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Experimental Determination of Fracture Toughness for Hybrid MMC Reinforced with B_4C and MoS_2

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Abstract

In current research work, Al2219 reinforced with constant 3% of Boron Carbide (B_4C) and with varying Molybdenum di sulphide (MoS_2) by method of stir casting technique. The prepared hybrid composites were examination under Scanning electron microscope for even disperse of reinforcement. CompactTension (CT) Specimen was prepared and test carried out in BISS axial universal testing machine to determining K_IC parameter. From this study stability of crack propagation under mode-I failure is analysed. The study reveals that adding same amount of boron carbide and varying percent of molybdenum disulphide makes increase in energy required to open the crack and crack propagation is increased and also in increase fracture toughness.

Keywords:*Al2219, Stir Casting, Microstructure, K_IC test*

1. INTRODUCTION

Metal matrix composites are modern and atraritve materials for usage in applications like aerospace automobile industry because of high strength to low density ratio and also it is fabrication and increasing demands highly in recent era. Usually composites of metal matrix are union of soft metal base alloy with reinforcing the hard materials shows rising pin on specific strength and specific stiffness at both room and high temperatures, good resistant to wear, good resistant to corrosion. With the increasing in advancement of research technology on material science, always everlasting demand to light weight harder, economical, energy saving and stronger material in the usage of high end applications like defence systems, research aircraft and highly in automation parts in these aluminium matrices composites are light spot applications. Al MMC possess good mechanical property such as wear resistant by adding reinforcement [1]. Mechanical property of MMC subjective to volume fraction and size of particles[2]. Although mechanical properties were induced in MMC's, the resistant to crack growth, less in ductility, toughness are obstacles to refer for criticalapplications [3]. Fracture toughness greatly influenced by even distribution of reinforcements, size of particles, material toughness [4]. In this paper hard particle B_4C and soft solid lubricant MoS_2 used as reinforcement for base alloy Al2219 to study stability of composites on Mode-I failure.

2. FABRICATION AND CHARACTERIZATION OF HYBRID COMPOSITES

Material: Aluminum alloy AA 2219 which is used as base matrix. Table 1.1 shows weight percent composition.

Table 1.1: Chemical composition of Al2219

Cu	Mg	Zi	Va	Ti	Al
6.30	0.30	0.18	0.10	0.06	Base

Figure1.1: Resistance furnace used for stir casting

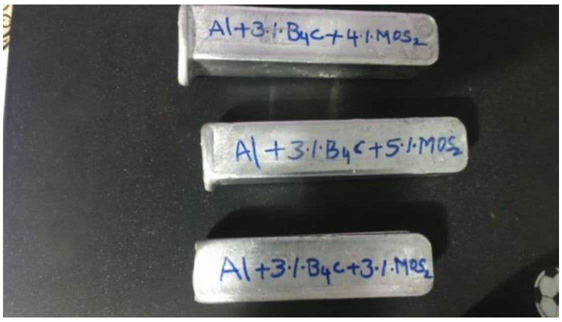

Figure1. 2: Prepared Al2219-B_4C-MoS_2 Composites

The reinforcement used are boron carbide and Molybdenum disulphide. The reistance furnace used for prepare hybrid comspoite by two stage stir casting technique as shown in figure 1. The Al2219 matrix melted at temperature 750ºC. the preheated reinforcements B4C and MoS2 [at 250ºC] were introduced to molten metal. stirring action is accomplished by zirconium coated stainless steel at 250 rpm about 5-6 min. the prepared composites are shown in figure 1.2.

