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Mechanical Behaviour Of Aluminium Based Metal Matrix Composites Reinforced With Coconut Shell Ash

Dr.M. Selvam[1] , Dr.kishore brahma[2]

[1]Asscociate Professor, Department of Mechanical Engineering.

[2] Professor, Department of Aeronautical Engineering, Dhanalakshmi Srinivasan College of Engineering and Technology, Mamallapuram.

ABSTRACT

Aluminium alloys are widely used in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. The excellent mechanical and physical properties of these materials and relatively low production cost make them a very attractive candidate for a variety of applications both from scientific and technological viewpoints. The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and Ceramics. Present work is focused on the study of behaviour of Aluminium Cast Alloy (AL7075) with coconut ash composite produced by the stir casting technique. 5% and 10% age of reinforcement is used. Hardness Test, tensile test, impact test and microstural study (microscope) performed on the samples obtained by the stir casting process. Hardness tester is employed to evaluate the interfacial bonding between the particles and the matrix by indenting the hardness with the constant load and constant time.

INTRODUCTION

The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and ceramics. The addition of high strength, high modulus refractory particles to a ductile metal matrix produce a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement. Aluminium is the most abundant metal in the Earth's crust, and the third most abundant element, after oxygen and silicon. It makes up about 8% by weight of the Earth's solid surface. Due to easy availability, High strength to weight ratio, easy machinability, durable, ductile and malleability Aluminium is the most widely used non-ferrous metal in 2005 was 31.9 million tonnes.

Composites are materials in which two phases are combined, usually with strong interfaces between them. They usually consist of a continuous phase called the matrix and discontinuous phase in the form of particle, whiskers or particles called the reinforcement. Considerable interest in composites has been generated in the past because many of their properties can be described by a combination of the individual properties of the constituent phases and the volume fraction in the mixture. Composite materials are gaining wide spread acceptance due to their characteristics of behaviour with their high strength to weight ratio. The interest in metal matrix composites (MMCs) is due to the relation of structure to properties such as specific stiffness or specific strength. Like all composites, aluminium matrix composites are not a single material but a family of materials whose stiffness, density and thermal and electrical properties can be tailored. composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc. The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material. Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short particle) is mixed with a molten matrix metal by means of mechanical stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.

LITERATURE REVIEW

Metal matrix composites are a combination of two phases, matrix and the reinforcement. Matrices can be selected from a number of Aluminium alloys e.g. AA 2000, 6000, 7000, A356 and many reinforcement types silicon oxide, flysh, Silicon carbide, B4C, Al2O3, AlN, and C etc. are available in different sizes, morphologies (particulates, short particle, long particle and platelets) and volume fractions. These reinforcements can be combined with the different matrices, resulting in large composite systems. Furthermore, several different processing routes, such as powder metallurgy, stir casting, squeeze casting, hot extrusion etc. N. Chawla, J.J. Williams, G. Piotrowski, and R. Saha [2003] Authors investigated the tensile strength processes in discontinuously reinforced aluminium (DRA).In this experiment author varies the average particle size (6-23 micro meter), Heat treatment is also given. Conclusion of this paper is that as particle size increases Tensile strength decreases. Heat treatment increases the tensile strength. Manoj Singla, D. Deepak Dwivedi, Lakhvir Singh, VikasChawla[2009] In this author studied to develop aluminium based Silicon carbideparticulate MMCs with an objective to develop a conventional low cost method of producing MMCs and to obtain homogenous dispersion of ceramic material. To achieve these objectives two method of stir casting technique has been adopted and subsequent property analysis has been made. Aluminium (98.41% C.P) and Silicon carbidehas been chosen as matrix and reinforcement material respectively. Experiments have been conducted by varying weight fraction of silicon carbide(5%, 4%, 15%, 20%, 25%, and 30%), while keeping all other parameters constant. An increasing trend of hardness and impact strength with increase in weight percentage of Silicon carbidehas been observed. The best results (maximum hardness 45.5 BHN & maximum impact strength of 36 N-m.) have been obtained at 25% weight fraction of Silicon carbidep. I. A. Ibrahim, F. A. Mohamed, E. J. Lavernia [2001] In this review author studied the mechanical properties that can be obtained with metal matrix composites by varying reinforcement percentage by 0, 10, 15, 20% and taking different alloy AA 7075, AA 2014, AA 356. Conclusion of this paper is by increasing reinforcement % age yield strength, ultimate strength is increasing but elongation of a Alloy decreases. D. J. Lloyd [1994] This review has primarily been concerned with the factors influencing the micro structural, mechanical properties relationship of composites shows the effect of different reinforcement. In this author study different reinforcement effect on different alloy are considered. Conclusions of this paper are elongation of composites decreases as increases percentage of reinforcement and tensile strength are increases.

