Characterization of Titanium Di boride particulate reinforced AA6082 Aluminium alloy composites produced via Stir casting

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Abstract - *Stir casting process is an economical method for fabrication of composite material in which a dispersed phase is mixed with molten matrix method by means of mechanical stirring. Aluminium Al 6082 has been taken as alloy material. Aluminium Al 6082 alloy is mainly used in automobile applications of alloy wheels, engine head, cylinder blocks, valves etc. In the past few years the global need for 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 6082 alloy material and Titanium Boride (TiB2) reinforcement. Titanium Boride is hard ceramic with high hardness, good thermal conductivity and better resistance to corrosion. When TiB2 is reinforced with aluminium matrix, the mechanical and tribological properties improve. The samples are fabricated by varying the reinforcement percentages as 1%, 2% and 3%.The sample have been tested for tensile strength, hardness and wear rate. The Optimal reinforcement percentage is found using the test results.*

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

1. INTRODUCTION

Casting is a manufacturing method where a solid is melted, heated to proper temperature (occasionally handled to adjust its chemical composition), and is then poured right into a hollow space or mold, which incorporates it within side the right form for the duration of solidification. Thus, in a single step, easy or complicated shapes may be crafted from any steel that may be melted. Casting has marked benefits within side the manufacturing of complicated shapes, elements having hollow sections or inner cavities, elements that contain irregular curved surfaces, very massive elements and elements crafted from metals which might be tough to machine. Because of those apparent benefits, casting is one of the maximum critical of the producing processes. A composite material is a material crafted from or greater constituent substances with substantially extraordinary physical or chemical residences that, while combined, produce a material with traits extraordinary from the individual additives. The individual additives remain separate and distinct in the completed structure, differentiating composites from mixtures and stable solutions. A metallic matrix composite is composite material with at the least constituent parts, one being a metallic necessarily, the alternative cloth can be a extraordinary metallic or another material, along with a ceramic or natural compound. When at the least 3 substances are present, it is known as a hybrid composite. Metal matrix composites production is carried out by the usage of extraordinary methods. They are stable state methods (warm isostatic pressing or extrusion), liquid state methods (stir casting or squeeze casting), semi-stable state methods, vapor deposition, in-situ fabrication technique. Stir casting is a liquid state technique of composite substances fabrication, wherein a dispersed section is blended with a molten matrix metallic by means of mechanical stirring. In Stir casting, a discontinuous reinforcement is stirred into molten steel, that is then allowed to solidify. Stir casting is one of the distinguished and inexpensive direction for improvement and processing of steel matrix composites substances. Properties of those substances depend upon many processing parameters and choice of matrix and reinforcements. Stir casting is executed through introducing the particles into the molten or in part solidified steel or alloy accompanied through casting in moulds.

Fig -1: Stir casting machine

2. MATERIALS AND METHODS

The materials used for this work are Aluminium alloy and Titanium di boride. Aluminium alloy 6082 used as matrix material and Titanium di boride used as reinforcement material

2.1 Aluminium Alloy 6082

6082 aluminium alloy is an alloy in the wrought aluminium-magnesium-silicon family (6000 or 6xxx series). It is one of the more popular alloys in its series (along alloys 6005, 6061, and 6063), even though it isn't strongly featured in ASTM (North American) standards. It is commonly formed by extrusion and rolling, however as a wrought alloy it isn't utilized in casting. It also can be cast and clad, however that isn't common practice with this alloy. It cannot be work hardened, however is usually heat treated to supply tempers with a better energy however decrease ductility.

Table -1: Properties of aluminium alloy

ELEMENTS	CONTRIBUTION (%)
Silicon (Si)	1.3
Iron (Fe)	0.5
Copper (Cu)	0.1
Manganese (Mn)	1
Magnesium (Mg)	1.2
Chromium (Cr)	0.25
Zinc (Zn)	0.2
Titanium (Ti)	0.1
Aluminium (Al)	95.2

2.2 Titanium di Boride

Titanium di boride (TiB2) is an extremely tough ceramic which has wonderful heat conductivity, oxidation balance and wear resistance. TiB2 is also an affordable electric conductor,[1] so it can be used as a cathode material in aluminium smelting and may be formed with the aid of using electric discharge machining.

Table -2: Properties of Titanium di-boride

PROPERTIES	VALUE
Coefficient of Thermal Expansion ($10^{-6}/^0C$)	4.5
Ultimate Tensile Strength (MPa)	550
Density (g/cm^3)	4.52

3. EXPERIMENTATION

The 6082 aluminium alloy is introduced to the melt furnace and it is melted at 650 °C. The TiB2 reinforcement is preheated at 300 °C for 30 minutes. Then the preheated reinforcement mix is added with the molten matrix materials. The stirring speed is set at 500 rpm and stirrer is moved down to mix the matrix material and the reinforcement material for 5 minutes. After sufficient mixing was done, the complete slurry was poured into the die using a switch which opens the gate.

