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ABRASION WEAR CHARACTERISTICS OF SAND CAST Al-7075-Al_2O_3 MMC

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ABSTRACT

In this investigation, attempts have been made to develop Al-7075-Al_2O_3 MMC through stir casting technique and using CO_2 hardened-sodium silicate bonded silica sand moulds. Further, influence of Al_2O_3 particulate on dry sand rubber wheel abrasion wear characteristics in the as-cast and heat-treated condition is carried out to explore the feasibility of using this MMC developed for abrasion wear resistance application. The details of the results obtained are presented in this paper.
Keywords : Al-7075, Al_2O_3, Abrasive Wear.

1. INTRODUCTION

The literature survey on MMCs indicate that much published information is not available on development and properties of Al-7075-Al_2O_3 particulate composites. From the literature survey, it is also apparent that melting and casting route for production of MMCs using particulate reinforcement is the most economical way of producing MMCs (1-7).

In the above context, in this study, the feasibility of developing cast Al-7075-Al_2O_3 particulate composites as an engineering material through stir casting technique, using CO_2 hardened-sodium silicate bonded silica sand moulds (rather than in permanent moulds) has been explored. The influence of Al_2O_3 particulates on the dry sand/rubber wheel abrasive wear characteristics, of the as-cast and heat treated Al-7075-Al_2O_3 particulate MMCs has been evaluated in order to explore the feasibility of using the MMC developed for abrasive wear resistant applications.

Since the base Al-7075 alloy is a heat-treatable alloy, the abrasive wear characteristics of the MMCs containing different weight percentage addition of Al_2O_3 particulates in solutionized and aged condition is also been evaluated.

2. EXPERIMENTAL DETAILS

The base metal used in this investigation was Al-7075 alloy. The chemical composition of the base alloy as found out by EDX analysis was 5.57 wt.% zinc, 2.50 wt.% Mg, 1.59 wt.% Cu, 0.34 wt% chromium, balance was Aluminium. Al_2O_3 particulate was used as the dispersoid. And the castings were produced through stir-casting technique using CO_2 hardened-sodium silicate bonded silica sand moulds. Abrasion resistance of the composite castings was assessed using a dry sand/rubber wheel abrasion test rig. Specimen, measuring 75 mm x 25 mm x 6 mm, prepared from test casting was used to evaluate abrasive wear characteristics. Test was conducted at a load of 13.25Kg. for a duration of 2000 revolutions. Speed of the rubber wheel was 200 rpm. Abrasive material used was silica sand grains of size AFS 60 and flow rate was 0.25 Kg./min.

3 RESULTS AND DISCUSSION

3.1 Dry sand abrasive wear characteristics of as-cast Al-7075-Al_2O_3 particulate MMCs

The dry sand/rubber wheel abrasive wear characteristics of as-cast Al-7075-Al_2O_3 particulate MMCs containing different weight percentages additions of Al_2O_3 particulates has been presented in Fig.1

From the study of the Fig.1 it can be observed that, as the Al_2O_3 particulate content in the Al-7075-Al_2O_3 MMC is increased, there has been a decrease in abrasive wear weight loss.

The hardness of MMCs containing different wt.% of Al_2O_3 particulates have been noted and a plot of rubber wheel dry abrasive wear weight loss v/s hardness expressed in BHN has been presented in Fig.2.

From the Fig.2 it can be observed that, the hardness of MMC has influence on the dry abrasive wear characteristics of the MMCs. Further, it can be observed that as the hardness of the MMCs increases, there has been a decrease in the dry sand/rubber wheel abrasive wear weight loss.

3.2 Dry sand/rubber wheel abrasive wear characteristics of heat-treated Al-7075-Al_2O_3 MMC

The dry sand/rubber wheel abrasive wear characteristics of heat-treated Al-7075-Al_2O_3 particulate MMCs containing 0wt.%, 1wt.%, 2wt.%, 3wt.%, 4wt.%, 5wt.% and 6wt.% of Al_2O_3 particulates has been presented in Fig.3.

