Proper Composition of Coated Particles for New Cemented Carbide Material

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Introduction

Regarding the history of WC-Co cemented carbides, efforts to improve the hardness were made for high-speed cutting tools. The cutting at faster speed and deeper depths results in increased removal rates and, consequently, cost-efficient machining. At the same time, this will cause significant heat generation, which exceeds the capabilities of cemented carbides. In addition to inherent high hardness, TiC and Al_2O_3 ceramics have the potential to improve it, because TiC ceramics possess higher thermal-shock resistance and thermal conductivity and Al_2O_3 presents higher refractory capabilities, good wear resistance, and chemical stability.

The present study is to investigate a proper composition of TiC and Al_2O_3 additions to give superior hardness property.

Experimental

WC (WC60-41400N), d_{50} = 6 μm is a core particle, Co (UM Cobalt & Energy Products), d_{50} = 1.4 μm is binding or matrix particles, Al_2O_3 (AL-160 SG-3, Showa Dekiko K.K.) d_{50} = 0.5 μm, and TiC (Wako Pure Chemical Industries, Ltd) d_{50} = 0.9 μm are fine particles. All of them were used as the starting material for coated particles. WC-Co/ TiC-Al_2O_3 coated powder contained from 5 to 30wt% TiC, from 5 to 30wt% Al_2O_3 with fixed percentage of 55WC-10Co and was prepared by means of Hybidizer™. The coated powders were sintered under vacuum at pressure of 50 MPa for 5 min. at 1680°C in graphite dies by means of Spark Plasma Sintering (SPS). For comparison, a 90WC-10Co, 55WC-10Co-35TiC, and 55WC-10Co-35Al_2O_3 by weight percent were also fabricated by the same method. The sintered samples were cut off and polished with a series of diamond slurry. Vicker's microhardness (HV1.0) was measured by an indentation method at load 1 kg. Each test was repeated at least five times.

Results and discussion

Hardness properties are summarized in Table 1. Highest hardness was obtained with the addition of 30TiC-5Al_2O_3 by weight percent into cemented carbide composite, and is shown in Fig.1 as well. Figure 1 shows changes in the hardness of WC-Co/ TiC-Al_2O_3 composites with various amount of TiC and Al_2O_3 additions, it is possible to infer the effect of TiC and Al_2O_3 additions on the hardness of composites. As a result, the hardness was increased with higher amount of TiC from 5 up to 30wt%. Whereas the increasing Al_2O_3 additions reduced the hardness. The addition of 0 to 15wt%TiC and 20 to 35wt%Al_2O_3 did not significantly affected the hardness in comparison with a commercial product (CM) and 90WC-10Co (without TiC-Al_2O_3 addition). The higher hardness beyond HV1.0 = 16.7 GPa (CM sample) were obtained with the addition of 20 to 30 wt%TiC and 5 to 15wt%Al_2O_3. With a sample of 35wt%TiC without Al_2O_3 addition lower hardness was obtained. Such a proper composite of 55WC-10Co/30TiC-5Al_2O_3 yields the superior hardness of HV1.0 = 21.4 GPa to suggest the potential to be used as a high-speed cutting tool material.

Table 1. Vicker's hardness of WC-Co/TiC-Al_2O_3 composites

Composition (wt%)	TiC content (wt%)	Al_2O_3 content (wt%)	HV1.0 (GPa)
90WC-10Co*	-	-	16.7
90WC-10Co	-	-	15.2
55WC-10Co	-	35	12.8
55WC-10Co	5	30	14.4
55WC-10Co	10	25	15.1
55WC-10Co	15	20	15.7
55WC-10Co	20	15	18.0
55WC-10Co	25	20	19.5
55WC-10Co	30	5	21.4
55WC-10Co	35	-	20.2

*Commercial product (CM)

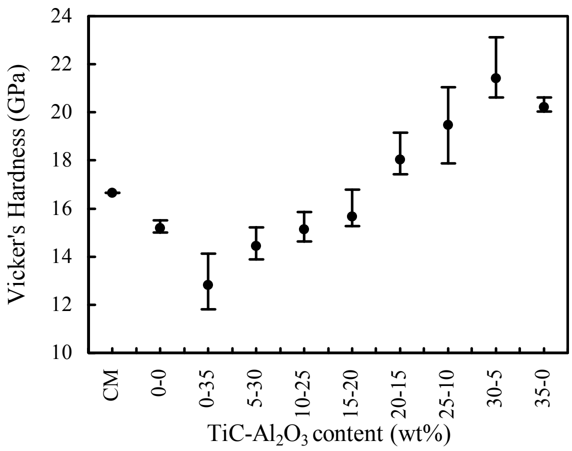

Fig. 1 Variation of Vickers hardness with TiC- Al_2O_3 content for WC-Co/ TiC-Al_2O_3 composite (CM, hardness of a commercial product 90WC-10Co). Error bar shows the minimum and maximum values observed.

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