STUDY ON MECHANICAL PROPERTIES OF HYBRID ALUMINIUM 7075 METAL MATRIX COMPOSITE

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Abstract : Aluminium metal matrix composites(MMC) are playing key role in current world of automotive sector as they provide better strength to weight ratio, tribological properties, hardness, tensile strength etc. Addition of reinforcement particles bring about the changes in properties of base material. In this present work Aluminium7075(AL7075) metal matrix composites are fabricated by stir casting method by adding B4C and E-glass as reinforcement particles. Addition of Reinforcement particles is carried by weight percentage. Effect of reinforcement particles on base aluminium7075 is studied. It has been observed that addition of E-glass and B4C has improved tensile strength and hardness of Aluminium 7075 metal matrix composite.

IndexTerms **- AL7075, B4C, E-glass, stir casting, MMC, Hardness.**

1. INTRODUCTION

Composites materials are the combination of two or more materials with main material as matrix and add on material as reinforcements, which are combined together in two phases. As both reinforcement and base metal maintain their original form, they tend to provide newer material a unique mechanical strength value which is lacking in the original metal[1] The first known human made composite is papyrus paper, kind of fibrous composite made by placing the strips of papyrus plants placed in perpendicular direction from layer to layer which was dated back to 4000BC and was made by Egyptians.AL7075 is an aluminium alloy, was first developed in the year 1943 that is nearly 7.5 decades ago[3]. The primary alloying element of this alloy is zinc. The mechanical properties of Aluminium 7075 alloy such as relative low density, high toughness, strength and moderate ductility with respect to many engineering materials makes it a very interesting material[1][4]. These vital properties make this alloy available to be used as missile parts, fittings of aircraft[4][5].

Recent days Hybrid composite materials have become attractive materials in the field of automobile sector and aerospace as these composites exhibit improved mechanical properties[6][7].

In a Study done by Mohammed Imran et al. sugarcane bagasse-ash and graphite were used as reinforcements and aluminium alloy 7075 as base metal and reinforcement percentage were varied from 1% to 6%. It was observed that 6% Bagasse–ash inclusion resulted in improved mechanical properties[8].

M.Dinesh et al. had investigated on tensile behavior of aluminium 7075 by reinforcing it with zinc and chromiuim. Percentage of reinforcements incorporation was by volume fractions. Zinc percentage was kept at constant 1% with increment in chromium inclusion percentage upto 6% with a increment of 1% and it was observed that there is increment in tensile strength upto certain extent and strength decreases afterwards[9].

Ajith kumar et al.in his study considered aluminium-silican alloy as base metal and fly-ash, silicon carbide as reinforcement material. Study was conducted for the maximum of 2.5% of reinforcements and hybrids were tested for the tensile, hardness properties. An improvement in properties were recorded for the increased addition of reinforcing particles[10].

A Ceramic like Boron carbide(B4C) is widely used in many applications of engineering field due to its unique mechanical and tribological properties. Due to its thermal properties such as boiling point and thermal stability, it is preferred in refractory applications. its superior tribological property allow it to usage as abrasive powder and as coatings. It exhibits high hardness and low density[11]. Addition of particulates like boron carbide to aluminium alloy 7075 has resulted in improved mechanical properties such as tensile strength and hardness[12].

E-glass exhibit good tensile property and Low density compared to other reinforcing materials[13]. Also its availability in chopped condition and its makes it suitable as secondary reinforcement agent for the current study. An extensive study on literature has shown that inclusion of reinforcements into base metals has significant effect on its properties as particulate materials tends enhance the properties of base metals. Also Stir casting proven to be most widely used fabrication technique for hybrid metal matrix composite preparation.

In the present work an attempt is made to develop hybrid metal matrix composite by adding boron carbide and E-glass to AL7075 alloy to evaluate the mechanical properties by varying weight percentages of reinforcement particles. Stir casting is used as fabrication technology for the preparation of aluminium composites [14] as it is the one of the low cost method for metal matrix composite preparation

2. MATERIALS AND METHODS

Aluminium 7075 is an alloy of alluminium with zinc as primary element, it has got fairly good strength compared to aluminium 6061 and aluminium 6063 alloy. The formability, corrosion resistance of this alloy is comparatively poorer than other grades aluminium alloys. Weldability of AL7075 is also poor than most of the aluminium grades[9]. The chemical composition of AL7075 is as shown in the below table 1

