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EFFECT OF THE HARDENING TREATMENT ON THE DAMPING PROPERTIES OF --ETC(U)
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EFFECT OF THE HARDENING TREATMENT ON THE DAMPING PROPERTIES OF THE TITANIUM ALLOYS

By

L. A. Bocharova, V.V. Matveyev, et al

FOREIGN TECHNOLOGY DIVISION

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EFFECT OF THE HARDENING TREATMENT ON THE DAMPING PROPERTIES OF THE TITANIUM ALLOYS

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
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.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

EFFECT OF THE HARDENING TREATMENT ON THE DAMPING PROPERTIES OF THE TITANIUM ALLOYS

L.A. BOCHAROVA, V.V MATVEYEV, O.A. NIKISHOV, Ye.Ye. SAVARI, O.P. SOLONINA, and B.S. CHAYKOVSKIY

The ability of titanium alloys to combine considerable strength with a low specific weight and high corrosive stability is the reason for their wide use in industry. Thus, it is of considerable interest to improve their mechanical properties by means of hardening heat treatment without additional alloying.

We are presenting the results of a study carried out on the effect of the various forms of hardening on the damping properties of three titanium alloys which are used extensively for manufacturing compressor blades.

The effect of the hardening heat treatment (quenching in water + aging) on the energy dissipation characteristics with transverse oscillations was tested on two heat hardened, two-phase alloys, VTZ-1 and VT-9. For this purpose the billets for the samples were processed as follows:

1) VTZ-1 alloy (hardened at 870°C for 1 h - cooled in water + aged at 550°C for 5 h - cooled in the air);

2) VT-9 alloy (hardened at 950°C for 1 h - cooled in water + aged at 560°C for 5 h - cooled in the air).

The effect of surface hardening was studied on a two-phase alloy, VTZ-1, and on the VT-18 alloy based on α-Ti.

The billets for the samples were processed using the established procedures of annealing (VTZ-1 alloy - 870°C - 1 h - furnace cooling down to 650°C - holding 2 h - air cooling; VT-18 alloy - 900°C - 1 h - air cooling) and had the structure of the equiaxial type. Subsequently, flat samples were prepared from the billets which, for the VTZ-1 alloy, were subjected to three types of surface hardening: oxidation, oxidation with subsequent light polishing, and vibrational tumbling. The samples prepared from the VT-18 alloy were hardened by oxidation and oxidation with subsequent light polishing. All samples were oxidized under the following conditions: heating to 530°C for two hours with subsequent air cooling.

The vibrational tumbling of the samples prepared from the VTZ-1 alloy was done according to the tumbling process used for blades. The working section of all the samples was prepared in accordance with the procedure used for the foil of a compressor blade.

The samples were studied on the D-7 installation which enabled us to obtain the initial dependences of the logarithmic decrement in the stress amplitude function during lateral vibrations of the samples under the conditions of pure bending. Fig. 1 shows an example of such a dependence for a heat hardened VT-9 alloy over the entire temperature range. Similar dependences were obtained for all the samples that were studied. In the figures given in this article, the indicators designating the alloys are assigned in accordance with the marking of the samples: the numerals 3, 9, and 8 designate the VTZ-1, VT-9, and VT-18 alloys, respectively; P - characterizes the equiaxial structure of the material in the annealed state; Y - hardening heat treatment; OK,-OД, and OB - corresponding surface hardening (oxidation, oxidation with polishing, and vibrational tumbling).

The graphs shown in Fig. 1 indicate that the logarithmic decrement of vibrations somewhat increases with an increase in stress, which occurs for all the samples that were studied. With regard to the temperature dependences shown in Figures 2–4 and which were constructed under a constant stress of bending $\sigma=20$ kg/mm^2, a noticeable increase in the damping properties was observed in the samples during the surface hardening for the alloys VTZ-1, VT-9, and VT-18 beginning at 300–350°C.

A graph shown in Fig. 5 was constructed for a clearer representation of the effect of thermal hardening on the damping properties of the VTZ-1 and VT-9 alloys, from which it is evident that the hardening heat treatment leads to a certain decrease in the logarithmic decrement in both alloys, a more significant decrease is observed at the maximum working temperatures. Thus, for example, in the VTZ-1 alloy the logarithmic decrement at 450°C drops from 0.136% to 0.126%; in the VT-9 alloy this change is less significant.

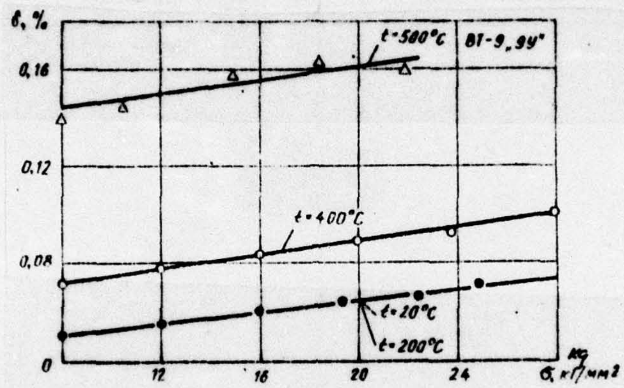

Fig. 1. Dependence δ=f(σ) for the heat-hardened titanium alloy VT-9 at various test temperatures.

