Characterisation of Boron nitride particulate reinforced AA7075 Aluminium alloy composites produced via Stir casting

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Abstract. Stir casting process is an economical method for fabrication of composite material. Aluminium Al 7075 has been taken as alloy material. It is mainly used in automobile applications of alloy wheels, engine head, cylinder blocks, valves etc. In the last decade the world required low cost, high performance and good quality materials has caused a shift in research from the aluminium materials. In this project work, samples have been fabricated by stir casting process using Al 7075 alloy material and Boron nitride reinforcement. Boron nitride is hard ceramic with high hardness, good thermal conductivity and better resistance to corrosion. The mechanical and tribological properties improve when TiB_2 is reinforced with aluminium matrix. 1%, 2% and 3% samples are fabricated by varying the reinforcement percentages. The samples have been tested for tensile strength, hardness and wear rate. The good reinforcement percentage is found using the test results.

Keywords: Aluminium hybrid composites, Stir casting, Mechanical properties, Tribological Properties, Optimal percentage

1. Introduction

Casting is one of the manufacturing processes where a metal is heated above its recrystalisation temperature and melted and then it is then poured into a cavity, which contains it in the required shape during solidification. Thus, simple or complex shapes can be made in a single step from any metal that can be melted, resistance to working stresses can be improved directional properties can be controlled. Cast parts range was high. Casting has an advantages in the production of complex shapes, shell structure, irregular curved surfaces. Since there are lot of advantages, it is important manufacturing process. A composite material is a material consists of two or more constituent materials with different properties combined to produce a material with characteristics different from the individual components. The fabricated material has combined properties and stucture.A metal matrix composite are composite material has two constituent parts. Hybrid composite consists of atleast three materials. Metal matrix composites manufacturing is done by using different methods. They are solid state methods (hot iso static pressing or extrusion), liquid state methods (stir casting or squeeze casting), semi-solid state methods, vapour deposition, In this fabrication Stir casting technique is used, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. Stir casting is a discontinuous reinforcement is stirred into molten metal, which is allowed to solidify [10]. The molten metal is infiltrated into the reinforcement through the use a king of pressure such as gas pressure. Stir casting is one of the effective and cheapest route for development and processing of metal matrix composites materials [1]. Properties of these materials may vary according to the working environment. Stir casting is done by introducing the particles into the molten or partially solidified metal or alloy followed by casting in moulds.

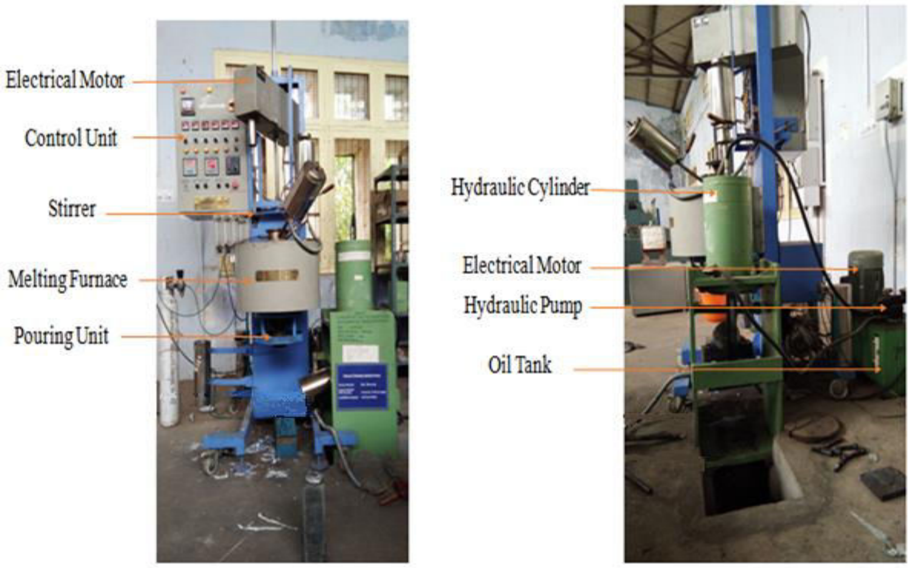

FIGURE 1. Stir casting machine

1.1 SPECIFICATION OF STIR CASTING

- Maximum temperature of pathway furnace: 1500 °C
- Maximum temperature of preheat chamber: 500 °C
- Stirring speed: Up to 1500 rpm
- Variable stirring time
- Die: Individual type to obtain a cast of 50 mm OD x 250 mm Long (Standard)

