DIGITAL AUTOMATED SYSTEM FOR CONTROLLING THE OPERATION OF A CONTINUOUS COLD-ROLLING MILL


A description is given of the different stages of reconstruction of the electrical equipment, the control systems of the electric drives, and the automation systems of the 1300 continuous cold-rolling mill at the plant operated by the company VIZ-STAL’ in Ekaterinburg. The upgrade has significantly improved the quality of the rolled product and the reliability of the equipment.

Many Russian metallurgical plants are currently making flat-rolled products on mills that were built and have been operating since the 1970s and 1980s.

The mechanical components of these mills are in fairly good condition, and the mills can roll products meeting current standards if they have been modernized by partial or complete replacement of their electrical equipment and the installation of hydraulic hold-down screws. However, such upgrades are expensive and require idling of the mill for a lengthy period of time.

Specialists at the company Automated Systems and Complexes (ASK) have devised a method that allows such mills to be upgraded in stages. Here, digital monitoring and control systems are introduced on different parts of the mill in succession. Thus, at a moderate cost for the upgrade, the existing mechanical components of the mill can continue to be used to produce flat-rolled gods with characteristics close to those obtained after the installation of hydraulic hold-down mechanisms.

One example of the realization of this concept is the staged reconstruction of the 1300 continuous cold-rolling mill at VIZ-STAL’ in Ekaterinburg, which received upgrades to its electrical equipment, the control systems of the electric drives, and the automation systems. The reconstruction of the mill has significantly improved product quality and the reliability of the mill’s equipment.

The four-stand 1300 mill was designed for cold-rolling pickled hot-rolled strip into coils. The coils weigh up to 15 tons (with an outside diameter of up to 1800 mm), the thickness of the starting strip is 2–3.5 mm, and the thickness of the finished product is 0.35–0.85 mm. The mill has electromechanical hold-down mechanisms. The pressure underneath each hold-down screw (which ranges up to 2400 ton-f) is monitored by means of hydraulic capsules, and radioisotope gages are used to measure strip thickness after the first, second, and final stands of the mill. The tension of the strip between the stands is measured with roller-equipped extensometers. Operations on the mill are controlled from ten local work stations and control panels located near the mill’s actuators. After the reconstruction project is complete, these operations will also be controlled by the senior mill operator located at the central automated work station (AWS). That work station will become the main work station of the system.
Before the reconstruction was begun, the mill was equipped with a contact-relay system for overall control of mill operations, an analog system for control of the speed regimes (SACS), a complex of analog systems for automatic control of strip thickness and tension (TACS and NACS), and a microprocessor system for positioning the hold-down mechanisms. The latter system is based on 8-bit processor KR-580.

In addition to modernizing the obsolete automatic control systems (ACS) of the mill’s electric drives, the reconstruction project had the goal of combining the different local automation systems into a single overall system composed of directly (rather than through the rolling process) integrated, functionally interdependent subsystems. The makeup of the electrical equipment of the mill was determined mainly by the time lag that was scheduled into the reconstruction project to complete successive parts of the project. For the purposes of this discussion, the project can be divided into two stages.

In the first stage, the plant modernized the ACS of the electric drives of the uncoiler, the stands, and the coiler. These systems were replaced by digital control systems based on controller V10 (UK V10), which is made by the All-Russia Research Institute of Electromechanics (VNIIÉM) in Moscow.

Controller V10 solves a certain set of protection and signalling problems common to all of the above-mentioned electric drives. It controls the operation of the thyristor in the armature circuit of the motor (the corresponding components of the existing converter were removed from the system), protects the motor from overheating, and performs various service functions.

Compact panels mounted in the door of the cabinets that house the controllers display general diagnostic information: the current condition of the drive; the connection of the drive, with prompts on the sequence of the actions to be executed; an error buffer, the buffer indicating the first error that occurred when an emergency develops and initiating shutdown of the necessary equipment. The performances of the ACS of the drives and the protective devices are checked in rapid succession, and the configuration of a given ACS can be changed automatically based on the regime chosen at the control panel. With the ultimate objective of the reconstruction project in mind, all of the signals associated with the production process (the signals from the sensors and the control elements, the control signals of the local automation systems, and the signals that control the auxiliary mechanisms of the mill) were concentrated in one location – the main distribution cabinet.

Completion of the first stage of the modernization project improved the reliability of the mechanisms of the mill, allowed quicker detection of errors, and improved working conditions for mill personnel. It also solved the important problem of automatically controlling the stability of the mechanical characteristics of the electric drives of the stands in the strip feed regime. The stability of these characteristics changes in relation to the amount by which the tension between the stands deviates from the control point, the assigned speeds for the drives, the static moment of the first stand, and certain parameters that characterize the current configuration of the TACS, NACS, and SACS subsystems. Automatic regulation of these characteristics’ stability in the strip feed regime has made it possible to significantly reduce the incidence of tearing of the strip during its entry into the mill.

The second stage of the modernization project involved the installation of digital systems in place of several components: the ACS for the thyristors of the hold-down mechanisms; the complex of systems used to automatically regulate thickness and tension; the system that positions the hold-down screws; the general control system and the system that regulates the speed regimes of the mill. Automated work stations (AWS) were installed for the electrician and process engineer. The overall system for automation of the 1300 mill (TA1300) was built on the basis of the Simadin D multiprocessor controller made by Siemens.

The ACS of the drives includes lower-level actuators with a well-defined set of functions. A given function in the ACS is activated by means of the TA1300 controller.

Figure 1 presents a simplified block diagram of the automatic control system presently in use on the 1300 mil. The functions of all the local control systems previously used on the mill are now concentrated in the single multiprocessor system Simadin D. The first processor module realizes the functions of the TACS and NACS, controls the system that supplies the mill with emulsion, and controls the press-tables; the second processor module controls the functioning of the positioning system for the hold-down mechanisms; the third module realizes the functions of the general control system of the mill and the system that controls its speed regimes. The third module also forms the data packet for the system server and controls the operation of the electrician’s AWS.