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USING ALLOYS OF Cr-Ni-Co SYSTEM AS METALLIC BOND IN POWDER METALLURGY PRODUCTS

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There is studied the possibility of using alloys of the Cr-Ni-Co system as a metallic bond in producing ceramet. As the basic material there was used titanium carbide. There were measured such mechanical properties as bending strength, tensile strength, impact viscosity. There is considered a possibility of using ceramet with a metallic bond of the Cr-Ni-Co system as a refractory material. As a heat resistance indicator there was estimated the limit of long durability. It is established that in the studied range of temperatures the material properties are the function of the bond content.

Key words: Cr-Ni-Co system, powder metallurgy, titanium carbide, mechanical properties, physical properties

INTRODUCTION

Ceramic-metallic materials, i.e. cermets, are obtained by pressing and baking the mix of ceramic powders (refractory carbides, oxides, silicates, etc.) and metal powders as binders. As a binder there is often used cobalt. After mixing the powders there is carried out baking at the temperature of 1 400-1 500 ^{o}C. In the course of agglomeration the bond dissolves a part of carbides and melts. As a result there is obtained a dense material (porosity doesn't exceed 2 %) which structure for 80 - 95 % consists of the carbide particles connected by a bond. The increasing of the bond content causes hardness decreasing but leads to durability and viscosity increasing [1, 3].

Due to the search of new high-temperature materials there appeared studies dealing with studying the impact of the bond type and content on the properties of materials, in particular on characteristics of creep and limit of long durability [4, 5]. Earlier studies have shown the promise of this trend.

EXPERIMENTAL STADIES

In this work there is studied the possibility of using alloys of the Ni-Cr and Ni-Cr-Co systems as metal binding and the impact on the properties of ceramet. At this there is varied the content of the bond depending on the product demanded properties. For example, if a material is to have high ultimate strength, and requirements for resistance to impact loadings are rather less important (for example, when used in disks of small turbines), it is desirable to use the materials containing approximately from 20 to 45 % (by weight) of a binding alloy [2, 3].

However, if to consider materials for the guiding devices of turbines where there is required a little smaller long durability but increased impact strength, it is possible to permit the use of a material containing from 50 to 65 % (on weight) of bonds [5].

In Table 1 there are presented the compositions of the used materials.

Table 1 **Materials composition and physical properties**

Alloys	Chemical Composition / %				Density / g/cm^3	Vickers hardness	Coefficient of linear expansion
	TiC	Ni	Co	Cr			
1	60	32	-	8	6,20	950	10,2
2	50	40	-	10	6,50	790	-
3	35	52	-	13	6,90	590	12,6
4	75	15	5	5	6,0	1 070	9,9
5	60	24	8	8	6,25	960	9,2
6	50	30	10	10	6,55	820	10,6
7	35	39	13	13	6,95	600	11,9

In the considered alloys the content of a bond by weight varied from 25 % to 65 %. All samples were prepared by usual methods of powder metallurgy, i.e. mixing powders of carbide and binding alloy in spherical mills with subsequent cold pressing, preliminary and final agglomeration. The operations of agglomeration were made in the vacuum furnace with molybdenum heaters at the temperature 1 500 ^{0}C; in the course of agglomeration there was supported vacuum about 0,1 mm Mercury.

As it is seen from the data of Table 1, the density of the studied materials fluctuates from 6 to 6,9 g/cm^3 and depends on the content of a bond. Vickers hardness (indentation size effect) also depends on the content of a bond decreasing with the increase of its quantity.

In Table 2 there are given mechanical properties of the studied materials at various temperatures. Studying

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Table 2 **Mechanical properties of the studied alloys**

Alloys	Bond content / %	Bending strength / MPa		Tensile strength / MPa		Impct viscosity / MJ/m^2		Elasticity module at 20 ° / MPa	100-hour long durability / MPa	
		20 °	900 °	20 °	900 °	20 °	900 °		800 °	1000 °
1	40	1 300-1 400	-	700-800	450	0,44	0,57	38 300	-	
2	50	1 590-1 700	-	900-1 000	500	0,57	0,89	-	-	-
3	65	1 700-1 790	-	950-1 050	420	0,91	-	-	-	-
4	25	1 200-1 300	-	600-700	-	0,38	0,43	41 800	-	-
5	40	1 340-1 500	-	800-900	500	0,43	-	39 400	-	11
6	50	159-179	70	90-100	450	0,53	0,81	35 600	32	9
7	60	174-188	62	100-108	380	0,97	1,20	32 300	26	6

mechanical properties was carried out by the corresponding state standard specifications.

Bending strength as well as tensile strength at the room temperature is rather high. Impact strength with increasing the content of a bond increases a little, and the module of elasticity and long durability decrease, on the contrary. Sample 6 under loading of 26,7 MPa at 800 ^{0} became torn after 1 064 hours, sample 7 was tested over 4 000 hours at 760 ^{0} under loading of 26 MPa.

In Figure 1 there is shown the temperature dependence of durability in bending two alloys 1 and 2. Alloy 6 with 50 % of the nickel-cobalt-chrome bond keeps durability in bending in the range of temperatures from 20 to 4 000 whereas durability in bending alloy 7 containing 65 % of the bond above the room temperature decreases slightly.

