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STUDY ON MECHANICAL BEHAVIOUR OF AL7075 – B4C-FLY ASH METAL MATRIX COMPOSITE FOR CONNECTING ROD

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Abstract

The Metal Matrix Composite (MMC) materials are widely used in automotive engineering applications. In this current work an attempt made with fabrication of Al7075-B4C-Fly ash MMC and its suitability for the Connecting rod applications. The present research work reports the evaluation of the mechanical properties of aluminium metal matrix composites. Aluminium 7075 matrix were fabricated by stir casting process. The samples of Al7075 metal matrix were fabricated with different weight percentages (5,10 and 15%) B4C and 2% wt of fly ash. The mechanical properties investigated in this work are hardness, tensile strength and impact strength. Finally AL 7075-B4C-Fly Ash connecting rods are analysed with the help of Ansys and the FEA results are compared with the existing connecting rod material.

Keywords — Aluminium7075, Boron Carbide, Fly Ash, Connecting Rod

1 INTRODUCTION

The demand for new materials with improved properties is ever growing. This led to new category of materials called Composite Materials. They are composed of combination of distinctly different two or more micro or macro elements that vary in their composition and it is insoluble in each other. The two main constituents of composite are reinforcement and matrix. The merit of composite is its good strength and stiffness, combined with low density when compared with other materials. Aluminum Metal Matrix Composite (AMMC) are always on the forefront of research.

Reinforcement usually adds rigidity and greatly impedes crack propagation. The role of the reinforcement in a composite material is basically one of increasing the mechanical properties of the tidy resin system. Boron Carbide, SiC and fly ash are some of the reinforcement materials used. Boron Carbide is the hardest materials known, ranking third behind diamond and cubic boron nitride. Its particles are characterized by its extreme hardness, high wear resistance and low density. This ceramic is used in abrasive Grit Blasting Nozzles, used for shaping hard surfaces. Fly ash reinforcement with commercially aluminum improving their properties in strength and hardness and reduces the weight of the commercially aluminum, more over it is good radiation absorber.

Aim of the many researchers is to fabricate MMC to achieve better mechanical properties. Number of researchers have fabricated and tested Aluminum Alloy based MMC[1]. In this respect Singla & Mediratta and Rahmanet al. has developed AMMC

(Aluminum Metal Matrix Composite) using silicon carbide as reinforcement. Mohantyet al. and Ashok et al. have improved mechanical properties like tensile strength, shear strength and toughness of AMMC by using Boron Carbide and Calcium Carbide[2]. Xiuet al. investigated XRD and SEM along with mechanical properties for 2024 Al (AMMC) with Boron Carbide. Parsad & Ramachandra studied abrasive wear of fabricate LM6 Aluminum with 7.5% by weight fly ash as reinforcement. Researchers have mostly used stir casting method for fabrication of composite materials

In present work an effort has been done to cast Aluminum 7075 with boron carbide and fly ash composite material using stir casting process. The parameters stirring timing, stirring speed and percentage of combination of boron carbide and fly ash as reinforcement has been optimized for mechanical properties using Taguchi method. For each parameter three levels have been considered

2 SELECTION OF MATERIALS

2.1 Composition used for metal matrix composite

Sample	Aluminm (7075) (wt%)	Boron carbide (wt%)	Fly Ash (wt%)
1	93	5	2
2	88	10	2
3	82	15	2

2.2 Material Description

Al7075 alloy was purchased in the form of cylindrical rod. The particles of boron carbide with an average particle size of 75micro meter and fly ash as secondary reinforcement were used as the reinforcements for developing the hybrid composites. Aluminium was used as matrix because of its light weight, high strength, durability and good machinability.

3 FABRICATION METHOD

3.1 Stir Casting

Among the variety of manufacturing processes available for discontinuous metal matrix composites, stir casting is generally accepted as a particularly promising route, currently practiced commercially, which is also least expensive compared to other process. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. In a stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirring [1]. Stir casting of metal matrix composites was initiated in 1968, when S. Ray introduced alumina particles into an aluminum melt by stirring molten aluminum alloys containing the ceramic powders. Mechanical stirring in the furnace is a key element of this process. The resultant molten alloy, with ceramic particles, can then be used for die casting, permanent mold casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement. The cast composites are sometimes further extruded to reduce porosity, refine the microstructure, and homogenize the distribution of the reinforcement.

