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Optimization of Technological Parameters of Hydropressing

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Abstract: This article discusses the optimization of technological parameters of hydropressing and the paths taken to further improve it. Since the search for optimal modes of hydropressing refractory metals and alloys (in particular molybdenum) will be incomplete without obtaining rods with a high level of physical and mechanical properties. Thus, the optimization carried out determined the area of technological regimes that guarantee increased requirements for molybdenum semi-finished products from subsequent limits.

Keywords: rod, hydropressing, parameter, workpiece, deformation, process, equipment, and interval.

The study of any technological process, including hydropressing , is carried out for its further improvement. In this case, two ways are possible. The first way is associated with experimental research, which makes it possible to select some rational parameters of the technological process and equipment. The selected parameters ensure that only one goal is achieved, which is the basis of the search strategy. In particular, during hydropressing it is possible to design an optimal technological process to obtain one of the specified properties: uniform distribution of local deformations and flow rates of metal particles over the cross-section of the workpiece, or maximum use of the plastic properties of the metal during deformation, or limiting heat generation and achieving a uniform distribution of deformation heating temperature over the cross-section in the focus of shape change and obtaining a uniform structural state, etc.

However, when constructing optimal processes, not one, but several, and competing, properties of the technological process are taken into account (quantity of production - metal consumption , specific forces - tool life). Consequently, the second way to improve the technological process is to simultaneously search for several optimal parameters, which is possible using a computer and the mathematical theory of optimization.

And so the search for optimal modes of hydropressing refractory metals and alloys (in particular molybdenum) will be incomplete without obtaining rods with a high level of physical and mechanical properties. Therefore, it is necessary to construct mathematical dependencies that reflect the relationship between the technological parameters of hydraulic pressing and mechanical characteristics of finished products made of refractory metals. In this regard, we studied molybdenum rods of the MChVP brand, subjected to high- temperature hydropressing in the range of billet heating temperatures θ_h from 850 to 1250 ^{0}C with a draw varying from 2.4 to 9. After hydropressing , the rods were annealed in a vacuum furnace in the range $\theta_{annealed}$ = 800... 1600 ^{0}C and tested for tension in the range of strain rates from 1 to 25 mm/min. The specified technological and experimental parameters served as planning factors. The mechanical characteristics of molybdenum rods after stretching were selected as response functions, and then, using regression analysis, the results were generalized to the sequence of these processes. When processing experimental data using the least squares method, analytical dependencies were obtained that established the relationship between the mechanical characteristics of hydropressed and annealed molybdenum and the technological parameters of the process in the form of expressions:

$\sigma = 569 - 129.89x_1 + 52.16x_2 - 107.5x_3 + 15.29x_4$;

$\sigma_{0.2 = 539.6} - 61.48x_1 + 38.7x_2 - 134.15x_3 + 2.0x_4$;

$K = 1.192 + 0.011x_1 + 0.035x_2 + 0.086x_3 - 0.014x_4$;

$HV = 2187.5 - 83.15x_1 + 116.0x_2 - 254.3x_3$;

$\delta = 25.48 + 1.05x_1 - 0.76x_2 + 2.12x_3 - 6.50x_4$;

$\psi_k = 28.7 - 1.59x_1 + 4.54x_2 - 1.49x_3 + 12.28x_4$;

where the following values are taken as the given coordinates:

$x_1 = (\theta_n - 1050)/200$; $x_2 = (\lambda - 5.7)/3.3$;

$x_3 = (\theta_{annealed} - 1200)/400$ $x_4 = (\log_5 \nu_d) - 1$;

ν_d – deformation rate, mm/min.

regression coefficients was assessed using the Student's t test.

The established analytical relationships between the mechanical characteristics of molybdenum and the technological parameters of high-temperature hydraulic pressing can be used to assess the influence of factors on the response functions, as well as to evaluate the degree of such influence. A comparative assessment of the degree of influence of factors on the response functions can be made by the percentage contribution of factors to the response function. The strength characteristics (σ; $\sigma_{0.2}$; HV) are significantly influenced by temperature factors (θ_n and $\theta_{annealed}$), the effect of drawing is less pronounced, and the drawing influences the hardness more strongly than on σ and $\sigma_{0.2}$. The effect of strain rate on strength characteristics is quite insignificant. Plastic characteristics (δ and ψ_k) are more influenced by the rate of deformation, and the influence of temperature factors is less pronounced than for strength characteristics.

This study involved the selection of the optimal range of parameters for high-temperature hydropressing , heat treatment and tensile testing to obtain semi-finished molybdenum products with the desired characteristics. Technological parameters have different effects on the strength and plastic characteristics of semi-finished products, that is, they are competing properties.

As a result of a comparative analysis of the features of the processes of primary pressure treatment of ingots from refractory metals, it was established that the process of high-temperature hydropressing is one of the effective methods of deformation of refractory metals, which ensures the production of rods with a diameter of . 20...40 mm of high quality with mechanical properties increased by 15...20% compared to conventional pressing.

Thus, the optimization carried out determined the area of technological regimes that guarantee increased requirements for molybdenum semi-finished products from subsequent limits.

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