IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

Effect of Fe Content on Strength and Toughness of TiC-2Mo2C-8Ni-20WC-8Co Cermets

To cite this article: Xuan Ye *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **233** 022002

Effect of Fe Content on Strength and Toughness of TiC-2Mo$_2$C-8Ni-20WC-8Co Cermets

YE Xuan[1], QIU Zhiwen[1], ZHONG Yanhui[1], TU Huajin[1], LING Yuxiang[2]

[1]Mechanical and Electrical Engineering College, Heyuan Polytechnic, Heyuan 517000, China; [2]Heyuan Yueao Cemented Carbide co., LTD Research and Development Department, Heyuan 517000, China.

yexuan 1216@sina.com

Abstract. Fe was introduced into TiC-2Mo$_2$C-8Ni-20WC-8Co cermets materials. Content of Co and Fe were 8-X and X respectively, and X was 0%, 2%, 4%, 6%, 8%. Density, bending strength and impact toughness of the material were tested. Results showed that it was feasible to add Fe into the material as binder to partially replace Co. Comparing with the specimen containing 0%Fe, properties of the specimen containing 6%Co and 2%Fe had not slashed. Its density, bending strength and impact toughness were 6.783g/cm^3, 847.7MPa and 16.1J/cm^2 respectively.

1. Introduction

Cermets, as one kind of high performance composite material, which have better cutting performance than WC-Co hard alloy[1], are suitable for high speed manufacturing, reducing cutting resistance, and increasing tool life[2]. Currently, cermets often contain matrix (TiC and Ti(C,N)) and binder (Ni, Mo, Co)[3-4]. However, cost of cermets containing Co and Ni rose sharply in recent years for the increasing price of Co, Ni. Cermets materials research scholars have been making great efforts to find a new kind of binder to replace the expensive Co, Ni materials. Among them, Fe is likely to be more suitable, which have big storage capacity and low cost comparing with Co, Ni. Therefore, many scholars try to use Fe to replace Co or Ni as the binder of cermets. For instance, literature [5] used Fe to replace Ni materials to prepare Ti(C,N)-20WC-6Mo$_2$C-5TaC-7Co-8Ni cermets. Literature [6] used Fe-Co-Ni as binder of Ti(C,N)-WC-Mo$_2$C-TaC cermets. Literature [7] tried adding Fe into TiC-based cermets. Literature [8] and [9] respectively used 304L and 316L material to prepare the cermets. In this paper, Fe was added into cermets of TiC-2Mo$_2$C-8Ni-20WC-8Co, attempting to replace Co with Fe, and the effect of Fe content on strength and toughness of TiC-2Mo$_2$C-8Ni-20WC-8Co material was studied.

2. Experiment method

2.1. Experiment materials

TiC powder (99.5% purity, 2.5μm), Mo$_2$C powder (99.5% purity, 2.7μm), Ni powder (99.5% purity, 2.3μm), WC powder (99.5% purity, 1.0μm), Co powder (99.5% purity, 1.18μm), Fe powder (99.5% purity, 30.0μm) were adopted. Composition proportion is shown at Table 1. T1-T5 specimens were prepared.

Table.1 Specimens composition proportion (wt %)

Specimen Number	TiC	Mo_2C	Ni	WC	Co	Fe
T1	the rest	2	8	20	8	0
T2	the rest	2	8	20	6	2
T3	the rest	2	8	20	4	4
T4	the rest	2	8	20	2	6
T5	the rest	2	8	20	0	8

2.2. Specimens preparation
Hydro-ball-milling technique was adopted to mix the raw materials in a 300L stainless steel ball mill, ratio of ball-to-powder was 5:1, mill medium was 85L alcohol, milling time was 24h. Steam was used to dry the milled materials at 120°C for 6h. The dried raw materials sifted through 80 meshes sieve. 90ml polyethylene glycol forming agent was added into every Kg of material. Green specimens were pressed by hydraulic press under 80 kN. Specimens were sintered in a vacuum sintering furnace for 12h with maximum sintering temperature of 1400°C which lasted for 120min.

2.3. Performance test
Density of specimens was tested. Three-point bending strength of specimens were tested by universal testing machine. Impact toughness of specimens was tested, non-notched specimens were adopted, and pendulum energy was 5.5J.

3. Results

3.1. Effect of Fe content on density of materials
Density of TiC-2Mo_2C-8Ni-20WC-8Co cermets with different Fe content is shown in Figure 1. As you can see, when the Fe content increases from 0% to 2%, namely T1 and T2 specimens, density of the material is not significantly lower. Density of the T1 specimen is 6.788g/cm^3 and density of T2 specimen is slightly reduced to 6.783g/cm^3. As Fe content increases to 4%, 6%, 8%, namely T3, T4 and T5 specimens, density of material reduced obviously to 6.556g/cm^3 and 6.452g/cm^3 and 6.143g/cm^3 respectively. Comparing with T1 specimen, density of T5 specimen is lower by 9.5%.