Table 1: Chemical composition of aluminium 7075

Chemical composition	Element Symbol	Composition % in Al 7075 by weight
Zinc	Zn	5.8
Copper	Cu	1.55
Magnesium	Mg	2.6
Ferrite	Fe	0.5
Manganese	Mn	0.3
Chromium	Cr	0.2
Titanium	Ti	0.2
Remaining aluminium	Al	

Electrical grade glass or E-glass was originally developed for insulation of wires. its area of application has increased Because of its excellent fibre forming capability and high tensile strength. E-glass has Silicon dioxide as primary element with 54% by weight and Calcium oxide with 17% and remaining elements. The chemical composition of E-glass is shown in table 2

Table 2: Chemical composition of E-glass

Chemical composition	Element Symbol	Composition % in E-glass by weight
Silicon dioxide	SiO_2	54.3
Calcium oxide	CaO	17.2
Boron oxide	B_2O	8.0
Aluminium oxide	AL_2O_3	5.2
Megnisium oxide	MgO	0.6

Boron carbide is procured from Speedfam (India) pvt. Ltd,Chennai . particle size of avg 53 microns of Boron carbide is selected for reinforcement

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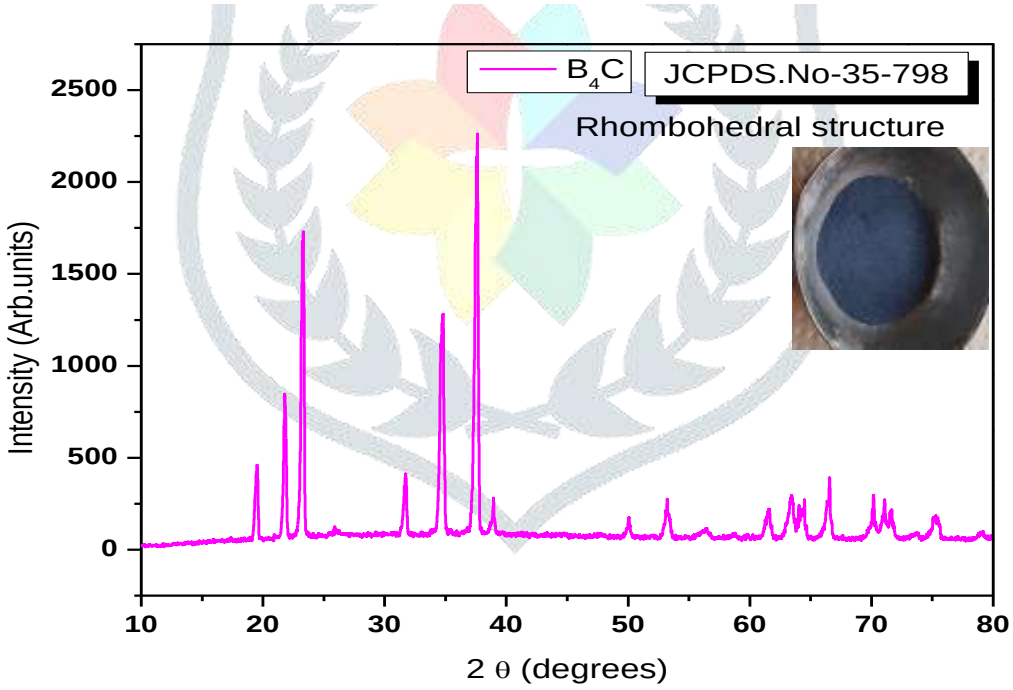


Figure 1: XRD of Boron Carbide inset Boron Carbide particles

2.2 PREPARATION OF CASTING COMPOSITES

Preparation of composites are carried out by Stir casting process as per the below explained procedure. Aluminium alloy and reinforcement particles are selected by weight percentage for different combinations of MMCs as shown in table 3. Aluminium is heated in graphite crucible to 750^{0}C [15] and is continued to heat at the same temperature until aluminium is completely turned to molten state. Small quantity of Magnesium is added to improve wettability[16]. Degassing agent is added to remove the entrapped gas in the molten material. Reinforcement particles are preheated to 350^{0}C before adding to molten aluminium in ordered to increase the wettability. Boron carbide and E-glass are added to the molten metal with steady pace and the mixture is stirred for 10 minutes at the speed of 350 RPM to ensure proper mixing of reinforcement particles. Molten mixture is then poured

into preheated die and die is allowed to cool in atmospheric Temperature through natural convection cooling method. Figure 2 represents the flow chart of fabrication process through stir casting method