In Fig.3 the effect of Al_2O_3 particulate content expressed in weight percent on dry sand/rubber wheel abrasion wear weight loss expressed in milligrams has been presented. In order to understand the effect of heat-treatment on dry sand/rubber wheel abrasive wear characteristics of both as-cast and heat-treated Al-7075 particulate MMCs evaluated under identical conditions have been plotted in the same figure.

For a given Al_2O_3 particulate content, under identical conditions the dry sand/rubber wheel abrasive wear weight loss for heat-treated Al-7075-Al_2O_3 particulate composite has been higher than the dry sand/rubber wheel abrasive wear weight loss of as-cast Al-7075-Al_2O_3 particulate composite by about 07% to 11% depending upon the content of Al2O3 particulate present in the MMCs.

However, as weight % of Al_2O_3 particulates is increased, the dry sand/rubber wheel abrasive wear weight loss reduces for both as-cast and heat-treated Al-7075-Al_2O_3 particulate composites. The hardness of MMCs containing different wt.% of Al_2O_3 particulate have been noted and a plot of dry sand/rubber heel abrasive wear weight loss v/s hardness expressed in BHN has been presented in Fig. 4.

The solutionizing and aging heat treatment may have softened the baseAl-7075 matrix alloy. Perhaps, this might be the reason for exhibition of lower wear resistance by heat-treated MMCs as compared to as-cast MMCs.

3.3 SEM analysis of the worn surfaces subjected to dry sand/rubber wheel abrasive wear

The SEM micrographs of the worn as-cast un-reinforced Al-7075 alloy and Al-7075-Al_2O_3 particulate composites containing typical 4wt.% addition of Al_2O_3 particulate and 6wt.% addition of Al_2O_3 particulate subjected for abrasive testing at a load of 13.25Kg. for a test

duration of 2000 revolutions at a magnification of 20X and 500X has been presented in Fig.5 (a) & Fig.5(b), Fig.6 (a) & Fig.6(b) and Fig.7 (a) & Fig.7(b).

The SEM micrographs of the worn heat-treated un-reinforced Al-7075 alloy and heat-treated Al-7075-Al_2O_3 particulate composite containing typical 4wt.% addition of Al_2O_3 particulate subjected for abrasive testing at a load of 13.25 Kgs. for a test duration 2000 revolutions at a magnification of 100X and 750X has been presented in Fig.8(a) & Fig.8(b) and Fig.9 (a) & Fig.9(b).

These Fig. 5 to 9, show the wear track morphology of the specimens tested. For the sake of brevity and convenience the micrographs of MMCs containing only typical weight percents of Al_2O_3 particulate have been presented. However, the explanation that follows holds good for MMCs containing other wt.% of Al_2O_3 particulates tested.

4. CONCLUSIONS

The results of the systematic investigation carried out indicate that within the scope of this investigation,

i). For a given Al_2O_3 particulate content, under identical conditions, the dry sand/rubber wheel abrasive wear weight loss for heat-treated Al-7075-Al_2O_3 particulate conposite is higher than the dry sand/rubbe wheel abrasive wear weight loss of as-cast Al-7075-Al_2O_3 particulate composite (by 7% to 10%, depending upon the content of Al_2O_3 particulate present in the MMCs.). This means that due to solutionizing and aging heat treatment the dry sand/rubber wheel abrasive wear resistance of the MMC decreases by 07% to 11% depending upon the content of Al_2O_3 particulate present in the MMCs. However, as weight % of Al_2O_3 particulates is increased, the dry sand/rubber wheel abrasive wear weight loss reduces for both as-cast and heat-treated Al-7075-Al_2O_3 particulate composites.

ii). The micrographs of as-cast specimens indicate that a number of parallel and continuous abrasive scratches on the wear surface of base alloy and the composites. These parallel and continuous abrasive scratches suggest that abrasive wear as characterized by the penetrations of the hard Al_2O_3 particulate into the softer surface, which is an important contributor to the abrasive wear behaviour of Al-7075–Al_2O_3 particulate composite.

