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ADHESIVE WEAR BEHAVIOUR OF CARBIDE COMPOSITES AND TOOL STEELS

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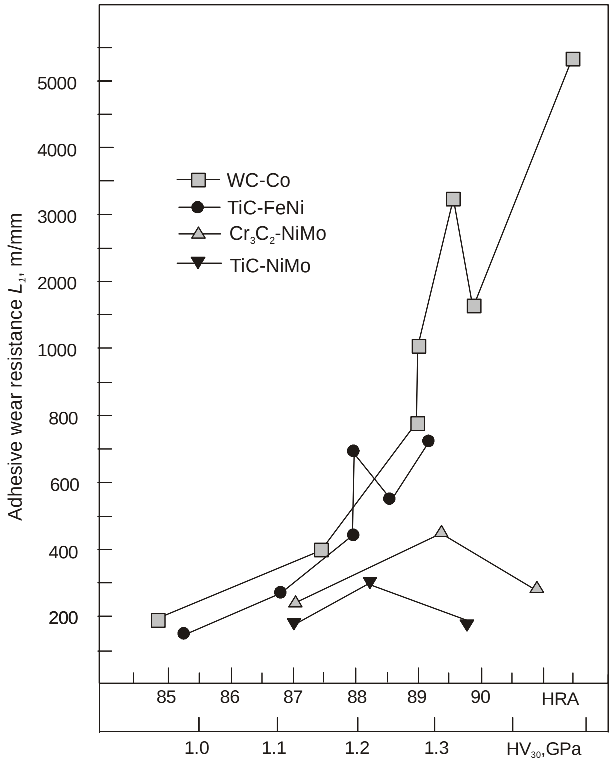
Abstract: *The performance of hard alloys – carbide composites and tool steels (of different composition and structure) in the conditions of prevailing adhesive surface failure (complemented by SEM studies) was investigated.*
It was shown that hardness does not enable us to estimate wear resistance of alloys exactly.
In respect to adhesive wear resistance, TiC-base cermets with a steel binder and high alloyed tool steels can compete with WC-base hardmetals.
Key words: cemented carbides, tool steels, adhesive wear

1. INTRODUCTION

Cemented carbides are the most widely used materials for different wear applications owing to their excellent combination of high wear resistance and good strength-toughness (Brooks, 1996). "Tungsten-free" cemented carbides – TiC and Cr_3C_2 base cermets may be successful in some applications because of their lower friction coefficient, higher specific strength and resistance to oxidation, and more favourable physical properties (Kübarsepp et. al., 1994; Reshetnyak et. al., 1995)
Carbide composites are mainly used in service conditions where either high performance in abrasive wear conditions or at elevated temperatures (high speed cutting operations) are required. In complicated service conditions – in non cutting operations, high alloyed tool steels have been more successful (Reshetnyak et. al., 1989).
This paper is focused on the tribological behaviour of some prospective TiC- and Cr_3C_2-base cermets – on their response as inserts in adhesive wear experiments. The performance of these cermets was compared with WC-base hardmetals and tool steels used in metalforming operations.

2. EXPERIMENTAL PROCEDURE

TiC-base cermets with 50, 60 wt% TiC cemented with Ni-steels (8,14 wt% Ni in binder) grades T60/8, T60/14, T70/8, T70/14 and conventional "tungsten-free" cermets on TiC and Cr_3C_2-basis, cemented with Ni-25%Mo alloy TN30, 40, 50 and C10, 20, 30 were studied. In addition, we analyzed WC-hardmetals with 10-20 wt% Co-binder (grades H10...H20 and fine grained H10F, H15F) and tool steels (differing in alloying degree 1 wt%...30 %wt), including high-speed steels (HSS).
Adhesive wear conditions were realized by cutting mild steel (HV≤180) at low (<20 m·min^{-1}) speed Reshetnyak et. al., 1989). The adhesive wear resistance was determined as the length of cutting path L_l, when the wear land h at the lathe tool (specimen) nose achieved the critical value 1 mm.



3. RESULTS AND DISCUSSION

3.1 Carbide composites

The relationships shown in Fig. 1 confirm the fact revealed previously that concerns the lack of satisfactory correlation
Fig. 1. Adhesive wear resistance of carbide composites vs. hardness.

between the abrasive wear resistance and hardness of hardmetals and cermets (Reshetnyak & Kübarsepp, 1994). At equal hardness level the adhesive wear resistance of different carbide composites investigated differed up to 15 times (hardmetal H15F with L_l = 5300 m/mm and Cr_3C_2-cermet C10 with L_l = 300 m/mm).
The results obtained refer to the obvious superiority (up to 12 times at equal hardness) of WC-base hardmetals over conventional "tungsten-free" composites – TiC and Cr_3C_2-base cermets with Ni-alloy binder. The Cr_3C_2-cermets demonstrate an extraordinary behaviour – a decrease in wear resistance with an increase in the carbide content and hardness. Contrary to the conventional cermets, TiC-base cermets with a steel binder show excellent performance (not lower than that of WC-hardmetals).