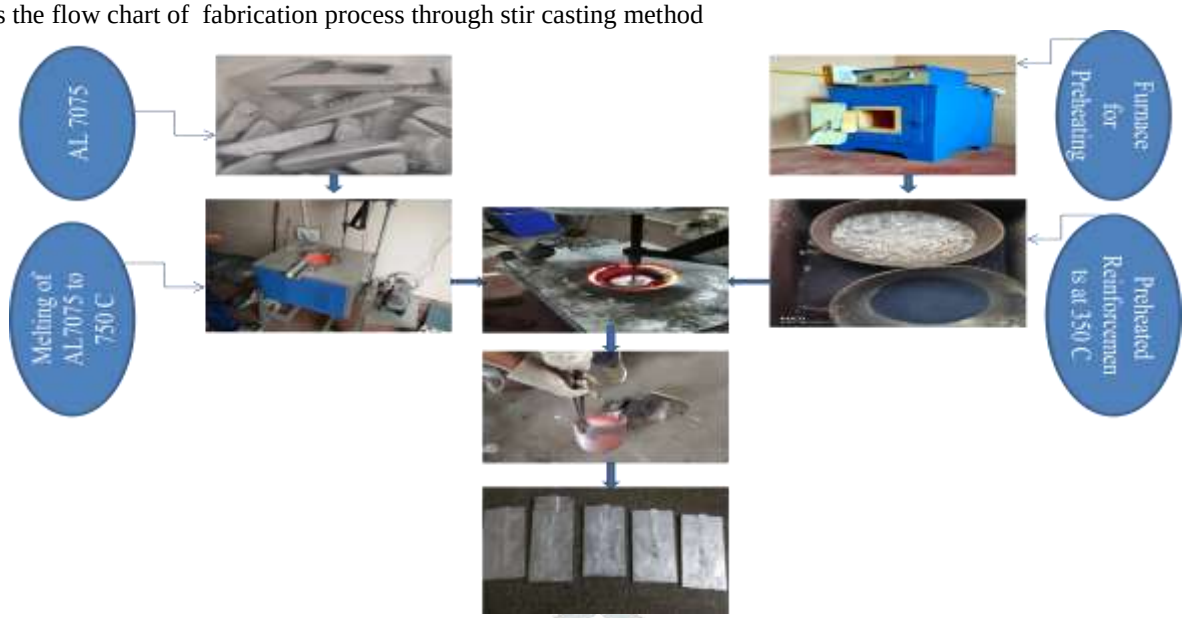


Figure 2: Flow chart showing Stir casting procedure involved preparation of MMCs

Table 4: Composition of aluminium 7075 metal matrix composite for different combinations reinforcement particles by weight percentage

Number	AL 7075 BY Weight percentage	Boron carbide by weight percentage	E-glass by weight percentage
A0	100	0	0
A1	98	2	0
A2	96	4	0
A3	94	6	0
A4	98	0	2
A5	96	0	4
A6	94	0	6
A7	96	2	2
A8	94	2	4
A9	92	2	6
A10	94	4	2
A11	92	4	4
A12	90	4	6
A13	92	6	2
A14	90	6	4
A15	88	6	6

Composite materials for different reinforcement percentage are prepared. Reinforcements are added by weight percentage. Reinforcement percentage is varied from 2% to 6% with a increment of 2%. A0 in the table 4 represents aluminium 7075 with zero reinforcement percentage and A15 is for composite with 6% boron carbide and 6% E-glass.

2.3 CHARACTERIZATION

Stir casting facility is available in Compoz-ITT Reseach center, Hassan. Setup has maximum 5kg material melting capacity by volume with a power rating of 6KW,Heating temperature range is upto 1200^0C.Stirrer has speed range of 200-6000RPM.

Scanning electron microscope (SEM) facility is availed in Research center, Jyothy institute of technology,Bengaluru.SEM is Hitachi SU 3500 model with a resolution of 30nm and upto 3,00,000X magnification. It uses low energy secondary electrons (SE) or high energy back scattered electrons (BSE) from the specimen surface for image formation.

