

Al-W-B powder materials

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Received 30 June 2009, in revised form 9 November 2009

Abstract. Al-W-B composite materials, obtained by hot pressing of separate layers of the fibres, previously covered with aluminium by thermal spraying, containing from 25% to 60% of B-W fibres, have been studied. The structure and some characteristics, in particular microhardness, of the materials and the possibility of crushing the Al-W-B material wastes into a powder were investigated. It has been shown that the bulk density of the final powder depends on the degree of crushing and microhardness of the solid phase, and the bulk density of the aluminium matrix of Al-W-B composite powders varies significantly. The compressibility of powders was investigated by the method of cold pressing and electrosintering and the properties of the obtained briquettes were studied. The samples after cold pressing and sintering had the density range from 2.1 to 2.3 g/cm³ and the compression strength from 70 to 90 MPa. Possible fields of application of powdered Al-W-B alloy materials, such as manufacturing of grinding tools, are considered.

Key words: boron-containing materials, Al-W-B powder, W-B fibres, aluminium matrix, crushing, pressing.

1. INTRODUCTION

Fibrous composite materials with a metal matrix are effectively used in modern industry because of their high durability, light weight and other valuable properties [1]. Among such materials, aluminium composites, reinforced by the fibres of boron, tungsten and carbide of silicon, are widely known [2,3]. The properties of such composites, depending on the technological parameters of the manufacturing process, the volumetric maintenance of fibres and other factors, are considered in [3].

Al-W-B materials are environmentally hazardous, so that their utilization is of great importance. Technological wastes, generated at various stages of manufacturing the Al-W-B composites (during manufacturing of W-B fibres, applying the Al-coating on a fibre, pressing the layers of the fibres, etc.) may be recycled.

One of the new fields of application of technological wastes of boron-aluminium composites is their crushing into a powder. The powders may be used

for production of new heterogeneous materials with different properties. The first results of this kind of applications were considered in [4].

2. CHARACTERISTICS OF Al-W-B TECHNOLOGICAL WASTES

W-B fibres were made by the method of boron tri-chloride deposition onto a tungsten fibre base with the thickness of 10 μm . The unidirectional structure of the W-B fibres makes them well fixed in the aluminium matrix.

The strips of the W-B fibres (Fig. 1) with a diameter of 70–90 μm , which are parallel and previously covered with the aluminium coating of 10 μm by thermal spraying, had a width of 40 mm and a length of 250 mm [5].

During crushing, axial destruction of the W-B fibre and exfoliation of the aluminium matrix take place (Fig. 2a), and the matrix becomes flat-shaped (Fig. 2b).

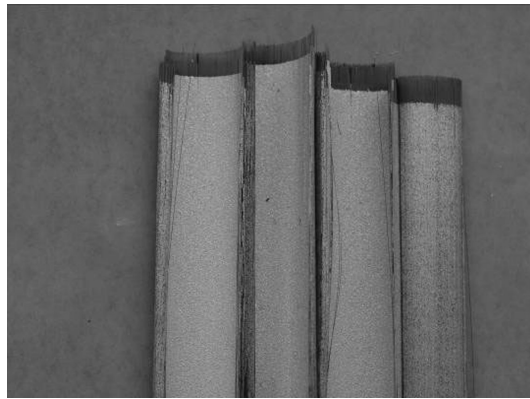


Fig. 1. Al-W-B strips.

