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PHYSICO-MECHANICAL CHARACTERISTICS OF HARD ALLOYS MADE OUT OF MANY CARBIDES

Stela CONSTANTINESCU

"Dunarea de Jos"University of Galati,
e-mail: Stela.Constantinescu@email.ro

ABSTRACT

The Hard alloys of type WC-TiC-Co can be used to process materials with long chips, such as steels [1].

Titanium carbide or TiC-WC solid solutions, added as alloying constituents in the compositions of WC-Co pseudo-alloys increases their corrosion resistance, hardness and refractoriness.

Moreover, the thermal conductibility of WC-TiC-Co alloys and their tendency to weld the chips is an indisputable quality in favor of the cutting process of steels and other metallic materials with long chips. The physico-mechanical characteristics of WC-TiC-Co alloys vary with the increase of titanium carbide amount.

In the factory programme of prestigious manufactures of hard alloys, made out of sintered metallic carbides, the alloys of type WC-Ti-Co have been replaced by the alloys type WC-TiC-TaC(NbC)-Co, intended to cutting process of steels. Of course, this is due to better endurance and cutting process performance. Alloys of type WC-TiC-TaC-Co offer better mechanical strength and also better craking strength values. These alloys are used both in cutting long and short chip materials, due to their characteristics and forming the so called universal alloys.

KEYWORDS: density, hardness, bending fracture strength, thermal conductibility, coefficient of thermal expansion, magnetization up to saturation.

1. Introduction

Hard alloys made out of metallic carbides manufactured to an industrial scale for cutting processing can be divided in two categories, according to their use. The second category of industrial products comprises the alloys out of many carbides used in cutting process of materials with long and continuous chips (all sorts of steel).

According to chemical composition, there are the following types of alloys: WC-TiC-Co; WC-TaC(NbC)-Co and WC-TiC-TaC(NbC)-Co.

Alloys based on many carbides with small or medium amount of TiC or TaC(NbC) can also be used for cutting materials with short chips and this way the so called "universal alloys" have emerged. These alloys can be used to cut any material, under certain cutting conditions. Almost all the sintered hard alloys made out of metallic carbides comprises a high amount of ternary or quaternary carbide type WC-TiC-TaC(NbC)-Co instead of secondary WC-TiC-Co or WC-TaC-Co. The specialised literature shows that the composition that offers the optimum tenacity values is: 50-70%WC, 3-10%TiC, 10-35%TaC and 5-15%Co.

This composition offers a better cracking strength than the alloys type WC-TiC-Co and a generally better endurance of the tool than WC-TaC-Co.

Hard alloys made out of carbides type WC-TiC-TaC-Co have been sucessfully inserted in the factory programmes of prestigious manufacturers worldwide in order replace the alloys based on only two carbides. It has to be emphasized that, due to higher costs of tantalum carbide and tantalum itself, the alloys containing quaternary complex carbides type WC-TiC-TaC(NbC)-Co are more expensive than the alloys containing only binary carbides type WC-TiC-Co.

2.Researching and experimental results

The density of pure titanium carbide TiC (4.90g/cm^3), considerably lower than the density of tungsten carbide (15.7g/cm^3) influences the density of the alloys type WC-TiC-Co, decreasing with the increase of TiC amount (fig.1).

Due to possible content of undesirable elements of TiO or TiN to be found in the titanium carbide or in the TiC-WC solid solutions, micropores can emerge and density measurement has to be done not only for sintering degree purposes, but also for the purity of the WC-TiC-Co alloys.

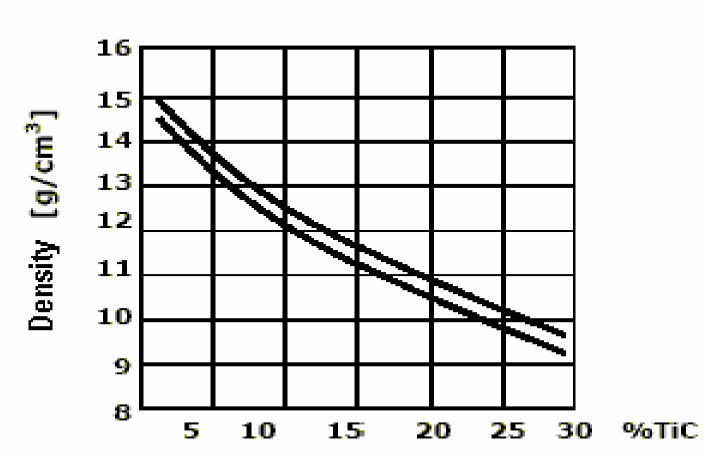

Fig.1 . *The dependence of WC-TiC-Co alloy density with the amount of titanium carbide (TiC%)*