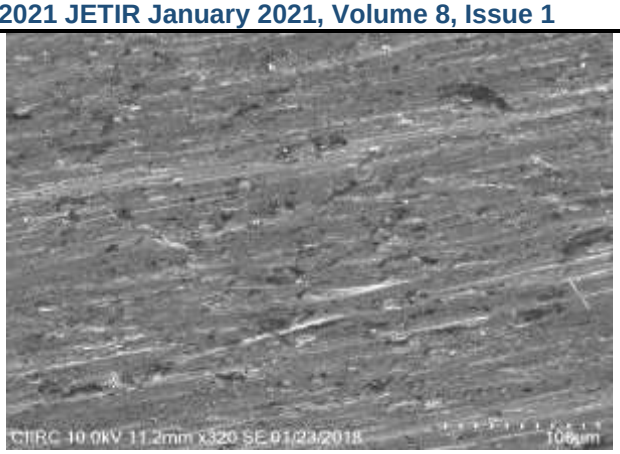


Figure. 3: Scanning Electronic Microscopic image of AL 7075

Figure. 4: Scanning Electronic Microscopic image of AL 7075 Reinforced with 2% Boron Carbide and 4% E-glass

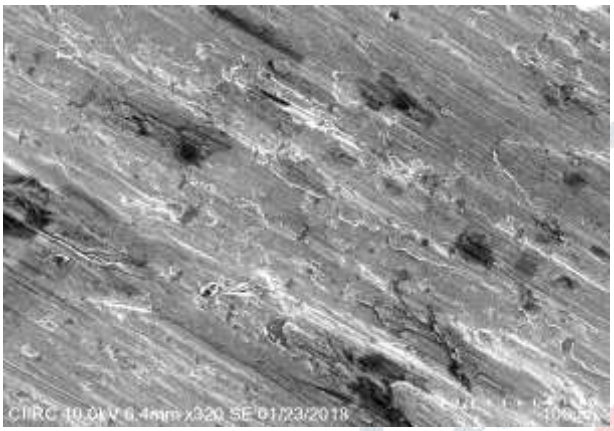


Figure. 5: Scanning Electronic Microscopic image of AL 7075 Reinforced with 4% Boron Carbide and 4 % E-glass

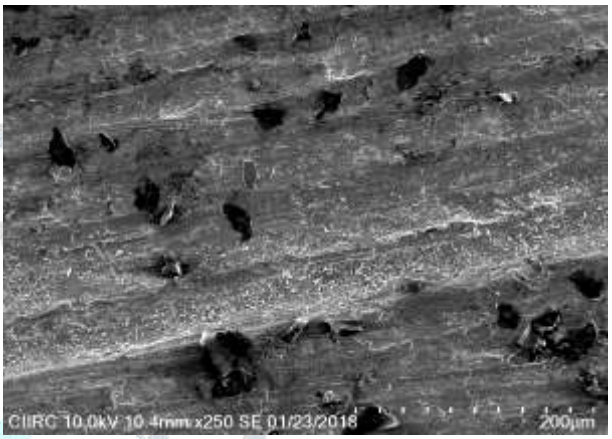


Figure. 6: Scanning Electronic Microscopic image of AL 7075 Reinforced with 6% Boron Carbide and 6 % E-glass

X ray diffractometer(XRD)) facility is available in Research center, Jyothy institute of technology, Bengaluru. XRD is D8 ADVANCE ECO model of Bruker. It has got angle range from -1100 to+1680 with SSD 160 detector.

Figure 1 Represents the XRD of boron carbide sample purchased, further it is compared with standard available with the help of Crystallographica Search-Match to establish its identity.

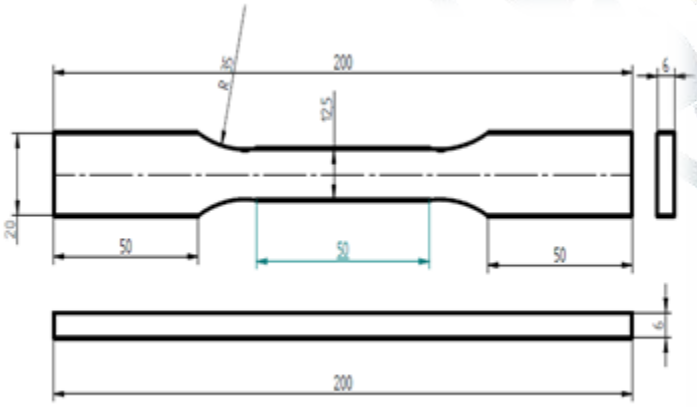


Figure.7: CAD model of Tensile test specimen

Figure.8: Tensile test specimen prepared as per ASTM (E8) Standard

Figure7 Represents the CAD model of Tensile test specimen to be for testing purpose with dimensions. Figure 8 Shows the Tensile specimen prepared according to ASTM standard using wire EDM in order to obtain specimen for exact dimensions