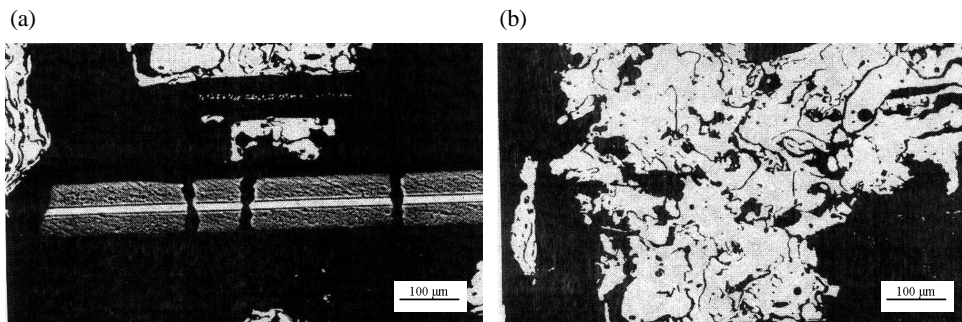


Fig. 2. Microstructure of the Al-W-B powder after grinding of non-sintered prepreps in a disk vibrating mill: a – W-B fibre; b – aluminium matrix.

A number of Al-W-B strips are piled, layer by layer, forming a multilayer structure, and hot-pressed at the temperature of 650–700 °C (Fig. 3).

Technological wastes in the form of pipes (Fig. 4) and plates were formed by grinding.

Grinding of the technological wastes was carried out on the equipment of Fritsch Company, using consecutively a lab-type jaw crusher, a disk vibrating mill and a rotor speed mill [6]. It is possible to separate a fraction of W-B from the aluminium matrix at an early stage of the initial large-scale grinding (Fig. 5).

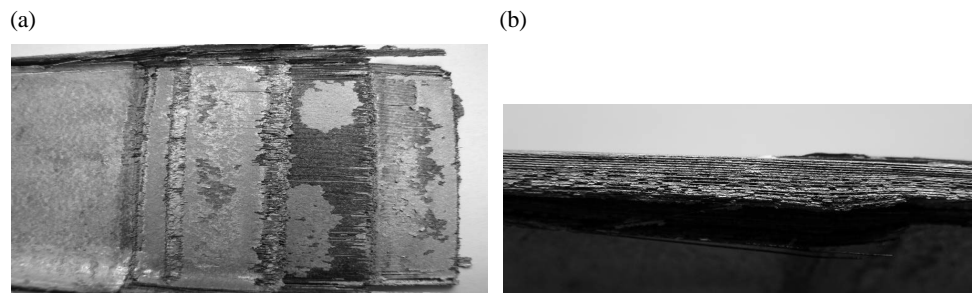


Fig. 3. Structure of Al-W-B strip: a – top view; b – cross-section.



Fig. 4. Technological wastes after hot pressing and drawing of Al-W-B prepregs.

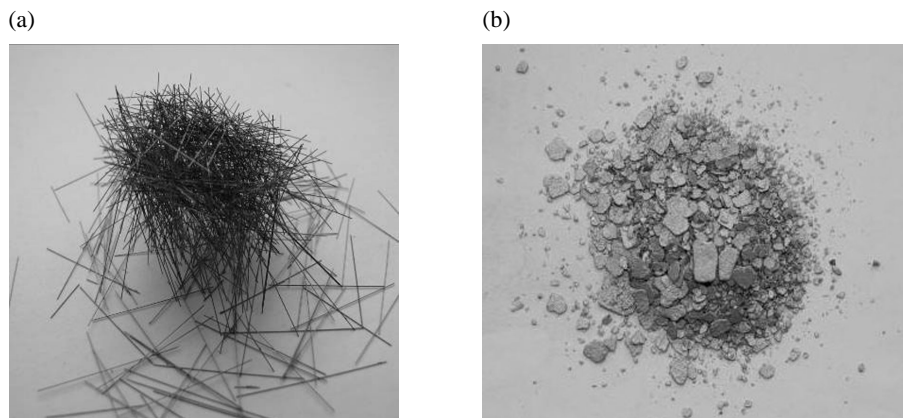


Fig. 5. W-B fibre (a) and Al matrix material (b) after crushing and separating.

Grinding in a disk vibrating mill was carried out till the size of the particles was in the range of 0.1–0.8 mm (Fig. 6).