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FIGURES

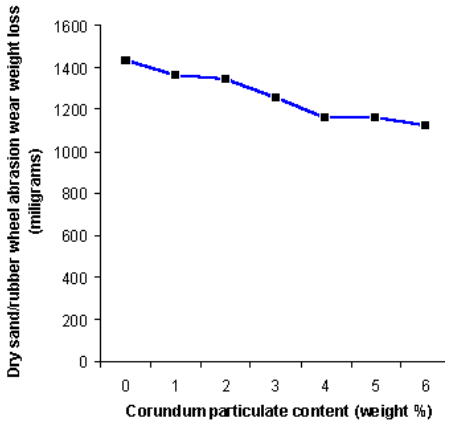


Fig. 1 Dry sand/rubber wheel abrasion wear weight loss of as-cast Al-7075-Al_2O_3 particulate MMC at different wt.% addition of Al_2O_3 particulates.

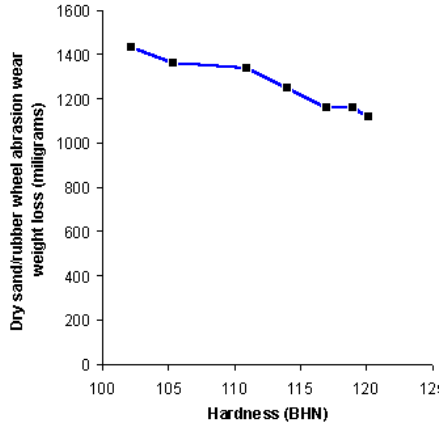


Fig. 2. Influence of hardness on dry sand/rubber wheel abrasion wear weight loss of as-cast Al-7075-Al_2O_3 particulate MMC

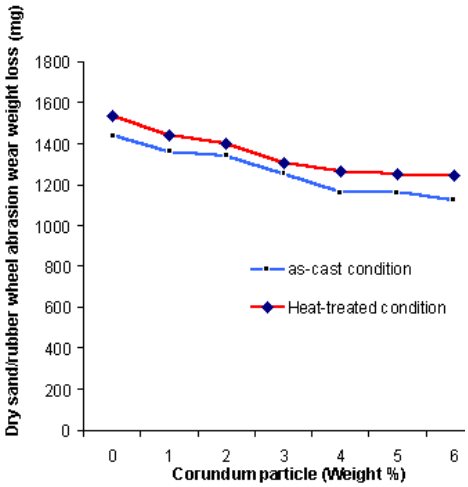


Fig. 3 Dry sand/rubber wheel abrasion wear weight loss of as-cast and heat-treated Al-7075- Al_2O_3 particulate MMC at different weight % of Al_2O_3 particulates

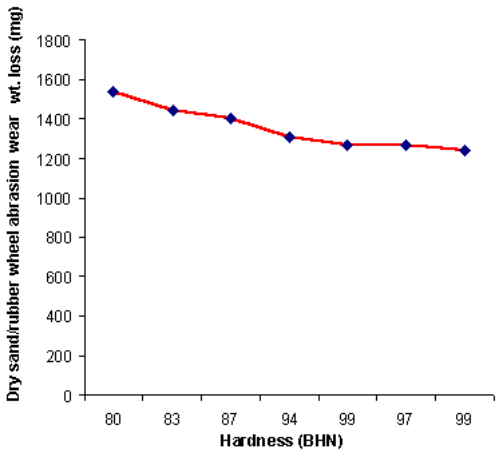


Fig. 4 Influence of hardness on dry sand/rubber wheel abrasion wear weight loss of heat-treated Al-7075- Al_2O_3 particulate MMC

