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Performance of Cemented Carbides in Cyclic Loading Wear Conditions

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Abstract

The present study describes the wear and mechanical behaviour of carbide composites in cyclic loading applications (blanking of sheet metal). Adhesive wear as well as fatigue endurance were tested, complemented by XRD studies. It was found that the blanking performance of a carbide composite is controlled by its resistance to adhesion wear and fatigue sensitivity. XRD studies revealed that fatigue damage is preceded by plastic strain in both phases of the composites

Keywords: cermet, cemented carbide, fatigue, blanking performance

1. Introduction

Hardmetals (WC-Co) are the most widely used wear resistant composites because of their excellent combination of wear resistance and strength. TiC-base cermets (tungsten-free hardmetals) have proved successful in some applications because of their fair specific strength and favourable physical properties.

This paper focuses on the mechanical and tribological behaviour of some advanced TiC-base cermets in terms of their performance as tool materials for cyclic loading (blanking) applications. Another important aim was to identify any correlation that might exist between blanking performance on the one hand and fatigue endurance and adhesive wear resistence on the other hand.

2. Experimental and Results

Table 1 shows the advanced TiC-base cermets, the performance of which was tested in complicated wear conditions (in relation to ordinary WC-hardmetal H15).

Durability tests followed the procedure used in the functional tests − in the blanking of electrotechnical sheet steel in a 3-position (reinforced with alloys – in Table 1) die. Durability was evaluated by the side wear Δ of the dies after the intermediate service time of 0.5×10^6 strokes [1]. Fatigue tests resembled those for the bending fatigue under repeated transverse bending load [2]. The wear performance of alloys was studied in the cutting adhesive wear conditions [1]. The wear resistance L_l was determined as the length of the cutting path (by turning mild steel at low peed). Tests were complemented by XRD studies. A decrease in the intensity ΔI of the X-ray reflection lines from carbides (as a measure of local plastic strain) was determined.

Table 1. Structural characteristics, hardness *HV* and transverse rupture strength R_{TZ} of composites

Grade	Carbide [wt%]	Binder composition, structure	*HV* [GPa]	R_{TZ} [GPa]
H15	85 WC	Co(W)	1.15	2.9
T70/14	70 TiC	Fe+14Ni steel, austenite	1.25	2.2
T60/8	60 TiC	Fe+8Ni steel, martensite-bainite	1.20	2.3

Results of functional tests – wear contours of cutting edges (and side wear Δ) of carbide tools refer to an superiority of the grade T70/14 over an ordinary WC-base hardmetal (grade H15) (Fig.1) and TiC-cermet grade T60/8. The results of adhesive wear trials confirm the superiority of grade T70/14 over H15 and T60/8.

The results of fatigue tests revealed a lower fatique sensitivity (slope of Wöhler curve, Fig.2) in relation to H15 in the behaviour of grade T70/14. There exists a good correlation between cemented carbide blanking performance, its fatigue sensitivity (factor $\Delta S = Sm_7 - Sm_3$) and adhesive wear resistance L_l.

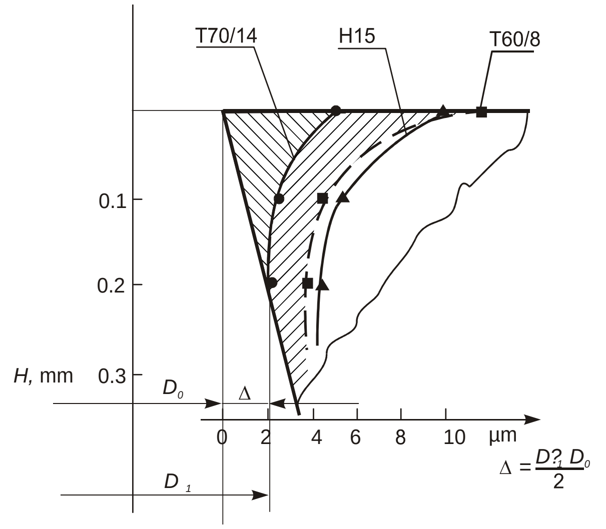

Fig. 1. Wear contours of cutting edge of dies from different cemented carbides

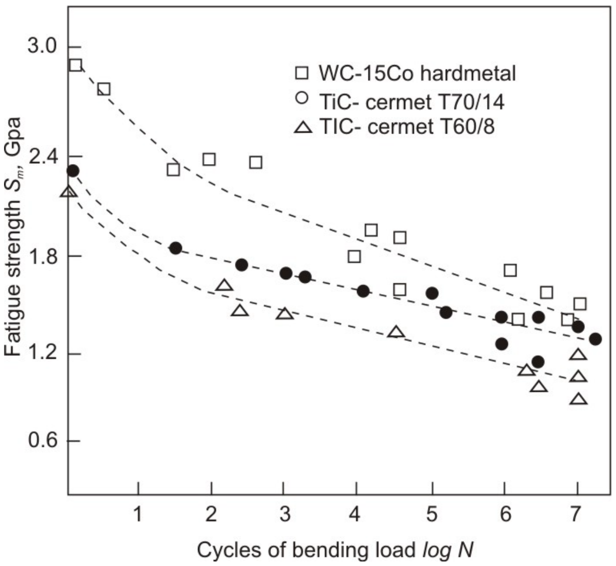

Fig. 2. Wöhler curves of carbide composites

Table 2. Intensity of lines of *X*-ray reflections from the carbide phase: I_o, I_m, I_c – intensities before and after monotonic (m) and cyclic (c) loadings, respectively

Grade	Carbide, line	Intensity, Lin [Cps]			Decrease in intensity		Embrittlement
		I_o	I_m	I_c	$m = I_0 / I_m$	$c = I_0 / I_C$	*m/c*
H15	WC, [001]	51	8	32	6.4	1.6	4.0
T70/14	TiC, [200]	78	37	57	2.1	1.4	1.5

The plastic strain (onset of failure) of cemented carbides in the case of static and cyclic loading starts and takes place mainly in the ductile binder [3, 4]. As a result of XRD investigations (Table 2), it can be concluded that the ability of a carbide composite to undergo plastic strain – its ability to absorb fracture energy by local plastic strain – depends on the plasticity of both the ductile binder and the "brittle" carbide-phase.

The ability of the carbide phase to undergo plastic strain depends on the loading mode. Cyclic loading results in a decrease of carbide ability to strain plastically in relation to monotonic loading (measures $c = I_o/I_c$ and $m = I_o/I_m$).

The plasticity of TiC in monotonic loading is less than that of WC ($m_{TiC} < m_{WC}$). On the contrary, in the cyclic loading conditions, TiC in cermet demonstrated a plasticity close to that of WC.

3. Summary

The blanking performance of a carbide composite is controlled by its adhesive wear resistance and fatigue sensitivity (slope of Wöhler curve).

Surface failures of a carbide composite in the cyclic loading wear conditions (blanking and fatigue) start in the binder and propagate in the carbide phase, being preceded by local plastic strain taking place in both phases.

In the conditions of cyclic loading, the plasticity of composites phases (in particular carbide phase) decreases.

The lower intensity in the decrease in plasticity occuring in the carbide composite phases results in the lower fatigue sensitivity of the composite.

4. References

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