MATERIALS AND METHODS

In this culture, aluminium alloy (Al7075) was used as base alloy. The production of the Metal Matrix Composite (MMC) used in the present study was carried out by liquid metallurgy technique (stir casting method). The composition of Al7075 aluminium alloy is presented in Tables 4.1.

Table 4.1 Chemical Composition of Aluminium (Al 7075) Alloy In weight percentage Element Si Fe Mn Mg C u Zn Ti Cr Al Compositio n (%) 0.4 0.5 0.3 2.5 1. 6 5.5 0.2 0.1 5 bal

PREPARATION OF TEST SPECIMENS

The pieces segmented from the aluminum ingot were immersed in 10% sodium hydroxide solution at 95-100oC for about 10 minutes and then washed with methanol. The weighted quantity of aluminium specimen were melted in a crucible after drying them in air completely. The stirring system has been developed by coupling motor with gearbox and a mild steel stirrer. All the melting operations were carried out in a graphite crucible in an oil-fired furnace. The Scraps of aluminum were preheated at 450oC for 3 to 4 hours before melting. The micro-coconut ash powdered particles were preheated at 1100oC for 1 to 3 hours to make their surfaces oxidized. The furnace temperature was first raised above the liquids to melt the alloy scraps completely and then it was cooled down just below the liquids to keep the slurry in a semi-solid state. At this stage, the preheated coconut ash Powdered particles were added and mixed manually. Manual mixing was used because it was very complicated to mix using automatic device when the alloy was in a semi-solid state. After sufficient manual mixing was done, the composite slurry was reheated to a fully liquid state and then automatic mechanical mixing was carried out for about 10 minutes at a normal stirring rate of 600 rpm. In the final mixing process, the furnace temperature was controlled within 760 ± 100 0 C. The Composite slurry is transferred to the sand mould prepared. The 40 micron sized coconut ashparticles are utilized for research activities .The required quantities of micro and nano coconut ash particles with the various weight fractions (5,10 percent by weight) were taken in powder containers. The coconut ash particles were preheated to 650oC for 15 minutes to eliminate moisture before mixing it with the aluminium melt. Cleaned aluminium ingots were melted above the super heating temperature of about 800oC in graphite crucibles under a layer of flux using an electrical resistance furnace as shown in Figure 4.1. The melt was degassed at 800 °C using solid dry hexa-chloroethane (C_2Cl_6) degasser. The preheated coconut ash particulates were then added to the molten metal and stirred continuously for about 15 minutes at an impeller speed of 600 rpm. Aluminium matrix and coconut ash particles were weighed using an electronic weighing machine (Accuracy 0.0001 g). During stirring, 1% by weight of magnesium was added to increase the wettability of Silicon carbide particles. The melt with reinforced particles was poured by gravity casting into the dried, cylindrical permanent metallic moulds of size 14 mm diameter and 120 mm length. The melt was allowed to solidify in the moulds for about 3 minutes and cooled to room temperature. For the purpose of comparison base alloy samples were also cast under similar processing conditions.

TESTING OF MECHANICAL PROPERTIES

HARDNESS TEST Abrasive wear or erosion and mechanical deformation are caused by reduced hardness of the material therefore it is important to identify the sample with greater hardness. The three test samples are subjected to Hardness test using Wilson Wolpert Micro hardness tester. Each sample was tested at four locations with the test specimen being subjected to a load of 0.5 kg for a dwell time of 10 seconds for each location. The specifications of the test are given below: Machine Name : Micro Vickers Hardness Tester Testing load range :10 grams to 1 Kg Load Make : Wilson Wolpert – Germany Vernier caliper least count : 0.01 mm Available Hardness testing Scale: HV, HRA, HRC, 15N, 30N etc.

