

# Densification and mechanical properties of WC-TiC-TaC-Co alloy

Pukyong National University, Young-Mi Chin, Hae-Woong Kwon  
Material Technology Dept, Korea Institution of Machinery & Materials  
Dae-Sik Im, Seong-Hyeon Hong, Byoung-Kee Kim

## 1. Introduction

Mechanical properties of WC-TiC-TaC-Co alloys can be effected by size of carbides in alloy. Recently, in order to increase wear resistance and tool life, ultrafine cemented carbide based on WC-Co were developed. In spite of development researches on ultrafine cemented carbides, development of ultrafine WC-TiC-TaC-Co based alloy has never been tried. In this study, ultrafine WC-TiC-TaC-Co composite powders were prepared by ball milling of ultrafine TiC-Co, WC-Co and TaC powder and the densification and mechanical properties of WC-TiC-TaC-Co alloys were studied.

## 2. Experimental

Ultrafine TiC-5%Co (KIMM), ultrafine WC-Co(Nanotech) and TaC(H.C Starck) powders were used as raw materials. The alloy systems studied in the research were P10 grade [WC-(18-22)TiC-(15-18)TaNbC-(8-10)Co] and P20 grade [(71.4-73.4)WC-(9-11)TiC-(8-10)Ta(NbC)-(7.6-9.6)Co] .

The raw materials, hexane, and cemented carbide balls were charged in stainless jar and milled for 24~72 hours. The milled powders were dried, compacted under the uniaxial pressure 3ton/cm<sup>2</sup> and then pressed in CIP. In order to degas during sintering schedule, the compacts were held at 1100°C for 30 min in vacuum. The specimens were sintered at 1320°C, 1350°C and 1400°C for 30 min in vacuum.

The mechanical properties such as hardness, transverse rupture strength were measured and fracture surfaces were also investigated by SEM. The density, coercive force and magnetic saturation of sintered specimens were also measured.

## 3. Results and discussion

### 1) Densification and mechanical properties of P10 grade

As the sintering temperature increased from 1300°C to 1400°C, the size of carbide increased as shown in Fig. 1. The full densification can be achieved at 1350°C due to fine powder in compact. The hardness of sintered specimen increased as sintering temperature increased from 1300°C to 1350°C~1400 as porosity in sinterd specimen decreased. The transverse rupture strength shows the maximum value in the specimen sintered at 1350°C for 30 min. The fine carbide size and no-porosity contribute to the maximum hardness of specimen sintered at 1350°C

### 2) Densification and mechanical properties of P20 grade.

The compact specimen was full-densified at above 1350°C and carbides in sintered specimen did not growth rapidly compared with those of P10 grade as shown in Fig. 1 and Fig. 2.

Usually, P10 grade has lower TiC content than P10 grade. TiC particles grow more rapidly than WC particles in liquid phase, and so P20 grade has fine carbide particles. The hardness and wear resistance of P20 specimen sintered at 1400°C were higher than

those of commercial P20 alloy due to fine carbide size.

### 3. Conclusions

Ultrafine WC-TiC-TaC-Co powder were fully densified at low temperature such as 1350°C. The P20 grade alloy prepared in this study has high hardness and wear-resistance due to fine carbide size.

### Acknowledgements

This research was supported by a grant from the Center for Advanced Materials Processing (CAMP) of the 21st Century Frontier R&D Program funded by the Ministry of Science & Technology, Republic of Korea.

Sintering condition	Hardness (kgf/mm <sup>2</sup> )	TRS (kgf/mm <sup>2</sup> )	K <sub>IC</sub> (kgf/mm <sup>3/2</sup> )	Density (%)	Coercive force (Hc)	Magnetic saturation (%)
1320°C,30min	1485(±39.6)	113.443	9.02(±0.57)	96.21	95	93.83
1350°C,30min	1646(±14.35)	203.437	10.75(±0.19)	99.16	141	93.55
1400°C,30min	1597(±6.96)	131.269	11.27(±1.64)	99.38	198	79.84
	1633(±25.18)	133.912	9.94(±0.23)	99.85	195	81.41

Table 1. Properties of ultrafine P10 alloy with sintering condition.

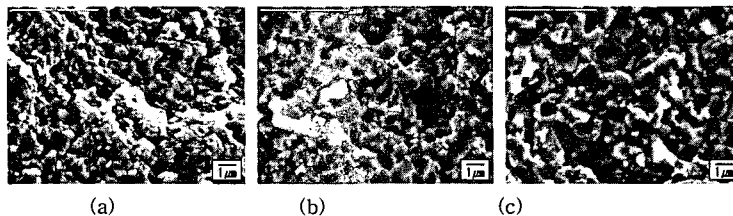


Fig 1. Fracture surface of ultrafine P10 alloy with sintering condition.(Carbide : 0.4 µm)  
: (a) 1320°C, 30min (b) 1350°C, 30min (c) 1400°C, 30min

Sintering condition	Hardness (kgf/mm <sup>2</sup> )	TRS (kgf/mm <sup>2</sup> )	K <sub>IC</sub> (kgf/mm <sup>3/2</sup> )	Density (%)	Coercive force (Hc)	Magnetic saturation (%)
1320°C,30min	630 (±9.30)	82.356	10.05 (±0.8)	89.91	270	81.9
	1722.8(±25.6)	89.728	10.3(±0.1)	98.21	256	73.93
1350°C,30min	2038(±16.04)	152.243	11.44(±0.29)	101.83	302	72.4
	2011.4(±16.98)	133.002	11.35(±0.73)	101.45	281	79.31
1400°C,30min	2030(±3.25)	128.409	11.4(±0.2)	101.38	321	63.59

Table 2. Properties of ultrafine P20 alloy with sintering condition.

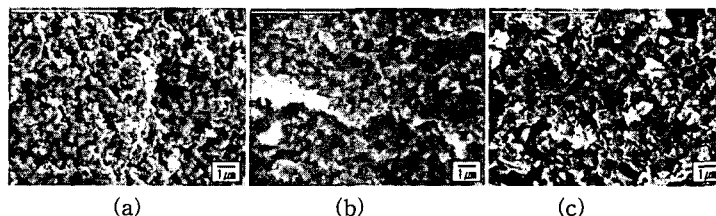


Fig 2. Fracture surface of ultrafine P20 alloy with sintering condition.(Carbide : 0.4 µm)  
: (a) 1320°C, 30min (b) 1350°C, 30min (c) 1400°C, 30min