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FOREIGN TECHNOLOGY DIVISION

DEFORMATION OF 5VMTs-TYPE ALLOYS

by

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М м	*М м*	M, m	Ь ь	*Ь ь*	'
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О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

DEFORMATION OF 5VMTs-TYPE ALLOYS

Ya. M. Okhrimenko, V. P. Troitskiy, I. A. Koterev
and V. I. Pyl'nikov

The technology of pressure treatment of niobium and its alloys is substantially effected by the introduction of impurities: carbon, nitrogen, hydrogen, and especially oxygen. According to data [1], the oxygen content in niobium for cold treatment must not be above 0.04-0.05%. Cold deformation of alloys becomes difficult with the oxygen content above 0.02%. Structural alloys of niobium, alloyed with molybdenum and tungsten within the limits up to 5%, deform at a temperature above 1100°C. Alloys of the same composition, but with an oxygen content of 0.05-0.08%, are destroyed in process of forging at a temperature of 1450-1500°C.

At the present the deformation process of similar alloys consists of the following operations: forging or pressing, roughing, hot rolling in a protective cover, roughing, annealing and warm rolling [2].

The goal of ~~this work is the~~ study of the effect of the addition of carbon on the technology of pressure treatment of the 5VMTs alloy, the carbon being a strengthener because of the separation of the second phase, in determining the optimum degrees of forging, the mechanical features and research on the conditions of thermal treatment of the obtained sheet material.

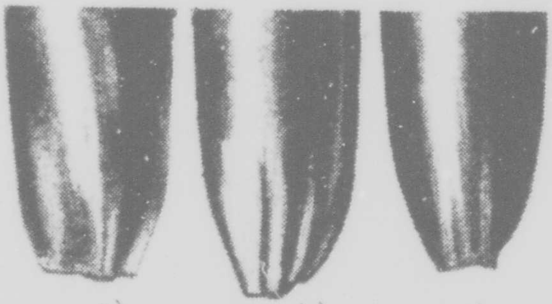
The scheme for the technological process of deformation is selected in accordance with recommendations [3], but the protective cover during hot rolling has been substituted by protective plastering, somewhat simplifying the process of treatment.

Ingots of the 5VMTs alloy 80 mm in diameter of a double ray remelt with impurity content: oxygen 0.008-0.012%, nitrogen 0.01-0.011%, the quantity of carbon in the alloy was variable and equalled 0.01; 0.04, and 0.1%.

Before primary deformation the ingots were sealed in a vacuum in a steel covering with a wall thickness of 5 mm. Heating was accomplished in a gas oven for 50 min to a temperature of 1350°C. Forging was carried out on a 2-ton hammer according to the following technological scheme [3]: drawing in notched hammer blocks (notch angle 90°) in a circle with a deformation stage of 20%, preheating to the initial temperature and subsequent forging with forging ratios of 1.8; 3.3; 4.2. End of forging was at 1100°C. During forging in the notched hammer blocks there was a buckling of end parts of ingots that, in the opinion of M. Ya. Dzugutov [4], attests to the appearance in their axial zone of contractile stresses. This led to scaling of bottoms of the protective cover and oxidation of end parts of forging, in which small cracks were detected.

Cracking, evidently, is explained by the following: a) a decrease in the plastic properties of the end parts of the forging as a result of intensive gas saturation upon decompression of the casing; b) a disadvantageous combination of stresses and deformations, because from the viewpoint of cracking such operations, during which positive deformations and stresses appear which coincide in sign in the places of low-plastic arrangement or very durable composing structures, are dangerous [5].

From the obtained billets samples were made and tested for tension at a temperature of 20°C. On the samples cut from forgings with reduction ratios of 1.8 and 3.3 (Fig. 1a, b), longitudinal grooves are noticeable on the neck that possibly, attest to the



a) b) c)

Fig. 1. Character of failure in the neck of specimens with the degrees of forging reduction ratio: a) - 1.8; b) - 3.3; c) - 4.2.

heterogeneity as a result of inadequate forging reduction ratio. The necks of the samples having a forging reduction ratio of 1.8 (Fig. 1a), do not have a correct conic form, but in cross section resemble an ellipsis. An inadequate level of deformation at forging reduction ratio 3.3 is indicated by the character of the microstructure (Fig. 2b). Specimens with a reduction ratio of 4.2 lack a longitudinal groove and the necks have the correct geometrical form (Fig. 1c).

Fig. 2. Microstructure of 5VMTs-alloy + 0.4%C with degrees of forging reduction ratio: a) 1.8; b) 3.3; c) 4.2 × 100.

Thus on the basis of experimental data it may be concluded that upon forging according to the accepted technological system a uniform structure of the forging can be achieved at a forging reduction ratio of approximately 4. Furthermore, it has been established that the addition of carbon in the given quantities does not have a negative effect on the conditions of forging.

This made it possible to determine the mode of forging of ingots to a sheet bar for subsequent rolling. It is identical for all compositions of the 5VMTs-alloy and it consists of the following: preliminary drawing in notched hammer blocks with a level of deformation of about 20% and subsequent forging on plane hammer blocks into sheet bars with a cross section size of 20 × 75 mm. Forging was accomplished entirely satisfactorily and the character of the defects corresponded to the afore-mentioned.

The sheet bars after roughing and application of the protective coating were hot rolled into rolled stock with thickness 5-6 mm, and after dressing and grinding were rolled in a four-high rolling mill into a sheet 1 mm thick. Specimens for determining the mechanical properties are manufactured from the sheets. Before the tests the specimens are annealed in a TVV-4 stove in a vacuum of $2-5 \cdot 10^{-5}$ mm Hg. The dependence of the mechanical properties of the alloys on the annealing temperature $t_{отж}$ withholding for 1 h and the content of carbon is shown in the table. The introduction of up to 0.1%C into alloys of 5VMTs-alloy does not impair the plastic properties of the alloy; the recrystallization temperature in this case rises approximately 100°C.

