Analysis of the Microstructure and Selected Properties of the MMC Composites Produced Via Suction Casting

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Abstrac
t： Over the years, metal matrix composites (MMCs) have been developed for various industries. In this work, the 718-TiB2 metal-matrix composites were fabricated through suction casting. The composites' microstructure, chemical composition, phase constitution, phase transformation temperatures, and hardness were investigated by scanning and energy-dispersive X-ray spectroscopy, thermodynamic simulation, and Vickers microhardness measurements. The results indicated that the MMC composites fabricated through suction casting exhibit a dendritic microstructure with the segregation of strengthening precipitates into interdendritic spaces. The addition of TiB2 particles increased the hardness and ultimate tensile strength.

Keywords: MMC, superalloy, composite, nanoparticles

1 Introduction

Composites can be manufactured using two main methods based on the temperature at which the metallic matrix is processed: liquid-state and solid-state processes. Creating MMCs aims to optimize the properties of both the matrix and the reinforcing precipitates, resulting in a unique combination of characteristics. MMCs integrate the strength and rigidity of non-metallic reinforcing particles with the ductility of a metal matrix, often resulting in a lower density that reduces the weight of the components. Ni-based alloys are particularly favored as a matrix for refractory composites in high-temperature applications due to their high strength, flexibility during service, and excellent resistance to hot corrosion and oxidation. The selection of ceramic particles is based on criteria such as their reactivity with the matrix, wetting ability, coefficient of thermal expansion, and density. For optimal performance, the chosen reinforcing particles should have a thermal expansion coefficient closely matching that of the matrix, minimizing the variance and promoting the generation of compressive or tensile stresses during service [1-3].

2 Experimental procedure

Alloy 718 and TiB_2 powders were used to produce the composites (Table 1). Its morphology is presented in Figure 1.

Table 1 Chemical composition of Alloy 718 powder, wt%

Ni	Fe	Cr	Mo
Bal.	18.55	19.8	2.98
Ti	**C**	**Al**	**Nb**
0.80	0.005	0.56	5.2

a) b)

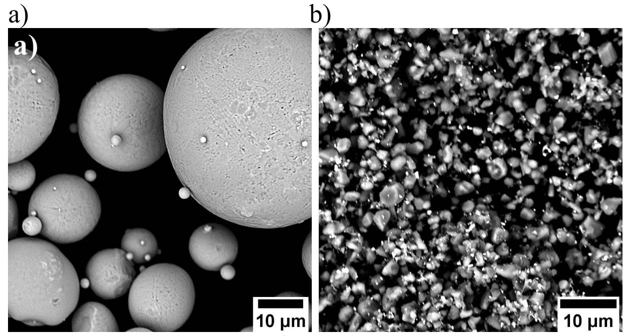

Figure 1. Morphology of the powder: a) Alloy 718; b) TiB2

The samples for microstructure analysis were taken and hot-embedded in Struers Polyfast conductive resin. Then, the grinding process was carried out on sandpaper of increasing grit levels, starting from #100 to #4000. After grinding, a three-stage polishing was conducted. Firstly, on Struers DiaDuo diamond suspension with a 3 µm particle size, followed by Struers DiaDuo diamond suspension with a 1 µm particle size, and finally using Struers OP-S reagent with a silica particle size of 0.06 µm. The unetched samples were then observed using a Leica DM/LM light microscope for preliminary observations. Subsequently, observations were carried out using a BSE (back-scattered electrons) detector to identify microstructural constituents and characterize the precipitates morphology. Point semi-quantitative analysis of the chemical composition, linear analysis of the distribution of selected elements, and distribution maps of selected alloying elements were performed using the EDX detector. The accelerating voltage for imaging and analyses was set at 20 kV.

3 Result and discussion

The microstructure of the 718-TiB_2 composites is presented in Fig. 2 and 3. The images of unetched microstructure confirm lack of the hot cracks and unacceptable discontinuities. Only a local microporosity has been observed.

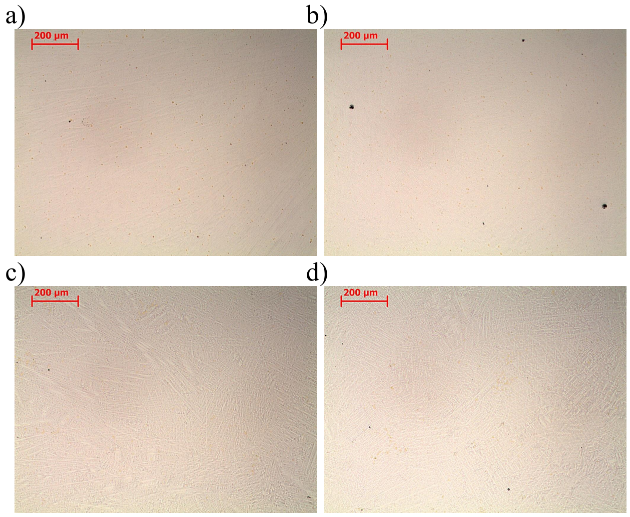

Figure 2. Microporosity in the 718-xTiB2 composite: a) x=1.25%; b) x=2.5%; c) x=3.75%; d) x=5.0%, LM

On the etched samples a dendritic structure is revealed (Fig. 3). A relatively homogeneous microstructure characterizes the dendritic regions, while in the interdendritic spaces the primary strengthening precipitates has been revealed.

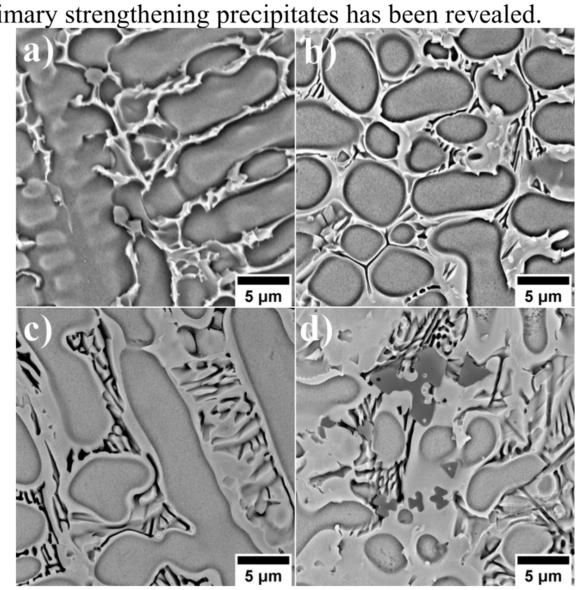

Figure 3. Morphology of precipitates in as-cast 718-xTiB2 composite: a) x=1.25%; b) x=2.5%; c) x=3.75%; d) x=5.0%, LM

4 Conclusions

The microstructure and selected properties of the MMC with different TiB_2 particles produced via suction casting were investigated. The following key results were obtained:

(1) Microporosity is the investigated composites occurring only locally and not exceeding 0.1%.

(2) The addition of TiB_2 particles led to an increase of the Alloy 718 hardness.

(3) Composites characterized by a dendritic morphology with segregation of alloying elements.

5 Acknowledgments

The authors gratefully acknowledge the funding by National Centre for Research and Development Poland under grant LIDER13/0036/2022 "Development of the manufacturing and deposition technology of metal ceramic nanocomposite coatings for the structural reconstruction of heat-resistant nickel-based superalloys".

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