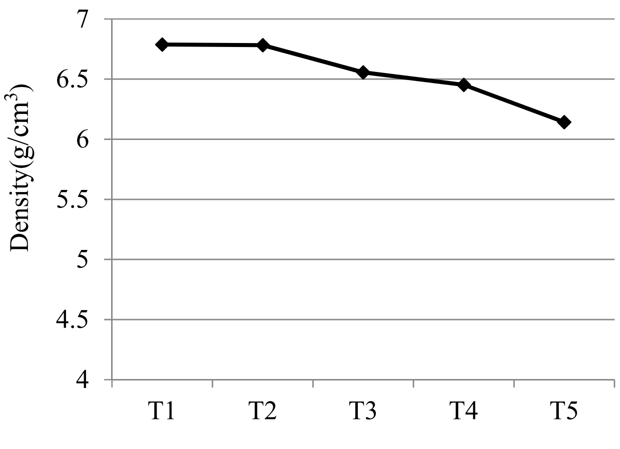

Figure.1 Density of specimens with different Fe content

3.2. Effect of Fe content on bending strength of materials
Bending strength of TiC-2Mo_2C-8Ni-20WC-8Co cermets with different Fe content is shown in Figure 2. As you can see, when the Fe content increases from 0% to 8%, bending strength of materials continue to drop from 953.2MPa of T1 specimen to 540.5MPa of T5 specimen. Among them, T2 specimen containing 2%Fe and T3 specimen containing 4%Fe still have high bending strength, which are

847.7MPa and 838.4MPa respectively. However, bending strength of T4 specimen containing 6% Fe and T5 specimen containing 8% Fe decrease obviously, which are 613.0MPa and 540.5MPa respectively. Therefore, it is of some practicability to use Fe to partly replace Co as binder to prepare TiC-based cermets.

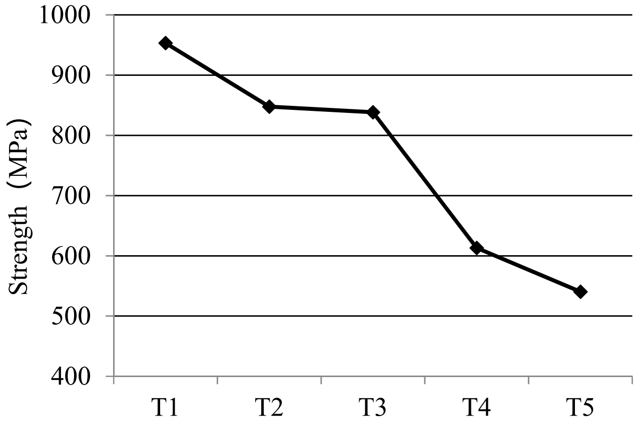

Figure.2 Bending strength of specimens with different Fe content

3.3. Effect of Fe content on impact toughness of materials

Impact toughness of TiC-2Mo_2C-8Ni-20WC-8Co cermets with different Fe content is shown in Figure 3. As you can see, T2 specimen containing 2%Fe has high impact toughness of 16.1J/cm^2, which is increased by 130% comparing with T1 specimen containing 0%Fe. When the Fe content increases to 4%, the impact strength is reduced to 6.0J/cm^2. When continues to increase Fe content to 6% and 8%, impact toughness of specimen are 7.0J/cm^2 and 6.5J/cm^2 respectively. It can be concluded that, it is of some practicability to use Fe to partly replace Co as binder to prepare TiC-based cermets. Especially, specimen of TiC-2Mo_2C-8Ni-20WC-8Co-2Fe has higher impact toughness.

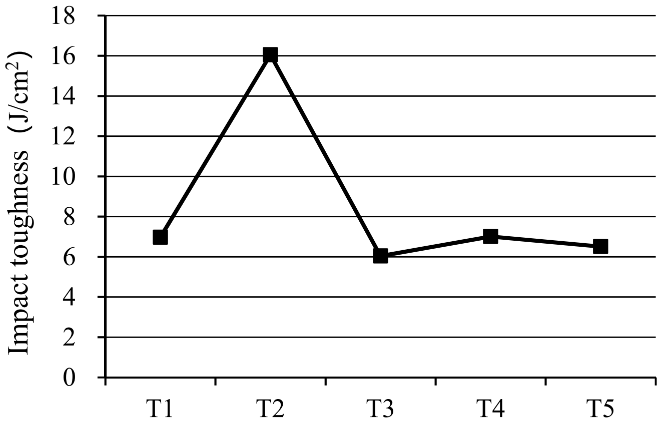

Figure.3 Impact toughness of specimens with different Fe content

4. Discussion

The choice of binder composition is very important for preparation of cermets. Currently, the binder of cermets is mainly the composition such as Co, Ni, Mo, but their expensive cost has created tremendous pressure to manufacturing enterprise of the field, especially in the case of intensifying market competition. Therefore, it may have good market prospects to replace the expensive Co, Ni with Fe.