Table 1 . *Compositions and characteristics of WC-TiC-Co alloys*

Composition %			Density [g/cm³]	Hardness HRA	Hardness Vickers [daN/mm²]	Banding cracking strenght [daN/mm²]	Compression stregth [daN/mm²]	Thermal conductibilit [cal/cms°C]	Coeff. of thermal expans. [10⁻⁶/°C]
WC	TiC	Co							
94	1	5	14,5-14,7	90-91	1500-1600	140-160	557	0,19	5
87,5	2,5	10	14,0-14,2	89-90	1400-1500	160-178	458	0,16	-
84,5	2,5	13	13,7-13,8	87-89	1300-1400	178-200	447	0,15	5,5
86	5	9	13,2-13,4	89-91	1450-1550	150-160	458	0,15	5,5
82	5	13	12,8-13,0	88-90	1350-1450	160-178	-	-	-
82	10	8	11,8-12,0	90-91	1500-1600	150-170	-	0,079	-
78	14	8	11,1-11,3	90-91	1550-1650	130-140	417	0,08	6,2
78	16	6	11,0-11,2	90-91,5	1600-1700	110-124	427	0,09	6
76	16	8	10,9-11,1	90-91	1550-1650	120-130	-	0,069	6
69	25	6	9,6-9,8	91-92	1650-1750	90-110	-	0,05	7
61	32	7	8,7-9,0	92-93	1650-1750	79-100	408	0,04	-
34	60	6	6,5-6,8	92-93	1750-1850	70-79	388	0,03	7,5

The dependence of physico-mechanical characteristics of WC-TiC-Co alloys with the increase of TiC amount is given in the table nr.1 [2]-[3].

Hardness of WC-TiC-Co alloys is affected by a large number of elements connected to the raw material, purity and component dispersion in the pseudo-alloy and the solid solution quality and grain size of components.

In the factory process, these elements are playing an ultimate role in effective hardness measurement of the material with a given chemical composition (fig.2).

Generally speaking, the hardness of WC-TiC-Co alloys increases with the TiC amount and decreases with cobalt amount increasement (fig.3).

The bending cracking strength values of WC-TiC-Co alloys decreases with the TiC amount increasement , this decreasement can only partially be counter-balanced by cobalt amount increasement.

The compression strength oh WC-TiC-Co alloys decreases with the TiC amount increasement.

Fig.2. *Metallographic appearance of pseudo-alloy with 80%WC, 12%TiC, 8%Co, x1500*

