MODELING OF SPECIAL CONDITIONS OF DIFFICULTALLY DEFORMABLE HETERO-PHASE METAL SYSTEMS

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When developing engineering software for predictive modeling of the state of a product in the process of its creation by the method of selective laser sintering, one of the questions is the development of a methodology for modeling hard-to-deform heterophase metal systems. The methodology of complex investigation of processes of increased deformation capacity (superplasticity) by methods of mathematical modeling, phase and structural analysis of hard-deformed heterophase metal systems (on the example of their typical representative - multicomponent high alloy steel of the iron-tungsten-molybdenum-chromium-vanadium-carbon system of the traditional redistribution of steel - grade P6M5).

With the use of optimal experiment planning and mathematical modeling, adequate mathematical models of the processes of plastic forming of steel for various stress state schemes have been constructed. On the basis of developed multifactor mathematical models of isothermal deformation of P6M5 steel, temperature-velocity intervals of increased plasticity and superplasticity (SP), kinetics and staging of their manifestation are determined.

Systematic data on the temperature-velocity parameters of SP in the interval of temperatures of phase transitions 750...850°C and strain rates 0.0001 ... 0.042s^{-1} are obtained. Temperature-velocity maps of lines of equal values of the investigated criteria (σ, δ, m, Q), increased plasticity and superplasticity of P6M5 steel are constructed. The superplasticity temperature range for steel draft was 800...820°C, and the strain rate is from 0.002 to 0.005s^{-1}. When stretching, the temperature intervals of increased ductility (δ> 90%) and superplasticity (δ> 120%) are detected: 760...770°C and 825...835°C. Superplasticity develops intensively at a temperature of 830°C and a deformation resistance of 80 MPa.

It is established that superplastic deformation increases the dispersion of the carbide phase and the chemical homogeneity of the P6M5 steel. In the case of draft and tension in the region of increased plasticity, the dispersion of the steel structure also increases in comparison with the initial state. Formation of blanks from steel R6M5 with increased performance characteristics during draft is ensured by SP due to increased dispersion and structural homogeneity. Degree of deformation of steel P6M5 with increased ductility exceeds 90%, and at SP 120%.

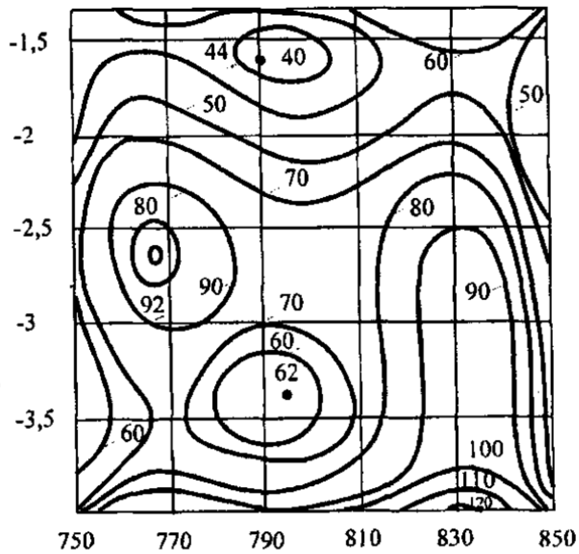

Figure 1. Lines of equal values of the relative elongation δ when tensile steel P6M5

A method has been developed for producing blanks of a metal cutting tool made of P6M5 steel under conditions of increased ductility and superplasticity, which allows to increase of coefficient of metal utilization to 0.8...0.9, reduce energy consumption and increase durability tool in 1,8...2,2 times. This allows it to be attributed to low-waste, resource-saving technologies of rational nature management. It is established that a protective coating based on liquid glass in SP conditions allows increasing the service life of the steel deformation capacity by 15...20%.

Areas of increased ductility (δ>90%) at 770°C and superplasticity (δ>120%) at a temperature of 830°C are found in which it is advisable to conduct resource-saving treatment of P6M5 steel at high degrees of deformation (Fig.1).

Analytical models of the effective activation energy of the process of plastic deformation under tension in a temperature-velocity field are obtained. It is established that a correlation exists between the deformation resistance σ, the relative elongation δ and the effective activation energy of the plastic deformation Q: a decrease in σ corresponds to an increase in δ and a decrease in Q in the temperature-velocity field under study.

Modeling of special states of metal systems (states of pre-transformations, increased deformation capacity, superplasticity) can be used to develop low-waste and resource-saving technologies for processing materials under various conditions and conditions [1-5].

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