ISSN 1392–1320 MATERIALS SCIENCE (MEDŽIAGOTYRA). Vol. 14, No. 4. 2008

Impact Wear of Chromium Carbide Based Cermets

Kristjan JUHANI*, **Jüri PIRSO, Mart VILJUS, Sergei LETUNOVITŠ**

Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia

Received 17 June 2008; accepted 08 July 2008

Chromium carbide based cermets are perspective materials to use in aggressive and abrasive conditions. Present paper considers the impact wear properties of chromium carbide based cermets with different chemical compositions (10 wt % – 50 wt % of Ni). The investigated chromium carbide based cermets were produced by a novel method reactive sintering and reference materials using chromium carbide powders produced by indirect and direct synthesis. The impact wear resistance of chromium carbide based cermets depends on binder content and cermets producing technology. The wear resistance increases in increase of binder content. Better wear resistance exhibited cermets made by using chromium carbide powder produced by indirect synthesis. The wear mechanism was investigated by SEM images of worn surfaces of cermets.

Keywords: chromium carbide, reactive sintering, impact wear, wear mechanism.

1. INTRODUCTION

Cr_3C_2 – Ni cermets are perspective materials to operate in corrosive and abrasive environments [1 – 6]. Main disadvantages of these cermets are their relatively low mechanical properties and wear resistance mainly because of their coarse-grained structure (the carbide grain size is usually over 4 μm).

The impact wear behaviour of different materials and coatings is investigated in [7 – 9].

In impact wear conditions multiphase materials exhibited the optimal wear resistance. Multiphase materials as cermets combined softer matrix dispersed with extremely hard grains. Chromium carbide based cermets are perspective materials for special applications such as high temperature or corrosive environments and in situations were high corrosion-abrasion resistance is required simultaneously [4, 10]. At the same time there is a lack of information about the impact wear behaviour of chromium carbide based cermets.

The aim of present paper was to investigate the impact wear resistance and wear mechanism of chromium carbide based cermets, made by different technologies.

2. MATERIALS AND EXPERIMENTAL

The investigated chromium carbide based cermets were fabricated at Tallinn University of Technology by a new technology – reactive carburizing sintering [11]. Reference cermets were produced using chromium carbide powders made by indirect and direct synthesis [12]. The ball milling of chromium carbide and nickel powders in case of chromium carbide produced by indirect synthesis were carried out for 160 hours.

The cermets are composed of chromium carbide grains in a metal binder with the mean grain size about 2 μm for reactive sintered cermets and about 4 μm for cermets, produced by conventional technology. Typical microstructures of chromium carbide cermets made by different methods are exhibited in Fig. 1.

Impact wear tests were carried out in experimental impact wear tester DESI, described in [13]. The principal scheme of impact wear tester is shown in Fig. 2. 15 kg of granite abrasive was used in tests; the granite abrasive fraction was 4 mm – 5 mm. The tests were carried out at the velocity of about 60 m/s and the estimated impact angles were about 90°.

The blocks were finished to a surface roughness of about 1 μm prior to each test. Each specimen was weighed before and after the testing with an accuracy of 0.1 mg.

Weight loss was converted into the volumetric wear rate.

The worn surfaces were observed with a scanning electron microscope JEOL JSM 840A to investigate the impact wear mechanism.