2.1 Characterization of prepared composites:

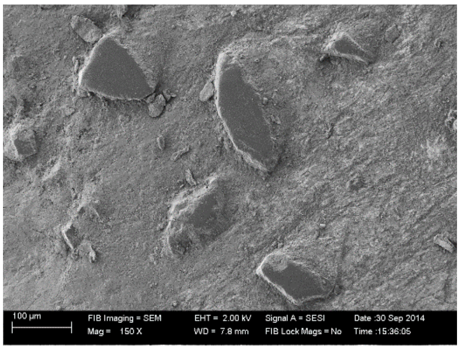

Figure1. 3:Microimages of Al2219-3 wt%B_4C-3 wt%MoS_2

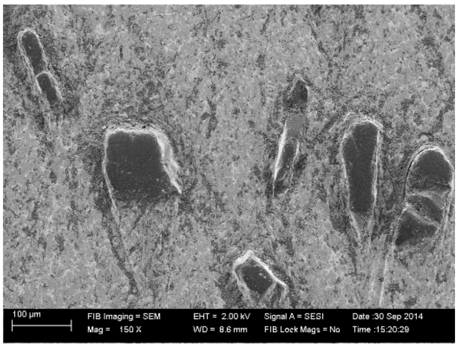

Figure 1.4: Microimages of Al2219-3 wt%B_4C-4 wt%MoS_2

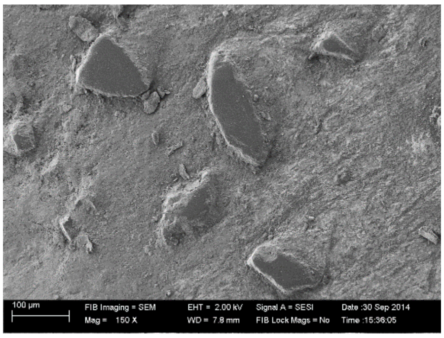

Figure 5: Microimages of Al2219-3 wt%B_4C-5 wt%MoS_2

The main intention of characterization of prepared composites is to identify whether the reinforcing particles uniformly disperse in the matrix. The reinforcement particle distribution and nature of interface are clearly identified by using field emission scanning electron microscopy. figure 1.3 shows Al2219 -3%B4C-3%MoS2, figure 4 shows Al2219-3%B4C-4%MoS2, figure 1.5 shows Al2219-3%B4C-5%MoS2. The SEM microimages clearly shows that distribution of boron carbide and Molybdenum disulphide to aluminium matrix.

3. EXPERIMENTAL DETAILS

3.1 Specimen preparation

For fracture toughness test Compact tension(CT) specimen is selected as dimension are conformity to E-647 standard. Initially 7.2 mm of notch length is made for precrackon thea/w ratio of 0.3 by wire EDM as shown in figure 1. 7. Generation of holedia of 6.35 mm by EDM drill process.

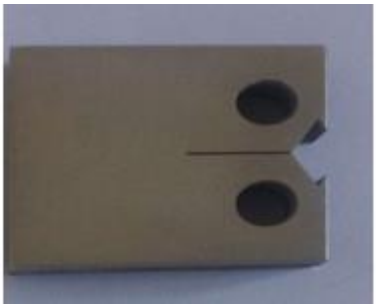

Figure1. 6: prepared CT specimen

Figure 1.7: Wire EDM used for Notch Preparation

Other dimensional parameters of compact tension specimen is as show in table 1.2

Table1.2: Dimensions of CT specimen as per ASTM standard

Factors	**Measurements**
Total length	31.75 mm
Total width	30.48 mm
W	25.5 mm
Thickness	6.35 mm
Hole dia	6.35 m(2 nos)

4. FRACTURE TOUGHNESS TEST

The crack can say ideal it should contain zero radius curvature at tip. Usually it prepared by two common method (1) by using machined slot (2) by using fatigue loading(for extension). Machined slot not make proper sharp notch because tip of cutting tool contains finite radius of curvature and also other reason is every engineering material are plastic flow(atleast some amount). So the prepared composites initially fabricated in wire EDM for a/w ratio of 0.31 and these composites are subjected to variable amplitude fatigue loading condition by BiSS UTM as shown in figure 8 by calculating fatigue load. At this point care should be take as growing sharp notch on fatigue load is much time consuming. For each and every fatigue load crack grows i.e, crack growth per unit cycle(da/dn) this growth is as small as 10^{-10} and it is tracked by clip gauge as shown in figure 9. As sharp notch continues from a/w ratio of 0.3 to a/w ratio 0.45 test will automatically stops. From this point material is loaded for K_IC test condition and continues load applied until brakage happens as shown in figure 10. After brakeage relation between load and COD obtained as shown from figure 1.11-1.14. This graphs provides critical load P_Q correspondingly K_Q will appear, this will validating by satisfying all specimen geometry constraints and it will become K_IC.

