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Effect of AL_2O_3 and fly ash reinforced particulates for fatigue behavior of the AL6061T6 alloy matrix composites.

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Abstract --- The Aluminium metal matrix composites are being considered for their strength to weight ratio and better mechanical characteristics, they find application in the field of automotive, aerospace, and construction. In present work the composite material is fabricated with fly ash composition of 9%,12%,&15% weight fraction and Alumina (Al2O3) with 6% weight fraction using vortex casting. SEM and EDS analysis revealed the particulate distribution as even and there by Mechanical test are carried out. It was observed that tensile and hardness properties were excellent when compared with monolithic alloy and the fatigue behaviour revealed that composite with 6% Al_2O_3 and 15 % fly ash has good fatigue life compared with monolithic alloy. The fatigue test was conducted using fully reversed cycle R=-1 using rotating bending machine at room temperature. Loads are defined by considering 0.5UTS, 0.7UTS and 0.9UTS to plot S-N curve.

I. Introduction

The particulate composite can be prepared by injecting the reinforcing particles into liquid matrix through liquid metallurgy by casting. Among the entire liquid state production routes, stir casting[1] is the simplest and cheapest one. The only problem associated with this process is the non uniform distribution of the particulate due to poor wet ability and gravity regulated segregation. Mechanical properties of composites are affected by the size, shape and volume fraction of the reinforcement, matrix material and reaction at the interface. To over come this problem magnesium is added to molten aluminium about 2% to achieve wettability. To ensure the proper mixing of particulate material a required amount of controlled vortex formation is produce during stiring operation. Fly ash was extracted from Raichur thermal plant and Al_2O_3 from locally. The magnesium removes oxygen from surface thus by eliminating gas layers and improving wettability. Hybrid Aluminium MMCs containing reinforcements such as Al_2O_3 with fly ash is available in the literatures [1-18]. Madeva Nagaral [1] et.al studied the effect of aluminum oxide particle reinforcements on mechanical properties of 6061 Al alloy composites. Author fabricated 6061Al composites with different weight percentage of Al_2O_3particles up to 9% by using stir casting technique. Author concluded that tensile strength yield strength of the composites is increases with increase in weight percentage of Al_2O_3 reinforcement particles.

Sajjadi.S.A[2]el.al Fabricated A356 alloy composites with stir casting with different weight percentage of Al_2O_3 reinforcements and with different reinforcement particle size. Author stated that compressive strength, tensile strength of the composites increased. Author also investigated the best stir speed for uniform mixing of reinforcements is 300rpm. Author observed that wettability of the reinforcement's particles within molten matrix decreases with increase reinforcement percentage and decreases with reinforcement particle size. It also revealed that hardness and porosity of the composites increases with increase in weight percentage of reinforcement and decreases in particle size.

K. Radhakrishna [3] et.al studied effects of copper and fly ash particulate reinforcements with aluminium alloy as matrix metal. Author concluded that reinforcement up to 15 percent are successfully dispersed in the matrix. Hardness and Wear resistance of the composites increased as the weight percentage of the reinforcements was increased.

M. Kok [4] has studied the effect of Al2O3 particles content and size of the particles on the mechanical properties of the composites produced by vortex method. In his work author added Al2O3 particles up to 30 weight % with 2024 Al alloy as a matrix composites. Author concluded that the mechanical properties like hardness and tensile strength of the composites increases with decrease in particles size and increases with increase in weight percentage of the reinforcement particles.

B G Park [5] et.al has investigated the high cycle fatigue behaviour of COMRAL-85 and 6061 aluminium-magnesium-silicon alloy reinforced with Al_2O_3 ceramic particles manufactured by liquid metallurgy route and by powder metallurgy. Author carried out fatigue tests for a stress ratio of R=-1 (fully reversed loading condition). Author concluded that all the composites were very similar on their fatigue threshold results. Also author stated that the fatigue properties of the composites produced by the powder metallurgy technique exhibits better results than the composites produced by liquid metallurgy technique. This is because of defects in the manufacturing technique of liquid metallic.

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Dr. G.K Purohit [17] et.al developed a mathematical model to predict the tensile behaviour and percentage elongation of Al7075/Al_2O_3 metal matrix composite and reported that ultimate tensile strength of the composite was increasing by 20% compared to that of matrix and percentage elongation was reduced by 30 percent

II. Experimentation

In present work Al6061 T6 is taken as matrix metal and Al_2O_3 and Flyash is taken as reinforced particulate.