2. Materials and Method

The materials used for this project are Aluminium alloy used as matrix material and Titanium di boride used as reinforcement material

2.1 Matrix Material: Aluminium Alloy 7075

Castings are standardized in the precipitation treated (TE) condition, solution treated, artificially aged and stabilized (TF7) condition and the fully heat treated (TF) condition.

2.2 AA7075 alloy chemical composition

Table 1. chemical composition of AA7075alloy

Copper	1.20-2.00 max
Magnesium	2.10-2.90 max
Silicon	0.40 max
Iron	0.50 max
Manganese	0.30 max
Titanium	0.20 max
Zinc	5.10-6.10 max
Chromium	0.18-0.28 max

2.3 Properties of AA7075

Table 2. properties of AA7075 alloy

Density	2.81 g/cm^3
Young's modulus	572 Mpa
Melting point	477 ^{0}C
Specific heat capacity	714.8 J/Kg-K
Tensile strength : Ultimate (UTS)	572 Mpa
Rockwell Hardness	87 HRB
Thermal Conductivity	196 W/Mk
Elongation	11 %

The mechanical properties of AA7075 depend greatly on the temper, or heat treatment, of the material.

Table 3. Mechanical properties of AA7075 alloy

Material	Maximum tensile strength (MPa)	maximum yield strength (MPa)	Elongation (%)
7075-0	280	140	10
7075-T6	510-540	430-480	5-11
7075-T651	570	500	3-9
7075-T7	505	435	13

Table 3 indicates the mechanical properties of AA7075 material

2.2 Method

The literature review has given an insight of the alloy research work and the gaps found in it enabled to identify problem areas find solution through the experimental methodology fulfilling the objective Stir casting is a liquid state method of composite materials fabrication, in which a molten matrix and dispersed phase is mixed with a molten matrix metal with the help of mechanical stirring. In Stir casting, a discontinuous reinforcement is stirred into molten metal, which is then allowed to solidify.

3. Experimentation

The 7075 aluminium alloy is introduced to the melt furnace and it is melted at 650 °C. The Boron nitride reinforcement is preheated at 300 °C for 30 minutes. Then the preheated reinforcement matrix is added with the molten matrix materials. The speed of stirring is set at 500 rpm and stirrer is moved down to mix the reinforcement material and the reinforcement material for five minutes. After sufficient mixing was done, the complete slurry was poured into the die using a switch which opens the gate.