Universal Testing machine(UTM) facility is available at Advanced metallurgicals, Bengaluru. UTM is computerized servo controlled with model number TUE C-400 and has maximum of 400 KN loading capacity. Tensile test specimen are prepared as per ASTM standard E8

Rockwell hardness test rig facility with a model number KAS from Krystal equipments is availed for testing purpose. Equipment has loading capacity of 150 kgs and is provided with 1/16'' ball diameter indenter and diamond indentor. Hardness testing on specimen is performed by selecting the loading of 100kgs(for alluminium alloys),ball indentor of 1/16".Testing is done on three different regions of specimen and average reading is taken

3. RESULTS AND DISCUSSION

Metal matrix composites for different composition of reinforcement by weight percentage are successfully synthesized by melting the Aluminium material at 750^{0}C and by adding particulates with stirring for 10 minutes.

Scanning electron microscopic images are taken for the base AL7075 as shown in Figure.3 and for AL7075 with different percentage of reinforcement particles as shown in Figure 4 to Figure 6. It is observed that there is uniform distribution of reinforcement particles.

Hardness testing is done as per ASTM standard E18.Significant improvement in the hardness with the increment in percentage of boron carbide in AL7075 is observed which is evident in Figure 9 to Figure.12.This could be due to increase in hard particles inclusion in soft material AL7075[11]. The variation of hardness number for different composition of metal matrix composites is shown in Figure 9 to Figure.12 and it can be observed that with increment in percentage of E-glass there is reduction in Hardness composite as E-glass is soft material[12].