3.2 Tool steels

The high alloyed tool steels, in particular the high-speed steels (HSS), demonstrated a high resistance to adhesive surface failure (Fig. 2).

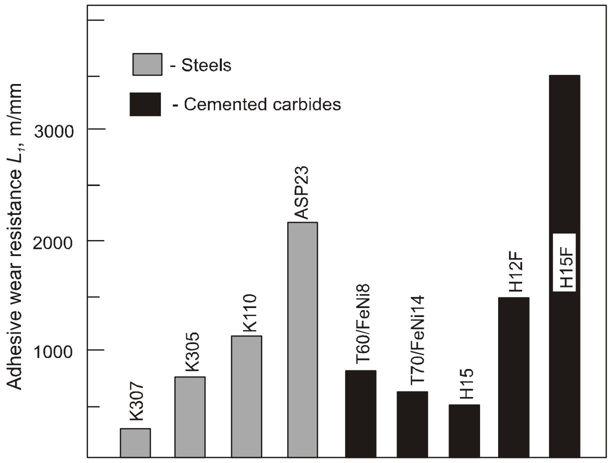


Fig. 2. Performance of different hard alloys (carbide composites and tool steels) in adhesive wear conditions.

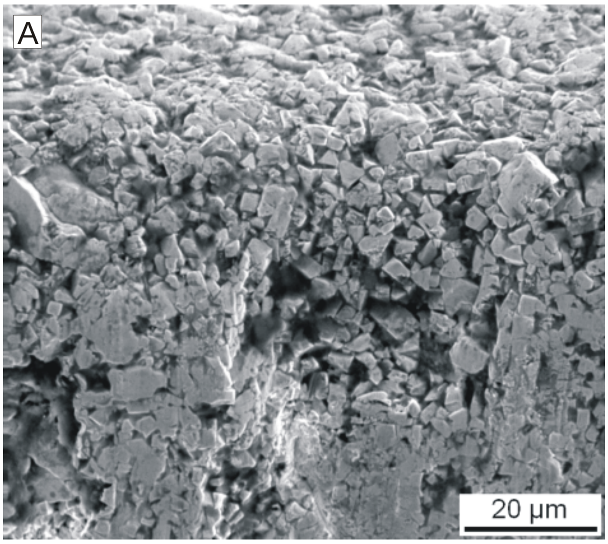


Fig. 3. SEM image of worn hardmetal H15 surface.

The performance of HSS exceeded most of the investigated conventional hardmetals and cermets (prospective for metalforming). HSS have in disadvantages not more than in relation to special carbide composites – fine grained hardmetals H15F, H10F, H12F.

The performance of tool steels depends sharply on the alloying degree. The increase in the alloying degree from 1 mass % (grade K305) to 30 mass% (HSS-ASP23) results in the improvement of wear resistance up to three times.

3.3 Wear mechanism

The SEM analysis of worn hardmetal surfaces (Fig. 3) shows that adhesive surface failure starts preferably in the binder phase (by extraction).

As stated, the removal of binder is preceded by the processes of adhesion interaction – local plastic strain of asperities, frustration of oxide films, origin of physical contacts and adhesive junctions between contacting-wearing surfaces binder – steel (Klaasen et. al., 2003)

Thus, the performance of hard alloys in adhesive wear conditions is controlled primarily by the amount and dimensions of the binder phase and its properties – resistance to adhesion interaction (resistance to local plastic strain and stability of oxide films) and to extraction (tension, bending strength).

4. CONCLUSIONS

1. The standard characteristic of wear resistance – hardness of alloys does not enable us to prognosticate exactly the performance of hard alloys (carbide composites and tool steels) in adhesive wear conditions. At equal level of hardness, the performance of different alloys may differ up to 15 times.
2. In respect to adhesive wear resistance WC-base hardmetals and TiC-base cermets with a steel binder have a market advantage over conventional "tungsten-free" hardmetals – TiC and Cr_3C_2-base cermets with Ni-alloy binder.
3. High alloyed tool steels, in particular high-speed steels (HSS) demonstrated high performance in adhesive wear conditions. Only special hardmetals – fine grained ones are superior over HSS.
4. The adhesive surface failure of hard alloys starts preferably in the binder phase and therefore their wear resistance depends primarily on the binder properties as well as on the amount and dimensions of the binder phase.

4. ACKNOWLEDGEMENTS

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