made every 2 ms

The subordinate hydraulic screw-down control loops process the sampling results at the rate of 500 times a second. This means that actual values are read in and compared with the setpoint value every 2 ms; the deviation is evaluated with help of a control algorithm and the new positioning signal is sent to the servo-valves. The operator can select between position and roll-force control. The preselected control mode has a tilt controller superimposed on it to ensure that the cylinders always move with the given reference tilting value.



After rolling has ended, a hard copy of the graphic display showing the strip thickness on the entry and exit sides of the mill is automatically printed out for quality control or archiving. **3**

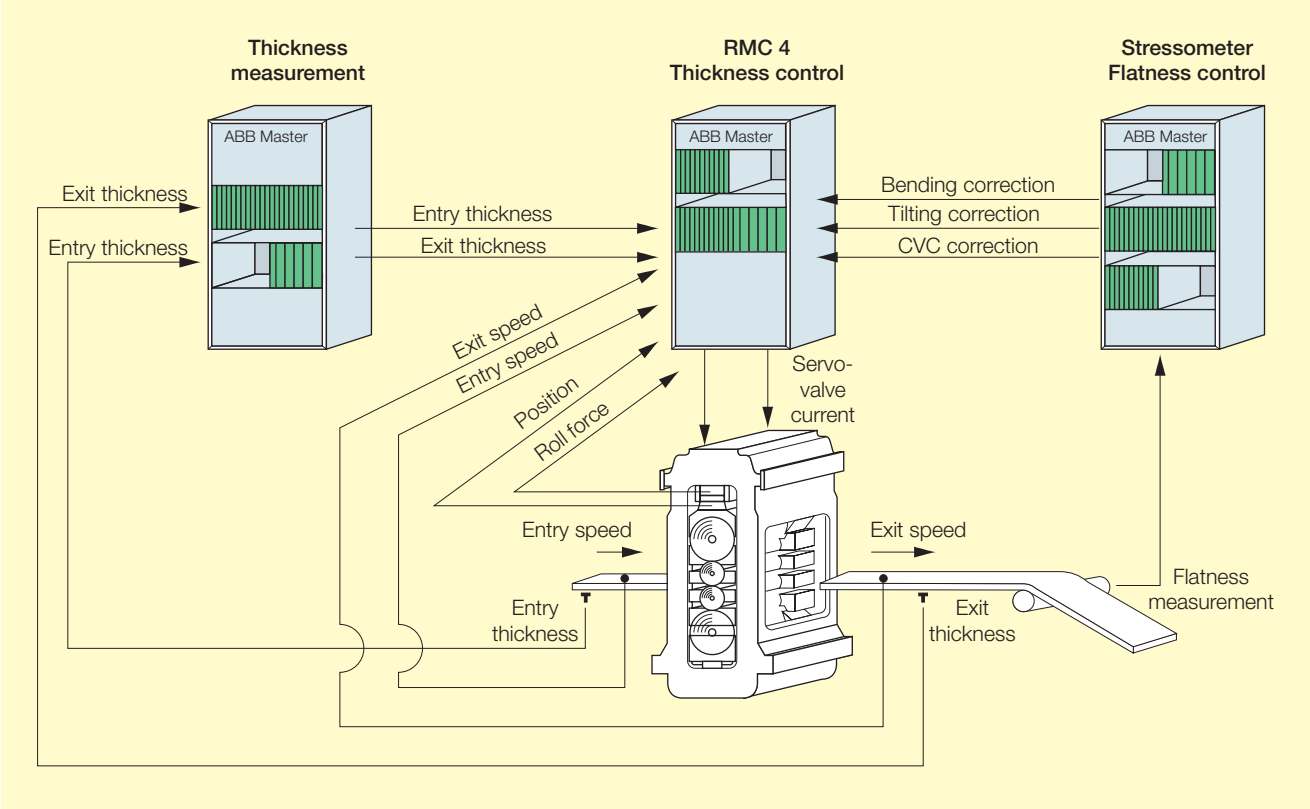
1/1000 millimeter resolution

In the case of thin strip, a tolerance of ≤3 µm is specified for at least 97.5 percent of the strip length. To meet this requirement the hydraulic screw-down position has to be measured by a high-resolution system. The industrial measuring system used has a resolution of 1 µm. Pulses with frequencies of up to 2.5 MHz are transmitted by the electronics, each pulse corresponding to a change in the path direction of 1 µm. The high counting frequency (in the megahertz range) calls for high-performance process automation. This is precisely the area in which ABB Master is strong. In the Chongqing mill, the generated pulses are read in with a pulse counter card. The fully digital interface created in this way is totally insensitive to disturbance and requires no maintenance.

