Study of TiCN Aditions to an 2xxx Series Aluminium Alloy

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Abstract

The increasing demand of PM parts for automobile and aerospace applications has caused a strong development of the aluminium based metal matrix composites (MMCs).Aluminium alloys are one of most widely used materials as matrix in MMCs, both in research and development as well as in industrial applications. In the present work, the influence of the ceramic reinforcement addition to a 2xxx series aluminium alloy is studied. Several percentages of TiCN have been added to the Al-Cu alloy using PM techniques, in order to analyze its influence on the liquid phase sintering process and on the final properties of the material.

Keywords : aluminium matrix composites (AMCs), ceramic reinforcement, liquid phase sintering

1. Introduction

Metal matrix composites (MMCs) have been considered as an important engineering material for potential applications in various industries from the days of their inception. During the last several decades, extensive research has shown the tremendous promise of metal matrix composites and a large number of conventional, as well as innovative, fabrication techniques have been developed to engineer composites for a diverse field of applications [1-6].

The requirement of lighter materials with high specific strength and stiffness has led to the development of a wide range of MMCs as an alternative to the conventional engineering alloys and the research on the ceramic reinforced MMCs has increased significantly. Even though composites have shown superior properties to the base metals currently being used, the promising use of the MMCs in several engineering applications remains doubtful. The superior properties of these MMCs make them ideal futuristic materials for a variety of applications in automobile, structural, electronic packaging industries, aerospace industries and critical defence-oriented fields [4-10].

The particulate reinforced MMCs are of particular interest due to their ease of fabrication, lower cost and more isotropic properties. It is also widely recognised that the size and volume fraction of the reinforcement phases as well as the nature of the matrix-reinforced interface control the properties of MMCs. An optimum set of mechanical properties tends to be obtained when fine and thermally stable ceramic particulates are dispersed in a metal matrix [2,4,6-14].

Most of the research on MMCs is being carried out on the Al based composites (AMCs) to improve its mechanical properties by the incorporation of hard ceramic oxides/carbides/nitrides into the metal matrices [10-16]. In this study, one AMC is consolidated by PM route, and the ceramic reinforcement influence on the final properties is analyzed in detail.

2. Experimental and Results

Aluminium matrix composites densification values are shown in Figure 1. It can be observed how densification increases as same time as the ceramic content. A maximum is reached when a 10wt% TiCN is added, regardless of the compaction pressure. Higher reinforcement quantities do not aid to improve material densification. Higher compaction pressures obviously lead to better densification values. The explanation to these enhanced densification values after TiCN incorporation could be related to the alumina layer disruption during the compaction step, since TiCN particles are harder than aluminium ones. These disruptions could aid to the liquid diffusion and spreading during the sintering process. Analyzing composites mechanical properties, the results obtained show how the bending strength values decrease when higher quantities of TiCN are added. These particles could aid to cracks beginning and propagation, and, as consequence, the strength of the material is reduced. Composites which have been compacted at higher pressures exhibit higher bending strength, although the differences between compaction at high or low pressures are not so marked.

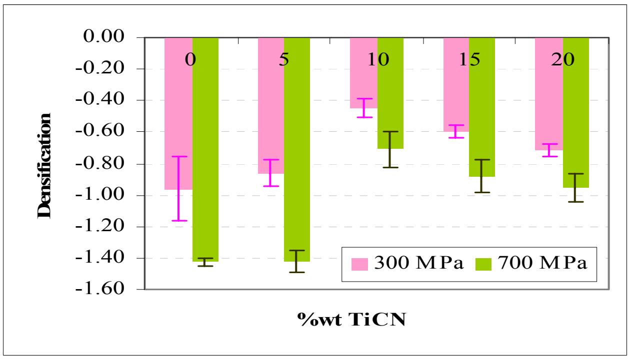

Fig. 1. Composites materials densification.

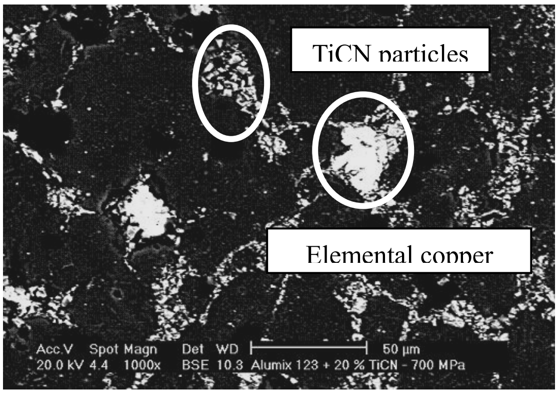

Fig. 2. Alumix 123 + 20wt% TiCN microstructure.

It can be seen an increased number of TiCN agglomerates when ceramic quantities are higher (Fig. 2). The TiCN agglomerations are located between Al particles and pores, giving to decreased mechanical properties since these zones could act as strain concentration points. When the TiCN content is higher, free copper zones can be identified. The location of the elemental copper zones is inside TiCN agglomerations, where it is kept, avoiding the contact with aluminium particles, and, as a consequence, avoiding the eutectic formation which leads to the liquid phase formation. Due to TiCN particles location, filling pores; composites porosity is reduced compared to Alumix 123.

3. Summary

AMCs present enhanced densification compared to Alumix 123 alloy, although the TiCN particles additions also affect to mechanical properties, since the ceramic reinforcement incorporation decrease bending strength. The reason would be related to the ceramic particles locations, which avoid aluminium particles bonding. On the other hand, composite hardness values are increased.

4. References

1. Kumar Ray, A., Venkateswarlu K., Chaudhury S.K., S.K. Das, B. Ravi Kumar, Phatak L.C., Mater. Sci. and Eng., vol. 8 (2002) 160-165
2. Robinson J.S., Cudd R.L., Evans J.T., Mater. Sci. and Tech., vol. 19 (2003) 143-155
3. Rajan T.P.D., Pillai R.M., Pai B.C., J. Mater. Sci., vol. 33 (1998) 3491-3503
4. Harris S.J., Composites Sci. and Tech., vol. 35 (1989) 99-103
5. Tang, F., Anderson I.E., Biner S.B., J. Light Metals, vol. 2 (2002) 201-214
6. Lee H.S., Yeo J.S., Hong S.H., Yong D.J, Na K.H., J. Mater. Proc. Tech., vol. 113 (2001) 202-208
7. Miracle D.B., Comp. Sci. and Tech., vol. 65 (2005) 2526-2540
8. Eliasson J, Sandström, R., Key Eng. Mater., Vol. 104-107 (1995) 3-36
9. Pitcher D., Shakesheff A.J., Lord J.D., Mater. Sci. and Tech., vol. 14 (1998) 1015-1023
10. Das S., Trans. Indian Inst. Met., vol. 57 (2004) 325-334
11. Kaczmar J. W., Pietrzak K., J. Mater. Proc. Tech., vol. 106 (2000) 58-67
12. Abouelmagd G., J. Mater. Proc. Tech., vol. 155-156 (2004) 1395-1401
13. Sahin Y., Mater. and Design, vol. 24 (2003) 671-679
14. Lindroos V.K., Talvitie M.J., J. Mater. Proc. Tech., vol. 53 (1995) 273-284
15. Dorward R. C., Pritchett T. R., Mater. and Design, vol. 9 (1988) 63-69
16. Ramachandran, T.R., Sharma P.K., Balasubramanian K., Trans. Indian Inst. Met., vol. 57 (2004) 409-425