Rolling mill automation control system (RACS)

AIC's rolling mill automation control system for long product mills is targeted at speed reference generation for rolling stands, rolling tension control, looper control and material continuity control, aiming for improved mill performance and yield. It is based on standard parts and PLC platforms and accessed via a user-friendly human-machine interface.

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AIC is a global system integrator that designs, manufactures and markets automation systems for many different industries, although its main business for more than 30 years has been steel industry process automation and control. AIC's international customers include Tata Corus, Sandvik Materials Technology, Gerdau Ameristeel, Riva Acciaio and Lucchini–Severstal Group.

GENERAL DESCRIPTION OF RACS

RACS is the name given by AIC to the software core of its automation system for long products rolling mills. RACS has been successfully implemented for quantity-focused systems, for example, construction steel mills (rebar and section) and quality-focused systems, for example, profile, special bar mills and titanium rolling mills. It is dedicated to automating the steel rolling process, and in essence it performs the following tasks:
- Speed reference generation for rolling stands
- Rolling tension control
- Looper control
- Material continuity control

RACS runs on the standard CPUs of standard PLC platforms (Siemens S7-400 or Allen-Bradley ControlLogix) without any custom cards, and deeply integrates with other parts of the control system, all implemented by AIC, such as:
- Shear control system with material saving real-time cutting optimisation strategy

![Simplified typical automation layout of a rolling mill](image-url)
according to customer-specific needs. The HMI system also includes an advanced recipe management tool that can be used for inputting, modifying, downloading, uploading and saving rolling parameters. This tool, integrated with RACS stand speed control, is able to load speed references without stopping the mill, thus saving time while setting up for a new product. It is also able to load parameters selectively for a subset of all the stands, to allow loading a recipe for only a section of the mill. A schematic automation layout of the typical AIC automation system for a rolling mill is shown in Figure 2.

High speed discharging devices onto cooling bed at up to 35m/s
Laying head positioning control system for wire rod lines up to 120m/s
Human machine interface (HMI) Level 1 and Level 2 systems based on standard PCs
Interface with the customer’s Level 3 production management system
Continuous casting system
Reheating furnace hot charging
Reheating furnace movement and combustion automation
CCTV camera system
Services (water and fumes treatment etc.)
Safety system (PILZ, Allen-Bradley, Siemens safety PLCs)

RACS is completed by a client-server, hot backup HMI system that allows the operator to continuously monitor and control the real-time process. HMI can be implemented using many different SCADA packages, according to customer-specific needs. The HMI system also includes an advanced recipe management tool that can be used for inputting, modifying, downloading, uploading and saving rolling parameters. This tool, integrated with RACS stand speed control, is able to load speed references without stopping the mill, thus saving time while setting up for a new product. It is also able to load parameters selectively for a subset of all the stands, to allow loading a recipe for only a section of the mill. A schematic automation layout of the typical AIC automation system for a rolling mill is shown in Figure 1. All components (PLCs, PCs, drives etc.) and communication networks (Ethernet, ControlNet, Profinet etc.) are standard market-available.

**GENERATION OF STAND SPEED REFERENCES**

In order to achieve the maximum quality of the rolled material the rolling process should minimise the stresses on the material, monitor and adjust the rolling torques on the material during the process (tension control) in
the roughing area of the mill, and form and recover the material loops (loop control) in the intermediate and finishing areas of the mill.

To achieve this result the system implements several different types of task-specific regulators, each with a dedicated set of parameters. RACS is designed to let the user focus on a few important parameters, while the other ones are set during commissioning and then recorded in recipes, so freeing the user from the necessity to continuously check and adjust internal parameters. Maintenance screens in the HMI system, accessible via a security password, are provided for technicians to adjust the parameters if needed.

These control systems automatically affect the speed references of the stands and also of all the auxiliary machines along the mill, integrating the calculated corrections to manual adjustment commanded by the operator. These adjustments can be done in single or tandem mode (cascade).

The general principles of RACS tension control are that where there is no looper between two stands the RACS system will keep the tension at a set point (which can be either tension or push, depending on the set point selected by the operator) by comparing the rolling torques of stand $X$ at the following times:

- After the head of the billet has passed through the rolls of stand $X$ and before entering the next stand
- After the head of the billet has passed through the rolls of stand $X+1$
- After the head of the billet has passed through the rolls of stand $X+2$ and so on

Based on the results of these comparisons RACS will adjust the speed references of the stands to achieve the desired tension value.

The general principles of looper control in backward cascade are that where there is a looper between two stands the RACS will form and recover the loop between the stands $X$ and $X+1$ as follows:

- After the head of the billet has passed through the rolls of stand $X+1$ the speed of stand $X$ temporarily increases and the loop former is activated
- The height of the loop is then kept to a fixed value by continuous regulation
- Before the tail of the billet leaves the rolls of stand $X$ the loop is recovered (the speed of stand $X$ decreases)

This kind of regulation is also applied for forward cascade, but by working on the downstream stand. Both tension and loop controllers have several dedicated parameters, the majority of which are set during initial startup and saved in recipes. These are not accessed by the operator but are available to technicians for maintenance. Figures 2 and 3 are typical process parameters screens. Figure 2 shows, for instance, speeds, power consumption and reduction factor. Figure 3 shows data for a 12 stand H-V mill.

**SHEAR CONTROL SYSTEM**

The AIC shear control system can control several types of shear, including clutch/brake, start/stop and rotary. Its most important characteristics are:

- **Cut repeatability** The system is designed to achieve the highest possible cut repeatability to allow high optimisation of cutting strategies
- **Head/tail cuts** It minimises the length of these cuts because of its very fast reaction to external signals (e.g., hot metal detectors) and its high repeatability
- **Cut to length** The system accurately tracks the length of the material being processed by means of encoder signals, to allow cuts to any desired length with high accuracy and repeatability
- **Cutting optimisation strategy** Based on saleable commercial lengths input by the operator, the system automatically calculates for every billet an optimal cutting strategy to minimise material scrapping. This system can also take advantage of pre-optimisation shear cuts to scrap the material in the middle of the rolling process
- **Ghost billet** The system can simulate the rolling process with no material at a given line speed (parameter in the HMI system), including shear...
Forming Processes

CONCLUSIONS
RACS increases performance and availability in many kinds of long product rolling mill thanks to tailored solutions developed and exploited over more than 30 years in rolling mill automation. Our long-term expertise is continuously increased by close cooperation with our customers, who help us develop new and improved solutions.

RACS has been successfully implemented in many mills, achieving availabilities of up to 97% of working hours. For example, RACS is currently used in many plants, including the following:
- Tifast – titanium and super-alloy special mill
- Lucchini Piombino – TMP mill (large profiles mill)
- Demirsan Haddecilik – medium section mill
- Feralpi and Ferriera Valsabbia – rebar mill

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A typical screen output is shown in Figure 4.

**Fig 4 Typical shear output screen**