3. RESULTS

3.1. Impact wear rate

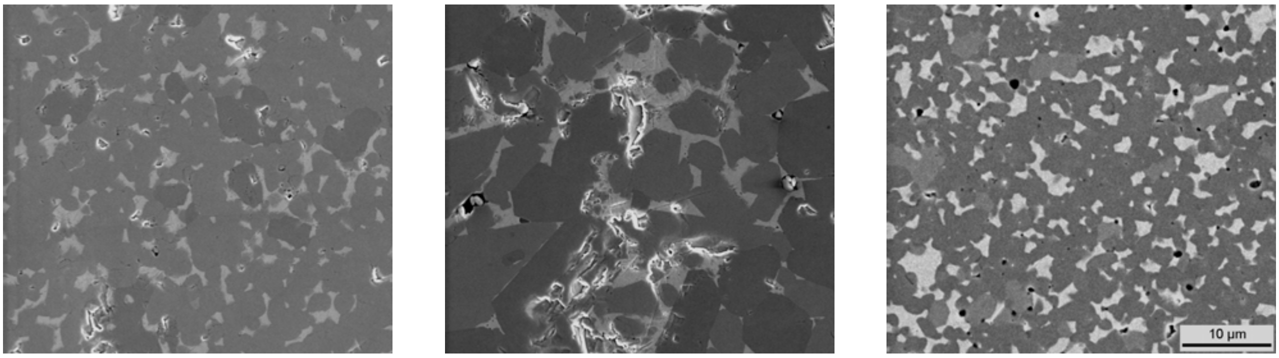
The volumetric wear rate for chromium carbide based cermets with different chemical compositions is shown in Fig. 3. The volumetric wear rate increases in increase of binder content. The bulk hardness of cermets decreases and the wear rate increases when binder content increases. Cermets made by using chromium carbide produced by indirect synthesis with lower binder content exhibited better wear resistance. In average, the cermets made by reactive sintering and by using chromium carbide made by direct synthesis exhibited comparable wear resistance.

3.2. Wear mechanism

The detailed mechanism of the impact wear mechanism of chromium carbide based cermets has not been studied yet.

The wear mechanism of chromium carbide based cermets was investigated analysing SEM images of the worn surfaces.

*Corresponding author. Tel.: +372-6203356; fax.: +372-6203196.
E-mail address: *kristjan.juhani@ttu.ee* (K. Juhani)



a b c

Fig. 1. Microstructure of Cr_3C_2 – 20 % Ni cermets depending on cermets producing technology: a – direct synthesis, b – indirect synthesis, c – reactive sintering

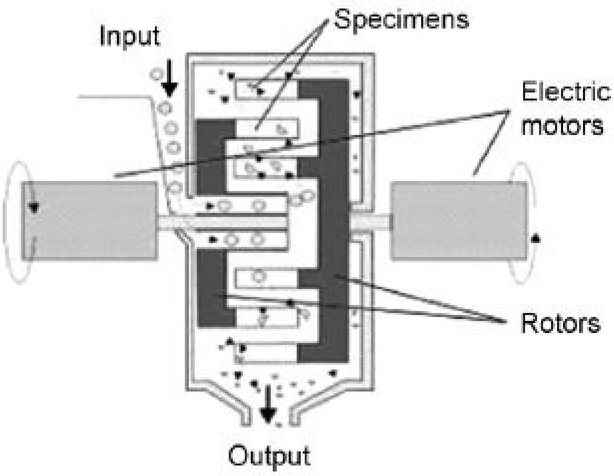


Fig. 2. Principal scheme of the impact wear test device [13]

