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Microstructure and Mechanical Properties of V-Me(Cr, W)-Zr-C Alloys as a Function of their Thermochemical Treatment Modes

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Nanostructured vanadium alloys of V-Me (Cr, W)-Zr-C system have good prospects as structural materials for a new generation of fusion and fission (fast) nuclear power reactors. The required properties of the alloys are achieved by methods of combined heat treatment, including conventional (traditional) thermomechanical treatment (TMT), as for the referenced V-4Ti-4Cr alloys (annealing at 1000 ℃ for 1 h), and additional thermochemical treatment (TCT –oxygen saturation and internal oxidation).
Alloys V-8.75Cr-0.14W-1.17Zr-0.01C-0.02O-0.01N (wt.%, ingot weight is 0.9 kg, sheet thickness is 1 mm) and V-4.23Cr-7.56W-1.69Zr-0.02C-0.02O-0.01N (wt.%, ingot weight is 1.2 kg, sheet thickness is 1 mm) have been smelted. Methods have been developed and combined treatment (TMT + TCT) of alloys obtained has been performed (internal oxidation with a given level of bulk oxygen concentration determined, in turn, by the zirconium concentration), which provides the formation of nanoscale particles ZrO2 of controlled dispersity in alloys, preservation of nanoscale heterophase structure up to the temperature 1300 –1400 ℃, increase of recrystallization temperature up to 1400 –1600 ℃.
Formation of such microstructure results in significant precipitate and substructure hardening and substantially (as compared to traditional TMT modes) improvement of the mechanical properties of the vanadium alloys throughout the whole range of temperatures up to 800 ℃. At the maximal hardening effects of the internally oxidized alloy specimens the value of elongation at room temperature remains high enough (about 12%). Obtained mechanical properties of the vanadium alloys by using the combined treatment are significantly higher than those achieved so far for the referenced alloy V-4Ti-4Cr.
High thermal stability of the specified nanoparticles and defect substructure indicates the prospects of using the proposed methods of combined treatment (TMT + TCT) to significantly improve the performance of not only short-term but also long-term high-temperature strength of new vanadium alloys. An important advantage of the combined method of the alloys treatment is the possibility of its implementation for semimanufacture articles or end-products (sheets, pipes, etc.) obtained from initially high technological (low strength and high ductility) vanadium alloys.

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Author: Prof. CHERNOV, Viacheslav (A.A.Bochvar High-technology Research Institute of Inorganic Materials, Moscow, Russia)

Co-authors: Prof. KOROTAEV, Alexander (Institute of Strength Physics and Materials Science SB RAS; V.D. Kuznetsov Siberian Physical-Technical Institute; Tomsk State University, Tomsk, Russia); Prof. TYUMENTSEV, Alexander (Institute of Strength Physics and Material Science SB RAS; V.D.Kuznetsov Sibirian Physical-Technical Institute; Tomsk State University, Tomsk, Russia); Dr DITENBERG, Ivan (Institute of Strength Physics and Material Science SB RAS; V.D. Kuznetsov Sibirian Physical-Technical Institute, Tomsk, Russia); Dr SMIRNOV, Ivan (V.D. Kuznetsov Siberian Physical-Technical Institute; Tomsk State University, Tomsk, Russia); Ms KRAVTSOVA, Marina (A.A.Bochvar High-technology Research Institute of Inorganic Materials, Moscow, Russia); Dr POTAPENKO, Mikhail (A.A.Bochvar High-technology Research Institute of Inorganic Materials, Moscow, Russia); Dr OVCHINNIKOV, Sergey (Institute of Strength Physics and Material Science SB RAS; V.D. Kuznetsov Sibirian Physical-Technical Institute, Tomsk, Russia); Dr DROBYSHEV, Valery (A.A.Bochvar High-technology Research Institute of Inorganic Materials, Moscow, Russia); Dr PINZHIN, Yury (Institute of Strength Physics and Materials Science SB RAS; V.D. Kuznetsov Siberian Physical-Technical Institute; Tomsk State University, Tomsk, Russia)

Presenter: Prof. CHERNOV, Viacheslav (A.A.Bochvar High-technology Research Institute of Inorganic Materials, Moscow, Russia)

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