All the above test results show that it is of some practicability to use Fe to partly replace Co as binder to prepare TiC-based cermets. Results of this paper show that when Fe content is 2% and 4%, bending strength of material is not significantly lower, which are 847.7MPa and 838.4MPa respectively. But when Fe content is increased to 8%, bending strength of material decreases and bending strength of T4 specimen containing 6%Fe and T5 specimen containing 8%Fe are reduced by 35.7% and 43.3% respectively in comparison with T1 specimen. T2 specimen containing 2%Fe, however, has better impact toughness than any other specimen. Therefore, using Fe to entirely replace Co to prepare TiC-$2Mo_2C$-8Ni-20WC-8Co cermets may have damage to material performance. The reason may be that the introduction of Fe can result in brittle phase and reduces wettability between binder and TiC particles, which is not conducive to formation of coating layer surrounding TiC particles, thus the TiC particles may easily agglomerate, which degrade performance of materials[10].

5. Conclusion

It is of some practicability to use Fe to partly replace Co as binder to prepare TiC-based cermets. Comparing with specimens containing 0%Fe, performance of TiC-$2Mo_2C$-8Ni-20WC cermets material containing 2%Fe and 6%Co as a binding phase does not degrade much, the density is 6.783g/cm^3, the bending strength is 847.7MPa, and the impact strength of 16.1J/cm^2. Therefore, the material still has high practicability.

Acknowledgments

Fund project: Science and technology plan of Yuancheng District Heyuan city of 2017 "Research and industrialization of new high wear-resistant particle reinforced Fe-matrix materials" (Yuanke [2017] No.16); Scientific research subject of Heyuan Polytechnic "Research and development of Fe-base binding phase metal ceramics" (2017kj04); First batch of fund project of higher vocational education characteristic specialty construction plan of Guangdong province (0035306); 2017 youth innovative talent project of education department of Guangdong province (natural science) (2017GkQNCX075, 2017GkQNCX076).

References

[1] Xu Qiang, Zhang Xinghong, Qu Wei, et al. Progress in research on cermets[J]. Cemented Carbide, 2012, 19(4): 221-225.
[2] Zhang Hongqin. Effect of binder phase on microstructure and the cutting properties of Ti(C,N)-based cermets[D]. Hefei University of Technology, 2009.
[3] Wu Wenhong, Li Yuxin, Bai Peikang, et al. Research Progress of Ti(C,N)-Based Cermets Composite[J]. Hot Working Technology, 2016, 45(6): 12-13, 19.
[4] E. B. Clark, B. Roebuck. Extending the application areas for titanium carbonitride cermets[J]. Refractory Metals & Hard Materials. 1992, 11(1): 23-33.
[5] Zhu Gang, Xie Ming, Liu Ying, et al. Effects of Fe content on microstructure and mechanical propertise of Ti(C,N)-based cermets[J]. Rare Metals and Cemented Carbides, 2016, 44(2): 30-34, 57.
[6] Zhu Gang, Xie Ming, Liu Ying, et al. Microstructure and phase transformation of ti(c,n) /fe-co-ni cermets during sintering process[J]. Chinese Journal of Rare Metals, 2016, 40(12): 1220-1225.
[7] P. Alvaredo, E. Gordo, O. Van der Biest. Microstructural development and mechanical properties of iron based cermets processed by pressureless and spark plasma sintering[J]. Materials Science and Engineering: A, 2012, 538(10): 28-34.
[8] Chukwuma C. Onuoha, Georges J. Kipouros, Zoheir N. Farhat. The reciprocating wear behaviour of TiC–304L stainless steel composites prepared by melt infiltration[J]. Wear, 2013, 303(1-2): 321-333.
[9] Chukwuma C. Onuoha, Georges J. Kipouros, Zoheir N. Farhat. The effects of metal binder content and carbide grain size on the aqueous corrosion behaviour of TiC–316L stainless steel cermets[J]. Int. Journal of Refractory Metals and Hard Materials, 2014, 44(3): 129-141.
[10] Ye Xuan, Tu Huajin, Zhong Yanhui, et al. Status of Research on Binder of Cermets[J]. Hot Working Technology, 2017, 24(46): 14-19, 24.