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ScienceDirect
Acta Metall. Sin.(Engl. Lett.) Vol.21 No.3 pp211-219 June 2008

ACTA
METALLURGICA SINICA
(ENGLISH LETTERS)
www.ams.org.cn

EFFECT OF Mo AND Mo_2C ON THE MICROSTRUCTURE AND PROPERTIES OF THE CERMETS BASED ON Ti(C,N)

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Manuscript received 23 July 2007; in revised form 8 November 2007

Effect of Mo and Mo_2C on the microstructure and properties of Ti(C,N)-based cermets was investigated in this article. The results have indicated that the weight percentage of Mo from 5 to 10 can reduce Ti(C,N) grain diameter and thickness of the rim, and Ti(C,N) grain can be wetted by Ni-Cu-Mo liquid so as to get small contiguity of Ti(C,N) grain. In that way, the transverse rupture strength of Ti(C,N)-based cermets has reached 1800–1900 MPa; the fracture toughness has been due to 16–18 MPa·$m^{1/2}$. But 15 wt pct Mo was not more effective on Ti(C,N)-based cermets, because the thickness of the rim becomes larger. In the circumstance of Mo_2C, 5 wt pct Mo_2C was good for microstructure and properties of Ti(C,N)-based cermets, but 11 wt pct Mo_2C has resulted in larger contiguity of Ti(C,N) grain and big Ti(C,N) grain diameter so as to reduce transverse rupture strength and fracture toughness. So that, the effect of Mo on Ti(C,N)-based cermets is better than Mo_2C.

KEY WORDS *Cermet; Transverse rupture strength (TRS); Contiguity; Fracture toughness*

1. Introduction

Titanium carbonitride-based (Ti(C,N)-based) cermets are important structural and wear-resistant materials which are widely appreciated in metal cutting application, owing to their excellent mechanical properties[1−3]. Recently, more and more conventional WC-Co-based hard alloys are being replaced by Ti(C,N)-based cermets, accompanied with the trend of high-speed machining. Comparing with WC-Co hard metal, the advantages of Ti(C,N)-based cermets lie in their higher hot hardness, wear resistance, chemical stability, and resistance to plastic deformation at elevated temperature.

Consequently, cermets cutting tools show improved surface finishing and tolerance control. Meanwhile, the cutting efficiency and tool life are also improved. On the whole, in high-speed finishing and semi-finishing cutting applications, Ti(C,N)-based cermets are more preferred than WC-Co hard metals[4−6]. The complex microstructure of Ti(C,N)-based cermets is the key to interpret their mechanical properties, and so it has been widely studied by several authors for years[7−9]. Generally, cermets material is composed of two

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phases: one is the ceramic phase (titanium carbonitride hard phase) and the other is metal binder phase (nickel or cobalt or a mixture of them) which bonds the ceramic phase. In general, ceramic phase provides high hardness to this class of materials, while the metal binder phase contributes to ductility, toughness, and thermal-shock resistance. Microstructure examination shows that a typical carbonitride grain often demonstrates a core/rim structure: black Ti(C,N) cores surrounded by grey (Ti, W, Mo, Nb, Ta, $\cdots$) (C,N) complex carbonitride rims (in scanning electron microscopy (SEM)-back scattered electron (BSE) contrast), resulting from a dissolution-reprecipitation process.

Previous study has shown that Mo or Mo_2C is an effective chemical continent for improving wettability[10−12], and by forming (Mo,Ti) (C,N) in the surface of Ti(C,N) particle, they may improve the interface bonding between Ti(C,N) and Ni. But there is argument about their amount and initial powder statue; the excellent properties can be obtained while the content of Mo is 10 wt pct–20 wt pct[13]. Also, it was reported that Mo_2C may reduce grains and increase properties of the cermets by forming (Mo,Ti) (C,N) rim phase in solid sintering, which prohibits Ti(C,N) dissolution in liquid sintering[14], and the excellent properties can be obtained while adding amount of Mo_2C is due to 10 wt pct[15].

In the cermets, ceramic particles are in contact with each other; the contact area percentage is defined as contiguity. In WC/Co hard alloys, the parameter contiguity is defined as[16]:

$$C = \frac{2S_{\rm cc}}{2S_{\rm cc} + S_{\rm cm}} \tag{1}$$

where, $S_{\rm cc}$ is the area between the carbon particles and $S_{\rm cm}$ is the area between the carbide particles and the matrix in a unit volume.

ASTM provides the recommended practice for estimation of the area fraction of a phase in a multiphase alloy by systematic point counting on a planar test section. The point fraction, $(P_{\rm P})_\alpha$ intercepted by the α phase, statistically interpreted, provides an estimate of the volume fraction, $(V_{\rm V})_\alpha$, area fraction, $(A_{\rm A})_\alpha$, and line fraction, $(L_{\rm L})_\alpha$, For random measurements.

$$(P_{\rm P})_\alpha = (L_{\rm L})_\alpha = (A_{\rm A})_\alpha = (V_{\rm V})_\alpha \tag{2}$$

The other structure parameters are obtained from boundary intercepts with test lines on planar sections; one determines the average number of intercepts per unit length of test line with traces of the carbide/cobalt interface, $(N_{\rm L})_{\rm WC/Co}$, and of carbide/carbide grain boundaries, $(N_{\rm L})_{\rm WC/WC}$. From these quantities, one can calculate the average carbide grain size:

$$D_{\rm WC} = L_{\rm WC}/(N_{\rm L})_{\rm WC/WC} \tag{3}$$

the contiguity of the WC phase:

$$C = 2(N_{\rm L})_{\rm WC/WC}/[2(N_{\rm L})_{\rm WC/WC} + (N_{\rm L})_{\rm WC/Co}] \tag{4}$$

And the mean free path in the binder phase:

$$\lambda_{\rm M} = L_{\rm Co}/(N_{\rm L})_{\rm WC/Co} \tag{5}$$