Determination of the dimensions of powder particles was performed using the Fritsch vibration screen Analyzette 3 [6]. The histogram of particle size distribution (Fig. 7) shows a wide spread of the particle sizes in the range of 5–200 μm .

The final crushing was carried out in a planetary ball mill until the particles size was in the range of 5–10 μm .

Microhardness test method was used for the estimation of mechanical properties of the powder particles. The dependence of the depth of an indenter on the microhardness characterizes the particles. The microhardness tests were performed using the original device, described in [5].

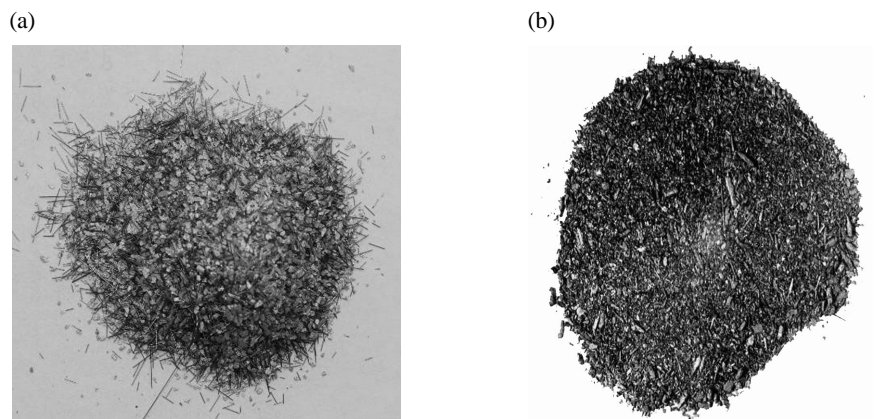


Fig. 6. Al-W-B powder after grinding: a – in the disk vibrating mill; b – in the disk rotor mill.

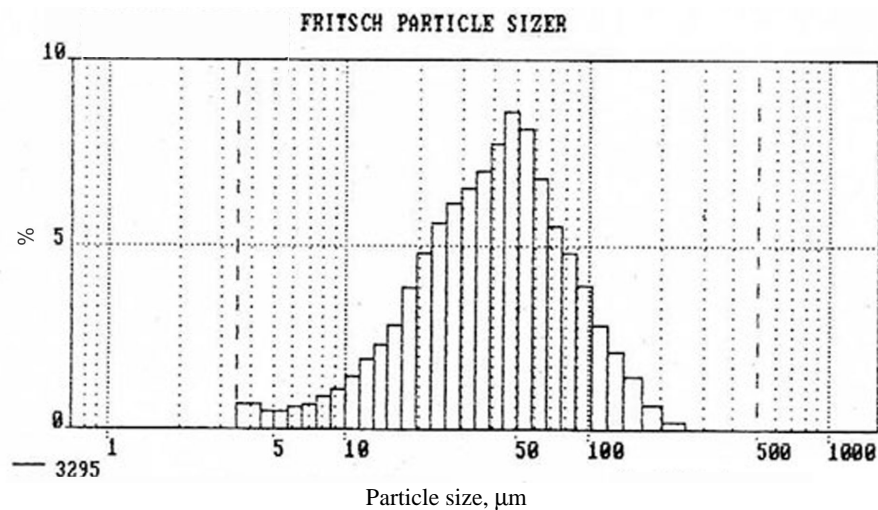


Fig. 7. Histogram of the Al-W-B powder particle size distribution.

The microhardness of a B-W fibre remained high (from 56 to 70 GPa) at all stages of crushing. It can be explained by the formation of hard phases during coating the heated fibre with boron (Table 1).

At the same time, the microhardness of the aluminium matrix at the moment of crushing increased from 1.0 to 4.5 GPa (Fig. 8).

The microstructure of the particles of the composite Al-W-B powder is represented in Fig. 9. The mentioned microstructures show a needle-shaped diamond-like structure of fibres. Matrix material can be easily removed by repeated grinding [7].