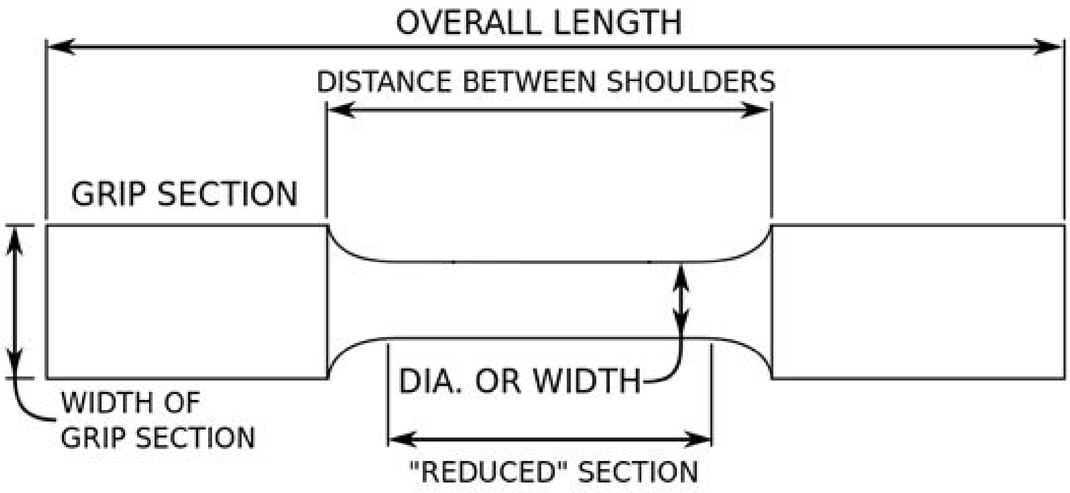

Figure 3. Tensile test Specimen Nomenclature

Figure 3 represents the dimension and the nomenclature of the tensile specimen.

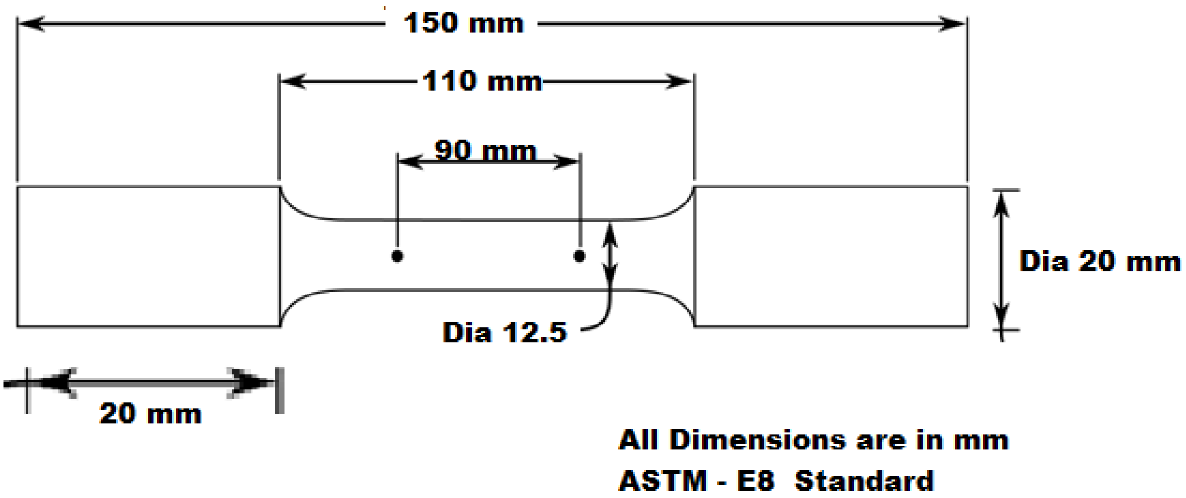

Figure 4. Dimension of tensile test Specimen

The required dimensions to prepare tensile specimen as shown in figure 4 these specimen is machined according to the ASTM - E8 standard. The shoulders Specimen preparation for wear test

The samples are machined and the required dimensions are achieved. The figure 4.11 shows the dimensions of the sample used in wear test. The required diameter is 10 mm and the required length of the samples is 30 mm. The surface of the disc is cleaned by using the acetone solution.

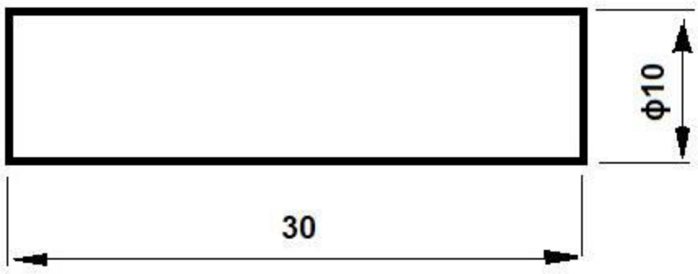

Figure 5. Wear test specimen nomenclature

3.1 Specimen preparation for Hardness test

The Vickers hardness test machine was used here to test the samples and to identify hardness values. This computerized machine internally has a microscope which is used to focus on the intended area and the readings are taken by using that taken images.

