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# Investigation of nonmetallic inclusions and the structure of pipe steel microalloyed with boron

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## Abstract

A study of the amount and composition of nonmetallic inclusions showed that when boron is introduced, the volume fraction of oxide and oxysulfide inclusions increases and the volume fraction of sulfide inclusions significantly decreases. At the same time steel alloying by boron increases the proportion of inclusions up to 98.7% with a size of no more than 5 microns, compared with 80.6% in the comparative metal. In the experimental metal, the proportion of nonmetallic inclusions larger than 10 μm does not exceed 0.6%, compared to 13.6% in a metal without boron. Studies of nonmetallic inclusions showed that in an experimental metal containing 0.006% boron, independent boron containing inclusions were not detected. Boron was not found in the composition of the investigated nonmetallic inclusions. In the samples of rolled metal for experimental and comparative melting, nonmetallic inclusions are predominantly oxides, oxysulfide and sulfide inclusions. The phase composition of nonmetallic inclusions in a comparative sample without boron, containing in % mass.: 1.4 Mn and 0.005 S, is represented by oxide and oxysulfide inclusions of complex composition and separate sulphide inclusions. In the experimental sample of pipe steel containing in mass%: 0.006 B, 1.4 Mn and 0.003 S, the most common are small inclusions having in 99% of cases a size of not more than 5 μm and represented by a large number of silicate glasses with iron and manganese oxides 1-2 μm in size and round oxysulfides. The steel microalloying by boron is accompanied by the formation of a dispersed ferritic-bainite structure, which consists of fine-grained ferrite with bainite sites. The increase in the dispersion of the structure of the experimental steel sample is indicated by the decrease in the size of the ferritic grain from 8.7 to 7.2 microns. The microalloying of pipe steel by boron practically did not affect the size of the austenite grain. The microhardness of ferrite and perlite, in the comparative steel sample without boron, does not exceed 180 and 214 HV10, respectively. The presence of boron in the test steel sample in an amount of 0.006% increases the microhardness of ferrite to 260 HV10 and bainite to 314 HV10. This is due to the fact that boron, being a sufficiently active element, segregates first at the interphase boundaries. This contributes to an increase in the concentration and uniformity of the distribution of carbon in the volume of grains and leads to an increase in the dispersity and hardness of the experimental metal structures under study.

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