Table 1. Bulk density and microhardness of Al-W-B powders, obtained by crushing hot-pressed composites

No. of sample	Bulk density, g/cm ³	Size of particles, mm		Microhardness of particles, GPa	
		Al	W-B	Al	B
Al-W-B (1)	0.60	1.5–2.5	2.5–5.0	2.3	70
Al-W-B (2)	0.75	1.0–1.5	2.0	4.3	56
Al-W-B (3)	1.0	0.2–0.5	1.0	4.3	60

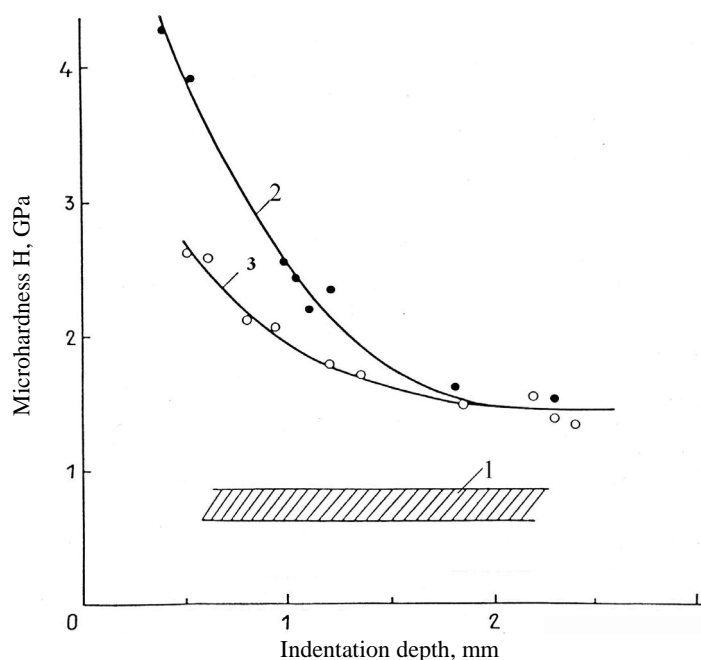


Fig. 8. Dependence of the microhardness on the indentation depth for Al matrix: 1 – before crushing; 2 – after crushing; 3 – after annealing by temperature 560 °C.

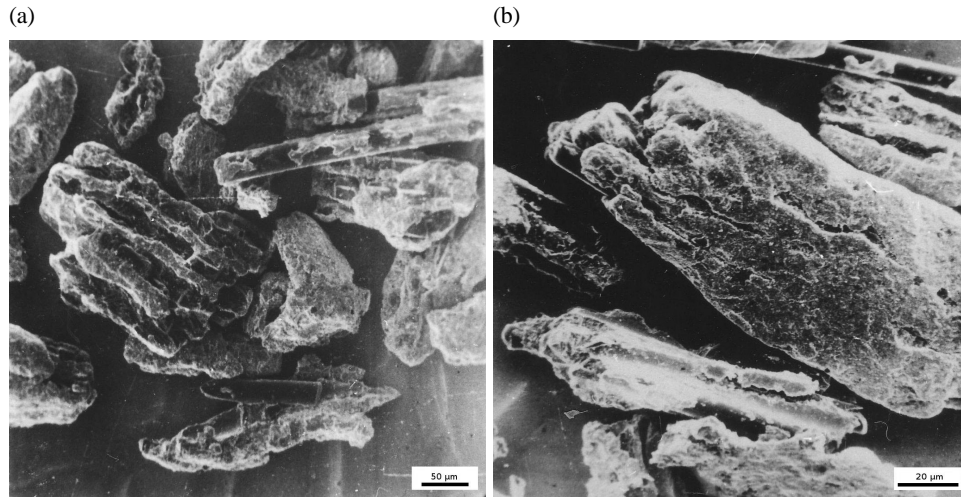


Fig. 9. Microstructure of Al-W-B composite powders after grinding in the vibrating mill: a – 3 min; b – 10 min.

