International Conference on Computational and Experimental Methods in Mechanical Engineering
G.L. Bajaj Institute of Technology and Management, Greater Noida (U.P) India ICCEMME-2017
8th- 9th December 2017, www.conferenceworld.in ISBN: 978-93-86171-85-6

Fabrication of A359 Alloy Reinforced With B_4C Particulates & Characterization of Mechanical Properties

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ABSTRACT

A Composite is formed by combination of two or more physically and chemically distinct substances. Metal matrix composite (MMC) are formed when the base metal is metal and reinforcement takes place in the form of powder, ceramics, fibres and whiskers. Reinforcements in metal matrix may be a metal or other material which may be ceramic or any other organic compound. MMC possess significantly enhanced properties which improve the functioning as well as service life of the various mechanical components. The trend towards the use of composites is increasing rapidly in the on-going scenario and is likely to increase more rapidly in the future. Now a days aluminium and its alloy based composites are gaining importance in the upcoming fields of automobile and aerospace industries. MMC possess superior strength, hardness, corrosion resistance, fatigue and creep resistance in addition to low weight advantage of aluminium.

In this paper Mechanical stir casting method was used to fabricate the composite. Experiment was design as per the ASTM standard and tensile test was performed on the computerised UTM machine. A359 alloy is reinforced with B4C particulates of 40µm size ranging from (2.5 to 12.5 %). Initially calculated amount of Al359 alloy was superheated to temperature of 800^0C in an electrical resistance furnace. The furnace temperature was controlled by using a digital temperature controller. B4C particles were preheated to a temperature of 200^0C in an oven to remove the absorbed gases from the particle surface and to avoid the oxidation.

Keyword: MMC, Mechanical Stir Casting

I INTRODUCTION

During the past few years material design and its selection has shifted its attention towards the materials which are lightweight, less costly and must possess the desired mechanical, physical, thermal and chemical properties. Composites are combination of different materials insoluble in each other, physically distinct and chemically inhomogeneous. A composite is formed when two or more different materials are combined together to attain

superior mechanical and microstructural properties. Composite was first used around 1500s B.C. when early Egyptians and Mesopotamian settlers used a mixture of mud and straw to create strong and durable buildings. Straw continued to provide reinforcement to ancient composite products including pottery and boats. Wattle and daub is one of the oldest man-made composite materials, at over 6000 years old.Composite materials have been used for advanced structural and non-structural applications in automotive, aircraft, marine and electrical industries [1].Stir casting technique is generally used to fabricate the composite due to economy and simplicity. Electromagnetic stir casting reduces the porosity in the matrix and improves the mechanical properties of the composite.

Goswami et al. (2000) conduct an experiment to synthesis of machinable quality of magnesium aluminium silicate for fabrication of insulators/spacers by two different routes. [1]. Bunma et al. (2011) investigated microstructural and mechanical property of SiC reinforced aluminium composites produced by powder injection casting. Experimental results reveal that unreinforced alloy gave minimum % internal void whereas the addition of SiC increases the porosity [2].Yc et al. (2012) evaluated the mechanical properties of Al 6061 matrix composites reinforced with glass particulate using stir casting route. The tensile strength and hardness increases by adding reinforcement and then decreases with increase with wt % of glass particles [3]. Rao et al. (2012) investigated the fabrication and mechanical properties of aluminium-boron carbide composites by stir casting method. The hardness and tensile strength of the composites was increased and density was decreased with increasing the amount of the boron carbide in the matrix phase [4]. Gargatte et al. (2012) investigated that the fabrication & characterization of Al-5083 alloy composite reinforced with SiC particles by stir casting process and the mechanical properties were compared with un-reinforced A359 matrix alloy [5]. Kumar et al. (2013) conducted fabrication and characterization of A359/Al_2O_3 metal matrix composite using electromagnetic stir casting method [6]. Boopathi et al. (2013) investigated that evaluation of fabricated Al 2024 in the presence of silicon carbide, fly ash and its combinations by stir casting method [7].Kumar et al. (2011) investigated the mechanical and tribological behaviour of Al6060 & Al7075 MMC. It was observed that Al7075 possess better properties [8]. Verma et al. (2012) investigated that processing of Al5083 alloy reinforced with Al_2O_3 through microwave sintering. Powder metallurgy method is the most suitable method for making MMC after stir casting. The Al_2O_3 powders were mixed in different composition with Al5083 by four point planetary ball mill [9]. Shadakshari et al. (2012) investigated carbon nanotube reinforced AMMC. Experimental result concludes CNTs are a promising reinforcement to obtain high damping capabilities at an elevated temperature [10]. Shaikusmansha et al. (2013) investigated the production and tribological characterization of stir-cast hybrid composite Al6061 reinforced with SiC and TiC. Enhancement of mechanical properties was observed [11]. Haque et al. (2014) investigated that the mechanical and machining properties analysis of Al6061-Cu-reinforced SiC MMC [12].Zakaulla et al. (2014) preformed studies of corrosion properties of Al 6061 reinforced with varying percentage of uncoated and Cu coated silicon carbide in 3.5 wt%. NaCl solution using weight loss method [13].Girisha et al. (2013) performed preparation, characterisation and wear study of Al356 reinforced with ZrO_2 nano particles prepared by dissolving ZrO $(NO_3)_2$ and $C_6H_12O_6$ stir casting .It was revealed

that the wear properties of the reinforced composite is enhanced compared to base metal[. Kishore et al. (2015) conducted fabrication and characterisation of Al-TiC composite by situ process .It was revealed that by the addition of TiC reinforcement to the Al6061 matrix hardness value was increased.