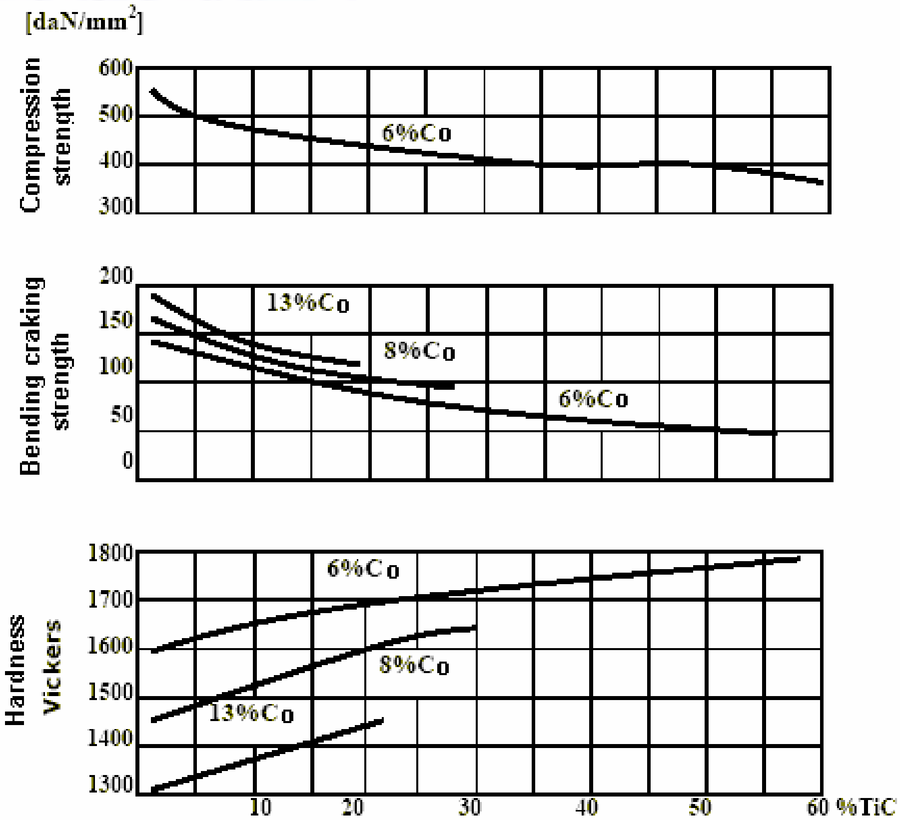

Fig.3. *The dependence of hardness, bending cracking strength and compression strength with the amount of titanium carbide (TiC%)*

The titanium carbide is a weak thermal conductor – the thermal conductibility of WC-TiC-Co alloys is lower than of WC-Co avearange alloys and keeps decreasing with TiC amount increasement. Tabel nr.1 shows the values of thermal conductibility of certain WC-TiC-Co compositions. For purposes of comparison, it is specified that the thermal conductibility value of rapid steels is 0.6[cal/cm s ^{o}C].

The coefficient of thermal expansion increases with titanium carbide amount increasement, but is smaller than that of rapid steels in all the WC-TiC-Co alloys.

The magnetic characteristics of WC-TiC-Co alloys are given in the tabel nr.2. Since the titanium carbide is not ferromagnetic, the magnetization up to saturation decreases with TiC amount increasement in the alloy. Thus, the values of the magnetization up to saturation, together with those of coercive force can describe the TiC amount of alloy.

Table 2. *The magnetic characteristics of WC-TiC-Co alloy*

Composition, %			Magnetization to saturation $4\pi\sigma$	Coercitive force HC
Wc	TiC	Co		
88	3	9	160-165	185
88	5	7	107-112	120-130
78	14	8	140-145	100-110
78	16	6	97-100	100-110
69	25	6	89-92	80-90
34	60	6	89-95	70-80

Consequently to those showed above, as well as due to a better corrosion resistance values of WC-TiC-Co alloys compared to average alloys [4], [5], there results in a better cutting processing behaviour of the first mentioned.

In the factory programme of prestigious manufactures of hard alloy, made out of sintered metallic carbides, the alloys of type WC-TiC-Co have been replaced by the alloys type WC-TiC-TaC(NbC)-Co, intended to cutting process of steels (fig. 4).

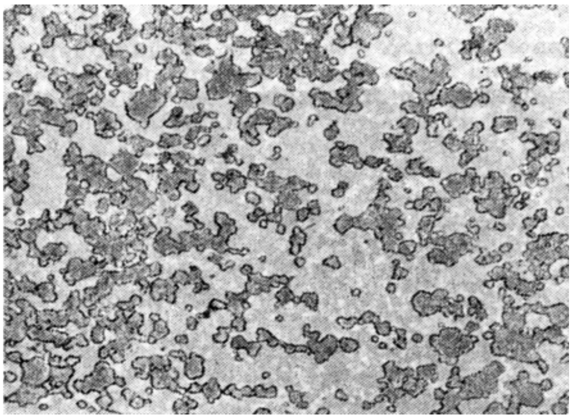

Fig 4. *The metalographic aspect of the pseudo alloy*
11% TiC, 14% TaC(NbC), 8% Co si 67% WC, x1500

Of course, this is due to better endurance and cutting process performance. Alloys of type WC-TiC-TaC-Co offer better mechanical strength and also better craking strength values. These alloys are used both in cutting long and short chip materials, due to their characteristics and forming the so called universal alloys.

3.Conclusions

The density of WC-TiC-Co alloys decreases with TiC amount increasement.

The hardness of WC-TiC-Co alloys increases with TiC amount increasement and decreases with cobalt amount increasement.

The bending cracking strength of WC-TiC-Co alloys decreases with TiC amount increasement. The compression strength of WC-TiC-Co alloys decreases with TiC amount increasement. The thermal conductibility WC-TiC-Co alloys keeps decreasing with TiC amount increasement. The coefficient of thermal expansion increases with titanium carbide amount increasement. The magnetization up to saturation decreases with TiC amount increasement in the alloy. Hard alloys made out of carbides type WC-TiC-TaC-Co offer better cracking strength than the alloys type WC-TiC-Co and a generally better endurance of the tool than WC-TaC-Co.

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