3. POTENTIAL AREAS OF APPLICATION OF Al-W-B COMPOSITE POWDERS

A preliminary study of the microstructure and properties of the new material allows us to make suggestions on some technological opportunities of its application.

One of them is using Al-W-B composite powders for the production of grinding and polishing tool cutters. For production of cutters, crushed Al-W-B composite powders were mixed with cement, copper or bakelite, bonded and compacted by pressing (Fig. 10).

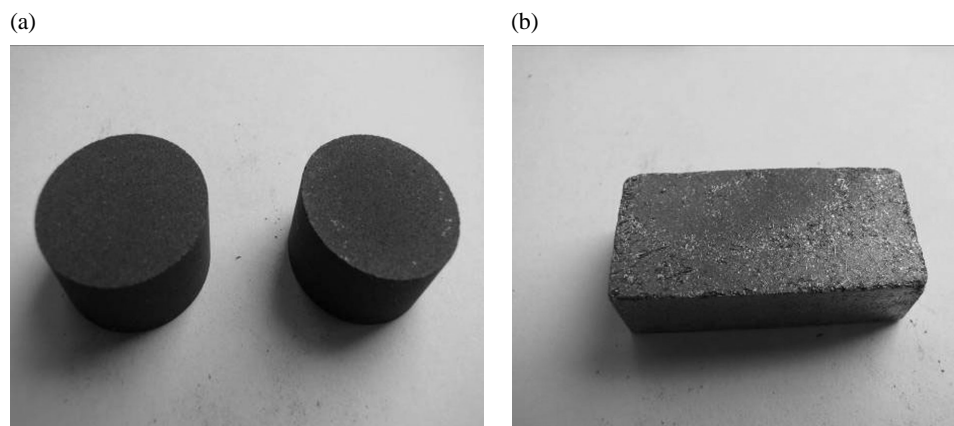


Fig. 10. Grinding elements with Al-W-B powder: a – on bakelite bond; b – on copper bond.

The samples on the copper bond had undergone electrosintering in an electric resistance machine. The sintered samples had a density of 2.1–2.3 g/cm³ and compression strength of 70–90 MPa.

Testing of the cutting properties was performed on a friction machine. The test results confirmed that this application area is promising. However, further investigations of the properties of the new material are necessary.

4. CONCLUSIONS

During the research, the possibility and effectiveness of crushing of technological wastes of boron-aluminium composites into a powder were shown. The size, properties and form of the particles depend on the method and duration of crushing. Due to the high residual hardness of crushed fibres and crystal-like shape of the particles, there is a possibility of their application for manufacturing some types of grinding and polishing tools.

ACKNOWLEDGEMENT

In the preparation of the samples, students E. Mihailova and A. Shishkin have taken part.

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Al-W-B-pulbermaterjalid

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Uurimisobjektiks olid eelnevalt alumiiniumiga kaetud B-W-kiudude (25%–60%) kuumpressimise teel saadud Al-W-B-komposiitmaterjalid. Uuriti nii komposiitmaterjalide struktuuri ja mikrokõvadust kui ka nende jäätmetest pulbrit

saamise võimalust jahvatamise teel. Selgitati välja, et lõpp-produkti – pulbri – tihedus varieerub laiades piirides ja sõltub eelkõige jahvatusastmest ning tardfaasi mikrokõvadusest. Pulbrite pressitavust uuriti külmpressimise ja elektrisädepaagutuse teel. Saadud toorikute tihedus oli piirides 2,1–2,3 g/cm³ ja survetugevus vahemikus 70–90 MPa. On vaadeldud mõningaid Al-W-B-sulamite pulbrite kasutusvõimalusi, näiteks lihvtööriistade valmistamisel.