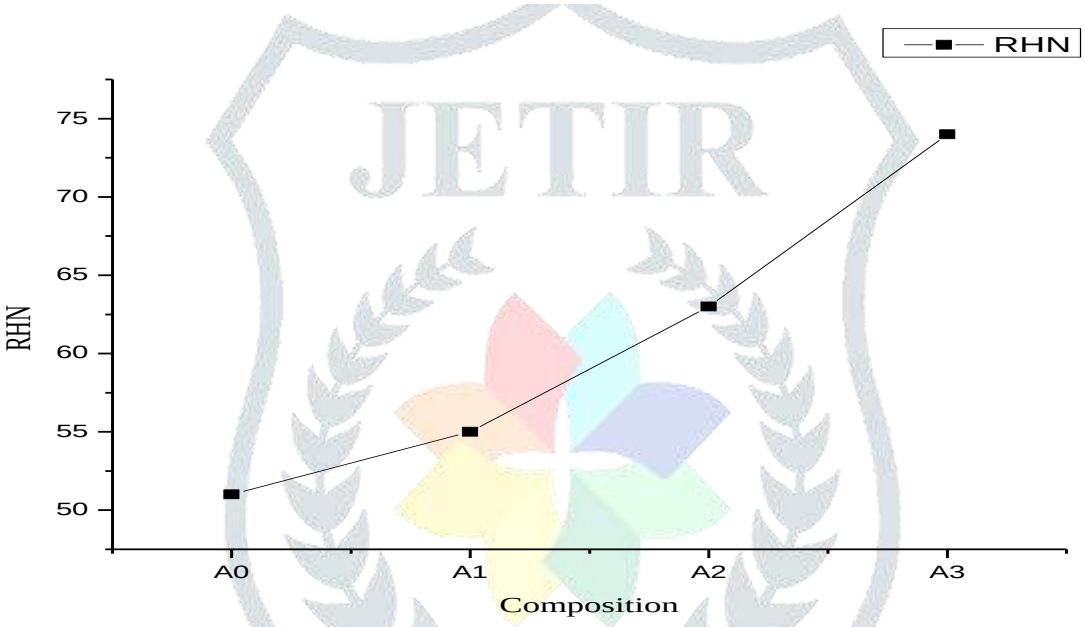


Figure. 9:Hardness v/s AL 7075 MMC with 2,4,6% Boron Carbide reinforcement

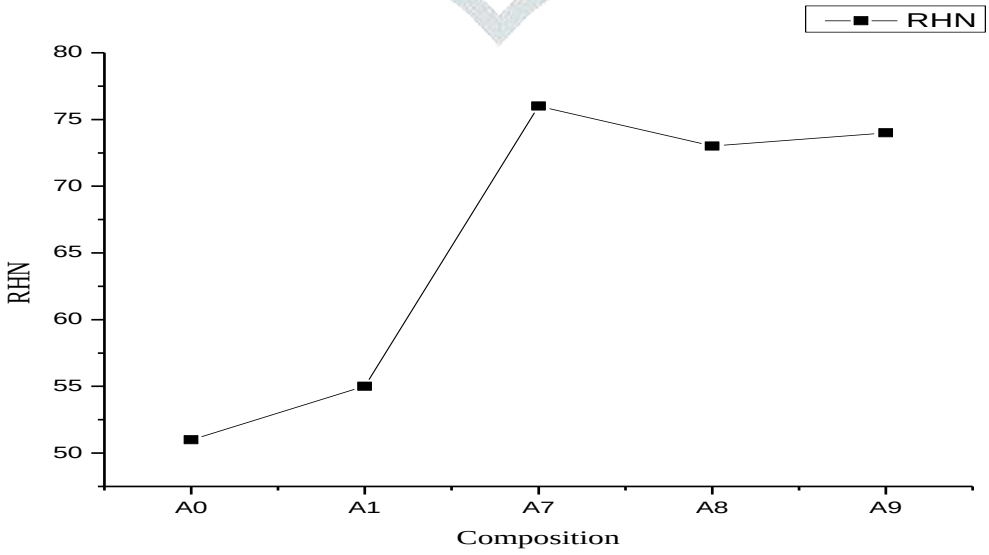


Figure. 10:Hardness v/s AL 7075 MMC with 2% Boron Carbide and 2,4,6% E-glass reinforcement

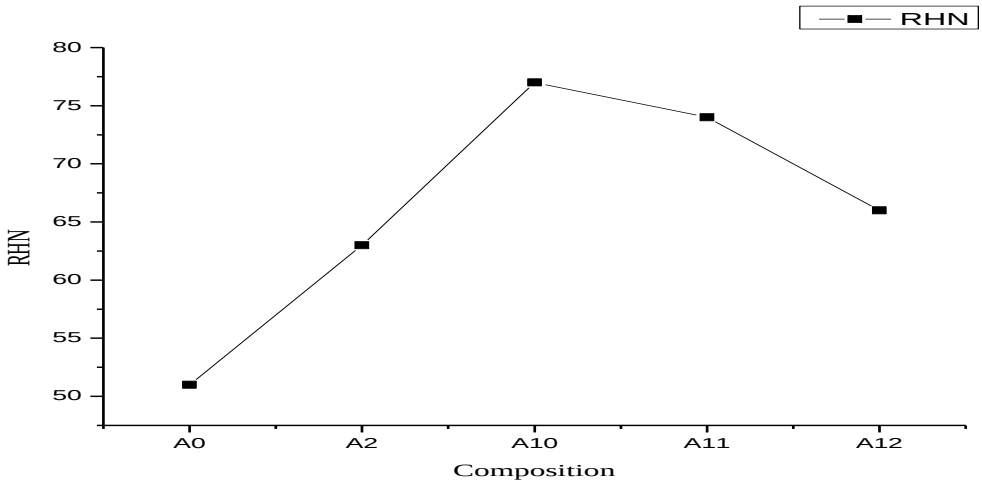


Figure. 11:Hardness v/s AL 7075 MMC with 4% Boron Carbide and 2,4,6% E-glass reinforcement