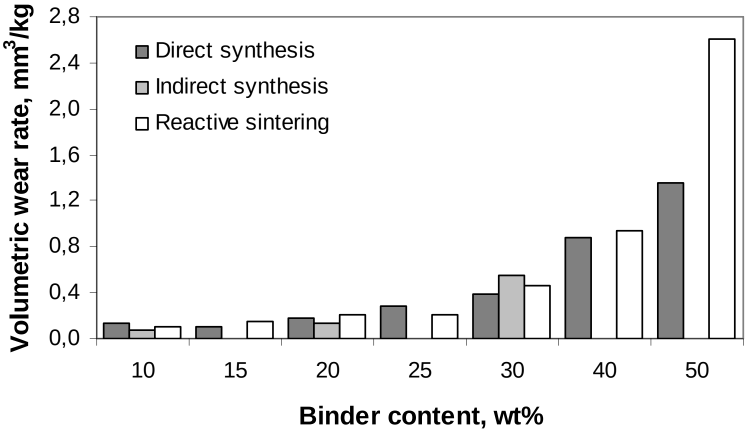
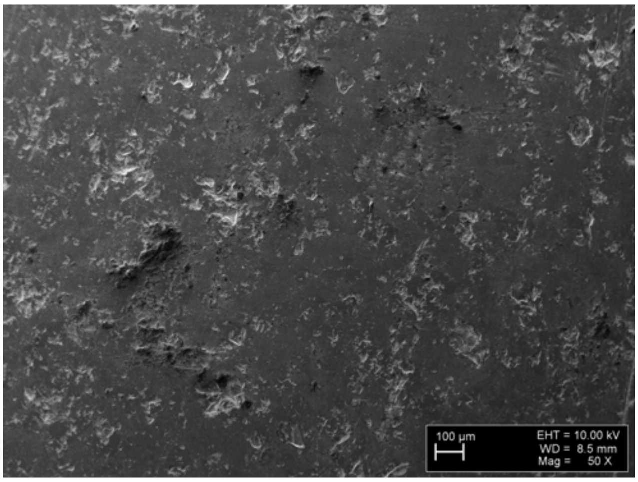
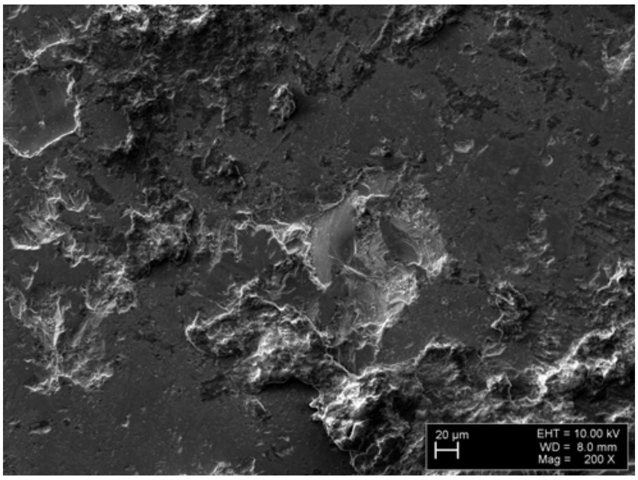


Fig. 3. Impact wear rate of chromium carbide based cermets with different chemical composition and made by different techniques

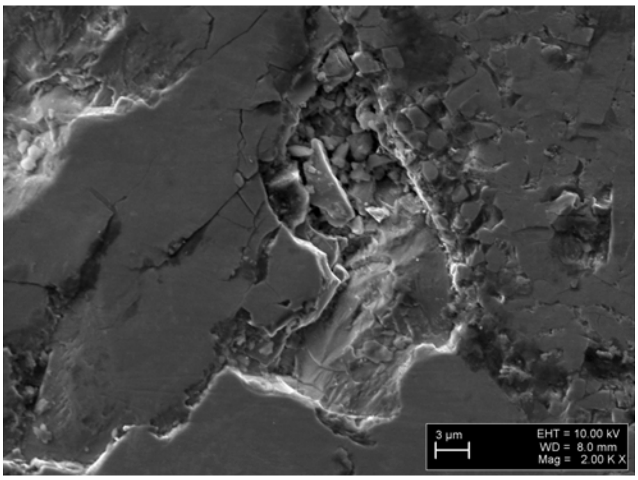
The wear mechanism for cermets made by different technologies is similar. The worn surfaces of Cr_3C_2 – 10 % Ni cermets are shown in Fig. 4. The worn surface of material is covered with tracks where the granite abrasive particles are pushed into the material surface (Fig. 4 , a). Abrasive particles penetrate into the material and deform plastically the binder phase and, at the same time, damage the carbide network and carbide grains. The binder phase is removed from the impact track to the edges of the track where the walls are formed; some of the binder phase is wiped out from the surface (Fig. 4 , b). The carbide network is crushed; some of the carbide grains are fractured or removed from the surface (Fig. 4, c). The parts of the carbide network are squeezed onto the walls of binder. During the wear process some of the granite abrasive particles is crushed and the formed granite dust damage thematerial surface locally; it penetrate into surface deform the binder phase plastically or remove it from the surface (Fig. 4 , a).