High-performance strip thickness control

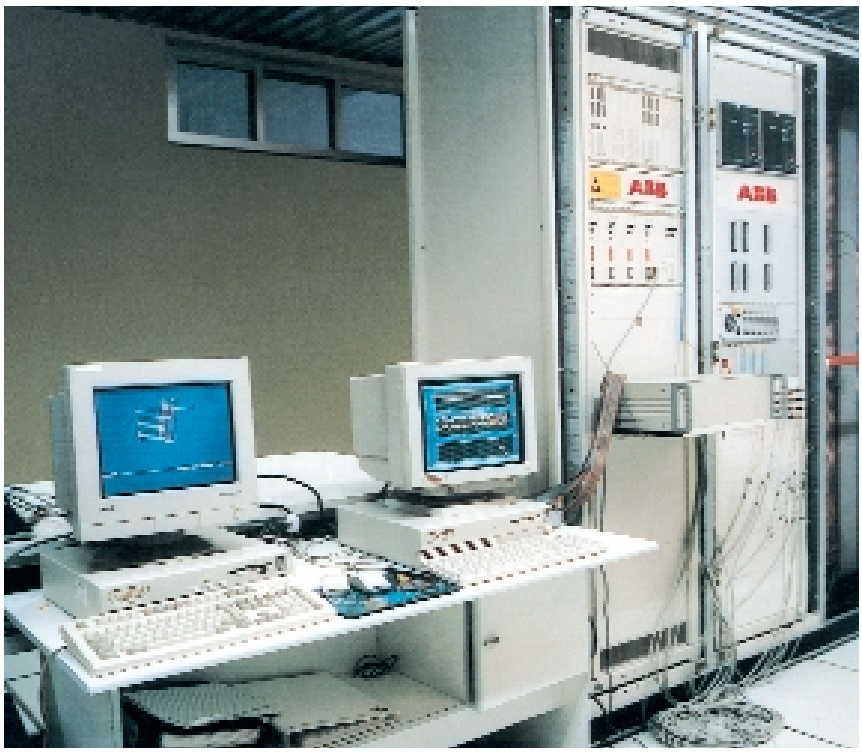
The demands made today on product quality and productivity can only be met with a control model that accurately reproduces the roll-gap conditions **4**.

The feedforward precontroller provides a setpoint correction signal every 5 ms, enabling an early response to deviations in the thickness of the incoming material. A shifting register delays the measured strip thickness deviation



Technological measurement and control in the Chongqing mill is based entirely on ABB Master. **4**

The parameter values stored at the end of every pass by the measured-value acquisition system can be used to analyze the fine-tuning. **5**



until the relevant segment of strip lies in the roll gap.

The feedback controller monitors the strip thickness deviation measured on the exit side and fine-tunes the thickness control to compensate for thermal effects. It is essential to determine the exact measurement delay; only when this is assured can the fastest possible response be guaranteed over the full speed range. This is important in Chongqing, where the maximum rolling speed is 1,500 m/min.

Rolling aluminium and its alloys makes high demands on the strip thickness control during the acceleration and deceleration phases. To meet these demands, a speed-related precontrol curve has been implemented which describes the change in friction in the roll gap via the parameters ‘slope’ and ‘stroke’. This enables the strip thickness tolerances to be reduced in the critical

phases to two thirds of the guaranteed values.

Self-optimization of the speed precontrol parameters

Since the mill is not equipped with a higher-order pass sequence optimization computer, the control system automatically optimizes the speed precontrol parameters. To maintain a constant exit thickness during acceleration and deceleration it is necessary to classify the parameters for the speed precontrol curve. A large number of parameters therefore need to be optimized.

At the end of each pass the actual values of the parameters are adapted once more on the basis of the values measured during the critical phases, and then stored 5. This simplifies and speeds up both start-up of operation as well as fine-tuning of the thickness controller. The optimized set of parameters can be returned to every time the same class of material has to be rolled. With the help of this feature, operators can respond more easily to changes in the rolling process itself (eg, a change in the thermal conditions) in order to optimize the acceleration and deceleration.

Process diagnostics with MasterView 850

The proven, user-friendly MasterView 850 system was chosen as the man-machine interface 6. This system offers a number of advanced functions for interactive operation. Typical display features are process diagrams, trend curves and lists. Manual intervention in the control sequences via interactive communication is possible, as is the display of disturbance messages and events. The system also allows long-time storage of historical data for trend curves and shows the current status of the control system. Another possibility is the sequential display of automatic processes.

User-friendly overviews of the key process data are displayed by ABB MasterView in the control cabin. 6

References

[1] R. Aggen: A cold mill for top-quality thin aluminium strip. ABB Review 6/7-94, 22–29.

[2] ABB Master Product Guide. Oct 94. ABB publ. BSE 003 378 R0001

[3] P. Steimer, P. Hartmann, C. Perrin, A. Rufer: PSR – the world's fastest programmable controller with function block language. ABB Review 2/93, 21–28.

[4] ABB ACV 700 Product Overview. ABB publ. 3 AFY 611 23512 R0025.

[5] ABB Large Drives: Cycloconverters for high performance speed and torque control, 1 to 34 MW. ABB publ. 3 AFY 639 18466 R0025

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