e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:03/March-2020 www.irjmets.com

FABRICATION AND TESTING OF ALUMINIUM BASED HYBRID METAL MATRIX COMPOSITE

Sivadharshan T[*1], Surya I[*2], Udhayakrishna A[*3], SampathkumarS[*4]

[*1,2,3,4] Department of Mechanical Engineering, Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India

ABSTRACT

Hybrid Metal Matrix composites (HMMCs) possess greater tensile strength when compared to mono composites. Aluminium Al6061 is reinforced with Silicon Carbide (SiC) and Zirconium Diboride (ZrB2) and tensile strength is observed. Three different composites were fabricated (Al6061+10%wt SiC, Al6061+10%wt ZrB2 , Al6061+5%wt ZrB2+5%wt SiC) through a novel fabrication process combining in-situ and stir casting methods. The weight percentage of each reinforcement was taken as 5% for the HMMC. Tensile Strength study is carried out on the fabricated composites and the results are observed. It is found that the tensile strength of the HMMC is 52% higher when compared to Al6061 cast.

Keywords: Al6061, Hybrid Metal Matrix Composite, SiC, ZrB_2, Tensile Strength Comparision. In-Situ Casting, Ex-Situ Casting.

I. INTRODUCTION

Metal matrix composites (MMCs) comprise a relatively wide range of materials defined by the metal matrix, reinforcement type, and reinforcement geometry. In the area of the matrix, most metallic systems have been explored for use in metal matrix composites, including Al, Be, Mg, Fe, Ni, Co, and Ag. By far the largest usage is in aluminium matrix composites. MMCs are finding increasing use in aerospace[1] and marine applications. This has increased concern about their tensile strength, corrosion resistance and thermal stability. MMCs is dependent on their constituent materials as well as on fabrication and processing. The main advantage of Aluminium based MMCs is the ease in its fabrication.

In the production of HMMC more than one reinforcement is being added to the metal matrix by a combination of stir casting and in-situ fabrication methods. The complexity in the fabrication of hybrid composite arises mainly due the varying natures of the reinforcements that are being used viz., density, size, shape, melting point, wettability apart from the routes of fabrication followed, process temperature and holding time. Al6061+5%wt SiC+5%wt ZrB_2 hybrid metal matrix was successfully fabricated in this present work.

II. METHODOLOGY

Three different composites fabricated in this work are Al6061+10%wt SiC, Al6061+10%wt ZrB_2 , Al6061+5%wt ZrB_2+5%wt SiC.The chemical composition of the matrix material viz., Al6061 T6 alloy is shown in Table.1

Table 1: The chemical composition of Al6061-T6 alloy

SN.	Element	% Weight
1	Chromium (Cr)	0.09
2	Copper (Cu)	0.17
3	Iron (Fe)	0.22
4	Magnesium (Mg)	0.95
5	Manganese (Mn)	0.13
6	Nickel (Ni)	0.02
7	Silicon (Si)	0.54
8	Titanium	0.01
9	Zinc (Zn)	0.08
10	Aluminium (Al)	Balance

a) Al 6061 + 10% SiC

Al6061+10%wt SiC was fabricated through Ex-Situ stir casting process[2]. The T6 aluminium alloy was preheated to 650°C using a graphite crucible and placed inside the furnace. The temperature of the furnace was maintained at 800°C.It is the optimum temperature for fabrication AMMCs. The matrix metal i.e., Al 6061-T6 alloy was heated using the preheated graphite crucible and Silicon Carbide of average size 8µm particles were added to the molten metal matrix. The automatic stirrer was setup to run at 400 rpm and the melt was then poured into a preheated die to solidify.

b) Al 6061 + 10% ZrB_2

Al6061+10% wt ZrB_2 MMC was fabricated through in-situ casting process. In in-situ casting process the reinforcements are produced internally due to the chemical reaction between the reactants during the fabrication process whereas in ex-situ casting process the reinforcement particles are added externally during the fabrication process. Potassium Tetrafluoborate (KBF_4) and Potassium Hexafluozirconate (K_2ZrF_6) mixed in the stoichiometric ratio were added into the molten matrix. The resulting chemical reaction between the salts led to the production of ZrB_2 inside the melt itself. The contents of the crucible stirred manually for 30 minutes were later transferred to the preheated die and allowed to solidify.

c) Al 6061 + 5% SiC +5% ZrB_2

Al6061+5% wt SiC+5% wt ZrB_2 HMMC was fabricated through a two-step process. The first stage in the fabrication of HMMC was the fabrication of Al6061+5% wt ZrB_2 MMC through the in-situ casting process. The Al6061+5% wt ZrB_2 monolithic metal matrix composite was then melted in the crucible to which 5% by weight SiC reinforcement particles were added. The contents of the crucible mechanically stirred for 30 minutes were transferred to a preheated cast iron die and allowed to solidify. The casting resulted was that of Al6061+5% wt SiC+5% wt ZrB_2 hybrid metal matrix composite.