Dependence of the mechanical properties of niobium alloys on the annealing temperature.

$t_{отж}$, °C	Mechanical properties								
	5VMTs + 0.01%C			5VMTs + 0.04%C			5VMTs + 0.1%C		
	$\sigma_{0.2}$, $\frac{kgf}{мм^2}$	σ_B, $\frac{kgf}{мм^2}$	δ, %	$\sigma_{0.2}$, $\frac{kgf}{мм^2}$	σ_B, $\frac{kgf}{мм^2}$	δ, %	$\sigma_{0.2}$, $\frac{kgf}{мм^2}$	σ_B, $\frac{kgf}{мм^2}$	δ, %
Original state	80,5	82,5	10,0	92,5	93,5	10,0	84,6	87,0	10,0
1000	58,5	65,7	19,5	60,7	65,9	12,5	62,4	67,5	19,0
1200	34,0	44,7	30,0	41,6	52,1	29,0	55,2	63,5	19,5
1300	32,2	47,5	32,0	35,5	46,8	31,5	41,7	53,7	26,5
1400	32,8	44,3	37,0	31,3	46,0	29,5	30,2	43,2	33,0
1500	32,9	44,8	31,5	32,6	48,5	38,5	31,0	46,0	37,0
1600	33,9	45,8	36,5	31,8	46,9	30,5	29,2	43,6	31,0
1800	35,3	50,0	30,5	30,7	49,0	31,0	31,5	46,2	32,0

In the range of annealing temperatures 1000-1400°C the relaxation of stress and recrystallization of the alloy takes place. A further increase in $t_{отж}$ up to 1800°C, although it leads to intensive growth in the gram size and a change in the form of separating carbides in an alloy with 0.1%C, has little influence on the strength and plastic characteristics of the alloy.

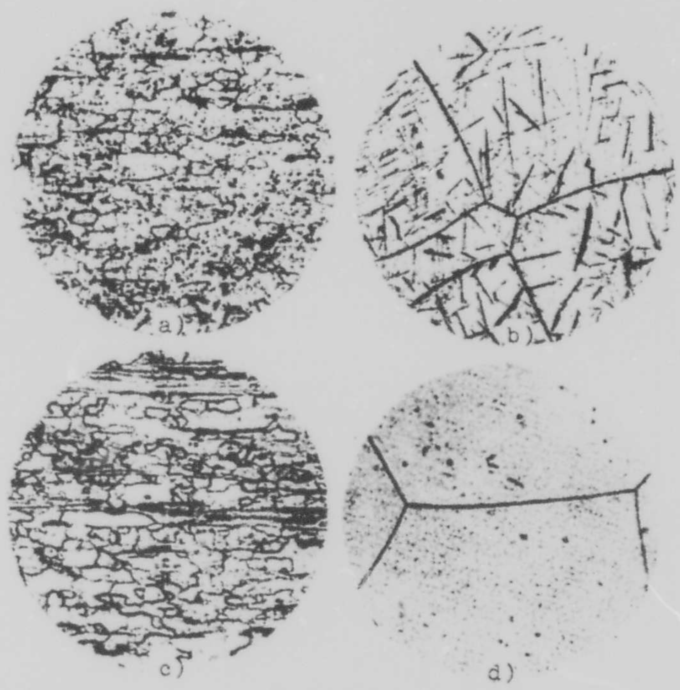


Fig. 3. Microstructure of the 5VMTs-alloy with different additives of carbon after thermal treatment: a) 5VMTs-alloy + 0.1%C, $t_{отж}$ = 1350°C; b) 5VMTs-alloy +0.1%C, $t_{отж}$ = 1800°C; c) 5VMTs-alloy + 0.01%C, $t_{отж}$ = 1350°C; d) 5VMTs-alloy + 0.01%C, $t_{отж}$ = 1800°C. (×200)

In an alloy containing 0.1%C, with an increase in the temperature of annealing the carbide deposits take a needle-shaped form (Fig. 3b), moreover the carbides are distributed in the body of the grain comparatively evenly. With a content of carbon of 0.04% the formation of carbide needles does not take place, but the carbides (Fig. 3d) are distributed in the form of isolated points. The investigations conducted make it possible to conclude that a relatively uniform structure of an alloy can be achieved with a forging reduction ratio, equal to ∿4, and additions to the 5VMTs-alloy of carbon in the quantity to 0.1% does not have a substantial effect on the plastic characteristics of the obtained material and its technological effectiveness, somewhat increasing the recrystallization temperature.

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13. ABSTRACT

The effect was investigated of C addns. on the pressure treatment of 5VMTs alloy, the C being the strengthening agent due to the pptn. of the secondary phase. It was also undertaken to det. the optimum steps of forging, the mech. properties, and also to study the thermal treatment conditions of the obtained sheet material. The samples which were subjected to deformation contained 0.008-0.012, N 0.01-0.011, and with C 0.01, 0.04, and 0.1 percent resp. Prior to the deformation the samples were heated for 50 min. up to 1350 degrees. Thereupon, they were deformed by forging, the deformation being 20 percent and the end of forging attained at 1100 degrees. Thus, the formation of cracks is explained. The subsequent rolling of the samples was also studied. Within the temp. range 1000-1400 degrees there is a redn. of the stresses and recrystn. of the alloy occurs. Further increase in the annealing temp. to 1800 degrees, although it results in increased grain size and a change in the shape of the carbides pptd. in the alloy, has only a slight effect on the strength and plastic characteristics of the alloy studied esp. if addns. to the alloy do not exceed 0.1 percent. [AP9049280]

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