a

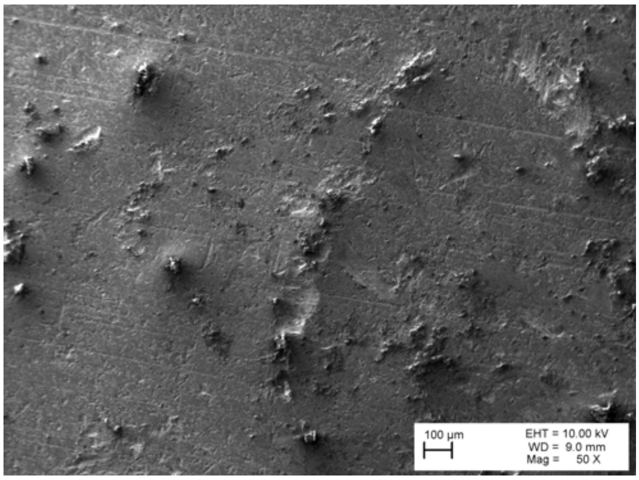


b

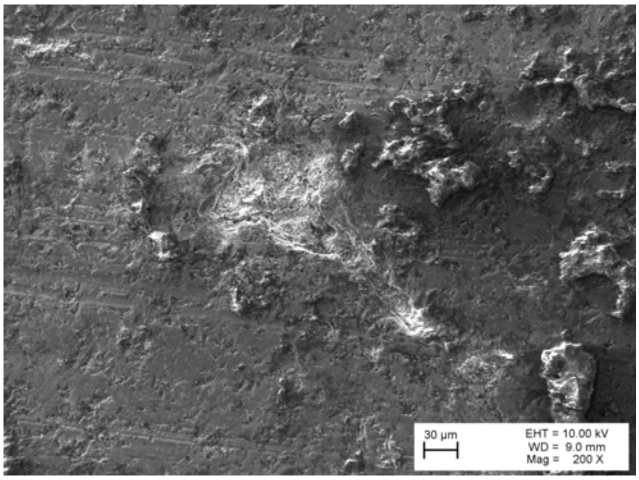


c

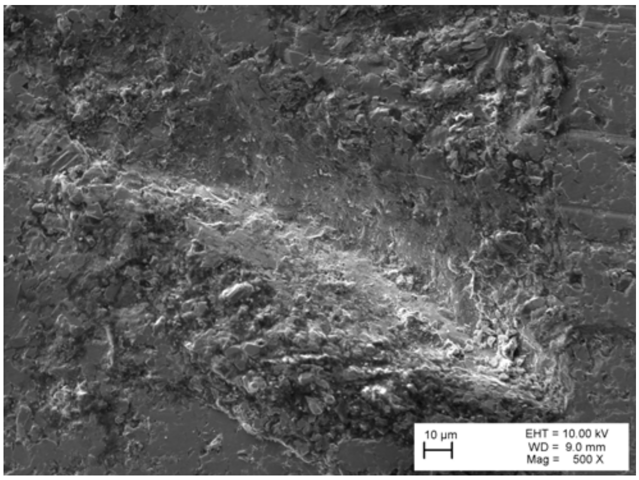
Fig. 4. Worn surface of Cr_3C_2 – 10 % Ni cermet



a



b



c

Fig. 5. Worn surface of Cr_3C_2 – 30 % Ni cermet

The SEM images of the worn surfaces of Cr_3C_2 – 30 % Ni cermet are shown in Fig. 5. The wear mechanism for high binder content cermet observes the same behaviour as for low binder material, the plastic deformation of the binder phase, the forming of the walls and the crushing and removing of weak carbide network and carbide grains.

4. CONCLUSIONS

1. The impact wear behaviour of chromium carbide cermets made by different technologies was investigated.
2. The impact wear resistance depends on the chemical composition (binder content) and on the cermets producing technology; volumetric wear rate increases

in increase of the binder content and decrease of the bulk hardness, better wear resistance for low binder content materials exhibited cermets made by using chromium carbide produced by indirect synthesis.

