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OPTIMIZATION OF SINTERING TEMPERATURE AND COMPACTION PRESSURE OF STAINLESS STEEL/SIC COMPOSITES

Óscar Carvalho, Delfim Soares and Filipe S. Silva
CT2M - Centre for Mechanical and Materials Technologies
Mechanical Engineering Department, University of Minho
Email: oscar.carvalho@dem.uminho.pt

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INTRODUCTION

Metal matrix composites, internationally known as MMCs represent a class of materials which much can be expected to solve complex problems related with aerospace, military, sports, biomedical, electrical transport and electronic components technologies. A great interest has emerged around MMCs due to its mechanical properties such as light weight and high elastic modulus (Yu, and Lee 2000). Primary Manufacturing processes of MMCs are often divided the liquid phase processes and solid state processes (Amaral Fortes and Ferreira 2003).

The strength properties of a MMC critically depend on the extent of interface reactions between the reinforcement and the matrix (Abenojar, et al. 2002). Systems in which interfacial reactions occur at some stage of fabrication or while exposed to temperature as a finished product are usually thermodynamically unstable, with renders their use questionable (Pelleg 1999).

The MMCs usually combine a metal matrix and ceramic reinforcement. One of the ceramic widely used in MMCs is the SiC. One of the problems when it is used SiC as the reinforcement is the solid state reaction between SiC and metals, especially, the transition metals, which results in the degradation of microstruture-associated proprieties of the systems as a whole (Tang et al 2002).

In this work, it will be study the mechanical proprieties and the chemical reactions of MMC, with a matrix of stainless steel martensitic 410 L and the reinforcement is SiC.

EXPERIMENTAL PROCEDURE

A stainless steel/SiC composite was produced by the powder technique. A martensitic 410L stainless steel powder was used 410L with a particle distribution of: 45% lower than 45 µm and 1% above 150 µm (Hoganas AB-Sweden). A SiC powder was used as reinforcement with a mean particle size of 118 µm.

After mixing the stainless steel with SiC particles, the mixture was compacted.

Three types of samples were produced by the use of an unidirectional load of 30 kN (374 MPa), 60 kN (749 MPa) and 90 kN (1123 MPa). The samples dimensions, after cold pressing, were: 10 mm in diameter and 9.36±0.82 mm of length.

Samples were sintered in resistance furnace, under a vacuum atmosphere, with a stage of 1 h at the maximum temperature .The stage temperatures used were 900, 1000, 1100 and 1180ºC.

The samples final microstructure was characterized by electronic scanning microscopy (SEM/EDS).

The sintered samples densities' was evaluated by the Archimedes principle method. The samples shear tests were made.

RESULTS AND DISCUSSION

The samples density was evaluated after the cold pressing and sintering operations. The increase on the cold compaction pressure increases the final density. With the increase in the sintering temperature there is an improvement of density but less pronounced when compared with the effect of the cold compacting pressure. The final sample density, for the sintering

temperature of 1100 ºC, approaches the value obtained with the higher compacting pressure (90kN).

The final samples density are very close to the theoretical properties, i.e. increasing compaction pressure and sintering temperature, there is an increase in density.

The reactivity between the metal alloy and SiC particles reinforcement was verified to be highly dependent on the sintering temperature. The use of higher sintering temperatures promotes de complete dissolution of the SiC particles.

The created alloy/SiC interface, at 1000 and 1100 ºC, is constituted by two zones: an internal zone near the SiC particles constituted by FeSi+C phases and an outer zone of Fe_3Si phase.

It was verified that increasing the compaction pressure and the sintering temperature the shear strength increases.

CONCLUSIONS

The alloy density, before sintering, is highly dependent on compaction pressure.

The reinforcement particles reacts with the matrix alloy. The reaction is highly temperature dependent and for sintering temperatures of 1180 ºC complete particle (SiC) dissolution was verified. The reaction interface is constituted by two zones with increasing carbon contents from the particle to the matrix side. These two zones were identified as: zone 1 is a two phase zone with $Fe_3(Si,Cr) + C$; zone 2 is mainly of phase Fe(Si,Cr).

The mechanical properties are also dependent on compaction pressure and sintering temperature. Shear strength and rupture strength increases with the compaction pressure and the sintering temperature. A similar effect was obtained with the sintering temperature. The higher improvements were obtained with the change from 1000 to 1100 ºC.

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