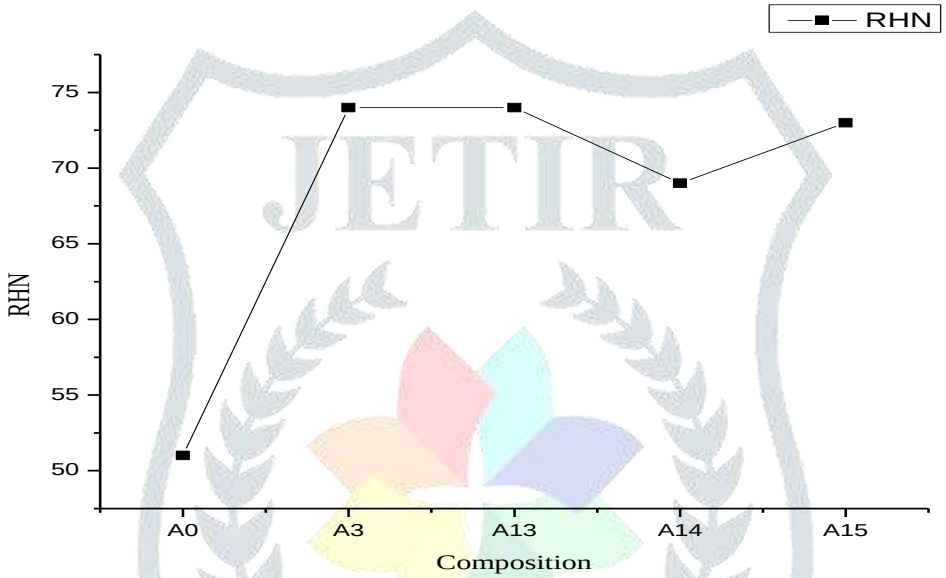


Figure. 12: Hardness v/s AL 7075 MMC with 6% Boron Carbide and 2,4,6% E-glass reinforcement

Tensile test specimen are prepared as per ASTM standard (E8) and Test is conducted to evaluate tensile nature of reinforced metal matrix composites. Graph of Ultimate tensile strength v/s composition is plotted and is shown in Fig 13 to Fig 16, improvement in tensile strength in reinforced metal matrix composite is noticed upto certain extent for the addition of E-glass.

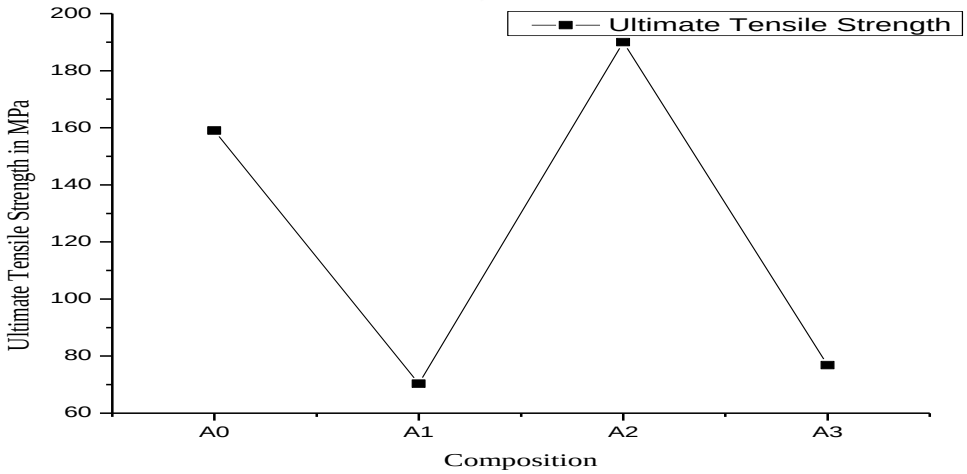
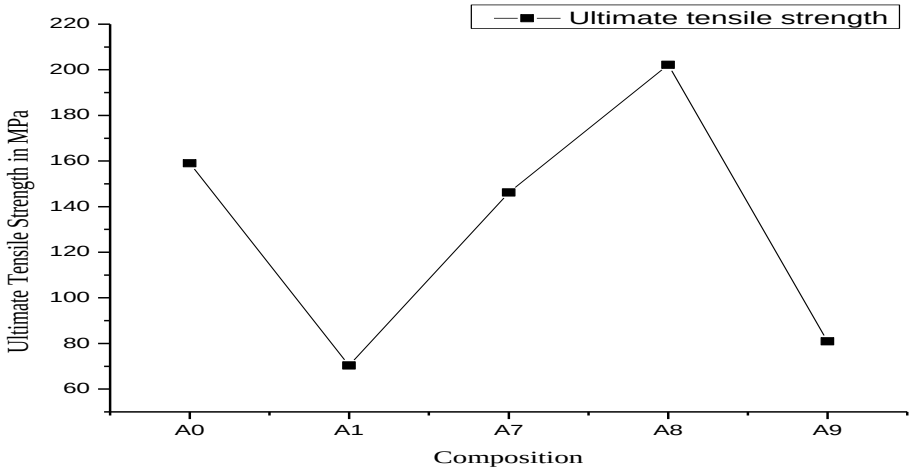


Figure. 13: Ultimate Tensile Strength v/s AL 7075 MMC with 2,4,6% Boron Carbide reinforcement



Figuer. 14: Ultimate Tensile Strength v/s AL 7075 MMC with 2% Boron Carbide and 2,4,6% E-glass reinforcement