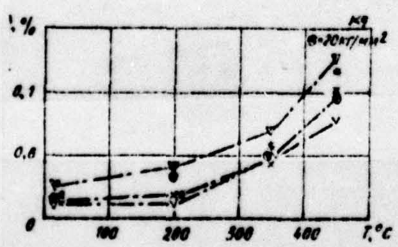

Fig. 2. Dependence δ=f(T) for the Ti alloy VTZ-1 with the various forms of surface and heat hardening:

θ – 3P; X – 30K; Ж30D; ▲ – 30B; Δ – 3Y.

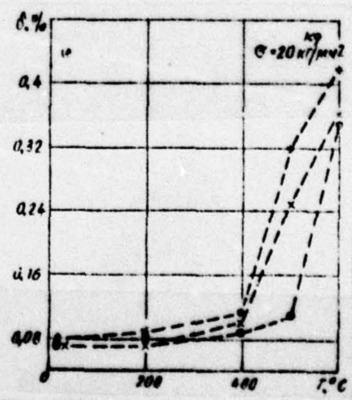

Fig. 3. Dependence δ=f(T) for Ti alloy VT-18 with the various forms of surface hardening:

θ – 8P; X – OK; Ж – 8OD.

The decrease in the decrement can be connected with the fact that the heat treatment used (quenching from the $\alpha + \beta$ = region and subsequent aging) leads to hardening due to the decomposition of the metastable phases [2].

The effect of surface hardening was estimated on the samples prepared from the VTZ-1 and VT-18 alloys. It follows from the curves on Fig. 6 that, of all the forms of surface hardening, oxidation with subsequent light polishing has the greatest effect on the damping properties of the VT-18 alloy, while for the samples prepared from the VTZ-1 it is vibrational tumbling. In the case of the VTZ-1 alloy, the intensive increase in the logarithmic decrement for the samples subjected to oxidation with subsequent polishing, as compared to the samples that were simply oxidized, is the same as in the samples hardened by vibrational tumbling as compared with the samples that were hardened and then polished. For the VTZ-1 alloy this is valid also at 20°C and at the maximum working temperature of 450°C.

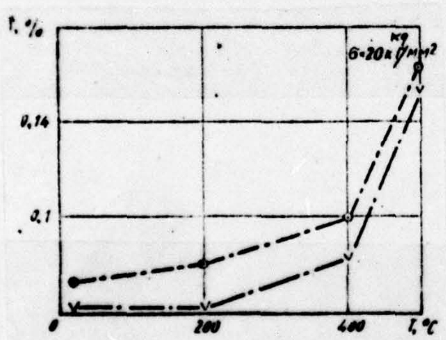

Fig. 4. Dependence $\delta = f(T)$ for the heat-hardened alloy VT-9: O - 9P; V - 9Y.

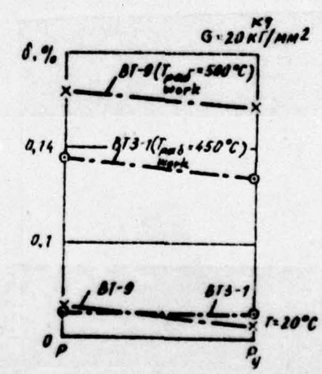

Fig. 5. Change in the damping properties of the Ti alloys VTZ-1 and VT-9 for the various structures at normal and working temperatures:

P - equilibrium; P_y - equiaxial with heat hardening.

Consequently, of all the forms of surface hardening, the most significant is the vibrational tumbling of the VTZ-1 alloy, which

leads to an increase in the logarithmic decrement from 0.135 to 0.16%, i. e., by more than 15%, and the oxidation with subsequent polishing for the VT-18 alloy, in which the logarithmic decrement of vibrations increases by about 20% as compared with the samples that were not hardened.

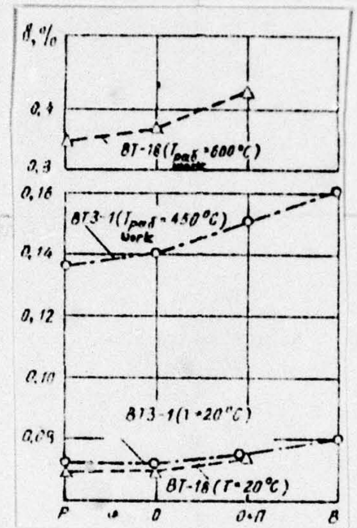

Fig. 6. Dependence of the damping properties of the Ti alloys VTZ-1 and VT-18 on the various forms of surface hardening:
P - equiaxial; O - oxidation; O + П - oxidation plus polishing; and B - vibrational tumbling.

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