Technologies and Properties of Modern Utility Materials XXIII

Edited by
Agnieszka Szczotok, Agnieszka Szkliniarz
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Selected, peer reviewed papers from the
XXIII Conference on
Technologies and Properties of Modern Utility Materials
(TPMUM 2015),
May 15, 2015, Katowice, Poland

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Trans Tech Publications Ltd
Churerstrasse 20
CH-8808 Pfaffikon
Switzerland
http://www.ttp.net

Volume 246 of
Solid State Phenomena
ISSN print 1012-0394
ISSN cd 1662-9787
ISSN web 1662-9779

(Pt. B of Diffusion and Defect Data - Solid State Data (ISSN 0377-6883))

Full text available online at *http://www.scientific.net*

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PREFACE

We are pleased to present the proceedings of The XXIII Conference on Technologies and Properties of Modern Utility Materials (TPMUM 2015) held on May 15, 2015 and hosted by The Faculty of Materials Engineering and Metallurgy of Silesian University of Technology in Katowice, Poland (www.wimim.polsl.pl).

The Faculty of Materials Engineering and Metallurgy is one of sixteen Faculties of Silesian University of Technology. The Faculty structure consist of four departments: Institute of Metals Technology, Institute of Materials Science, Department of Production Engineering and Department of Industrial Informatics.

The TPMUM Conference is organised annually in conjunction with the celebration of National Metallurgist's Day in Poland. It is the occasion for faculty members, students and guests to share and discuss the results of their research and plans for the future development of the Faculty. The scope includes topics related to materials engineering, in particular, advanced analytical methods in materials science, development and application of metal alloys, ceramics, composites, their processing techniques and related environmental issues.

In addition to plenary and seminar sessions a poster session open to participants and faculty students is also organised. Selected, peer reviewed papers are published.

This year's proceedings include 62 papers peer reviewed by international specialists from Turkey, Portugal, the United States of America, South Africa, Poland, Czech Republic, Slovakia, Germany, and Romania. Papers are categorised in four chapters:
I. Analysis, Testing and Properties of Materials, II. Surface Engineering and Corrosion Resistance, III. Processing Technologies, and IV. Decisions in Area of Industrial Engineering. Chapter I concerns with microstructure studies and correlation between microstructure and properties of materials. Chapter II contains papers related to the development of protective coatings and other methods that increase corrosion resistance of metal alloys. Chapter III. related to development of materials processing techniques and evaluation of materials properties during processing Chapter IV includes papers that describe waste and industrial management, environmental impact of materials processing industry and optimization of processing technologies.

Conference should be considered a success. As the Editors of this proceedings we would like to thank all participants for their attendance and the effort with preparing the papers. We appreciate all reviewers' effort and expertise in contribution to reviewing.

Editors

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ISSN: 1662-9779, Vol. 246, pp 3-6
doi:10.4028/www.scientific.net/SSP.246.3

Submitted: 2015-05-30
Revised: 2015-10-26
Accepted: 2015-10-26

Application of Micro Wear Testing in Investigations of Super Coarse WC-Co Type Sintered Carbides

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Keywords: Sintered carbides, super coarse grains, alternative binders, mechanical properties.

Abstract. The mico-wear abrasion test has recently become a popular method for the measurements of wear resistance of both coated and solid materials. It provides insight into abrasion micromechanisms and quantitative information (wear coefficient) of the tested samples. The investigated super coarse WC-Co composite (WC particles average size of 6-10 μm) reveals the biggest fracture resistance within the whole size range of sintered carbides, at the certain expense of hardness. Super coarse grades are used, among other, as coal mining tools and rock cutting/driling bits. In this work, ball-cratering wear tests were performed using 1 μm diamond particles as the abrasion medium; the abrasives used produced well-defined craters. The worn areas were observed and measured using optical and electronic microscopy, the wear coefficient was calculated based on the increasing sliding distance method. It was found that super coarse sinters abraded with 1 μm diamond grains were more wear resistant than the more fine grained counterparts. This result is attributed to the influence of the large size ratio of WC particles and diamond grains and consequent stronger WC embeding in the metal matrix.

Introduction

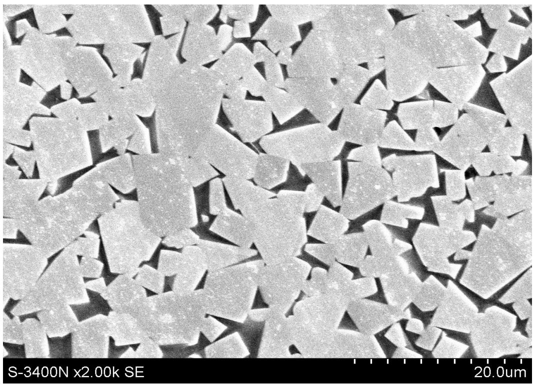
The ball cratering wear test is more and more popular as a method for the small-scale tribological evaluation of bulk and coated materials abrasion resistance. In this type of testing a fine abrasive medium has been applied. Silicon carbide with a 4 μm grain size is the most common type of abradant; however , the use of other abrasives is possible and allowed [1,2].