Figure1.8: Universal Testing Machine (Axial)

Figure1.9: Fatigue Loading Condition

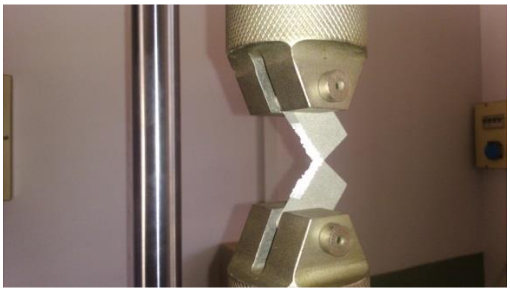

Figure1.10: Breakage of Specimen

5. RESULT AND DISCUSSION

Load vs COD comparison:

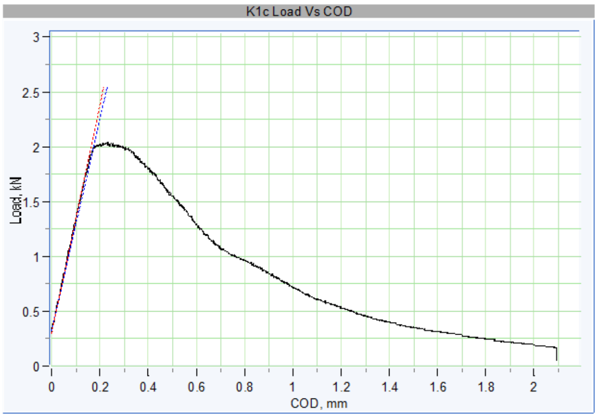

Figure1.11:Al2219

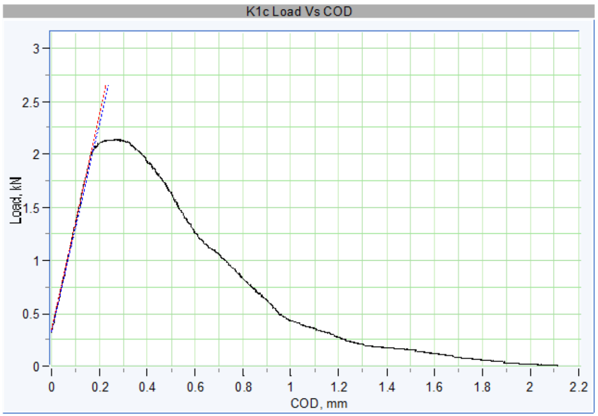

Figure 1. 12:Al2219-3%B_4C-3%MoS_2

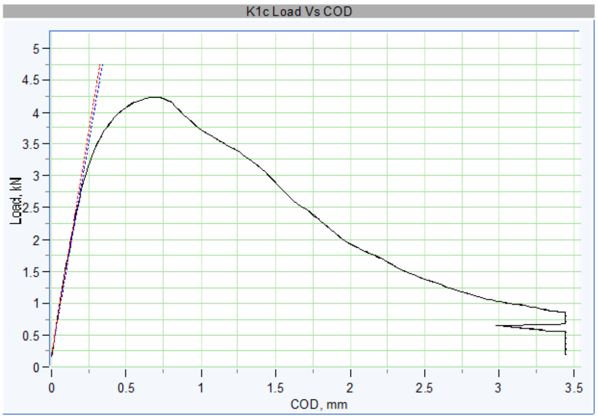

Figure1.13:Al2219-3%B_4C-4%MoS_2

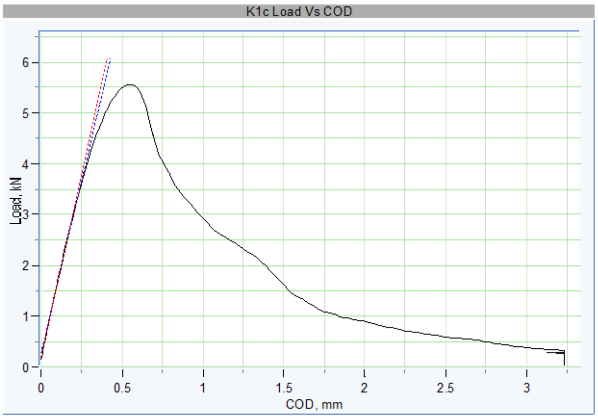

Figure 1. 14:Al2219-3%B_4C-5%MoS_2

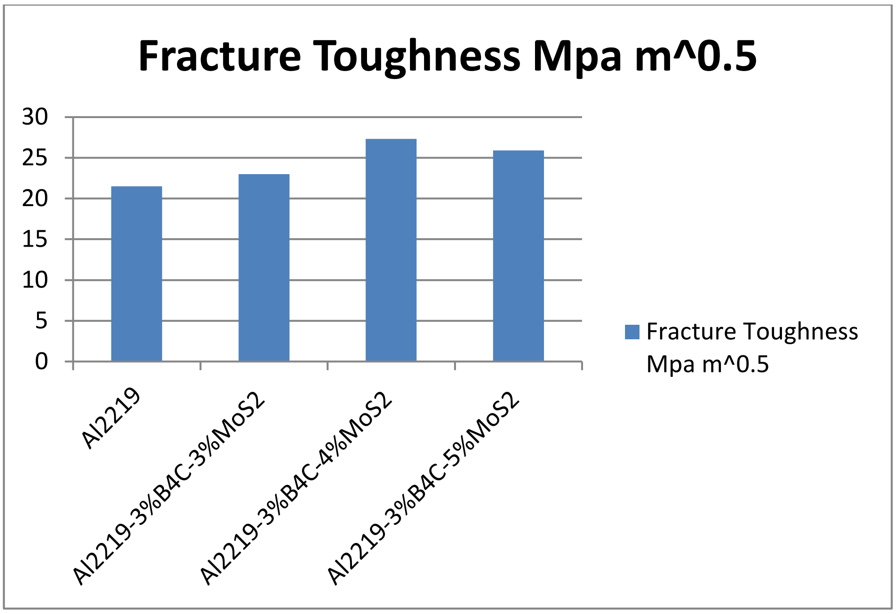

Figure 1. 15: Comparison of composites with Fracture toughness

Above mentioned Load vs COD images are clearly expose the load requires to open the crack.from the figure11 as cast alloy of aluminium 2219 requires load of 2.037 KN of load. From referring figure 12 the composite Al2219-3%B_4C-3%MoS_2requires minor increase from base alloy to open up the crack because of initiating B_4C to matrix. From figure 13 the compositeAl2219-3%B_4C-%MoS_2 reveals that load slightly increase to bearing the crack front and slight increase in extension after crack. From the figure 14 the composite Al2219-3%B_4C-5%MoS_2 requires somewhat more load compare to other two composites and it is highest among the prepared compositesbecause of increase in particles of MoS_2 in matrix. Due to addition of soft solid lubricant MoS_2, the energy absorbtion capacity of the specimen is improved, can overcome crack resistance. This makes instant sharp crack is blunted due to plastic flow of metal (LEFM) correspondingly elongation increases as seen in figure1. 13.

6. CONCLUSION

This current report makes an attempt to study crack opening displacement and fracture toughness having mode I failure. The prepared composite having uniform distribution of B_4C and MoS_2 this is by examine the composite under FESEM. By adding B_4C and MoS_2 it makes increase in bearing load to open the crack front. As compared to base alloy and all composites, the composite Al2219-3 wt% B_4C-5 wt%MoS_2 is higher load withstand but affected to comparatively less fracture toughness to Al2219-3 wt% B_4C-4 wt%. But rise in adding Molybdenum disulphide makes increase in extension after crack and increase in load to open the crack front as compared from figure 12 to figure 14, because of its soft nature property. These above mentions were concluded from investigation of hybrid composites.

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