d) Cutting & Testing

After casting the three components, they were cut into ASTM E8 standard pieces for testing[3]. The ASTM E8 standard size is shown in Figure (1). The tensile test is done on this piece of cut material using the Universal Testing Machine. The casted material were cut using the Electrical Discharge Machining[4] technique because even little changes in dimensions of cut material might change the value of tensile strength and thus skew the results. Two pieces in each weight concentration were cut and the average value of the two were calculated. These value are tabulated in the results below.

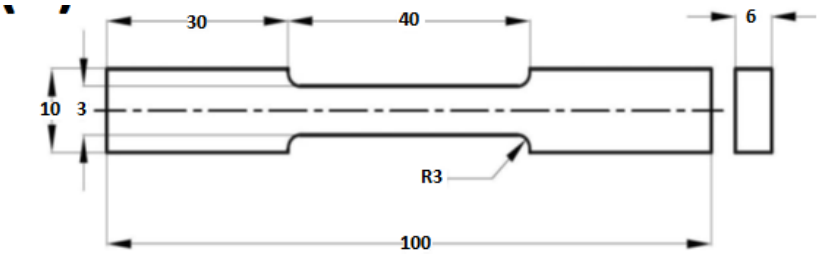


Figure 1: ASTM E8 Standard Size

III. RESULTS AND DISCUSSION

After the cutting is carried out to get the required specimens for tensile test from the castings developed. ASTM E8 describes tensile testing of metals such as steel or metal alloys. This test determines important mechanical properties such as yield strength, ultimate tensile strength, elongation, and reduction of area.
Sample specimens after tensile testing are shown in Figure (2). It is seen that for every weight concentration, two specimens were created and their tensile strength were measured.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:03/March-2020 www.irjmets.com

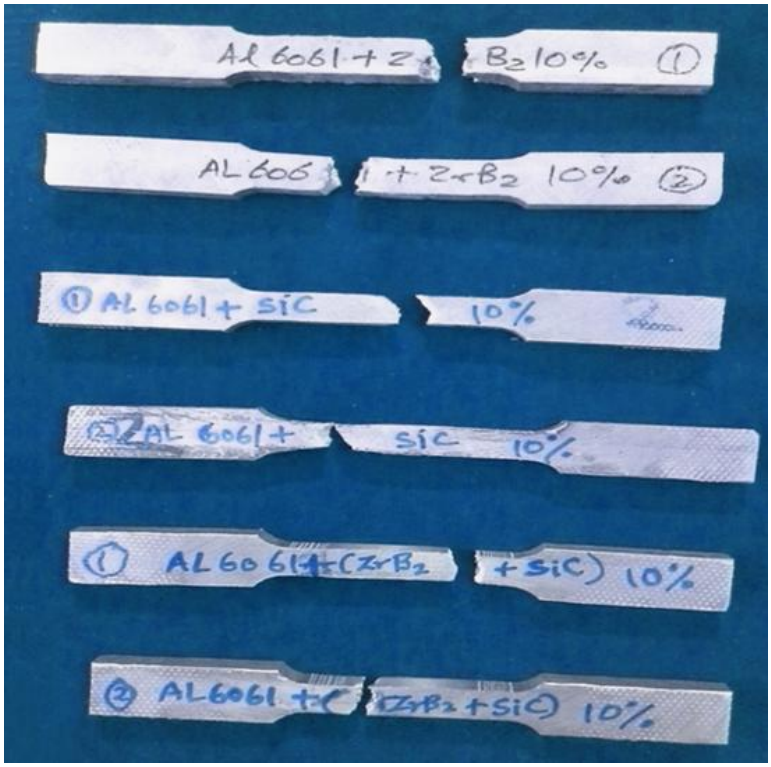


Figure 2: Sample Specimens after ASTM E8 Testing.

Table 2: The percentage of reinforcement for each specimen is shown in the table below.