WC-Co sintered carbides possess a favourable combination of high hardness, reasonable fracture toughness and high wear resistance. Tungsten carbide-cobalt binder hardmetals are employed in a wide variety of application, especially where mechanical stressing occurs, for example mining, masonry, wood and metal cutting and drilling tools. Commonly the producers recommend the fine grained hardmetals for abrasion resistant applications at possibly mild impact loads, whereas coarse grained grades are intended for more severe situations regarding possible brittle fracture. The properties of WC-Co sinters strongly depend on the WC grain size and the cobalt content. Variation of these factors can also be expressed in terms of changes in Co mean free path, which is the essential element in controlling the thermo-mechanical fatigue behavior in WC-Co materials. Typically a correlation between the WC grain size (hence hardness) and wear resistance has been observed [3,4,5]. Nevertheless, certain works [3,6] report a higher wear resistance of materials of a coarser microstructure, especially in mild (low load) abrasion situations.

Material for examination

Samples of super coarse WC - 9.5 wt.% Co composite have been examined. For comparison reasons samples of a submicrometre grained grade with similar cobalt binder content have been tested; the bulk hardness of the samples amounts 1600 HV30 (submicrometre) and 1050 HV30 (super coarse). Examples of the microstructures of the sinters investigated are shown in Fig. 1.

a) b)



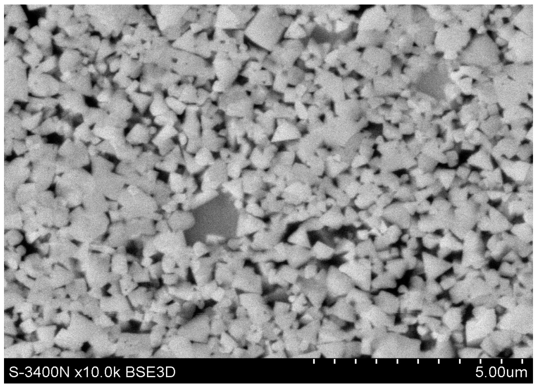


Fig. 1. Scanning electron microscopy micrograph of WC-Co with super coarse (a) and super fine grain size (b)

Experimental procedure and results

The geometry of the crater produced through the micro-wear testing is assumed to reproduce the ball geometry. The wear volume can be related to the total distance of sliding, *S*, and the applied normal load, *N*, by a model which is equivalent to the Archard equation for sliding wear:

$$V = k \cdot S \cdot N \qquad [m^3] \tag{1}$$

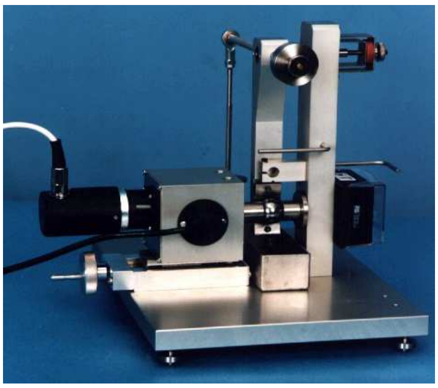
where k is the wear coefficient.

The volume of the crater formed with a diameter *b*, resulting from the use of a metal ball with a diameter $2 \cdot R$, for b <<*R* is approximately equal to:

$$\pi \cdot b^4 / 64 \cdot R \qquad [m^3] \tag{2}$$

In the current work a Plint Te-66 Phoenix Tribology device was used (Fig. 2a). A steel ball of 25mm diameter was driven directly by clamping the ball against the co-axial driver shafts. A specimen was loaded against the rotating ball by a dead weight hanging from a lever arm in the presence of an abrasive slurry (Fig. 2b).

a) b)



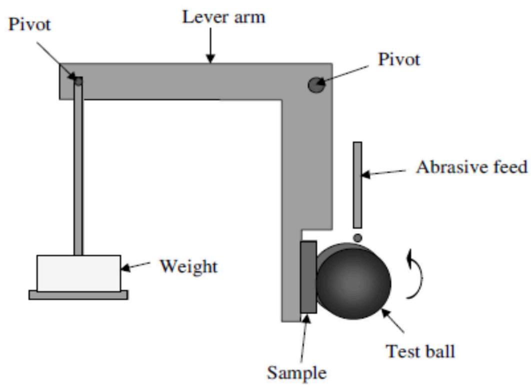


Fig. 2. Plint TE-66 micro-abrasion tester (a) and schematic diagram of the micro-scale abrasion apparatus (b) [2,7]

The tests were carried out under the same conditions, at a constant load of 0.4 N and a sliding speed of 0.05 $m \cdot s^{-1}$. Because the commonly used 4 µm SiC abrasives in case of the super coarse samples proved to produce very ill-defined craters, a diamond slurry with a mean particle size of 1 µm as abrasive was applied. The results were obtained from a series of increasing wear distances of 10 to 30 m.