In Figure 2 there is shown a similar dependence of tensile strength. While tensile durability at the room temperature increases with increasing the content of a bond, the curves "tensile durability – temperature" for various alloys at higher temperatures are crossing. So, at 1 000 ^{0} tensile strength with a larger content of a bond decreases. It is seen in Figure 3 where this dependence is presented.

The main indicator of heat resisting materials quality is the limit of long durability. In Figure 4 there are shown the curves of long durability for alloy 6 at 800 and 1 000 ^{0}. The "flat" form of these curves is characteristic almost of all cermets.

In Figure 5 there is shown the impact of temperature on durability at loading within 100 hours of some alloys. Long durability decreases with increasing the bond content, as well as the usual fracture strength at high temperatures.

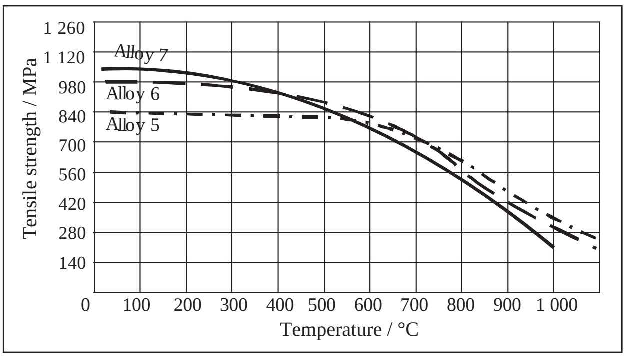

Figure 2 Tensile strength at increased Temperatures

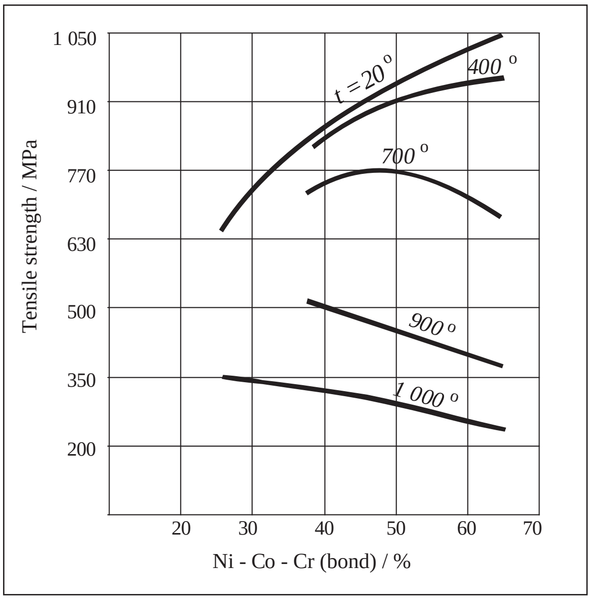

Figure 3 Tensile strength at various temperatures depending on the bond content

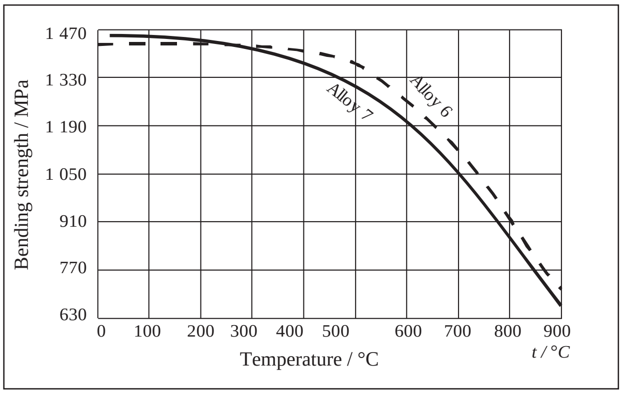

Figure 1 Bending strength at increased temperatures

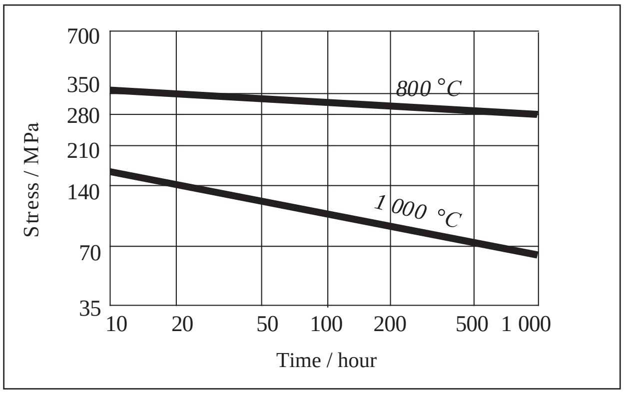

Figure 4 Graph of alloy 7 long durability

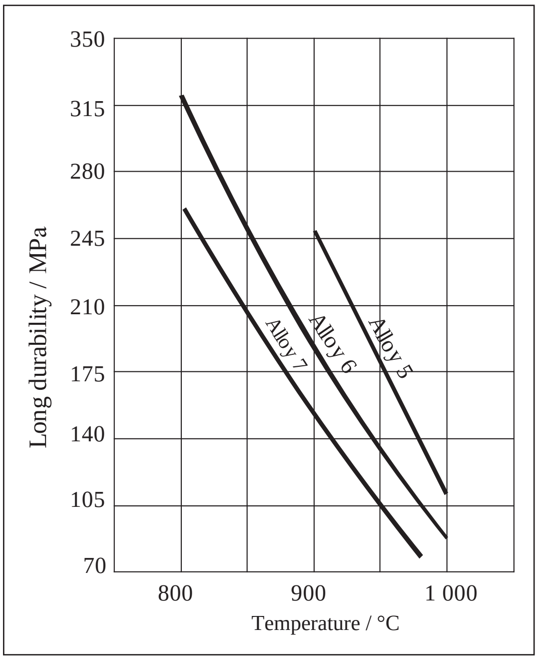

Figure 5 Long durability (in 100-hour testing) of some alloys at various temperatures

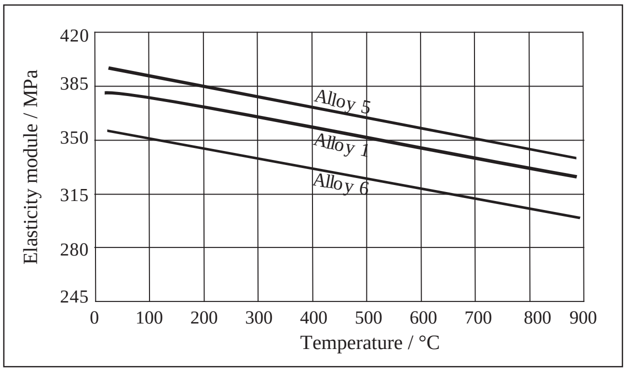

Figure 6 Alloys elasticity module depending on temperature

