COMPARISON MECHANICAL PROPERTIES OF COMBUSTION SYNTHESIZED TiC-NiAl WITH SINTERING MECHANICAL SEAL RINGS AND CUTTING TOOLS

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1. Abstract

The main aim in this study is based on replacement possibility of combustion synthesis procedure with conventionally sintering method for fabrication some of the mechanical seal rings and cutting tools, because of simplicity and economic of this procedure. As TiC-NiAl composite has excellent wear resistant, it was chosen as a relevant material for mechanical seals and cutting tools. Therefore microstructure and their mechanical property of combustion synthesized TiC-NiAl composite such as hardness and fracture toughness was compared with those of usual compounds of cutting tools and mechanical seal rings, like silicon carbide, alumina and tungsten carbide-cobalt that be produced by sintering method. The primary evaluation of mechanical properties shows that TiC-NiAl has acceptable hardness and fracture toughness in comparison SiC, Al_2O_3 and WC-Co. Therefore by combustion synthesis method can produce some of materials with mechanical properties similar to the mechanical seal rings and cutting tools.

2. Introduction

Cutting tools are made from very hard materials and have been applied in wide variety of turnery industries and machining operations. For cutting tools, these sintering materials usually include tungsten carbide and alumina. Cutting materials for extreme requirements (for example, interrupted cuts or machining of high strength materials) can consequently not be made from one single material, but may be realized by composite materials. This tools produce by hot press and hot isostatic pressing of carbide mixture (cemented carbide) [1, 2].

Mechanical seals are machine elements specially designed to prevent fluid leakage from pressurized chambers in fluid (gas or liquid) transport systems at high temperature or to avoid hot lubricant outflow in general equipment moving parts. Many different materials and combinations of them have been successfully tested and are routinely used today in the industry. In an engineering sense, the term generally refers to a class of materials that are characterized by their high hardness, high stiffness, low thermal expansion, and good wear resistance. For mechanical seals, these include silicon carbide, tungsten carbide and alumina. Other materials such as silicon nitride are used in special applications. These tools can be synthesized by sintering method [3, 4].

The self-propagating high-temperature synthesis procedure has low energy consumption and has large potentials for industrial applications due to the high productivity and the very simple equipment involved [5]. Due to excellent wear behavior of TiC-NiAl [6], in this paper mechanical properties of combustion synthesized TiC-NiAl in comparison with sintering alumina, silicon carbide and cemented carbide samples was evaluated for use in cutting tools and high temperature mechanical seals.

3. Experimental procedure

The dense samples were sectioned with wire cut and grinded for microstructure observation and mechanical property analysis. The constituted phases of the synthesized TiC-NiAl samples, alumina, silicon carbide and cemented carbide were characterized employing X-ray diffraction (XRD-Philips X'pert-MPD) and microstructure observation by scanning electron microscopy (SEM-S360 and SEM-XL3) equipped with EDS Analyzer. Micro-hardness of dense samples was

measured under 5 N load, with Vickers diamond indenter. Macro-hardness was evaluated by a Vickers diamond indenter at loads of 50 N.

The fracture toughness was measured by the Vickers indentation method. Indentation test was conducted on polished samples with a load between 200 N to 300 N that held for 15 s.

The density of the synthesized bulk samples was measured by using water, according Archimedes test method [2].

4. Results and discussion

Fig. 1 gives an overview of the recorded diffraction patterns of the sintering SiC. As it can be seen in Fig. 1, XRD pattern shows that SiC phase is in SiC seal ring sample.

Furthermore SEM observations as seen in Fig. 5, shows continuous structure for sintering SiC, alumina, cemented carbide and combustion synthesized TiC-NiAl. Moreover low pore density and relatively same sizes were in samples too.

Mechanical properties tests of samples are put into table. 1. As it is shown TiC-NiAl composite has high hardness and fracture toughness in acceptable limited in sintering samples of cutting tools and mechanical seal rings.

compound	Relative density	density	Micro hardness ($HV_{.5}$)	Macro hardness (Gpa)	Fracture thoughness (MPa$\sqrt{m}$)
SiC	~ 95.6	3.06	2443	21.6	2-3.5
Al_2O_3	~ 95	3.675	1010	12.02	3-4.5
WC-Co	~ 98.6	13	1436	13.36	9-14
TiC-NiAl	~ 97.6	5.174	1077	9.95	7-10

Table 1. Mechanical properties of samples.

5. Conclusions

TiC-NiAl composite has high hardness and fracture toughness in acceptable limitation in comparison sintering cutting tools and mechanical seal ring samples. Therefore primary evaluation shown by combustion synthesis can produce composite compound with excellent mechanical properties like mechanical seal and cutting tools. Also TiC-NiAl has good primary condition for use in mechanical seal and cutting tools.

6. References

[1] K.L. Choy (2003). Chemical vapour deposition of coatings, *Prog in Mater Sci*., **114**, 57-170.

[2] D. Richerson (1992). *Modern Ceramic Engineering: Properties, Processing, and Use in Design*", 2nd, Marcel Dekker, New York, 126-131.