The craters obtained and the morphology of the resulting wear of the super coarse and fine grades caused by the diamond slurry are presented in Fig. 3. The increase of the crater volume with the value of the S·N product for super coarse WC-Co samples is presented in Fig. 4. The abrasion coefficient was calculated as the value of the straight line slope and amounted 3.88 x 10^{-13} $m^2 \cdot N^{-1}$ for the super coarse sample and 6.09 x 10^{-13} $m^2 \cdot N^{-1}$ for the fine grained sinter.

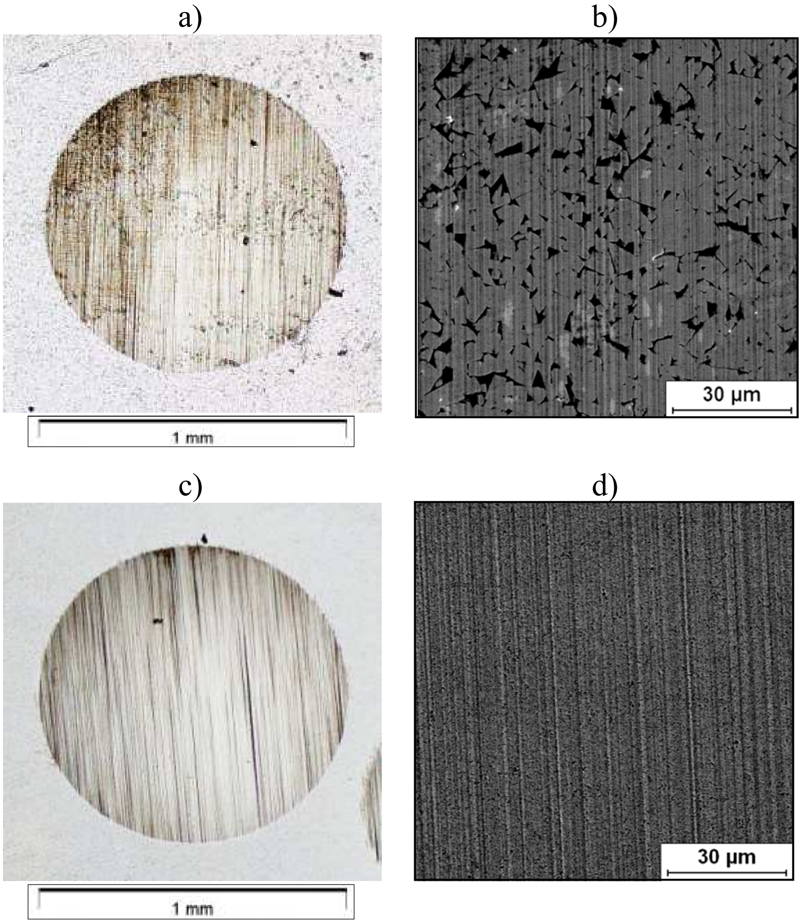


Fig. 3. Craters after 30 m distance abrasion and wear scars morphology of the super coarse WC-Co sample (a,b) and fine grade sinter (c,d)