In Figure 6 there is shown the elasticity module changing of three alloys depending on temperatures.

Stability of these materials against oxidation was defined in the motionless air at 1 000 ^{0}; in Figure 7 there are presented the results of testing in the form of curves "weight increase – time". The parabolic form of these curves specifies that in the hold time there is formed a protective layer.

In Figure 8 there is compared the materials impact viscosity at the room temperature and at 900 ^{0}.

In this work there is not considered the issue of the metallic bond introduction in the ceramet structure impact. Meanwhile, as studies [1, 2] show, this moment is of a great value since in fact it forms the «skeleton» of a future product.

CONCLUSIONS

Summarizing the data of the ceramet properties based on titanium carbide with a bond like nickel-chrome and nickel-cobalt-chrome, it is possible to note that at any temperature the properties are the function of the bond content.

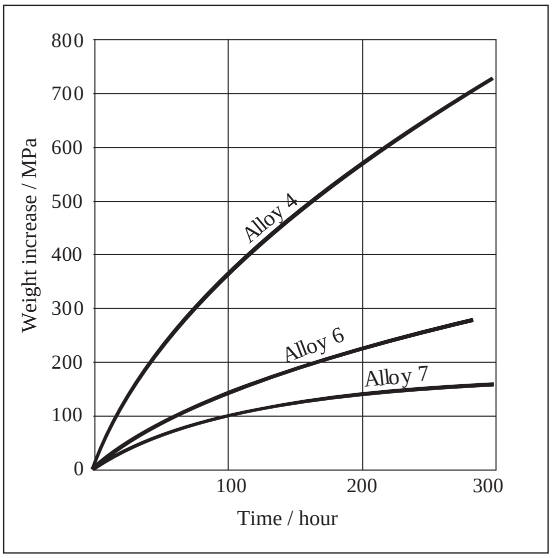

Figure 7 Alloys oxidation at 1 000 ^{0}in a stationary state

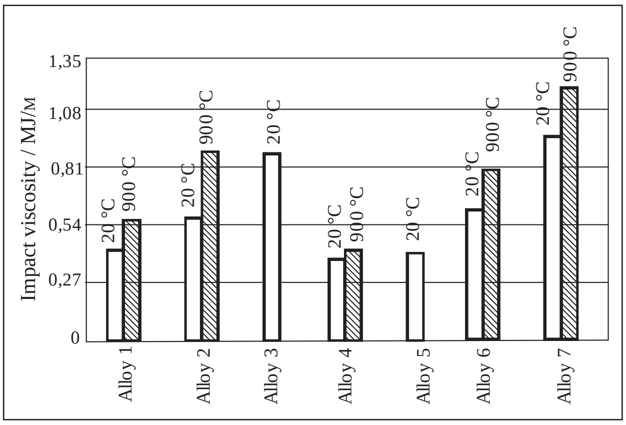

Figure 8 Alloys impact viscosity at the temperatures 20 and 900 ^{0}C

The optimum bond content makes about 40 % (by weight), at this, certainly, the structure of the bond is important. According to the obtained data, such a structure is as follows: 24 % of Ni, 8 % of Co, 8 % of Cr.

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Note: The responsible for England language is Nataliya Drag, Karaganda Kazakhstan