A major concern associated with the stir casting process is the segregation of reinforcing particles which is caused by the surfacing or settling of the reinforcement particles during the melting and casting processes. The final distribution of the particles in the solid depends on material properties and process parameters such as the wetting condition of the particles with the melt, strength of mixing, relative density, and rate of solidification .The distribution of the particles in the molten matrix depends on the geometry of the mechanical stirrer, stirring parameters, placement of the mechanical stirrer in the melt, melting temperature, and the characteristics of the particles added. An interesting recent development in stir casting is a two-step mixing process. In this process, the matrix material is heated to above its liquids temperature so that the metal is totally melted. The melt is then cooled down to a temperature between the liquids and solidus points and kept in a semi-solid state. At this stage, the preheated particles are added and mixed. The slurry is again heated to a fully liquid state and mixed thoroughly. This two-step mixing process has been used in the fabrication of aluminum.

In the past few years the global need for low cost, high performance and good quality materials has caused a shift in research from monolithic to composite materials [1]. In case of MMC's, aluminum matrix composite due their high strength to weight ratio, low cost and high wear resistance are widely manufactured and used in structural applications along with aerospace and automobile industry. Also a simple and cost effective method for manufacturing of the composites is very essential for expanding their application. Reinforcements like particulate alumina, silicon carbide, graphite, fly ash etc can easily be incorporated in the melt using cheap and widely available stir casting method.

The following variable parameters are to be considered, while preparing the MMC by stir casting, Speed of rotation, Stirring speed, Stirring temperature, Reinforcement pre-heat temperature, Stirring time, Pouring temperature, Mould temperature . Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) 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. Density of the particles is one of the important factors determining the distribution of the particles in molten metal. Particles having higher density than molten metal can settle at the bottom of the bath slowly and particles of lower density can segregate at the top. During subsequent pouring of the composite melt, the particle content may vary from one casting to another or even it can vary in the same casting from one region to another. Therefore uniform distribution of the particles in the melt is a necessary condition for uniform distribution of particles in the castings. The properties of composites are finally dependent on the distribution of the particles. Hence the study of the distribution of the particles in the composite is of great significance.Stir casting process which is one of the liquid metallurgy techniques is used to AMC.

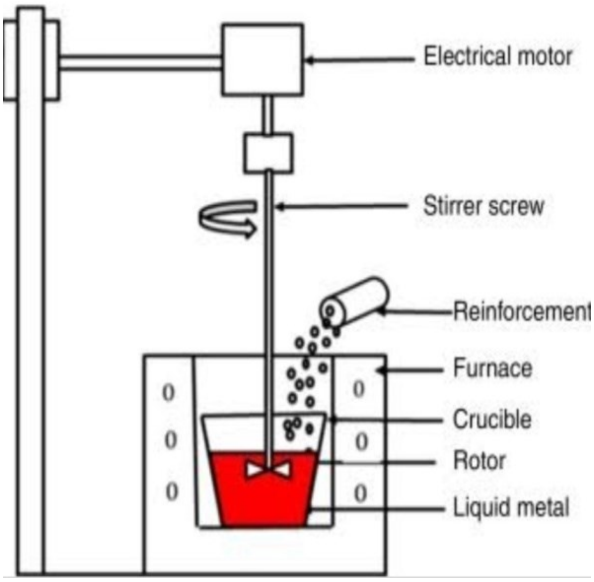

Fig 3. Stir Casting equipment

4.MECHANICAL PROPERTIES

4.1 Tensile Strength

In this research, the test results show the decrease in the tensile strength with increasing the weight percentage of B4C-FA. The composite with 5wt.% B4C and 2wt.% FA had maximum tensile strength up to 111 MPa, which was 66% higher than the unreinforced Al 7075 matrix alloy. The addition of weight percentage of reinforcements decreases the tensile strength up to 10wt.% B4C and 2wt.% FA, and further addition of reinforcement increases the tensile strength of composites[4]. The presence of FA and lower weight percentage of B4C increased the strengthening effect and absorbed load in composite materials. The composite containing 10wt.% B4C and 2wt.% FA had the lowest value in the percentage of elongation among all of the composite materials produced. From the previous research. The interfacial bonding between reinforcement and matrix forms the micro pores, initiating the propagation which caused fracture of composites. It reduced the plasticity behaviour of hybrid composites. The ductile fracture occurred in the composites due to microvoids leads to the crack initiation and formation . The ductile fracture is described by finer dimple formation in the fracture surface.

Fig 4. Tensile test machine

Fig 5. AMMC material after tensile test

4.2 Hardness

The hardness values of composites were measured at three locations in each sample and the average of three hardness values for each sample is taken. It indicates that hardness of composite material increases with addition of B4C and FA reinforcement in aluminium alloy. The increasing wt.% of reinforcement gives increment value of hardness from 46.57BHN to 49.17BHN [4].The multiple reinforcements contribute to minimizing the porosity and fine grain structure of particles as well as creating the resistance to plastic deformation which increases the hardness of hybrid composites.