II EXPERIMENTAL SETUP

In this study A359 alloy is reinforced with B4C particulates of 40µmsize ranging from 2.5 to 12.5 %.Stir casting technique is used to fabricate the composite. The schematics diagram of stir casting process is as shown in Fig.1. Initially calculated amount of Al359 alloy was superheated to temperature of 800^0C in an electrical resistance furnace. The furnace temperature was controlled by using a digital temperature controller. B4C particles were preheated to a temperature of 200^0C in an oven to remove the absorbed gases from the particle surface and to avoid high drop of temperature after addition ofparticulates. An envelope of inert gas (He) is used to prevent the inclusion of foreign particle during the solidification. The systematic diagram for the casting of composite materials are as shown in Fig.3 and Fig.4.

For the investigation of tensile strength specimen was prepared as per the ASTM standard as shown in Fig.2 to check the repeatability of results 3 samples are created for each set of experiment. Final result is averaging of these three values. A computerized U.T.M is used for the testing of tensile test. The actual fabricated sample for the tensile test is as shown in Fig.5.

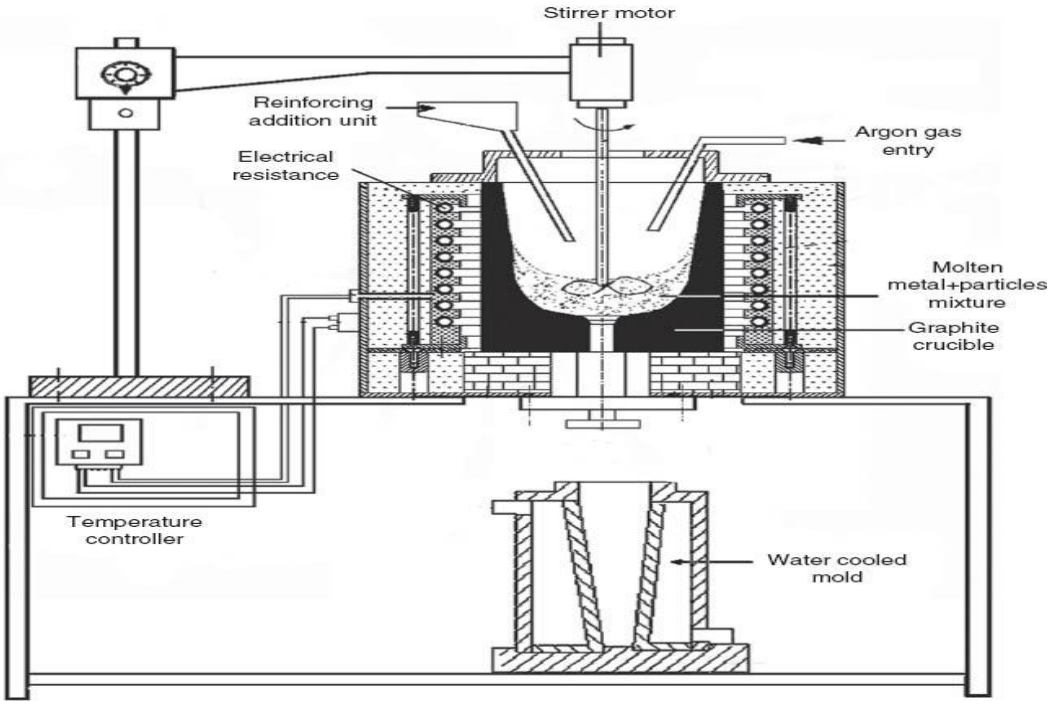

Fig.1 Block Diagram of Stir Casting Method[11]