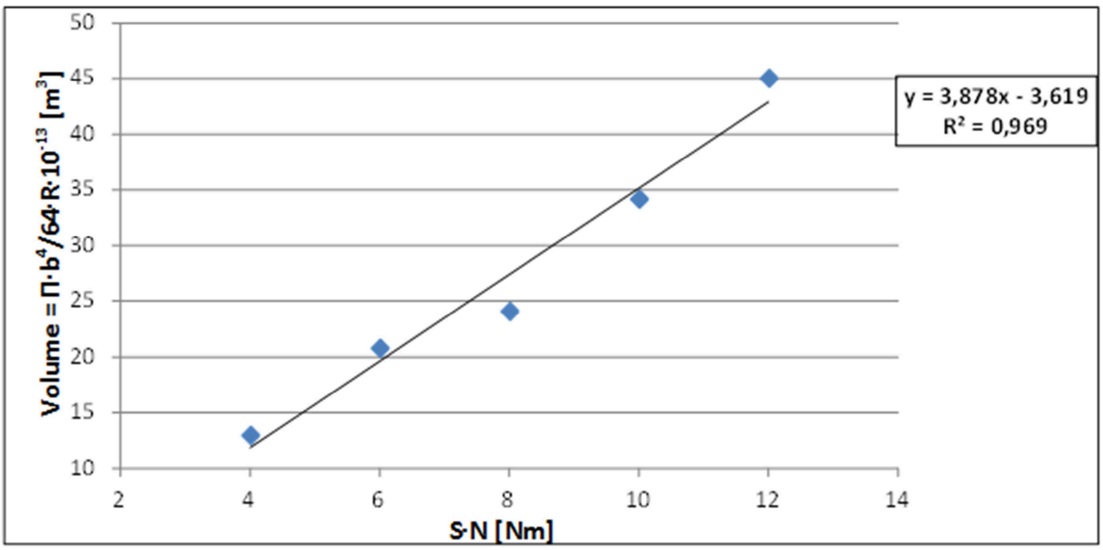


Fig. 4. Development of worn crater volume vs normal load and sliding distance product (super coarse sintered carbides abraded with 1 µm grain size diamond abrasives)

Summary and conclusions

The general view regarding wear resistance increase with material bulk hardness considers mainly metals and alloys. In the case of multiphase materials with hard particles, the wear micromechanisms are more complicated. Among others grain size, or rather the ratio of sizes of abrasive particles to hard phase particles becomes a structural factor controlling the wear resistance.

The result obtained – an increase of micro wear resistance with grain size in WC-Co sinters, can be attributed to a few interrelated factors:

- in micro wear cratering the test conditions, especially the small load applied, is not conducive to WC grains fracturing,
- the high surface to volume ratio of WC particles in the super coarse grade increases their embedding in the cobalt matrix,
- in case of the bigger grain size of the super coarse samples, abrasion of the metal matrix enabling individual WC particles pullout is deeper (hence more difficult) as compared to the much more fine grained sintered carbide samples.

Owing to these structural factors the wear resistance measured through ball cratering using a 1 μm diamond particle abrasive proved to be higher for the super coarse sintered carbide grade in spite of its lower bulk hardness. This finding might extend the possible application range of super coarse hardmetals for fracture and mild wear resisting situations.

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Solid State Phenomena
ISSN: 1662-9779, Vol. 246, pp 7-10
doi:10.4028/www.scientific.net/SSP.246.7

Submitted: 2015-06-02
Revised: 2015-09-07
Accepted: 2015-10-05

Assessment of the Acoustic Properties in Octavo Bands for Selected Polyurethane Materials

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Keywords: noise, sound absorption coefficient, polyurethane materials, Kundt's tube.

Abstract. The article presents the acoustic properties of selected polyurethane materials. The study involved a porous polyurethane foam primary and secondary, for whom assigned the value of sound absorption coefficients in the frequency range of 100-1250 Hz. The study was conducted in impedance tube Kundt.

Introduction

Noise is one of the factors that has particular negative impact on the environment, and thus on the man in his life. Costs related to exposure to noise shall be borne by all of society, including losses in production, decline in the quality of services, damage to the health of workers. Consequently, any solution which may contribute to a reduction of noise are most desirable.

The article presents the results of measurements of sound absorption coefficients of polyurethane materials which, due to its structure can be applied to reduce noise during ongoing processes. There are a broad class of materials which have the sound-absorbing properties, but due to its form (granules, wool), the mass burning properties, strength can not find an industrial application. The selection of sound-absorbing material, in addition to the physical parameters of the same material, requires consideration of the specifics of ongoing processes.

Characteristics of research material

For testing was chosen foamed polyurethane primary and secondary. Polyurethanes are among the segmented polymers, consisting of alternating segments of rigid and flexible. They are not pure plastics, but polymers of different chemical composition [1]. The properties of these materials depends mainly on the form and purpose. By analyzing their functional forms can be distinguished [2]:

- flexible foams are characterized by open pores, which under pressure have little resistance to strain gauge,
- rigid foams characterized by high resistance of the strain gauge under pressure, which are characterized by low thermal conductivity and ease of connection to the facings,
- integral foam structure differs depending on the manufacturing process (flexible foam, rigid, glass fiber),
- engineering plastics, polyurethane preparation in the form of moldings, sheets, films, and thick coatings.

For the tests were initially foamed polyurethane materials labeled "P1" having a density of 22 [kg/m^3], and "P2" with a density of 25 [kg/m^3]. Secondarily foamed materials labeled "W1" – the density of 220 [kg/m^3] and "W2" – a density of 240 [kg/m^3]. For testing was used a sample having a thickness of 40 mm.

Characteristics of the test method

One of the parameters characterizing the materials, products and soundproof – insulating structure is the sound absorption coefficient. Sound absorption is a phenomenon collection of acoustic energy