Wear and Impact Properties of Harmonic Structure Composites with Cemented Carbide/High-Speed Steel

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Dies can mass-produce the same shaped products and are indispensable in modern industries. A high hardness and high toughness metal is used for the die material. The hardness affects to the wear resistance of the die material and the toughness affects to die life. However, the relationship between hardness and toughness is a trade-off. Thus, it is difficult to provide the two properties at the same time. To achieve both high wear resistance and high toughness, a harmonic structure composite that combines cemented carbide with a high hardness and high-speed steel with a high toughness is fabricated by a mechanical milling and spark plasma sintering process. The microstructure of the harmonic structure composite consists of a three-dimensionally network area of a hard material and distributed areas of relatively soft material. In this study, the harmonic structure composite with high-hardness cemented carbide in the network area and high-tough ness high-speed steel in the dispersed area is investigated the microstructure and wear and impact properties in detail.

Cemented carbide powder (WC-13%Co) and high-speed steel powder (Fe-1.27C-4.12Cr-4.92Mo-2.92V-5.89W) were used in this study. These powders were mechanically milled using a planetary ball mill equipment with an SKD11 vessel and cemented carbide balls (ϕ5 mm) in Ar atmosphere at room temperature. Mixed powder consisting of cemented carbide (15 g) and high-speed steel (35 g) was mechanically milled at a ball-to-powder weight ratio of 2 : 1, an MM time of 345.6ks and a rotation speed of 150 rpm. The MM powder was sintered an SPS apparatus at 1223 K and 100 MPa for 0.6 ks. The wear test was performed using a ball-on-disk type friction wear tester under the conditions of a load of 10 N, a rotation radius of 3 mm, a rotation speed of 300 rpm, and a sliding distance of 56.5 m. The wear properties were evaluated by calculating the comparative abrasion quantity. In an impact property evaluation, a split-Hopkinson bar type compression impact test was performed under the condition of an impact bar ejection pressure of 1.0 to 1.5 MPa.

Figure 1 shows an electron micrograph of the cemented carbide/high-speed steel harmonic structure composite. The bright area corresponds to the cemented carbide area with the network connected throughout the microstructure. On the other hand, the dark field corresponds to the high-speed steel area, which is distributed between the cemented carbide networks.

The specific wear amount of the cemented carbide/high-speed steel harmonic structure composite was 3.23×10^{-15} m^3/Nm for the 1223K sintered body and 2.12×10^{-15} m^3/Nm for the compact sintered at 1173K. The specific wear amount at a ratio of 30% carbide shows excellent values from the point of view of the rule of mixture. Also, the impact absorption energy density to fracture of the cemented carbide/high-speed steel harmonic structure composite was about 500 MJ/m^3. It showed a value about twice the impact absorption energy density of a cemented carbide compact. The cemented carbide/high-speed steel harmonic structure composite demonstrates high wear resistance and excellent impact resistance.

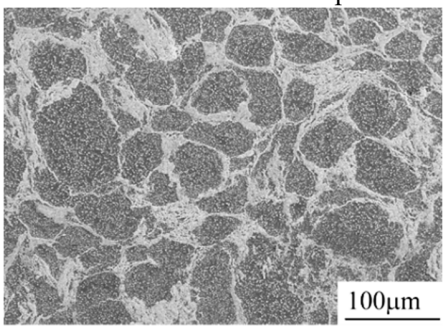

Fig.1 SEM micrograph of the cemented carbide / high speed steel harmonic structure composite.