Table1: Chemical Composition Of Al6061 T6

Content	Al	Cu	Mg
%	97.99	0.206	0.729
Si	Fe	Mn	Ni
0.533	0.191	0.076	<0.050
Pb	Sn	Ti	Zn
0.024	0.011	0.094	0.064

Table 2: Chemical composition of Fly ash

Content	SiO2	Al2O3
%	65.56	19.9
Fe2O3	CaO	MgO
3.79	7.56	1.24
TiO2	LOI	
1.2	0.7	

ALUMINIUM OXIDE Al2O3

The chemical formula of aluminium oxide is Al_2O_3. It is commonly referred to as alumina, or corundum in its crystalline form, as well as many other names, reflecting its widespread occurrence in nature and industry. Alumina (Al_2O_3) is the most cost effective and widely used material in the family of engineering ceramics. The raw material from which this high performance technical grade ceramic is made is readily available and reasonably priced, resulting in good value for the cost in fabricated alumina shapes. Its most significant use is in the production of aluminium metal, although it is also used as an abrasive due to its hardness and as a refractory material due to its high melting point

FLY ASH

Fly ash is one of the residues generated in the combustion of coal. It is an industrial by-product recovered from the flue gas of coal burning electric power plants. Fly ash includes substantial amounts of silica (silicon dioxide, SiO_2) and lime (calcium oxide, CaO). In general, fly ash consists of SiO_2, Al_2O_3, and Fe_2O_3 as major constituents and oxides of Mg, Ca, Na, K etc. as minor constituent. Fly ash particles are mostly spherical in shape and range from less than 1 µm to 150 µm with a specific surface area, typically between 250 and 600 m2/kg. The specific gravity of fly ash vary in the range of 0.6-2.8 gm/cc.

In present work composite is fabricated with a weight % of 9%,12% & 15% fly ash and 6 % of Al_2O_3 using stir casting method as shown in figure 1 and aluminium 6061T6 is also casted.

Fig 1: Stir Casting Setup

- 3 kg of Al6061 alloy is taken in the billet form and placed in the furnace and is melted at 718^0 C. (total mixture of 3 kg including reinforcement)
- The reinforcement fly ash of weight percentage 9%, 12%,& 15% is measured and pre heated to 450-600° Celsius and maintained at that temperature for about 20 minutes to remove the moisture content.
- Then other reinforcement such as alumina (Al_2O_3) weight percentage 6% is pre heated.
- To avoid slag formation scum powder is added to molten metal.
- The molten metal should be degassed at a temperature of 780 degree Celsius using solid dry hexachloro-ethane tablets. (<.5% weight)
- Then the molten metal was stirred to create a vortex and pre heated fly ash and alumina are slowly added to the molten metal maintained at >720 degree Celsius, with continuous stirring at a speed of 350-500 rpm to a time of 6-8 minutes
- Before stiring magnesium about >2% should be added to ensure good wet ability.
- Then the melt with the reinforced particles are poured in to moulds the pouring temperature should be maintained at 680 degree Celsius.
- Then it is left for minimum 3 hours to solidify before withdrawing the specimens from the mould.

III. Mechanical Characteristics

3.1 Tensile strength

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Tensile test is conducted with Universal testing machine and the specimen is prepared with ASTM standards dimensions.

3.3 Fatigue test

To carry out a fatigue test a specimen is prepared with ASTM standard dimensions and tested using rotating bending machine with predetermined value of loads by considering 0.5UTS,0.7UTS and 0.9UTS [6] and for which required stress level and cycles up to failure were documented which is used in plotting S-N curve.

IV. Results and discussion

Al-AL_2O_3-flyash composite is casted and test for which results are

Fly ash %	Al2O3 6%
0	320
9	391
12	395
15	401

Table 3: Mechanical properties of Al-Al_2O_3-FA

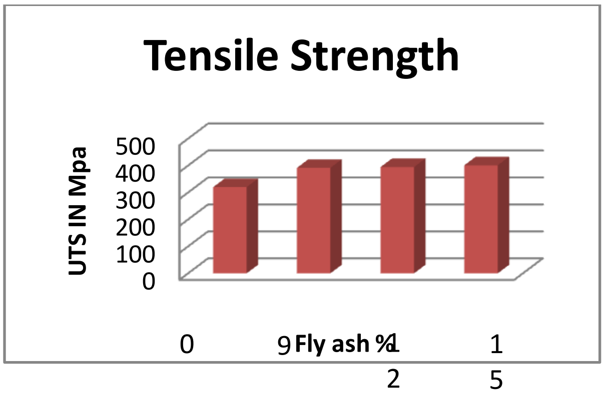

Fig 2: Tensile v/s % Al2O3

From table 3 and figure 2 it is evident that tensile strength of the composite has enhanced and at 15 % Fly ash composition is highest when compared to the monolithic AL6061 T6 and from figure 3 it can be observed that the