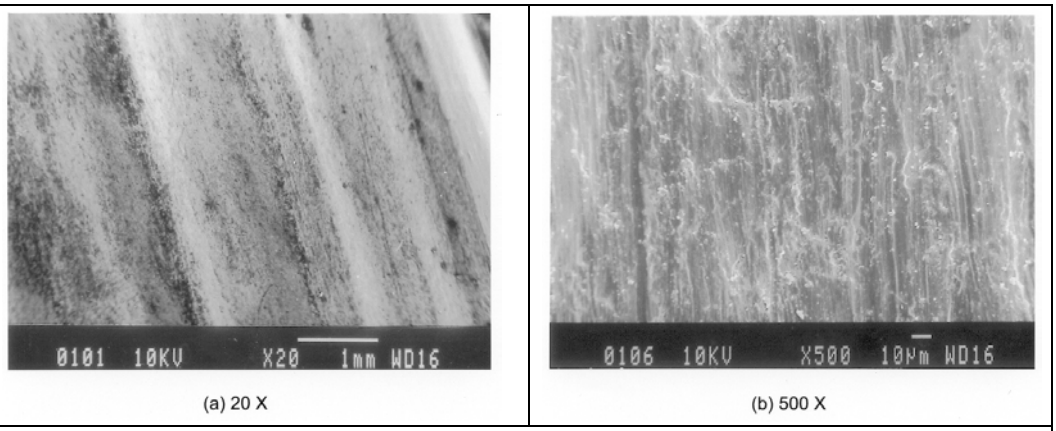


Fig. 5 Typical photographs of as-cast Al-7075 dry sand/rubber wheel abrasive wear test specimens without any Al_2O_3 particulate addition at a magnification of 20X and 500x as observed under SEM.

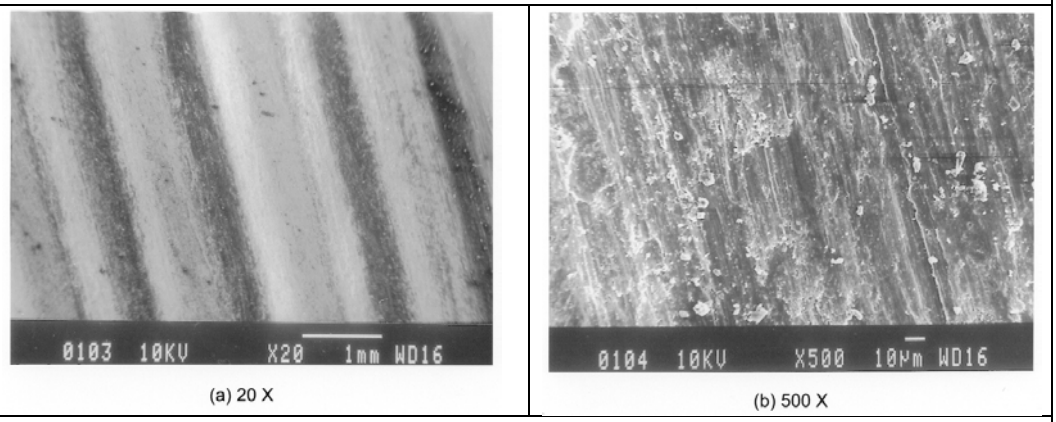


Fig. 6 Typical photographs of as-cast Al-7075- Al_2O_3 particulate MMC containing 4wt.% Al_2O_3 particulates when tested for dry sand/rubber wheel abrasive wear test at a magnification of 20X and 500X as observed under SEM

