CONTROLLED ROLLING OF SKELP
ON LOW-POWER MILLS

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Large-diameter pipes are one of the most metal-intensive products that are made. Russian industry annually produces 700,000–1,000,000 tons of such pipe just to fill the orders placed by Gazprom. The metal of these pipes must meet exacting standards for strength characteristics, low-temperature toughness, ductility, weldability, and cold resistance. The last property is particularly important, and obtaining it requires the use of a special technology. Cold resistance is determined from the results of drop-weight tear tests (DWTT) of specimens of normal thickness. The percentage of the tough component in the fracture of DWTT specimens tested at the service temperature should be at least 85%. After this requirement was incorporated into existing standards, the number of fractures of gas pipelines decreased sharply, brittle fractures longer than one pipe length were completely eliminated (the number of such fractures previously totalled 100 m or more), and it became possible to transport gas in 1420-mm-diam. pipes with a working pressure of 7.5–10.0 MPa.

A special rolling operation was developed to satisfy the standards on the percentage of the tough component in DWTT specimens. The new technology involved the use of a variable thermomechanical treatment and was given the name controlled rolling. This energy-saving technology almost completely replaces the previously used method, which involved quenching, tempering, and double heating. In addition, thanks to the exceptionally fine-grained microstructure of the metal and the presence of texture from the rolling operation, the new technology is more advantageous than the earlier method in terms of its ability to satisfy the specifications on cold resistance.

Controlled rolling is usually done on specialized reversing mills with an allowable unit load of 1.5–2.0 tons/mm roll body. The finishing temperature is within the range 700–800°C. Such characteristics are typical of the finishing stands of modern 5000 mills such as those operated in Japan, Germany, and Italy.

In the USSR, the special 3000 mill at the Il’ich Metallurgical Plant has capabilities similar to the above (the allowable pressure on the rolls is 7000 tons). The 3600 mill at the Azovstal’ plant has slightly lower characteristics. In controlled rolling, the finishing temperature on the mills may be as low as 670–690°C. Both of the Mariupol’ mills were left in Ukraine after the breakup of the Soviet Union. Controlled rolling was not done on reversing mills in Russia due to the low power of the 2800 mills (such as the one at the Ural’skaya Stal’ (Orsk-Khalilovo Metallurgical Combine (OKhMK)) and Severstal’ OAO), while the 5000 mill at the factory in Kolpino required a major overhaul. The first research into controlled-rolling regimes for the low-power 2800 mill at the OKhMK (allowable unit load of 2800 tons) was begun in 1993. Following the recommendations of one of the founders of Russian metallurgy – I. P. Bardin – on taking a multi-faceted approach to research, a group of scientists at different institutes (TsNIIchermet, the All-Russia Scientific Research Institute of Hard Alloys (VNIIST), and the All-Russia Scientific Research Institute of Natural Gas (VNIIGaz)) collaborated with factory specialists at Ural Steel and the Chelyabinsk Pipe Plant (ChTPZ) to conduct studies.

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The resistance of steel to deformation at the rolling temperature is the main factor that limits the use of controlled-rolling schemes on low-power mills. Figure 1 shows the changes in the plastic flow stresses of steels in relation to the deformation temperature [1]. The increase in resistance to deformation with a decrease in temperature is most clearly expressed for high-strength microalloyed tube steels. The high degree of deformation per pass and the low treatment temperature account for the extremely high rolling force. Thus, the first such steels that were developed (Tables 1 and 2) were intended for rolling with the completion of deformation in the lower part of the austenitic region ($T_{fs} \approx 820–840 ^\circ C$). The set of properties associated with strength classes from K52 (steel 12GSB) to K60 (steels 10G2SFB and 08G1NFB-PL) were obtained on these steels, which have found wide use in the production of cold-resistant pipes for gas pipelines operating at a pressure of 75 atm and having a diameter of 530–820 mm (one-seam pipes) or 1020–1220 mm (two-seam pipes). Such pipes have been made by the Vyksa Metallurgical Plant (VMZ) and ChTPZ. Flat and coiled rolled products of steel 12GSB are being made not only on the 2800 mill at Ural’skaya Stal’, but also on the 2800 mill at Severstal’ and the continuous wide-strip 2000 mills at Severstal’ and the MMK.

The ChTPZ has employed the process of LTMT (local thermomechanical treatment) to make unique, nearly seamless 1020–1220-mm-diam. pipes of steel 08G1NFB-PL in strength class K60. However, plant has had success in this area only in regard to the production of plates up to 12 mm thick. It must take the next step needed and develop a controlled-rolling technology for rolling plates thicker than 12 mm. Work in this direction was begun in 2002. It is apparent from Table 1 that all of the steels that have been developed contain niobium, which is a unique microalloying element that can be used in