Optimizing the sintering parameters for pure titanium carbonitride (TiCN) based cermet via Spark Plasma Sintering route.

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Highlights

- Consolidation of TiCN based cermet by Spark Plasma Sintering was successfully achieved.
- Maximum relative density of 99% was obtained on the sample with $TiC_{0.9}N_{0.1}$ composition.
- An improvement of micro hardness and fracture toughness on the densified cermets was observed.

1. Introduction

Cermets based titanium carbonitride (TiCN) have been successfully used in a variety of tribological applications, mainly because of their superior mechanical properties and chemical stability. This type of cermets find its application in high performance wear parts, semi-finished and finished cutting tools due to their high hardness, thermal stability, thermal conductivity and wear resistance. Recently, conventional WC-Co based hard alloys are being replaced by TiCN based cermets accompanied by the trend of high speed machining. When compared to WC-Co based hard metals, TiCN based cermets possesses improved surface finishing, excellent chip and tolerance control to provide geometrical accuracy in the workpiece. Furthermore, TiCN based cermet increase the feeding speed and remain fixed in critical dimensions. Cermets based on TiCN are also much more competitive in price and performance, especially in high cutting speed and finishing operations [1]. Extensive research has been carried out on TiCN by various researchers primarily in the processing of densified TiCN based cermets at low sintering temperatures using conventional sintering techniques. There have been work done on incorporating different metallic binders, Fe based alloys and carbides to improve their high temperature mechanical and wear properties. [2-4]. Verma and Kumar investigated the tribological behaviour of TiCN based cermets in different wear and cutting conditions [5;6]. However, there is limited work done on pure or binder-less TiCN based cermets. The present work investigates the effect of optimizing sintering temperatures on the three different compositions of TiCN based cermets ($TiC_{0.9}N_{0.1;}$ $TiC_{0.7}N_{0.3}$ and $TiC_{0.5}N_{0.5}$), consolidated using Spark Plasma Sintering.

2. Methods

Three varying titanium carbonitride (TiCN) based cermet powders (APS of 1.0 – 1.5 and purity of 99%) were used as the starting powders in this experiment. Powders were supplied by HC Starck, Germany ($TiC_{0.7}N_{0.3}$and $TiC_{0.5}N_{0.5}$) and Japan New Metals Co. Ltd ($TiC_{0.9}N_{0.1}$). The powders were then consolidated using spark plasma sintering system model HHPD25 FCT, Germany and powders were sintered at the temperatures 1600 – 2100 and pressure of 50 MPa. Subsequently, Archimedes principle was used to measure the densification of the sintered compacts using a weighing balance, OHAUS FCF system. The micro hardness (HV) was evaluated by Vickers indentation (Innovatest Falcon 500 series) using a load of 5kg/f and a dwell time of 10 s. The fracture toughness (Kic) values were obtained by measuring indentation cracks and calculated according to Palmqvist method. The microstructures of the sintered samples were observed by scanning electron microscopy (F.E. SEM, JSM – 7600F Jeol, Japan) and phase analysis was done using a PANanalytical Empyrean X-ray diffractometer.

3. Results and discussion

It was confirmed that SPS can successfully accomplish full densified TiCN based cermet. It is due to an increase in temperature that the densification of the cermets was attained. At 1600 ˚C, the cermet exhibited pores which led to the material failing to obtain full densification while at the highest temperature (2100 ˚C), maximum relative density (99%) was reached. It can be observed that $TiC_{0.9}N_{0.1}$ composition exhibit noticeable improvement in relative density as compared to the other two compositions ($TiC_{0.7}N_{0.3}$and $TiC_{0.5}N_{0.5}$) used. The cemet also shows an improvement in micro hardness and fracture toughness.

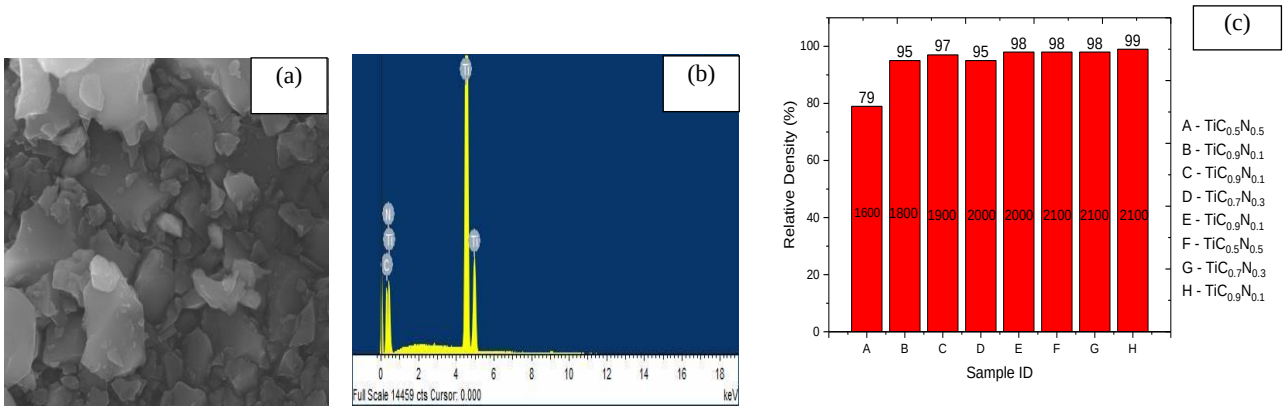

Figure 1. (a) SEM morphology of TiCN based powder, (b) EDS analysis of TiCN powder and (c) Relative density of the sintered samples.

4. Conclusions

In this work, the sintering parameters for pure TiCN based cermet were investigated using SPS. The results were discussed in detail and based on the outcome reports: TiCN based cermet was successfully consolidated using SPS and the highest value of relative density (99%) was obtained with $TiC_{0.9}N_{0.1}$ composition while 98% was reported for $TiC_{0.7}N_{0.3}$ and $TiC_{0.5}N_{0.5}$ compositions. An improvement in micro hardness and fracture toughness was also observed on the densified cermet.

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Keywords
TiCN based cermet, Spark Plasma Sintering, Mechanical properties, densification