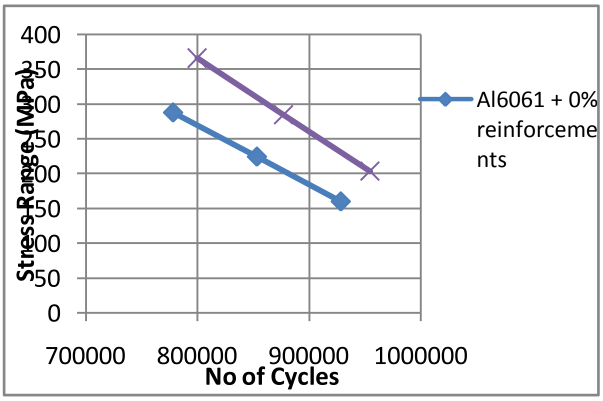

Fig 4: S-N curve for 0%, 6% and 9 % AL2O3

Fatigue strength of the composite with 6% AL_2O_3 and 15% fly ash reinforcement is having good fatigue performance compared to the monolithic AL6061 T6 alloy.

V. SEM Analysis

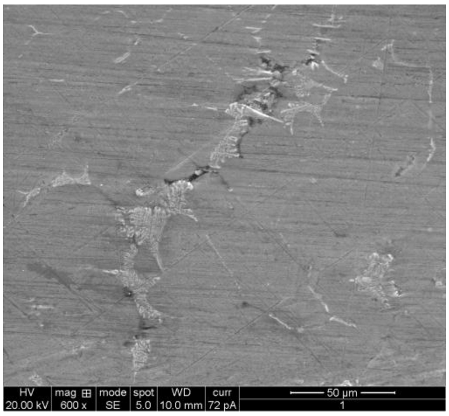

Fig 5: 6% AL2O3 and 9% Fly ash

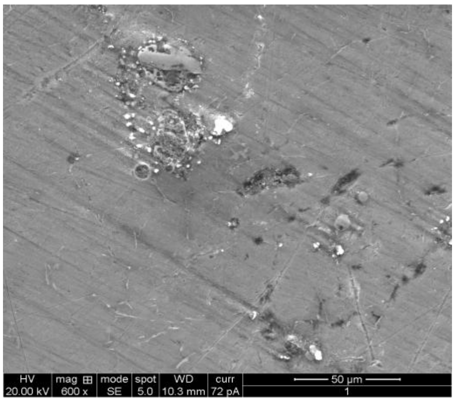

Fig 6: 6% Al2O3 and 12% Fly ash

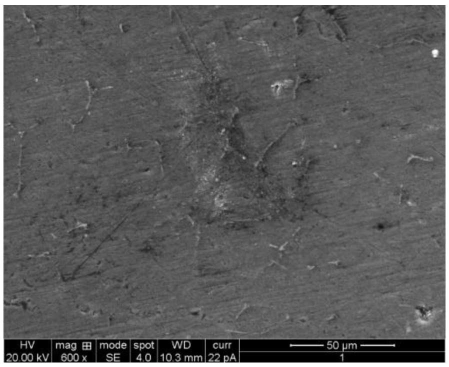

Fig 7: 6% Al2O3 and 15% Fly ash

From SEM analysis it can be seen that the reinforced material has been faily distributed in the metal matrix

VI. Conclusion

From the results obtained from the experiment and observation we can conclude that

- The fly ash can be effectively used for the fabrication of composite there by eliminating storage problem.
- Fly ash is successfully dispersed in Al6061T6 alloy by stir casting.
- The ultimate tensile strength has also enhanced with increase in Fly Ash weight percentage and compared to base metal it has increased by 21.1%.
- The fatigue life has been increased with the increase in weight percentage of fly ash and it can be seen from S-N curve that Al2O3 6% give better results when compared to monolithic alloy.

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