Accepted Manuscript

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Amir Hadian, Cyrus Zamani, Frank Jörg Clemens

PII:	S0263-4368(17)30947-2
DOI:	doi:10.1016/j.ijrmhm.2018.02.021
Reference:	RMHM 4681
To appear in:	*International Journal of Refractory Metals and Hard Materials*
Received date:	11 January 2018
Revised date:	17 February 2018
Accepted date:	26 February 2018

Please cite this article as: Amir Hadian, Cyrus Zamani, Frank Jörg Clemens , Effect of sintering temperature on microstructural evolution of M48 high speed tool steel bonded NbC matrix cemented carbides sintered in inert atmosphere. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Rmhm(2017), doi:10.1016/j.ijrmhm.2018.02.021

Effect of sintering temperature on microstructural evolution of M48 high speed tool steel bonded NbC matrix cemented carbides sintered in inert atmosphere

Amir Hadian [a,b] , Cyrus Zamani [b*], Frank Jörg Clemens [a]

[a] Empa, Swiss Federal Laboratories for Materials Science & Technology, Laboratory for High Performance Ceramics, 8600, Dübendorf, Switzerland.

[b] School of Metallurgy and Materials Engineering, College of Engineering, University of Tehran, Tehran, Iran.

Abstract

This work presents the results on microstructure and hardness evaluation of NbC-12wt% M48 high speed steel (HSS) cemented carbides, pressureless sintered at different temperatures in argon atmosphere. To evaluate the effect of sintering process on the microstructure, sintering was performed in the range of 1260 ˚C to 1420 ˚C according to dilatometer analysis. The sintered samples were characterized using several techniques, including determination of density by Archimedes, measurement of hardness and fracture resistance, microstructural analysis by scanning electron microscope (SEM), phase analysis using X-ray diffraction (XRD) and energy dispersive spectroscopy (EDS). As expected, microstructural results indicated higher NbC grain growth at elevated sintering temperatures. The high speed steel wetted the NbC particles at high temperature (> 1340 ˚C). As a result, the metallic binder spread and a homogenous distribution between the NbC grains could be achieved. Mechanical analysis showed a dependence of mechanical properties on NbC grain size and the state of the microstructure. A maximum hardness of 14.91 ± 0.14 GPa was measured for cemented carbide samples sintered at 1300 ˚C, while the highest fracture resistance (1.56 ± 0.3 $MPa.m^{1/2}$) was associated with the sample sintered at 1380 ˚C

Keywords: Niobium carbide, cemented carbide, sintering, high speed steel, microstructure, Cryogenic milling

1. Introduction

WC-Co cemented carbides materials have excellent mechanical and wear properties to be used for cutting tool and wear applications. Due to the proven toxic nature of WO_3, researches have been taking place during the past decade to substitute WC with non- toxic materials [1,2]. Nowadays, Niobium carbide (NbC) has received particular attention as a replace candidate, due to its mechanical properties being comparable to WC [3,4]. Pure NbC has high melting point (3600˚C), high hardness (19.6 GPa) and low density (7.79 gr/cm^3) [5]. Compared to WC, It not only shows higher oxidation resistance in air, but also the Nb_2O_5 is more stable than WO_3 at elevated temperatures. Combining the as mentioned advantages with lower dissolution rate in Iron, NbC has better stability when getting in contact with Fe based steels at high temperatures [6]. Moreover, NbC and Nb_2O_2 are not water soluble and so far no report has been published on their toxicity to human contrary to WO_3 [7–9]. Recent studies on wear properties of NbC cemented carbides shows their promising tribo-active characteristic due to the formation of stable Nb_2O_5 in the contact area [3,4].

In recent years, different metallic components used as binder for NbC matrix cemented carbides. Earlier efforts on using pure Iron binder resulted in products with low density values and poor mechanical properties. Inferior mechanical properties of Iron as the binder along with the presence of Fe_2Nb intermetallic phase results in poor mechanical performance of the final cermet [10]. Enhanced tribological and mechanical behavior were observed in Co bonded NbC cemented carbides [4]. Remarkable wear properties were related to intrinsic wear resistance of pure NbC. Wear behavior of binderless NbC (hot-pressed) was benchmarked with different ceramics and hardmetals revealing the strong position of

* Corresponding author.
Email addresses: a.hadian@ut.ac.ir , amir.hadian@empa.ch (Amir Hadian),
c.zamani@ut.ac.ir (Cyrus Zamani), frank.clemens@empa.ch (Frank Jörg Clemens)