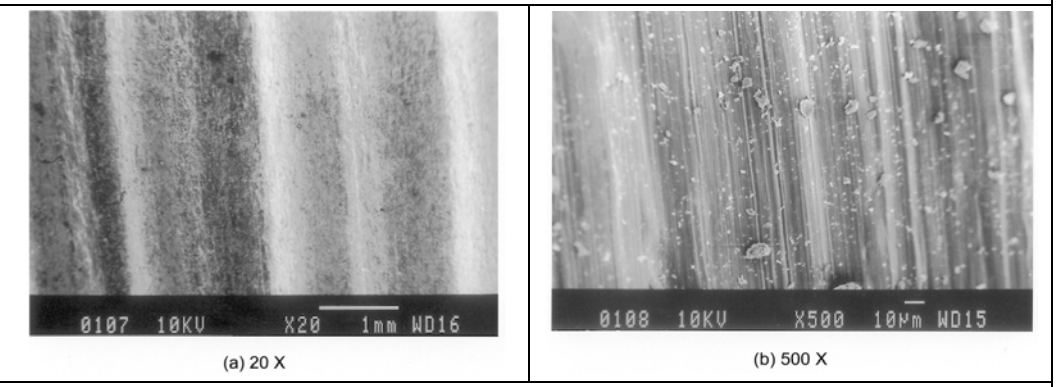
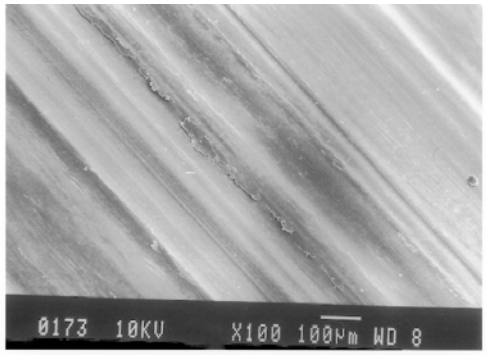
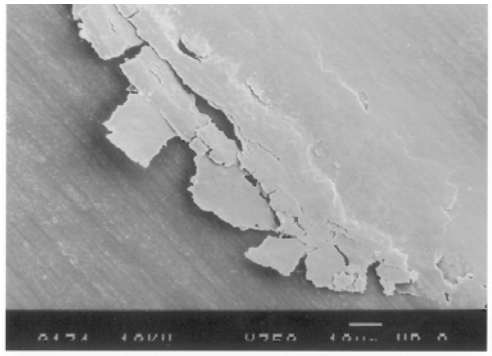


Fig. 7 Typical photographs of as-cast Al-7075- Al_2O_3 particulate MMC containing 6wt.% Al_2O_3 particulates when tested for dry sand/rubber wheel abrasive wear test at a magnification of 20X and 500X as observed under SEM

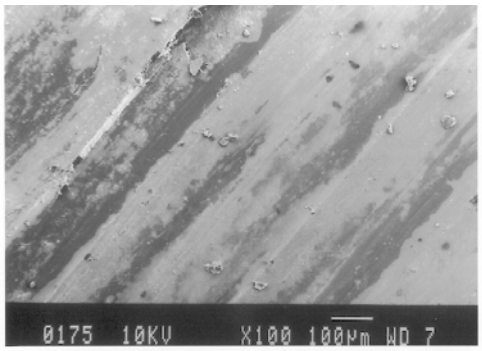


(a) 100 X

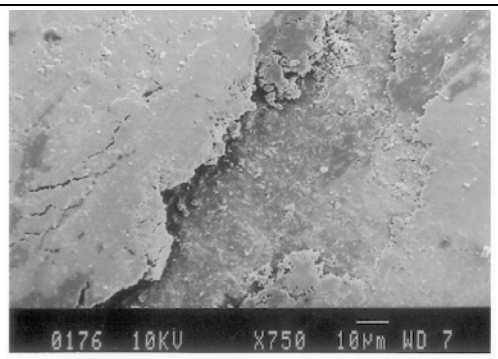


(b) 750 X

Fig. 8 Typical photographs of heat-treated Al-7075 dry sand/rubber wheel abrasive wear tested specimens without any Al_2O_3 particulate addition at 100X and 750X as observed under SEM.



(a) 100 X



(b) 750 X

Fig. 9 Typical photographs of heat-treated Al-7075- Al_2O_3 particulate MMC containing 4wt.% Al_2O_3 particulates when tested for dry sand/rubber wheel abrasive wear test at a magnification of 100X and 750X as observed under SEM.