 ISBN: 978-93-86171-85-6

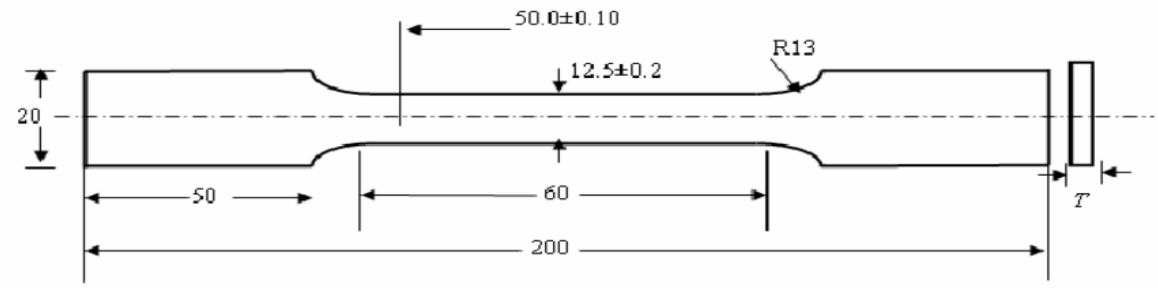

Fig.2 Standared Specimen sizess

Fig.3. Molten Composite & Mould

Fig.4. MMC in Rod form

Fig.5. Sample prepared for testing

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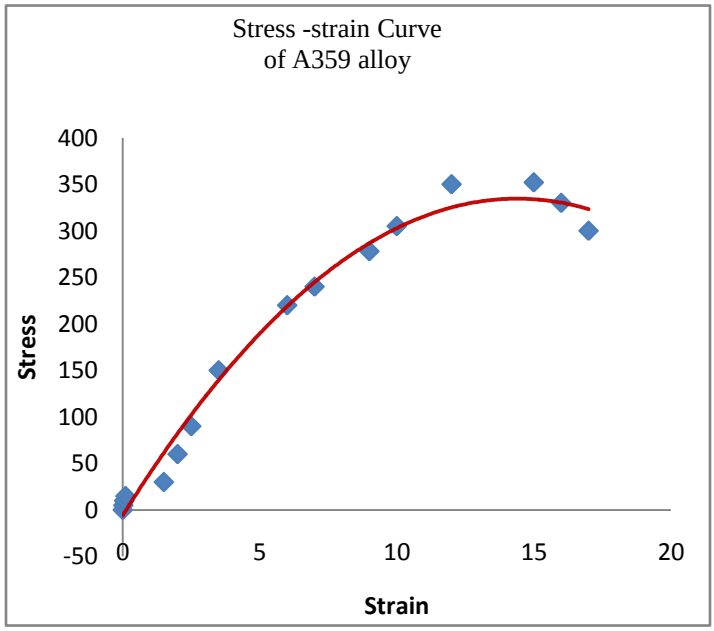
III RESULTS AND DISCUSSION

The tensile behaviour of all the samples was examined to determine the tensile strength. The specimens were loaded hydraulically in the computerized UTM machine. The load at which yield point was reached was noted. The experimental result reveals that composites have higher tensile strength than un-reinforced A359 alloy.The graph 1 shows stress strain curve for A359 alloy &The graph 2 shows the stress – strain curve for various reinforced % of B4C in al359 alloy obtained during experiment. It was observed that tensile strength of the composite increases up-to(7.5%) an extent with the increase of B4C particles. Strength is an important mechanical property of a composite material which limits its widespread application. The strength of MMC is enhanced by reinforcing B4C particles with it. It was also observed that beyond the 7.5% tensile strength decreases with the increase of B4C%. The maximum value of ultimate strength (386MPa) was obtained at 7.5% B4C.



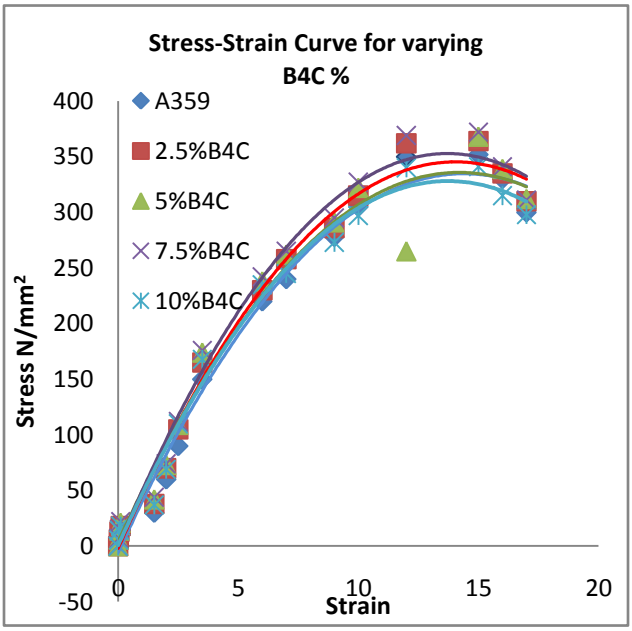


Fig. 6 Stress- Strain curve for A359 alloyFig.7 Stress- Strain curve for the composite materials

IV CONCLUSION

The approach of fabricating MMC by stir casting technique is proved to be successful. Initially preheating of B4C particles was helpful to remove the moisture and thus reduces the level of porosity.The following conclusions are based on experimental observation on the distribution of B4C particles on Al359 via stir casting and following analysis of part strength are conducted.

1. The tensile strength of MMC is higher than unreinforced metal matrix and the tensile strength of MMC increases with increase in wt. fraction of B4C.
2. The maximum value of ultimate strength was obtained corresponding to the 7.5% of B4C.

3. After the 7.5% tensile strength starts decreases.

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