STUDIES ON STRENGTH, FRACTURE, FATIGUE AND WEAR BEHAVIOUR OF Al-SiC PARTICULATE COMPOSITES

by

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hardness testing & wear testing

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In the name of Allah the Beneficent the Merciful

"All praise be to Allah who created man and taught him what he knew not"

O

To my late Father and who have been the inspiration

all along

&

my beloved

Mother & Sister who suffered infinite neglect during this work

CERTIFICATE

This is to certify that the thesis titled "**STUDIES ON STRENGTH, FRACTURE, FATIGUE AND WEAR BEHAVIOUR OF Al-SiC PARTICULATE COMPOSITES**" being submitted by **ZAHIR HASAN** to the Indian Institute of Technology, Delhi, India for the award of the degree of '**Doctor of Philosophy**' in Applied Mechanics Department is a record of bonafide research work carried out by him under our supervision and guidance. The thesis work, in our opinion, has reached the standard fulfilling the requirements for the degree of 'Doctor of Philosophy'. The research report and results presented in this thesis have not been submitted in part or in full to any other university or institute for the award of any degree or diploma.

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ABSTRACT

The Al-alloys containing dispersion of second phase ceramic particles have wide potentiality as viable engineering materials for a number of applications such as bearing, piston, cylinder liners, aerospace applications, defence related applications etc. The present investigation is concerned with the studies on Al-SiC particulate composites. The effect of weight % of particulate phase has been investigated on the elastic modulus, strength properties, ductility, fracture toughness, fatigue crack growth behaviour and wear characteristics in these composites.

The thesis is divided into eight chapters and these are as follows.

Chapter 1 gives an **Introduction** to metal matrix composites with particular reference to Al-base particulate composites. The superior properties of Al-base composites have been outlined and their engineering applications discussed.

Chapter 2 provides a **Review of Literature** on particulate composites. It covers prominent methods of manufacturing the particulate composites. The effect of particulate phase on properties like elastic modulus, yield strength, ductility, fracture energy etc are given. The micromechanism for void formation, growth and coalescence of voids in two phase materials has discussed. A review of fracture toughness parameters such as K_{IC}, δ_c, J-integral etc has been presented. Fatigue crack growth behaviour using fracture mechanics approach has also been discussed. The micromechanism of crack propagation in particulate composites as reported by different workers has been included. The wear behaviour of Al-base particulate composites has also been out lined. At the end, the objectives of the present investigation have been spelt out.

Chapter 3 is concerned with **Experimental Programme.** In this chapter the methods of composite fabrication in the present work have been given. The

microstructural characterization using optical microscope as well as SEM has been presented. Fracture toughness test and fatigue crack propagation test in the materials have been described. The experiments on wear studies in the composites as well as in Al-Si piston alloy have been detailed. Finally SEM examinations of various fracture surfaces (e.g. tensile fracture, fracture surface from fracture toughness specimen, fatigue fracture surface etc) have been conducted. In addition, the wear surfaces have also been examined under SEM to study the wear mechanism.

Chapter 4 deals with **Materials Characterization and Mechanical Behaviour**. In this chapter results on microstructure and particulate size distribution etc have been given. Also the results on hardness measurement and tensile testing are reported. Various tensile properties such as yield strength, tensile strength, strain hardening exponent, fracture strength, % elongation etc have been presented. The effect of particulate phase on the elastic modulus has been discussed in the light of some existing models. Also the effect of particulate phase on strength, deformation and facture behaviour of composites has been discussed. A comparative study of mechanical and fracture behaviour of composites with respect to the Al-base alloy has been presented. The micromechanism of fracture in tensile specimens has also been discussed.

Chapter 5 deals with **Fracture Toughness and Mechanism of Fracture**. In this chapter results on evaluation of fracture toughness parameters CTOD, K_{IC} and J_{IC} are presented. Attempts have been made to predict fracture toughness using some of the models available in literature. However, existing models do not appear to be applicable in the composites of present investigation. Effect of particulate phase on the fracture toughness of the composites has been discussed. The size of fracture process zone at the crack tip has been evaluated and based on that the micromechanism of fracture has been discussed. The results on SEM studies of fracture surfaces have also been included and the observations of salient microfractural features have been presented.

Chapter 6 is based on **Fatigue Crack Growth Kinetics and Fatigue Micromechanics**. In this chapter the kinetics of crack growth in the materials of the present investigation has been obtained as a function of ΔK taking into account crack closure effects. The ΔK_{eff} values have been obtained and crack growth kinetics have also been presented in the form of ΔK_{eff}. Attempt has been made to obtain threshold stress intensity factor i.e. ΔK_{th} in the composites. The micromechanism of fatigue propagation has been discussed in the light of fractographic results. The effect of particulate phase on kinetics of fatigue crack propagation has been discussed and beneficial effect of particulate phase has been brought out.

Chapter 7 is based on **Wear Characterization** in Al-alloys as well as Al-SiC composites. The results on weight loss have been presented as a function of sliding distance in Al-base alloy, Al-Si piston alloy and the Al-SiC composites against emery papers of 400, 600 and 800 grades. The wear rate has been evaluated in term of weight loss as well as wear volume in all the materials investigated. Further the evaluation of wear rate has also been conducted against grey cast iron surface. The effect of load and counterfacing surface on the wear rate has been discussed. The mechanism of wear is studied using SEM. Effect of particulate phase on the wear rate of composites has been highlighted. In addition, the effect of abrasive size on wear rate of composites has also been discussed.

Chapter 8 provides **Conclusions and Recommendations for Future Work**. The main findings of the investigation have been listed out. The suggestions for future work have also been indicated.

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