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SYNTHESIS, STRUCTURE, AND PROPERTIES OF HIGH-ENTROPY MATERIALS

Abstracts of the III International Conference and School of Young Scientists

Institute of Metallurgy, Ural Branch
of the Russian Academy of Sciences,
Ekaterinburg, Russia, October 11-15, 2021

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titanium is alloyed with other elements that can weaken the corrosion resistance of the material and impair biocompatibility. In addition to alloying, it is possible to obtain high strength due to severe plastic deformations (SPD), due to which an ultrafine-grained (UFG) structure is formed [1].

This study is a process of high pressure torsion torsion (HPT) followed by annealing of commercially pure titanium Grade 4, which includes a minimum amount of alloying elements, one of which is iron - 0.4 wt%.

The deformation was carried out on an HPT SKRUZH-200 installation. Microhardness was measured using a «Duramin» device according to the Vickers method. A JEOL JEM-2100 transmission electron microscope (TEM) was used to obtain images of the fine microstructure. X-ray phase analysis (XRD) was performed using a Rigaku Ultima IV X-ray diffractometer on CuKα radiation (λ = 0.1540562 nm).

After HPT, an UFG structure was obtained with an average grain size of about 120 nm. To select the annealing temperature after HPT, the Grade4 alloy in the hot rolled and deformed state was subjected to various heat treatments. Thus, an annealing temperature of 700 ° C was chosen with a holding time of 30 minutes.

After annealing of the hot-rolled and deformed state, in addition to the α-phase, nanodispersed precipitates of various morphologies were present in the structure within the grains and along the boundaries. In the annealed hot rolled state, globular and acicular precipitates are 30-80 nm in size, and in the deformed annealed state, globular and ellipsoidal precipitates are 70-350 nm in size.

Research of titanium Grade 4, using TEM and XRD, revealed the formation of precipitates of second phases at temperatures above 650 °C, indicated as a Ti + Fe compound. After annealing titanium Grade 4 after HPT treatment, despite the growth of grains, the hardness does not drop to low values, but remains abnormally high for the annealed state, due to the precipitation of particles of the second phase.

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References:

[1] R.Z. Valiev, A.P. Zhilyaev, T.G. Langdon. Bulk nanostructured materials: Fundamentals and applications. NJ. USA, TMS-Wiley, Hoboken (2014) 440 p.

EVOLUTION OF THE PERLITE STEEL STRUCTURE AT MULTIPLE LONG-TERM DEFORMATION IMPACT

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Railway rails are taken as an object, on the surface of which deformation has been posed repeatedly and for a long time. At present, at EVRAZ ZSMK JSC, rails are made of E76HF steel and, after accelerated cooling in a special unit, have pearlite structure.

Chemical composition is determined by TU 0921-276-01124323-2012.

The rails have been in operation at the Shcherbinka Experimental Range, and were seized after 1,769,037 thousand gross tons passing.

Macrostructure of the metal has been revealed by deep etching in a 50% aqueous solution of hydrochloric acid. The study of microstructure of metal of rails has been carried out by means of optical and scanning electron microscopy. Defective substructure of the rail metal has been studied by transmission electron diffraction microscopy.

Study of the macrostructure has shown the absence of any internal defects, as well as discontinuities.

Investigations of microstructure of the rails metal, carried out on etched sections, has revealed grains of lamellar pearlite and, in a small amount, areas of ferrite; no bainite has been found in microstructure. It has been revealed that, with distance from the rolling surface, pearlite dispersion decreases, which is consistent with cooling conditions during thermal hardening.

More detailed study of microstructure of the rail head metal has been carried out on etched sections by scanning electron microscopy and transmission electron microscopy (thin foil method).

Scanning microscopy has shown that the main share of pearlite is regular colonies with regular alternation of cementite and ferrite plates.

Transmission electron microscopy has shown that as a result of repeated exposure to deformation, a significant transformation in steel structure occurs, namely, in state of lamellar pearlite grains. Impact of deformation, accompanied by destruction of cementite plates by cutting them with moving dislocations and by dissolving with the escape of carbon from the cementite lattice at dislocation lines, at low-angle and high-angle boundaries. At nanoscale level, formation of a subgrain structure containing nano-size cementite particles located at joints and along the boundaries of subgrains has been revealed. Subgrain sizes vary from 110 nm to 200 nm; the size of cementite particles is from 25 nm to 60 nm.

It has been found that transformation during rails operation under the deformation effect of pearlite structure of lamellar morphology relative to the central axis proceeds at a significantly slower rate compared to change in structure relative to the radius of fillet rounding. It has been shown that the subgrain structure is formed exclusively in surfacelayer of the rail metal. The relative content of subgrain structure in the surface layer of working fillet is 5 times higher than in the surface layer of rolling surface.

GLASS-FORMING ABILITY AND MAGNETIC SUSCEPTIBILITY OF CO-FE-SI-B-NB AMORPHOUS ALLOYS

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Co- and Fe-based bulk metallic glasses (BMG) and amorphous ribbons are being actively studied due to their unique magnetic and electrical properties. Nowadays these alloys are used as highly sensitive sensors. Unfortunately, these alloys have a low glass-forming ability (GFA). In this work we investigated crystallization processes, GFA and magnetic susceptibility of Co-Fe-Si-B-Nb-R (R = Nd, Sm, Tb, Yb) alloys in amorphous and liquid states.

Base composition $Co_{48}Fe_{25}Si_4B_{19}Nb_4$ and alloys with small additions of rare-earth metals – Nd, Sm, Yb, Yb (1 at. % and 2 at. %) were prepared by remelting of pure initial components in induction furnace at 1900 K during half of hour in argon atmosphere. Amorphous ribbons (3-5 mm width and 37-40 μm thickness) were produced by planar flow casting method. BMG cylinders (2 mm in diameter and 25 mm height) were prepared by suction casting method. Amorphous structure of the alloys was checked by X-rays (Bruker D8 Advance Cu-Kα). Magnetic susceptibility of the alloys in solid and liquid states was measured by Faraday's method on an automated experimental set-up in helium atmosphere.

It was found that crystallization of these alloys goes in two stages and depends on rare-earth addition and its content in the alloy. GFA criteria were calculated. It was shown that the