With the ongoing restructuring of the market for rolled products, manufacturers are finding that some customers are making greater demands in regard to the quality of the finished products they buy. In response, manufacturers are improving the technologies and equipment used to make these products while also using their existing production facilities to the maximum extent possible. This article analyzes the technological capabilities of the welding complexes in the strip shop at the Magnitogorsk Metallurgical Combine. The equipment is evaluated from the standpoint of its ability to help make a wide range of cold-rolled products while not slowing the operation of other, continuously operating equipment in the shop. The components of the existing butt-welding machines that reinforce the coils and form a continuous loop of the strip were found to be bottlenecks in the production process.

The fact that consumers of finished cold-rolled products are increasingly demanding that those products meet higher standards is making it necessary to improve the technology and equipment used in the manufacturing process. One product made in large quantities is cold-rolled strip, which is produced by flat-rolled products shop No. 8 at the Magnitogorsk Metallurgical Combine.

The shop was originally built to make cold-rolled strip 1–4 mm thick and 10–450 mm wide. The strip is made of carbon steel with a carbon content no greater than 0.55%. All of the equipment in the shop was designed to make strip within a certain thickness range from hot-rolled metal 2.5–7 mm thick. Construction of the shop was completed at the end of 1982. During the startup of the shop and over the course of subsequent operating periods, the initial range of cold-rolled sheet that was made was expanded to include the thickness range 0.5–4.5 mm and the width range 10–470 mm. The range of grades of steel was also broadened to include medium-carbon steels with a carbon content up to 0.75% and alloy steels with a carbon content up to 0.7%. The thickness of the hot-rolled semifinished product used for the thinner sheets was decreased to 2.0 mm. The shop was provided with the following main equipment: a unit for coiling and uncoiling the strip (CUU); a continuous pickling unit (CPU) employing salt-acid pickling; a continuous five-stand 630 rolling mill; single-stack bell-type furnaces with a nitrogen-hydrogen atmosphere; a two-stand 630 temper-rolling mill; five longitudinal shears with packaging lines. The CUU and CPU include equipment for spot-welding the ends of successive small coils to one another. This equipment makes it possible to obtain quality welds on strip having a thickness of 2–7 mm and a width within the range 700–1500 mm (CUU) or 250–485 mm (CPU). The maximum outside diameter of the coils is 2100 mm.

New regimes for welding the strip and heat-treating the welds in the electrodes of the butt-welding machine were developed and successfully introduced for steels of the above-indicated grades. They are the first such regimes to be used in Russian metallurgy for the heat treatment of welds on wide (CUU) and narrow (CPU) strip. The main problem that had to be overcome was ensuring that the ends of the coils being welded together are evenly heated over the width of the strip dur-
ing the heat treatment. Studies showed that temperature was nonuniform along the length of the weld during the heating operation: the edges of the weld were significantly hotter than the middle. The degree of nonuniformity of the weld’s heating in the length direction is affected by many factors, including the variation in the thickness of the semifinished product over its width, the condition of the surface of the coil ends being welded (the presence of different types of scale), and the grade of steel being welded. The problem of ensuring uniform heating of the weld region was fully resolved in the course of developing and introducing the weld heat-treatment technology.

The welding complexes that were installed in the line of the high-capacity CUU and CPU (both of which operate continuously) restrict the productivity of the strip processing facility as a whole. However, they also reduce the amount of waste generated in the form of crop.

In accordance with the original design of shop No. 8, the butt-welding machines were intended to be used to weld hot-rolled products made of steel with carbon contents up to 0.55%. According to the classification of these steels, the steels themselves have good weldability and the welds do not require heat treatment after the welding operation. In the course of mastering the production of cold-rolled strip made of medium-carbon steel with carbon contents up to 0.75% and alloy steels with carbon contents up to 0.7%, the shop found it necessary to heat-treat the weld zone in the electrodes of the welding machine in order to allow uninterrupted processing of the strip coming from the CUU and CPU.

Four schemes were devised for butt-welding the ends of coils of the hot-rolled strip as the shop was developing and introducing the technology to produce cold-rolled steel strip of the above-indicated grades. The technology traditionally employed for the butt-welding of low-carbon steel (spot welding with continuous fusion) was used to make products for which the equipment was designed: medium-carbon steel strip with carbon contents up to 0.55% and low-alloy steels with carbon contents up to 0.35% (examples include steels 30G, 30G2, 20Kh, and 08GSYuT). Among the steps in this technology are positioning the ends of the strips in the electrodes of the welding machine, melting the metal in the end regions, upsetting the ends, intercepting the electrodes, and removing flash from the weld.

To make strip outside the design range of the equipment, it was necessary to devise three other regimes for welding strips of three types of steel:

- medium-carbon steels with a carbon content of 0.56–0.75% (steels 60, 65, 70) and low-alloy steels with a carbon content of 0.46–0.7% (steels 50G and 65G);
- alloy steels in which the contents of the alloying elements range up to 3.5% and carbon content is within the range 0.20–0.34% (steel 30KhGSA);
- alloy steels in which the contents of the alloying elements range up to 3.0% and carbon content is within the range 0.48–0.7% (steels 50KhGFA and 7KhNM).

Steels of the first type are considered to have good weldability. After the electrodes have been cut off, the weld region must be heat-treated in the electrodes of the welding machine for 10–40 sec before the flash can be removed. Steels of the second type above are considered to have conditionally good weldability. Welds of these steels must be heat-treated between the upsetting operation and the electrode cutoff. Another heat treatment, lasting 50–90 sec, is necessary after the cutoff in order to remove flash. Steels of the third class are considered to have poor weldability. Their welds require a complicated and lengthy heat treatment between the upsetting operation and electrode cutoff and another 4–10 min of treatment after the cutoff, to remove flash. Whereas no more than 10–20 min is needed for adjustment of the butt-welding machine to obtain quality welds on strip made of the steels that have usually been welded by the conventional technology, the adjustment time increases to 30 min for steels of the first type, 40–45 min for steels of the second type, and 1–3 h for steels of the third type. Thus, there is a significant reduction in the hourly productivity of the CUU and CPU when strip is being made from hot-rolled semifinished products composed of nonstandard grades of steel. The decrease in productivity compared to the welding of standard steels is 20–30% for grades of the first type and 30–40% for grades of the second type. The productivity decrease is two- or threefold for steels in the third category.

One current trend in world metallurgy is the overproduction of ferrous-metal rolled products, including cold-rolled strip. Thus, metal producers need to be ready to adapt to a global market in which huge orders for cold-rolled strip made of nonstandard grades of steel – especially grades of the third type – may be received on short notice and have to be executed