Effect of Sinter/HIP Technology on Properties of TiC-NiMo Cermets

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Abstract

The present work is a study on the argon gas pressure effects of Sinter/HIP sintering on microstructure and strength of different grades of TiC-NiMo cermets. Titanium carbide in the composition of different grades of TiC-NiMo cermets was ranged from 40 to 80 wt.% and the ratio of nickel to molybdenum in the initial powder composition was 1:1, 2:1 and 4:1 respectively. On the sintered alloys, the main strength characteristic, transverse rupture strength (TRS) was measured. Furthermore, the microstructure parameters of some alloys were measured and the pressure effect on pore elimination was evaluated. All the results were compared with common, vacuum sintered alloys. The TRS values of TiC-NiMo cermets could be considerably improved by using Sinter/HIP technique, for high-carbide fraction alloys and for alloys sintered at elevated temperatures.

Keywords : TiC-NiMo cermets, Sinter/HIP technology, transverse rupture strength, microstructure

1. Introduction

One of the main disadvantages of TiC-NiMo cermets, compared to common tungsten carbide base hardmetals is the comparatively low strength characteristics. For enhancing the strength of hardmetals pressure assisted sintering (Sinter/HIP) is used, which for tungsten carbide cermets has found wide use in the industry.
Althouhg there are some information about positive effect of pressure sintering on strength properties of TiCN based cermets [1,2], for our knowledge at the present time there is no published information about TiC-NiMo cermets covering the different effect of pressure on structure formation. This work is done for giving an overview of the pressure effects of strength properties and microstructutal evolution of different grades of TiC-NiMo cermets, ranging from constructional materials (40 wt% of TiC) to tool materials with high carbide fraction (80 wt.% of TiC).

2. Experimental Procedure

The standard technologies were used for producing cermet materials. The initial powder mixtures can be seen in Table 1. Sintering temperature was 1440 and 1500°C, depending on the grade sintered and held for 40 min.
For Sinter/HIP sintering, the heating under vacuum atmosphere ($<2 \cdot 10^{-1}$ mBar) to r 15 minutes, after which the argon pressure was gradually raised to 90 Bar for 10 min and held for 15 min at the maximum gas pressure.

3. Results

Microstructure analysis
For grades with binder composition of Ni:Mo of 2:1, it was found that the applied pressure could not completely eliminate the microporosity from the structure (Table 2).

Table 1. Nominal composition of TiC- NiMo cermets [wt.%].

Grade	TiC	Ni	Mo	Grade	TiC	Ni	Mo	Grade	TiC	Ni	Mo
T20A	80	10	10	T40A	60	20	20	T60A	40	30	30
T20B	80	13.3	6.7	T40B	60	26.7	13.3	T60B	40	40	20
T20C	80	15	5	T40C	60	30	10	T60C	40	45	15

Table 2. Microstructure parameters for different TiC-NiMo grades (from 20 to 60 wt.% of binder) with Ni:Mo ratio of 2:1.

Grade	Porosity		Binder, vol. %		Core, vol. %		Rim, vol. %	
	Vacuum	Sinter/HIP	Vacuum	Sinter/HIP	Vacuum	Sinter/HIP	Vacuum	Sinter/HIP
T20B	0,95	0,55	8.1	8.0	24.9	19.8	67.0	72.2
$T40B_1$ (T_{sint}=1440°C)	0,12	0,26	22.5	18.6	16.9	19.3	60.6	62.1
$T40B_2$ (T_{sint}=1500°C)	0,08	0,13	28.8	23.2	14.3	15.7	56.9	61.1
T60B	0,03	0,07	24.2	31.2	14.1	11.9	61.7	56.9

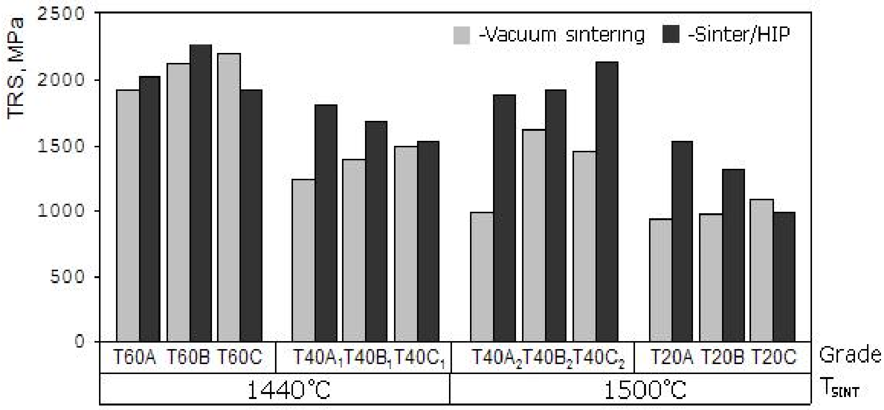

Fig. 1. TRS of TiC - NiMo cermets depending on binder content and sintering parameters.

Especially, intergranular porosity occurred in the core-rim interface area (Fig. 1.). Yet, the larger pores, present in high-carbide alloys, were removed.

Transverse rupture strengths

For the higher binder (40wt% of TiC) fraction materials, there was no positive effect from pressure sintering on the stength properties found (Fig. 1.).

With the grades with 60wt.% of TiC, sintered at normal temperature of 1440 ^{o}C. There was only a slight increase in the TRS values. When the sintering temperature was increased to 1500 ^{o}C, there was substatial growth (up to 60%) in bending strength. In the case of 80 wt% of TiC fraction alloys the property improvement for the lowest nickel content (Grade T20A) is most significant. For alloys with Ni:Mo ratio of 4:1 (T20C), this effect was not observed.

4. Conclusions

Based on the results of our experiments, the following conclusions could be drawn.

1. The TRS values for low-binder grades can be improved. But as much as the pore removal is important, so is the hindered binder evaporation and the Ni-binder alloy composition affected from the pressurized gas atmosphere during sintering and cooling.
2. For medium-carbide fraction alloys, it is possible to use Sinter/HIP sintering at elevated temperatures, leading to homogeneous microstructures and superior strength properties of the cermets.
3. The use of Sinter/HIP did not have a positive effect on erosion resistance in abrasive media.

5. References

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