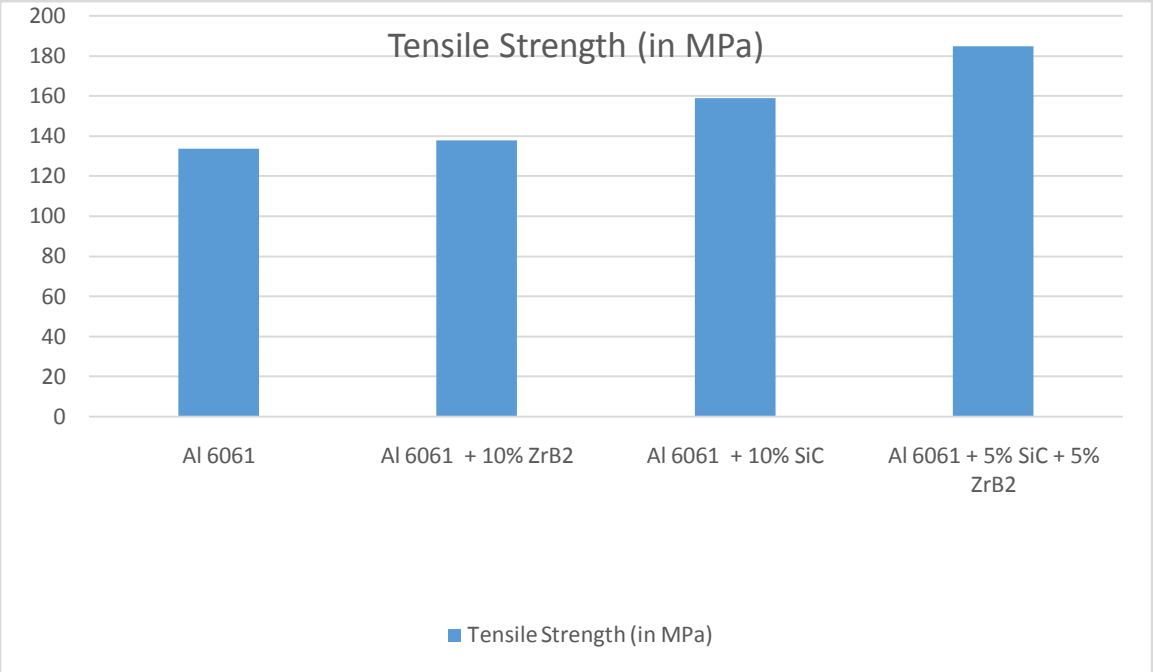
Sample	Model Type	SiC	ZrB_2
1	Al 6061 base metal	0	0
2	Al 6061+10% wt ZrB2	0	10
3	Al 6061+10% wt SiC	10	0
4	Al 6061+5% wt SiC+5% wt ZrB2	5	5

Tensile strength found out for the specimens are tabulated in the table (3) and plotted in the graph (1)

Table 3: The percentage of reinforcement for each specimen is shown in the table below.

Sample	Model Type	Tensile Strength
1	Al 6061 base metal	134 MPa
2	Al 6061+10% wt ZrB2	138 MPa
3	Al 6061+10% wt SiC	159 MPa
4	Al 6061+5% wt SiC+5% wt ZrB2	186 MPa

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:03/March-2020 www.irjmets.com



Graph 1: A graph comparing the tensile strength of the four samples

From the graph it can be found that HMMC provide highest tensile strength when compared with the monolithic composites. 52% increase in tensile strength was observed in the HMMC when compared to as-cast Al6061.

Table 4: Percentage of increase in tensile strength compared with as cast base alloy Al6061

Composite	**% Increase in Strength**
Al 6061+10% wt ZrB2	6
Al 6061+10% wt SiC	24
Al 6061+5% wt SiC+5% wt ZrB2	52

The average thermal expansion coefficient of AA6061 is 24×10−6/°C while that of ZrB_2 is 6.6×10−6/°C and SiC is 4.0×10-6/°C. The increase in tensile strength of the composite is due to the fact that the matrix material AA6061 and the reinforcements ZrB_2 and SiC have different thermal expansion coefficients. This difference in thermal expansion between the matrix and the reinforcement tends to append high density of dislocations around ZrB_2 and SiC particles during solidification.HMMC consists of two different reinforcements with two different thermal expansion coefficients which tends to produce higher density of dislocations around the reinforcement particles. The increase in dislocation density will reduce the propagation of facture.It is also found that strength of stircast SiC MMC is comparatively higher than that off the in-situ formed ZrB_2 MMC. This is due to homogeneous distribution of the reinforcement particles (SiC) in the alloy matrix AlSiC whereas the distribution is non homogeneous in Al + ZrB_2.

