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CREEP RATE OF THE COMPOUND $MnNi_3$ AS A FUNCTION OF THE EQUILIBRIUM STATE

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Metallic compounds play an important role in the strengthening of metals. Owing to the high strength of their chemical bonds, such compounds have greater resistance to creep than the components composing them or solid solutions. Therefore they can serve as the basis of new heat-resistant alloys, as has been shown in a number of works ([1-3]). Kurnakov compounds formed from solid solutions as a result of ordering of the structure ([4]) also have higher values of heat resistance than their constituent components ([1,2]).

We have shown ([5]) that the formation from solid solutions of Kurnakov compounds—$FeNi_3$, $MnNi_3$, $CrNi_3$, and VNi_3—is accompanied by a considerable thermal effect. This indicates that the ordering processes of solid solutions proceed with the formation of strong and stable compounds, which must have independent regions of existence in the phase diagram of the system and be regarded as first-order phase transformations.

The high strength of the chemical bond in the compounds $FeNi_3$, $MnNi_3$, and VNi_3, determined by the heats of formation, makes it possible to suppose that, within the interval of stable states, these compounds have greater strength than the solid solutions from which they are formed. It is therefore of interest to study the heat resistance of Kurnakov-type compounds in the equilibrium state and under the conditions of quenched solid solutions from which they are formed. There have been no systematic investigations in this direction, with the exception of work ([6]), in which the authors, by the microhardness method, studied the softening processes of alloys of the Cu—Au system in the state of ordered phases (Cu_3Au and CuAu) and in disordered solid solutions of the same compositions.

To investigate this important question, we selected the compound $MnNi_3$, which is formed from the γ-solid solution of the nickel—manganese system by an exothermic reaction, according to ([5]), with the release of 2.40 kcal/g-at. The equilibrium temperature of its formation is 540°. Alloys of composition $MnNi_3$ were prepared from electrolytic nickel and manganese by crucibleless melting in the suspended state in a helium atmosphere, followed by casting into cylindrical molds measuring 6 × 60 mm. The composition of the alloys prepared in this

Fig. 1

Figure 1: Fig. 1

way, according to chemical analysis, corresponded exactly to the stoichiometric composition $MnNi_3$.

The heat treatment of the alloys consisted of high-temperature homogenizing annealing at 950° for 24 hours and quenching in water from this temperature. Since the process of formation of the compound $MnNi_3$ from the solid solution proceeds very slowly, it was quite possible to retain the solid solution by quenching. The microstructure of the specimens after homogenization and quenching was a polycrystalline single-phase structure of the solid solution. A certain number of specimens were then subjected to prolonged tempering at 450° for 1400 hours; this time, as investigations ([5]) showed, ensured complete transformation of the solid solution into the compound $MnNi_3$.

The creep study was carried out by the centrifugal bending method [7] on quenched specimens corresponding to the state of a solid solution, and on specimens annealed for a long time, corresponding to the compound $MnNi_3$. The test was carried out at a temperature of 450° and a stress σ equal to 25 kg/mm^2, on three parallel specimens of each state.

Figure 1 presents the creep curves of an alloy of composition $MnNi_3$ in the compound state (long-annealed alloys) and in the solid-solution state (quenched alloys).

Fig. 1. Creep rate of the compound $MnNi_3$ (2) and of the solid solution (1) of the same composition at 450° and $\sigma = 25$ kg/mm^2

As can be seen from Fig. 1, the alloy in the stable state of the $MnNi_3$ compound is distinguished by a considerably lower creep rate than the solid solution of the same chemical composition from which the compound is formed. At the high creep rate of the solid solution under the indicated deformation conditions, the specimens failed after 150 hours of testing. The same alloy composition in the stable state of the $MnNi_3$ compound does not fail during 600 hours of testing.

Thus, a large difference has been established in the creep rate of the $MnNi_3$ compound and of the solid solution from which it is formed. The results of this study are of interest for the physicochemical theory of heat resistance [2]. From this point of view, the phenomena we observed may be given the following explanation. Metallic compounds with an ordered structure have a greater strength of chemical bonding than the solid solutions from which they are formed, and lower mobility of atoms in the crystal lattice. Under the test conditions, the alloy in the solid-solution state is unstable and is in the process of transformation into the $MnNi_3$ compound. This reaction process of compound formation is associated with the movement of atoms during the transition from a disordered to an ordered arrangement in the alloy lattice.

Such a process, occurring in the solid solution, is combined with the diffusion mechanism of creep and the movement of atoms in the lattice. This additionally leads to an increase in the creep rate of alloys under stress. Attention was drawn to this in work [6].

Subsequent studies may show that other Kurnakov-type compounds, formed in many systems with continuous and limited solid solutions, also differ by having a higher resistance to creep than the solid solutions from which they are formed.

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