then it is possible to conclude a priori that in the absence in a real structure of stresses perpendicular to a sheet such metal is probably more reliable than solid metal as the result of formation of cleavages, but in the presence of stresses in the z direction the use of metal prone toward cleavage is unacceptable.

CONCLUSIONS

1. After controlled rolling steel possesses a low resistance to plastic deformation in the z direction (across the sheet thickness). As the result of this, plastic deformation leads to numerous breakdowns in soundness of the metal even before origin of a crack; so-called cleavages are formed.

2. Propagation of a main crack perpendicular to the cleavages is difficult, which is confirmed by the increase in impact strength. The transition temperature as determined from the share of fibrous in each layer is lower than in a solid sample of the same metal since the layer is thinner than the sample.

Therefore, after controlled rolling, according to the formal parameters of fracture resistance the steel is better than solid normalized steel; the impact strength is higher and the transition temperature (temperature of half-brittleness) is lower.

However, in the presence in a structure of stresses transverse to the sheet the use of such material is hardly acceptable.

LITERATURE CITED


EFFECT OF ELECTROSLAG REMELTING ON THE STRUCTURE AND PROPERTIES OF STEEL 9Kh2MF

Yu. A. Bashnin, V. N. Isakina, and L. I. Maslov

A promising method of improving the structural strength of rolls for cold rolling mills is electroslag remelting of the steel (ESR). It has been established that rolls made from ESR steel have a long operating life in comparison with rolls made from steel prepared by open arc melting (OAC). However, the reason for the positive effect of refining on the structural strength has not been determined.

We investigated the effect of ESR on the structure and properties of steel 9Kh2MF, which is commonly used for rolls in cold rolling mills.

ESR steels with different amounts of residual aluminum were obtained by remelting electrodes 220 mm in diameter in the R-951R apparatus with a water-cooled copper crystallizer 350 mm in diameter under ANF-6 flux. The electrodes were prepared from steel melted in a 10-ton arc furnace. Scrap rolls were used to prepare the rolls with a cast barrel of ESR steel.

The quality of the steel and its technological and operating characteristics were determined in the cast and forged conditions, depending on the structural zones of the ingot (the OAC ingot weighed 1790 kg, the ESR ingots 1000 and 2500 kg) and forged rolls with a barrel diameter of 220 mm (ESR) and 260 mm (OAC).

Analysis of the macrostructure of transverse samples of the forged rolls showed that forging does not completely remove the defects in the ingot. At internal defects not removed in forging the strength is lower than the stresses occurring in the rolls, which leads to cracks in the axial zone of the rolls. Forged rolls of ESR steel, as in the case of cast rolls, have a dense structure with no discontinuities or porosities, in contrast to forged rolls made from the OAC steel.

The dendritic heterogeneity was determined from microhardness measurements in axial and interaxial sections of the dendritic structure with the PMT-3 apparatus under a load of 0.5 N and magnification 487×, with examination of 20 axial and 20 interaxial sections of each microsection (transverse samples across the section of the ingot and forgings from two areas of the ingot—the top and at a distance of one-third the height from the bottom). The degree of microheterogeneity was determined from the relationship $A = \frac{(H_{MO} - H_O)}{H_O} \cdot 100\%$, where $H_O$ and $H_{MO}$ are the microhardness of axial and interaxial sections, respectively. Dendritic segregation was minimal at the surface of the ingots and amounted to 9.8 and 20-28% for the OAC steel (directly on the surface in both areas of the ingot) and 30-37% for the ESR steel (at a depth of 20 mm from the surface). The microheterogeneity increases up to the transition zone (columnar misoriented crystals) and then rises slightly or remains almost unchanged toward the center of the ingots. The greatest dendritic segregation is observed in the OAC ingots, amounting to 60.3% for the central area of the upper level and 48% for the level at one-third the height. The greatest dendritic segregation is 45-51% in ESR ingots. The differences in dendritic segregation for OAC and ESR steels are slight due to the small size of the ingots. In the process of forging and annealing of the forged rolls the dendritic segregation decreases by an average of 15-20% and the microheterogeneity of the central areas by more than a factor of two. The difference in the degree of dendritic segregation along the height of the OAC ingot is responsible for the differences in the properties of rolls prepared from it.

The segregation factors from the basic alloying elements determined by statistical microprobe analysis are smaller in the ESR steel than in the OAC steel, which is due to the more even distribution of alloying elements in the ESR steel. No reduction of the segregation factor in forgings as compared with the ingot is observed. Nonmetallic inclusions, which are stress concentrators, have a considerable effect on the service life of rolls. Contamination with nonmetallic inclusions was determined by means of the MIM-8M light microscope at a magnification of 420× (GOST 1778-70) by the P method with examination of 900 fields from each heat (relative error of the measurements 8-10%), with separation of the inclusions into sulfides, oxides, oxysulfides, and titanium nitrides.

Microprobe analysis with the Cameca MS-46 analyzer showed that the sulfides are manganese sulfides and the basic components of the oxides are aluminum and silicon, regardless of the melting procedure. The melting procedure has a considerable effect on the quantity, shape, and distribution of nonmetallic inclusions. Electroslag remelting ensures more even distribution of sulfides and oxides through the metal and eliminates the clusters and stringers of corundum and silicates that are characteristic of the OAC steel (Fig. 1). The size distribution of the inclusions indicates that ESR reduces the size of oxides and sulfides; the ESR steel has a