This is due to the reinforcement of B4C and FA particles in the aluminium matrix composites. The maximum hardness was 49.17 BHN by cumulative reinforcement of 15wt.% B4C and 2wt%FlyAsh particles in aluminum alloy[5]. Similar results were found in the fly ash particle reinforced composites, which improved hardness of the aluminum matrix composite Earlier research results also revealed that the aluminium alloy with reinforcement particles like boron carbide and fly ash reinforcement offered maximum tensile strength as compared to the unreinforced Al alloy.

Fig 6.Brinell hardness test machine

The reinforcement of particles induced the higher strength and offered more resistance to the tensile stresses . The load transfer from the matrix to the reinforcement particles gives maximum tensile strength of composites. It was observed that the elongation of all the produced composites was within the rangeof 9.8% to 13.8% and there is a consistent trend in decreasing the ductility of composites.

However, results revealed that ductility of composites decreased while adding the reinforcements in the matrix. From the previous research, The addition of B4C-FA particles in the Al7075 aluminium matrix composites was initiatives of cleavage planes at the grain boundaries. It led to the brittle fracture in the specimens because of the applied tensile force in the composite materials. This is also evident from the previous work in the fracture surface that the resistance properties of the hybrid composites to tensile force varied because of its crack initiation and propagation which results in brittle and ductile fracture.

4.3 Impact Strength

The impact energy of composites against the cumulative weight percentage of B4C-FA was found that increasing the impact energy.From the previous research Furtheraddition of reinforcements reduced the impact energy due to the micropores in the composites and crack initiation in the reinforcements-matrixinterfaces, which resulted in the failure at the earlier stage. It was concluded that the composites strengthening can be improved by adding thereinforcements.It was observe Good interfacial bonding between the matrix and reinforcement led to higher impact toughness.

Fig 7. Impact test machine

The test result shows that the absorbed energy for all the sample is 02 joules. All the three samples of aluminium metal matrix composites have equal impact energy. It is higher than the aluminium alloy.

Fig 8. AMMC material after impact test

5.RESULT AND DISCUSSION

5.1 AL7075 (93%)-B4C (5%)- FLY ASH (2%)

Sample 1 consist of 93% 0f aluminium 7075 , 5% of boron carbide and 2% of fly ash . This sample is made by stir casting method. The mechanical properties of sample 1 was found. The yield strength of sample 1 is 79MPa ultimate tensile strength of sample 1 is 111MPa and % of elongation is 3. The average hardness of sample 1 is 47.7. Absorbed energy is 2 joules.

5.2 AL7075 (88%) – B4C (10%) –FLY ASH (2%)

Sample 2 consist of 88% 0f aluminium 7075 , 10% of boron carbide and 2% of fly ash . This sample is made by stir casting method. The mechanical properties of sample 2 was found. The yield strength of sample 2 is 72MPa ultimate tensile strength of sample 2 is 101MPa and % of elongation is 3.50. The average hardness of sample 2 is 46.56 . Absorbed energy is 2 joules.

5.3 AL7075 (83%) – B4C (15%) – FLY ASH (2%)

This sample is made by stir casting method. The mechanical properties of sample 3 was found. The yield strength of sample 3 is 77MPa ultimate tensile strength of sample 3 is 103MPa and % of elongation is 3.The average hardness of sample 3 is 49.16 . Absorbed energy is 2 joules.Sample 3consist of 83% 0f aluminium 7075 , 15% of boron carbide and 2% of fly ash.

5.4 Tensile Test Result

SAMPLE ID	AL93%+B_4C 5%+FLY ASH 2%	AL88%+B_4C 10%+FLY ASH 2%	AL83%+B_4C 15%+FLY ASH 2%
Yield strength (MPa)	**79**	**72**	**77**
Ultimate tensile strength (MPa)	**111**	**101**	**103**
%of elongation	**3**	**3.50**	**3**

5.5 Brinell Hardness Test Result

SAMPLE NO	OBSERVED VALUES
1	47.5,48.6,47
2	45.6, 47.7, 46.4
3	49.7, 49.2, 48.6

6 CONCLUSION

Aluminum7075 with BoronCarbide and Fly Ash at different levels and parameters have been successfully casted using stir casting method. The tensile strength decreases with increasing in weight of the boron carbide till 10% of boron carbide then it increases. Ithasbeen exposed that hardness of composite increased with increasing the weight (%) of B4C.

According to this study we found new material Al-B4C-FA composite which having similar mechanical properties and having less deformation and high hardness as compared to aluminium IC connecting rod.

The Al7075-B4C-Fly Ash material has lower deformation than aluminium. It increases the life time of connecting rod. Al7075-B4C-Fly Ash material has lower strain than aluminium it increases the hardness of material.

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