Microstructure images showing the presense of reinforcements Figure 3(a) - Al 6061 + 10% SiC MMC, Figure 3(b) – Al 6061 + 10% $ZrB_2$and Figure 3(c) Al 6061 + 5% SiC + 5% ZrB_2

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:03/March-2020 www.irjmets.com

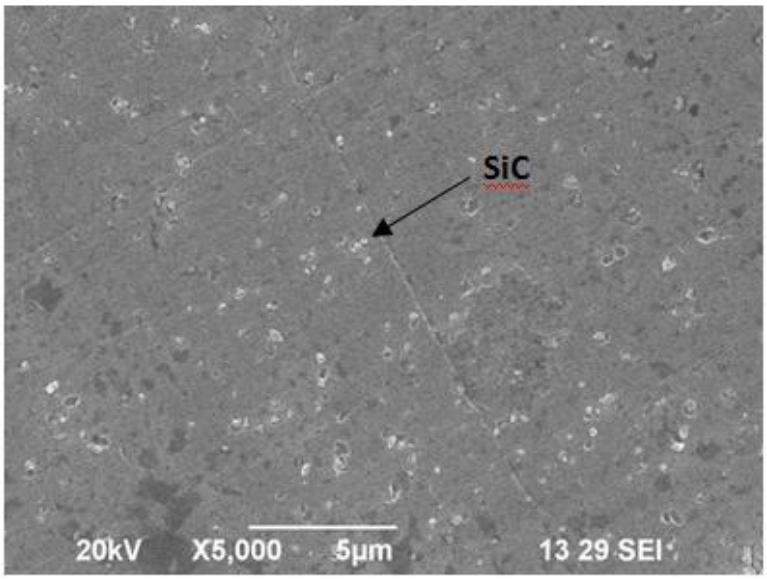


Figure 3(a) – 10% SiC in Al 6061 Matrix, the SiC are seen as randomized polygonal structures in the matrix.

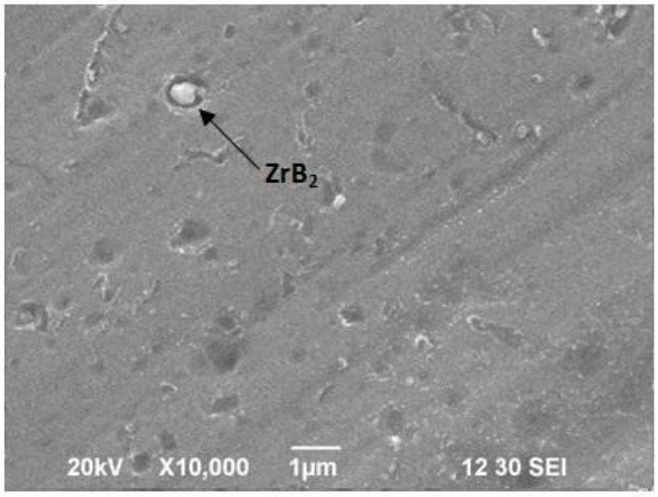


Figure 3(b) – 10% ZrB_2in Al 6061 Matrix, the ZrB_2 are seen as random spherical structures in the matrix.

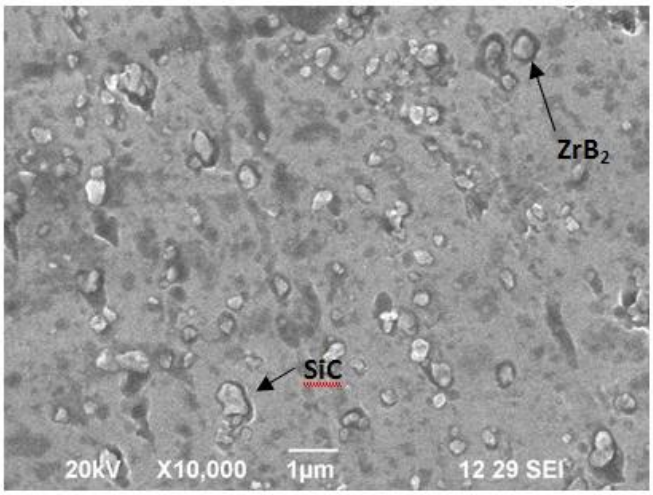


Figure 3(c) – 5% SiC + 5% ZrB_2 in Al 6061 Matrix, the $ZrB_2$and SiC are seen in the matrix.

IV. CONCLUSION

Monolithic composites (Al6061+10%wt SiC , Al6061+10%wt ZrB2) and Hybrid Metal matrix composites (Al6061+5%wt ZrB2+5%wt SiC) were successfully fabricated. Tensile strength of the composites were observed and it is found that hybrid metal matrix composite exhibits the highest tensile strength compared to the other monolithic composites.

V. REFERENCES

[1] Suraj Rawal (2001). Metal-Matrix Composites for Space Applications.
[2] Rajeshkumar Gangaram Bhandare, Parshuram M. Sonawane (2013). Preparation of Aluminium Matrix Composite by Using Stir Casting Method.
[3] John Slotwinski, Shawn Moylan (2014). Applicability of Existing Materials Testing Standards for Additive Manufacturing Materials.
[4] Anthony Xavior Ma, Ajith Kumar J (2017). Machinability of Hybrid Metal Matrix Composite - A Review.