ELSEVIER

International Journal of Refractory Metals & Hard Materials 21 (2003) 171–182

International Journal of
REFRACTORY METALS
& HARD MATERIALS

www.elsevier.com/locate/ijrmhm

Sintering behavior of mechanically coated WC–Co/TiC–Al_2O_3 particles by high-speed rotational impact blending

Sukasem Kangwantrakool [a], Kunio Shinohara [b,*]

[a] *School of Ceramic Engineering, Institute of Engineering, Suranaree University of Technology, Nakhon Ratchasima 30000, Thailand*

[b] *Division of Materials Science and Engineering, Graduate School of Engineering, Hokkaido University, West 8, North 13, Kita-ku, Sapporo 060-8628, Japan*

Abstract

The sintering behavior of WC–Co/TiC–Al_2O_3 composite has been investigated from its microstructure. The coated particles were prepared by high-speed rotational impact blending and sintered by spark plasma method (SPS) and hot press. The powder of the same composition was also mixed by means of an ordinary ball mill (BM) for comparison of their microstructural uniformities and mechanical properties. The microstructure was quantitatively measured on scanning electron microscopy photos by image analysis technique, and characterized by void size distribution curves. The results revealed that the sintered sample prepared with coated particles and with SPS possesses excellent morphological characteristics, such as smaller WC and Al_2O_3 mean grain sizes and uniform spatial distributions of hardest β-phase to yield higher mechanical properties such as hardness and transverse rupture strength than the cases of the BM and the hot press. The superior mechanical properties were obtained at higher sintering temperature with moderate sintering time of SPS.

Keywords: Sintering behavior; Coated particles; Spark-plasma; Cemented carbides; Microstructure

1. Introduction

The mechanical properties of WC–Co alloys have extensively been investigated for improvement by adding several kinds of additive materials. From the corresponding findings, it may be said that mixing methods for powder preparations and the sintering procedure determine to a large extent the properties of obtained composites. Recently, the authors [1,2] synthesized a WC–Co/TiC–Al_2O_3 composite with mechanically coated particles prepared by means of a high-speed rotational impact blending machine. TiC and Al_2O_3 were added to the WC–Co alloy to improve hardness at low and high temperature, respectively. Further, as compared with the case of a ball mill (BM), the enhanced mechanical properties of the sintered materials were attributed to higher dispersive uniformity of each component in the microscopic scale, as a consequence of the higher degree of powder mixing. However, a more complete research on the sintering behavior is still needed. In fact, when a material is fabricated, the properties will be determined by the morphology of the microstructure which depends on the mixing method, sintering process, and sintering conditions used.

The objective of this paper is, therefore, to study the sintering behavior and its influence on the relationship between the microstructure and mechanical properties of WC–Co/TiC–Al_2O_3 composite materials. Such a research is conducted by quantifying the effect of mixing methods, sintering methods and sintering conditions on the areal fraction, the grain size distribution and the uniformity of spatial distribution of each component with the aid of the image analysis technique.

2. Experimental

2.1. Apparatus

Surface composite particles were prepared by high-speed rotational impact blending using a Hybridizer (Type NHS-1; Nara Machinery Co., Ltd.), as shown in Fig. 1. The coating chamber is surrounded with a jacket

* Corresponding author. Tel./fax: +81-11-706-6590.
E-mail address: kushinoh@eng.hokudai.ac.jp (K. Shinohara).

0263-4368/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0263-4368(03)00030-1