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Powder metallurgy route in production of aluminium alloy matrix particulate composites

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Abstract

Metal matrix composites based on an aluminium alloys were produced by powder metallurgy route, involved unidirectionally hot pressing under 500 MPa for 15 minutes at temperature about 0.95 Ts [Solidus Temperature]. Metal matrix contains different weight percents of SiC, $\alpha\text{-Al}_2\text{O}_3$, WC and Si_3N_4 with different particle size. Wear and mechanical tests have been carried out on composites, and it was found that about 90% of wear reduction occurred in composite with 30% SiC compared with pressed matrix.

Introduction

Aluminium alloys reinforced with ceramic particles showing an improvement of the wear resistance and mechanical properties [1]. In recent years significant advances have been made on development of application of these composites [2]. The most generally used reinforcements are SiC and Al_2O_3 particles and the main advantages of particle reinforced alloys as compared with fiber reinforced materials are availability of different particles form, low cost production of composites and nearly isotropic properties of composites [3]. Most of previous investigation have been conducted on the mechanical properties [4], but very few studies on the wear resistance have been available in the literatures. The aim of this work is to produce Al-metal matrix composites by powder metallurgy route and to study the wear resistance and some mechanical properties of composites.

Experimental Details

Several of Al alloys matrix composites were produced by powder metallurgy route to avoid the problem with difficult preparation of these materials by foundry technique. The matrices powders were produced by the milling of as-cast alloy and the powders were sieved below 45 μm . Composite specimens [diameter=10mm, length=12mm] of AlSi alloys with 0-30Wt% of reinforcing additions of SiC, $\alpha\text{-Al}_2\text{O}_3$, Si_3N_4 , and WC with different particle size have been prepared by unidirectional hot pressing under constant pressure 500 MPa for 15 minutes and at temperature 0.95 Ts. The chemical composition of the matrix powders and pressing temperatures are given in Table 1.

Matrix	Chemical composition	Pressing Temp °C
M1	AlSi20 Ni2 Cu13 Mn2 Ti0.5 Fe1.5	540
M5	AlSi20 Ni10 Cu10	500
M6	AlSi20 Ni5	540

Table 1: Chemical composition (in Wt%) of aluminium alloys matrix and pressing temperature.

Results and Discussion

Wear and some mechanical tests have been carried out on composites. Figures 1 and 2 show the comparison of hardness (HB) and relative wear (Wrel) achieved for the individual matrices M₁, M₅, and M₆ with different wt% (0-30%) of SiC, Si₃N₄, Al₂O₃, and -Al₂O₃. The relative wear test (Wrel) was carried as the volume loss of the test specimen on grid 120 grinding paper [test path 46.15m, contact pressure 0.029 MPa] relate to the volume loss of reference material - ČSN 12020 steel (66 HRB), Wrel=1). The Wrel was calculated from the relation:

$$Wrel = \frac{\Delta m_{sp} \cdot \rho_{st}}{\Delta m_{st} \cdot \rho_{sp}}$$

Where Δm_{sp} and Δm_{st} are the difference of the masses (in gram) of specimen and standard material respectively before and after the test. ρ_{sp} and ρ_{st} are the densities (in gm/cm³) of the specimen and standard material respectively.

Fig.1 The hardness (HB) of M1, M5, and M6 matrix with 0-30Wt% of SiC, Si₃N₄, WC and Al₂O₃.

Fig.2 The relative wear (Wrel) of M5 and M6 matrix with 30Wt% of WC, Si₃N₄, SiC and Al₂O₃.

Relative wear (Wrel) was achieved also on M1 with 30 Wt% SiC of different particle sizes of SiC and this is shown in Figure 3.

Fig.3 The Wrel of M1 with 30 Wt% of SiC of different particle sizes.

Compression strength have been done on M1, matrix with 30 Wt% of SiC of different particles size and this shown in figure 4.

Fig.4 Compression strength (comp) of M1/30 Wt% SiC of different particle size.

Optimum properties have been achieved in these composites and the composites show increasing in hardness and wear resistance with the increase of ceramic wt% up to 30 wt%, and the best results were obtained with particle size between 100 mm and 250 mm of ceramic powder (30wt%SiC) and this agree with several investigations, and this is, may be due to good homogeneity of composites.

Conclusion

The present work has shown that AlSi-base composite materials with different weight percents of ceramic particles, have high values of hardness and good wear resistance as comparison of the matrix. The beset results were obtained for composite which contains matrix M₅ with 30 wt% SiC. This composite has higher hardness and excellent wear resistance compared with other composites which were studied.

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