Rational groove configurations not only prevent rolling defects (creases, cuts) but also reduce the depth of ingot defects (cracks, scabs); in some cases, ingot defects may be completely eliminated. Currently, there is no consensus regarding the influence of the groove configuration on the amelioration of defects. Some authors believe that a rhombus–square groove system is optimal in terms of improving the surface quality [1]. Others replace the rhombic groove with a box groove [2]. Most researchers assume that the tipping conditions have no influence on the surface quality of the rolled product. However, some suggest that frequent tipping has a favorable influence [3]. Overall, theoretical and experimental data indicate that the mitigation of surface defects depends in a complex manner on the geometric and deformational characteristics of rolling [4–7]. In particular, defects along the groove junctions increase in depth, but the absolute crack depth is inversely proportional to the total degree of deformation, according to [6]. Other data suggest that cracks branch and grow on deformation [2]. Thus, there is still a pressing need to investigate the influence of the groove on surface defects.

An industrial experiment has been conducted on the 250-2 small-bar mill at OAO Zapadno-Sibirskee Metallurgicheskii Kombinat (ZSMK) to determine the influence of the groove configuration in the roughing group on the surface quality of 20Kh steel bar with a diameter of 25 mm (State Standard GOST 10702–78). The mill is shown in Fig. 1. Longitudinal defects (depth 5 mm; width 2 mm; length 1000 mm) are applied artificially to 100 × 100 mm billet by means of a milling tool. The defect configuration (Fig. 2) is chosen on the basis of the need to investigate their distortion as a function of the billet position in the grooves. Three rolling procedures are adopted: I) with the existing groove configuration (Fig. 3a); II) with a modified tipping direction after cells 2 and 6 (Fig. 3b); III) with modified grooves in cells 5, 6, and 7 and with modified direction of tipping after cells 2 and 6 (Fig. 3c). Thus, the baseline for procedure II is procedure I; the baseline for procedure III is procedure II. In all cases, samples are taken from the final bar at a distance of 8–10 m from the rear end, in order to estimate the change in defect depth. The results are presented in Fig. 4 and in the table.

As is evident, in all three cases, the improvement in the defects on the faces of the billet is 1.3–2.0 times greater than for defects at the edges.

In procedure II, the improvement in the defects (in terms of the depth) is 2.0 times that in procedure I for

![Fig. 1. Configuration of 250-2 small-bar mill.](image1)

![Fig. 2. Scheme of the arrangement of defects on billets.](image2)
Fig. 3. Groove configuration of the roughing group for rolling 25-mm bar: (a) existing procedure; (b) with modified tipping direction; (c) with modified groove pattern in cells 5, 6, 7 and modified tipping direction.