MICROSTRUCTURE AND THERMAL STABILITY OF 0.08%C-17.0%Cr-0.8%Ti STEEL AFTER HIGH-TEMPERATURE NITRIDING AND HIGH PRESSURE TORSION

МИКРОСТРУКТУРА И ТЕРМИЧЕСКАЯ СТАБИЛЬНОСТЬ СТАЛИ 08Х17Т ПОСЛЕ ВЫСОКОТЕМПЕРАТУРНОГО АЗОТИРОВАНИЯ И КРУЧЕНИЯ ПОД ВЫСОКИМ ДАВЛЕНИЕМ

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Abstract: The influence of high pressure torsion (HPT) on structure, phase composition, microhardness and thermal stability of 0.08%C-17.0%Cr-0.8%Ti steel subjected to volume high-temperature nitriding were investigated. HPT results in the formation of the nanostructure with structural elements size of 55-85 nm. Microhardness of nitrided steel after HPT increases by 2.2-2.7 times. Hardening is retained when heated to 450 °C.

KEY WORDS: HIGH PRESSURE TORSION, HIGH-TEMPERATURE NITRIDING, FERRITIC STEEL, NANOSTRUCTURE

1. Introduction

The possibility of significant refinement of grain structure and improve the complex properties by severe plastic deformation was shown for many materials, including to low-carbon low-alloy steel [1-5], and corrosion-resistant austenitic steels [6-9]. The nature and morphology of the second phase play an important role in the refinement of the structure of multi-phase alloys.

In present study, we analyze the influence of high pressure torsion (HPT) on structure, phase composition, microhardness and thermal stability of 0.08%C-17.0%Cr-0.8%Ti steel subjected to volume high-temperature nitriding. In [10] the high-temperature volume nitriding with subsequent annealing, provides a uniform hardening of thin-walled 0.08%C-17.0%Cr-0.8%Ti steel products, with the structure of the material consists of a nitrogen ferrite and second phase particles such as Cr₂N with different morphology.

2. Experimental procedure

Nitriding of flat samples 0.5 mm thick in the recrystallized state were carried out in pure nitrogen at 1075 °C. The samples were processed under two conditions: nitriding for 4 hours and annealing in vacuum at 700 °C for 1.5 hours (condition 1); nitriding for 1 hours and annealing in vacuum at 900 °C for 5 hours (condition 2). After this treatment, the nitrogen ferrite structure with second phase particles such as Cr₂N (lamellar form in condition 1 and oval form in condition 2) were observed over the entire cross section of samples (Fig. 1).

The results of TEM and electron microprobe analysis of replicas showed that oval Cr₂N particles with size of 50-300 nm were observed in the steel structure after HPT. Microhardness of nitrided steel after HPT (measured at the middle radius of the sample) increases with 320±8 HV to 860±20 HV and with...
350±38 HV to 780±20 HV, for conditions 1 and 2, respectively (Fig. 3). Hardening is retained when heated to 450 °C.

Fig. 3. The distribution of the microhardness of the diameter of the sample after the HPT

X-ray phase analysis of steels prior HPT showed the presence of solid solution of chromium in the α-iron and Cr$_2$N nitrides with a volume fraction of 6.1 and 2.2 % for the conditions 1 and 2, respectively. After HPT the volume fraction of the Cr$_2$N nitrides in the steel of conditions 1 and 2 was 3.3 and 3.7 %, respectively. The heating of the steel after the HPT to 450 °C leads to the formation of predominantly equiaxed grain structure (Fig. 4).

Fig. 4. The microstructure of the steel after HPT and annealing at 450 °C (TEM): a - condition 1; b - condition 2

The volume fraction of Cr$_2$N particles is increased up to 8-10 %.

4. Conclusion

High pressure torsion (HPT) of 0.08%C-17.0%Cr-0.8%Ti steel subjected to volume high-temperature nitriding results in the formation of the nanostructure with structural elements size of 55-85 nm. HPT leads both fragmentation and dissolution of nitrides and their precipitate in the steel structure (depending on the volume fraction and morphology of the nitrides present in the steel structure before HPT). Microhardness of nitrided steel after HPT increases by 2.2-2.7 times (to 9 GPa). Hardening is retained when heated to 450 °C.

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4. Literature