TENSILE TEST FOR THE SPECIMEN As per ASTM E8 standard, the tensile strength was determined by intron computerized tensile compression testing. The specimen used for testing was machined according to ASTM E8 standard. The ultimate breaking load, elongation and ultimate stress were observed to be increased with the increase in the percentage of coconut ash. The occurrence of cup & cone fracture explains that the tensile strength increase with the increase in coconut ash percentage. The improvement in tensile strength is due to the fact that the filler coconut ash possesses higher strength and lower fineness of dispersion.

Properties Wt. % of CA with Al 7075 0 5 106217 Tensile Strength (MPa) 177.42 184.10 189.43 Ultimate Break Load (KN) 18.10 19.54 20.24 Yield Strength (MPa) 139.24 143.65 148.45 Strain (%) 6.7 5.1 4.4

RESULTS AND DISCUSSION

Effect of Micro Sized coconut ash Percentage on Hardness

Hardness of composite specimens of different volume fractions (0%, 5% and 10%) of micro sized Coconut Ash particles are tabulated and presented in Table 5.1. Composite materials are generally characterized by an increased hardness compared to the unreinforced aluminium alloy. Micro hardness values of composite specimens illustrate an increase in hardness with increase in micro sized Coconut Ash particles. Hardness of the composites also increased with increase in micro sized Coconut Ash content which gives a close to linear relationship with hardness. Hardness of the composites increased with increase in Coconut Ash particle size. Since the Coconut Ash is hard and brittle, the increase in volume fraction of this ceramic phase (Coconut Ash) improves the hardness of the composite. Hardness value of pure aluminium matrix was 26.4 HV. Composites reinforced with micro sized Coconut Ash particles at 5 % volume fraction shows the lowest hardness value (36.4 HV) while composites reinforced with particles at 10 wt.% shows the highest hardness (62.7HV). The maximum observed increase in hardness of composites compared to unreinforced aluminium alloy was 54%. The observed increase in hardness was due to hard micro sized Coconut Ash particles acting as a hindrance for the movement of dislocations within the matrix and exhibit greater resistance to indentation. Furthermore, it was evident that an increase in particle size also increased the hardness. Porosity also reduces as the volume fraction of Coconut Ash is increased. A galloping increase in Hardness is observed between 5% to 10% volume fraction since the dispersion of Coconut Ash in Al-7075 is prominent and more uniform and the hardness properties are transferred from Coconut Ash to Al matrix. This intact bonding between the Sic and Al Matrix is also increased. Hamouda et al (2007), Manoj Singla et al (2009) reported similar increase in hardness with increase in addition of Coconut Ash in aluminium alloy (LM6) and aluminium scrap respectively. Mahendra and Radhakrishna (2007) observed an increase in hardness while reinforcing micro sized Sic particles with Al/ Coconut Ash alloy produced by conventional casting technique. A similar trend of increase in hardness while reinforcing micro sized Coconut Ash particles in aluminium alloy was also reported by Babu Rao et al (2010) and Rohatgi et al (2002) in their studies on aluminium micro sized Coconut Ash composites. The table 5.1 shows the hardness test samples results and the fig 5.1 shows the test samples of Al6061 reinforced with micro sized Coconut Ash. Fig below shows the variation of hardness of Coconut Ash - reinforced AMC due to the increase in volume fraction.

CONCLUSION

In this project aluminium coconut ash metal matrix composite material is suggested for the manufacture of automobile component. The MMC is prepared and tested by both mechanically and analytically. The results show that this MMC has properties that can replace the material that is used conventionally. Better results have been obtained when the composition is of 90% aluminium and 10% coconut ash. Specimen manufactured from this material provides 60% less weight compared to the conventional steel material. Thus providing more life than conventional components.

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