The principle is to determine the material's ability to resist plastic deformation from a standard source. The hardness test is done in Vickers hardness test. The unit of hardness is Pyramid Number (HV) or Diamond Pyramid Hardness (DPH).

The hardness number is determined by the load over the surface area of the indentation and not the area normal to the force.

Figure 6. Vickers hardness test

4. Results

4.1 Tensile test results

Figure 7. Tensile Test Specimen

figure 7 shows that the breaking of tensile test specimen after load is applied

Table 4. Tensile test results

S.NO	REINFORCEMENT	TENSILE TEST N/mm^2
1	AA7075 +BN (1 %)	286.43
2	AA7075 + BN (2 %)	333.67
3	AA7075 + BN (3 %)	382.75

From the table 3, it is observed that, highest tensile strength occurred for 3 wt % reinforced material was 382.75 N/mm^2. The lowest tensile strength was occurred for 1 wt% reinforced material and the tensile strength value was 283.43 N/mm^2.

4.2 Hardness test results

Figure 4 shows surface of the specimen after hardness test. Hardness test results are shown in table 4.

Table 5. Hardness test results

S.No	SAMPLE 1	SAMPLE 2	SAMPLE 3
1.	89.8	90.7	102.6
2.	91.2	93.7	107
3.	90.5	96.7	99.4
4.	89.8	97.3	104.5
5.	89.3	94.6	105.8
RESULT	90.12	94.6	103.86

From the table 4, it is observed that, the highest hardness occurred for sample 3 is 105.8 materials and the lowest hardness value was 99.4.

4.3 WEAR RESULTS

Wear results are tabulated. From the table we can understand that least wear rate was occurred at 3 wt% reinforced composite material with 20 N load, sliding speed 500 rpm. The least wear rate was 152 µm. Maximum wear rate was occurred at 1 wt % reinforced composite material and the wear rate was 206 µm [12].

Table 6. Wear test results

S NO	Load	Sliding speed	Track Diameter	Hybrid Reinforcement	Wear rate	Friction force
	N	RPM	Mm	%	µm	N
1	10	500	2	1	5.904	5.901
2	20	500	2	1	7.791	7.782
3	30	500	2	1	6.097	6.092

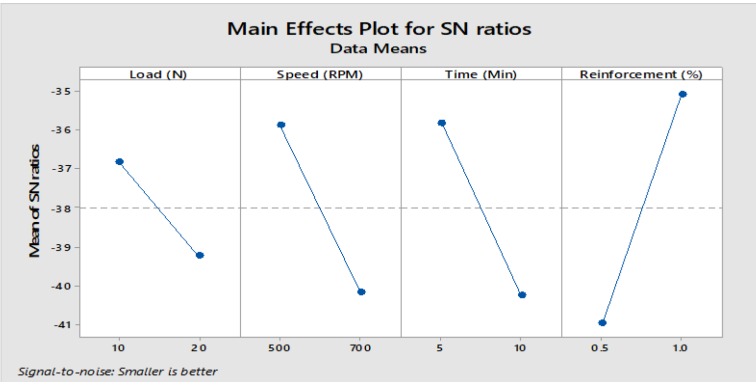

Figure 8. Wear rate

The figure 8 show the graph obtained at minimum wear rate.

5. CONCLUSION

- The Hybrid composite sample of Aluminium Alloy 7075 as matrix, Boron Nitride Particulates as reinforcement was fabricated using stir casting process. The mechanical properties such as tensile test, hardness, wear test and microstructure were investigated from the fabricated samples. The microstructure analysis shows fairly even distribution of particles and some agglomeration of Boron Nitride.
- The hybrid composite exhibited superior wear resistance when compared with base aluminium 7075 matrix alloy and the wear resistance get increased.
- It is clear from the S/N ratio that Load is the most significant factor followed by speed and time.
- From the comparison charts we can conclude that when the load increased the wear rate increases tremendously at low speed. And also the wear rate decreases with increases in the speed.

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