3. The impact wear mechanism of the investigated materials concluded in plastic deformation of binder phase and the concurrent crushing of carbide network and carbide grains, during those processes some of the material is removed from the surface.

Acknowledgements

The Estonian Ministry of Education and the Estonian Science Foundation (grant No. 6758) supported this work.

REFERENCES

1. **Kayuk, V. G., Masljuk, V. A., Kostenko, A. D.** Tribological Properties of Hard Alloys Based on Chromium Carbide *Powder Metallurgy and Metal Ceramics* 42 2003: pp. 257 – 261.
2. **Letunovits, S., Viljus, M., Pirso, J.** Sliding Wear of Cr_3C_2-Ni Base Cermets *Materials Science* (*Medžiagotyra*) 8 (4) 2002: pp. 477 – 480.
3. **Kayuk, V. G., Masljuk, V. A., Yuga, A. I.** Production, Mechanical and Tribological Properties of Layered Composite Materials Based on a Chromium Carbide Alloy *Powder Metallurgy and Metal Ceramics* 42 2003: pp. 31 – 37.
4. **Hussainova, I., Pirso, J., Viljus, M.** Processing and Tribological Properties of Chromium Carbide Based Cermets *Proceedings of World Congress on Powder Metallurgy and Particulate Materials* USA, Metal Powder Industry Federation 6 2002: pp. 166 – 173.
5. **Pirso, J., Viljus, M., Kübarsepp, J.** Abrasive Erosion of Chromium Carbide Based Cermets *Proceedings of the 9th Nordic Symposium on Tribology* NORDTRIB 2000, Porvoo, Finland 3 2000: pp. 959 – 967.
6. **Tkachenko, Yu. G., Klimenko, V. N., Gorbatov, I. N., Masljuk, V. A., Jurchenko, D. Z.** Friction and Wearing of Chromium Carbide-Nickel Alloys at Temperatures of 20-1000 °C *Poroshkovaya Metalurgiya* Kiev, Ukraine 11 1978: pp. 60 – 63 (in Russian).
7. **Kulu, P., Tarbe, R., Vallikivi, A.** Abrasive Wear of Powder Materials and Coatings *Materials Science* (*Medžiagotyra*) 11 (3) 2005: pp. 230 – 234.
8. **Saarna, M., Kulu, P., Veinthal, R., Tarbe, R.** Study of Surface Fatigue of Wear Resistant Powder Metallurgical Materials *Proceedings of the Estonian Academy of Sciences Engineering* 12 (4) 2006: pp. 377 – 387.
9. **Kulu, P., Veinthal, R., Saarna, M., Tarbe, R.** Surface Fatigue Processes at Impact Wear of Powder Materials *Wear* 263 2007: pp. 463 – 471.
10. **Pirso, J., Viljus, M., Letunovits, S.** Friction and Dry Sliding Wear of Cermets *Wear* 260 2006: pp. 815 – 824.
11. **Pirso, J., Viljus, M., Letunovitš, S., Juhani, K.** Reactive Carburizing Sintering – a Novel Production Method for High Quality Chromium Carbide – Nickel Cermets *International Journal of Refractory Metals & Hard Materials* 24 (3) 2006: pp. 263 – 270.
12. **Letunovitš, S.** Tribology of Fine Grained Cermets *Doctoral Theses of Tallinn Technical University* TTU Press Tallinn, Estonia, 2003.
13. **Tarbe, R., Kulu, P.** Impact Wear Tester for the Study of Abrasive Erosion and Milling Processes *Proceedings of the 6th International DAAAM Baltic Conference "INDUSTRIAL ENGINEERING"* Tallinn, Estonia 2008: pp. 561 – 566.

Presented at the 17th International Conference
"Materials Engineering'2008"
(*Kaunas, Lithuania, November 06 – 07, 2008*)