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Mechanical properties of WC/Co cemented carbide with larger WC grain size

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Abstract

The mechanical properties of WC/Co cemented carbide with WC grain size of up to 30 μm are investigated through compressive and transverse rupture tests, because it is now to produce WC/Co cemented carbide of which grain sizes are from 20 to 30 μm. From testing specimens with a WC grain size of 3–30 μm and Co content of 5–20 wt.%, it is found that WC/Co cemented carbide with larger WC grains (20–30 μm) exhibit ductility, whereas smaller-grained materials are characteristically brittle.
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Keywords: WC/Co cemented carbide; WC grain size; Co content; Ductility; Brittleness; Strength

1. Introduction

WC/Co cemented carbide bits are currently used in tunnel boring. For such applications, the bits must have a long lifespan due to the difficulty in replacing bits during tunnel excavation. Our group has been conducting research on prolonging the life of WC/Co cemented carbide bits by improvement of mechanical properties [1–3]. The effect of WC grain size and Co content has been investigated extensively. Stephenson et al. [4] examined these variations and the effect of heat treatment on the fatigue properties, and Porat and Malek [5] has reported the change in mechanical and magnetic properties. Milman et al. [6] reported the Vickers hardness of materials of various compositions at temperatures between −196 and 900 °C, and Fal'kovskii et al. [7] determined the hardness, rupture force, compressive strength and stress intensity factors. Through this research, it has been determined that the compressive or tensile strength breakage strength increases with decreasing WC grain size. However, previous research has only considered WC grain sizes of 10 μm or less, for it was not possible to produce WC/Co cemented carbide having WC grain sizes larger than 10 μm.

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While, the present authors can now produce WC/Co cemented carbide of which WC grain sizes are from 20 to 30 μm.

In the present study, the mechanical properties of WC/Co cemented carbide with large-grain WC are examined through compressive and transverse rupture tests.

2. Methods

Tests were conducted on WC/Co cemented carbide with various WC grain sizes and Co contents. Test specimens with a Co content of 10 wt.% were prepared with WC grain sizes of 3, 6, 20 and 30 μm. Another set of specimens having a WC grain size of 20 μm and Co contents of 5, 10, 15 and 20 wt.% were evaluated. Three specimens were used for each set of experimental conditions.

Compressive tests were carried out to determine the stress–strain diagram, Young's modulus and Poisson's ratio. Fig. 1 shows the experimental setup for these tests. The test pieces were 10 mm in diameter and 20 mm in length, fixed to a WC/Co cemented carbide platen. Biaxial strain gages (KFG-1-120-D16-11L3M2S, Kyowa Electronic Instruments) were set at symmetrical positions on either side of the test piece. Teflon sheets coated with molybdenum grease (MoS_2) were inserted between the test piece and the platen to lower the friction at the interface.

A universal testing machine (UH-1000 kNA, Shimadzu) was used for these tests at a strain rate of less than 0.003%/s [8] to ensure semi-static force. The strain was measured using a PCD-300A instrument (Kyowa Electronic Instruments).

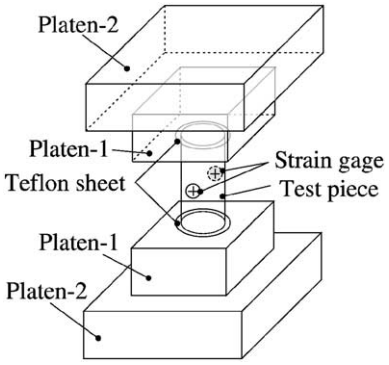

Fig. 1. Compressive tests.

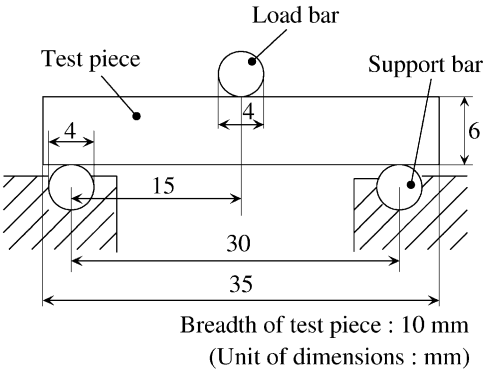

Fig. 2. Rupture tests.

The tensile strength is usually determined by tensile tests. However, due to the extreme hardness of the cemented carbide, which makes it difficult to cut appropriately shaped pieces for tensile testing, a transverse rupture test was conducted using a three-point bending instrument based on the Japanese Industrial Standard JIS H 5501. The test configuration is shown in Fig. 2. The test pieces were rectangular in shape and supported on two cylindrical

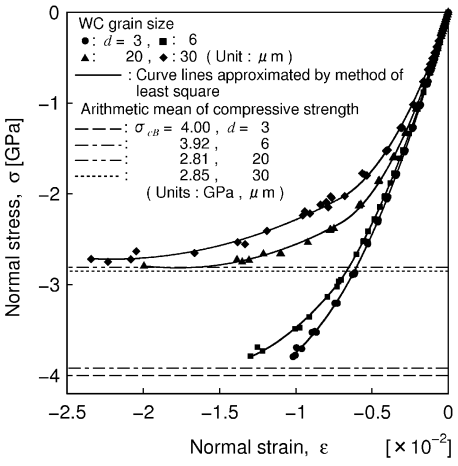

Fig. 3. Stress–strain diagram determined by compressive test for WC/Co cemented carbide with various WC grain sizes and a Co content of 10 wt.%. Three specimens were used for each set of experimental conditions. Arithmetic means for determination of compressive strength are indicated by straight lines.

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