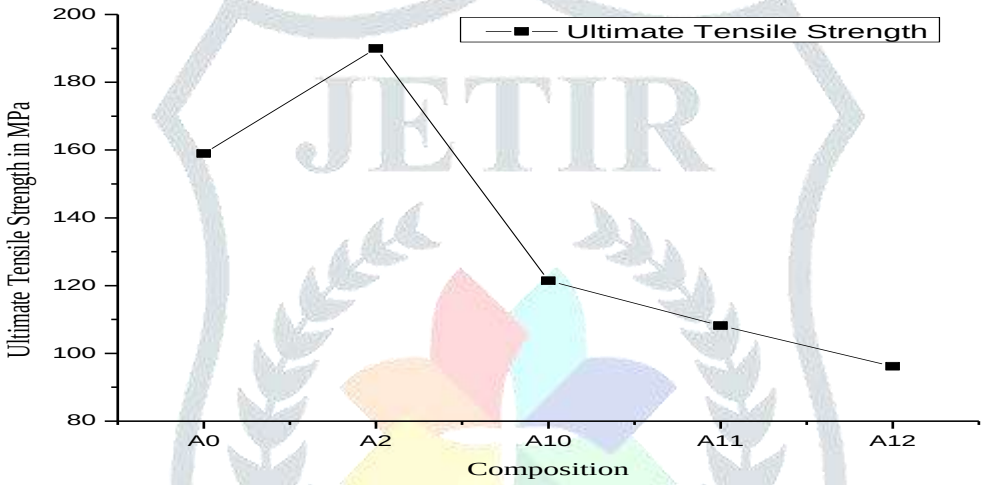


Figure. 15: Ultimate Tensile Strength v/s AL 7075 MMC with 4% Boron Carbide and 2,4,6% E-glass reinforcement

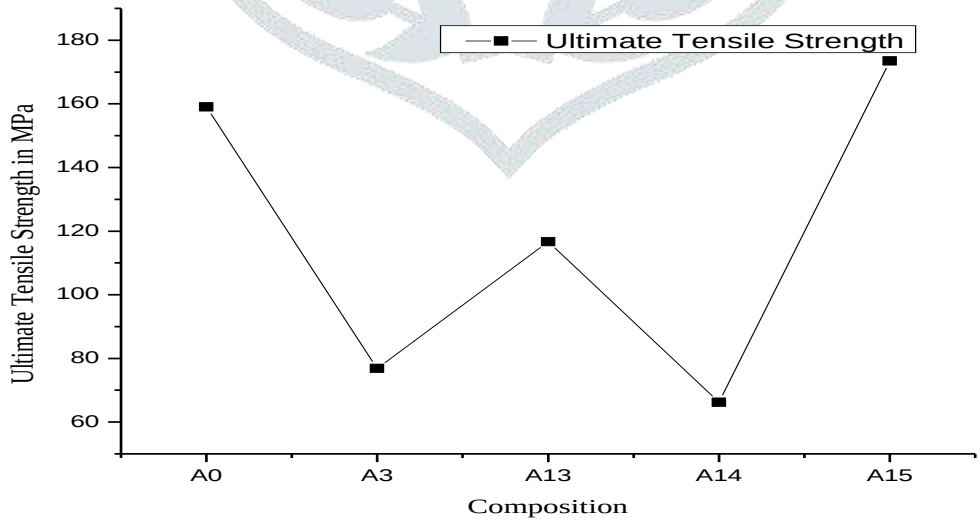


Figure. 16: Ultimate Tensile Strength v/s AL 7075 MMC with 6% Boron Carbide and 2,4,6% E-glass reinforcement

4. CONCLUSION

Metal matrix composites of different percentage of reinforcement are prepared by using stir casting fabrication technology. Reinforcement particles are Preheated to increase the wettability and further it is improved by the addition of magnesium. Uniform distribution of reinforcement particles in the base material is achieved with stirring speed of 350 rpm for maintained for 10 minutes. From the study the following conclusions are derived.

- Stir casting method was used to prepare composite materials successfully and was proven to be effective way fabrication technique.
- Surface analysis through scanning electron microscope has shown the Uniform distribution of reinforcement particles.
- Hardness of AL7075 increases with increase addition of hard boron carbide reinforcement particles
- Micro hardness was found to be maximum with aluminium MMC with composition of 4% boron carbide and 4% E-glass. 51% improvement in Hardness is noticed.
- Ultimate Tensile Strength of Reinforced Aluminium composite is found to be maximum in the composion of 2% boron carbide and 4%E-glass and there is improvement of 27.2% in Ultimate Tensile Strength

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