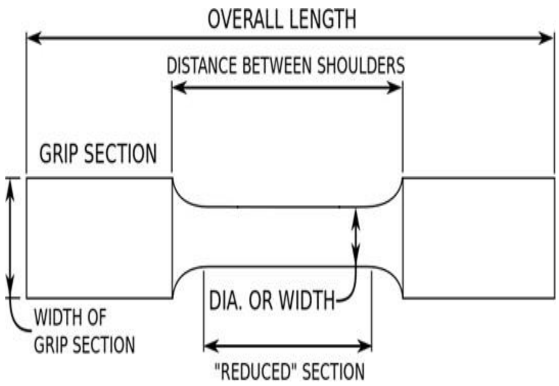


Fig -2: Tensile test Specimen Nomenclature

The dimension nomenclature of the tensile specimen as shown in figure 3, these specimen is a standardized sample cross-section. It has two shoulders and a gage (section) in between.

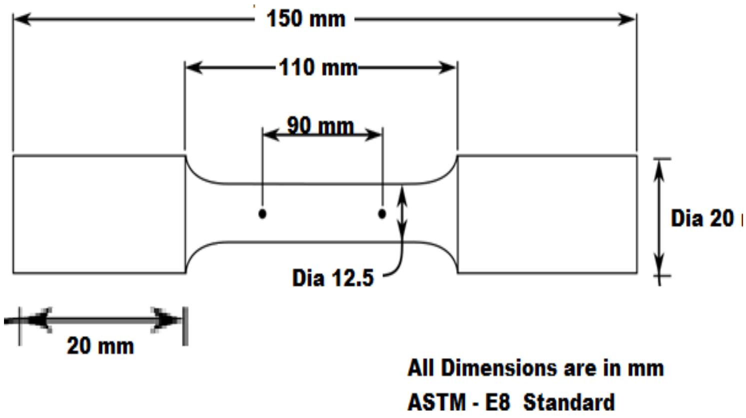


Fig -3: Dimension of tensile test Specimen

The required dimensions to prepare tensile specimen as shown in figure 4.5, these specimen is machined according to the ASTM - E8 standard. The shoulders are large so they can be readily gripped, whereas the gauge section has a smaller cross-section so that the deformation and failure can occur in this area.

3.1 Specimen preparation for wear test

The samples are machined and the required dimensions are achieved. The figure 4 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 has some metal particles that can be removed and cleaned by using the acetone solution.

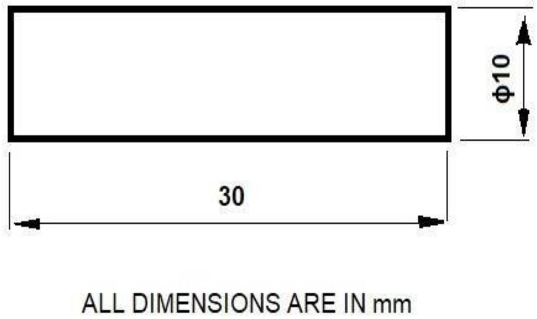


Fig -4: Dimensions of Wear test specimen

3.2 Specimen preparation for Hardness test

The hardness property of the composite material is identified by doing this test. The Vickers hardness test machine was used here to test the samples. 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 basic principle, as with all common measures of hardness, is to observe a material's ability to resist plastic deformation from a standard source. The Vickers test can be used for all metals and has one of the widest scales among hardness tests. The unit of hardness given by the test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH). The hardness number can be converted into units of pascals, but should not be confused with pressure, which uses the same units. The hardness number is determined by the load over the surface area of the indentation and not the area normal to the force.

Fig -5: Vickers Hardness Tester

4. RESULTS

4.1 Tensile test results

Fig -6: Tensile Test Specimen

Figure 6 shows that the breaking of tensile test specimen after load is applied.

Table -3: Tensile test results

Sample No	Aluminium 6082 (%)	Hybrid Reinforcement %	Tensile Strength N/mm²
1	99	1	150.43
2	98	2	167.56
3	97	3	184.75

From the table 3, it is observed that, highest tensile strength occurred for 3 wt % reinforced material. The higher tensile strength occurred was 184.75 N/mm^2. The lowest tensile strength was occurred for 1 wt% reinforced material and the tensile strength value was 150.43 N/mm^2.

4.2 Hardness test results

Table -4: Hardness test results

Sample no	Aluminium 6082 (%)	Hybrid Reinforcement (%)	Hardness (HV)			
			Trial 1	Trial 2	Trial 3	Avg
1	99	1	136.2	132.3	137.2	135.2
2	98	2	150.6	147.2	151.3	149.7
3	97	3	235.2	190.2	182.4	202.6

From the table 4, it is observed that, the highest hardness occurred for 3 % reinforced material. The highest hardness occurred is 202.6 HV. The lowest hardness occurred for 1% reinforced material and the lowest hardness value was 135.2 HV.

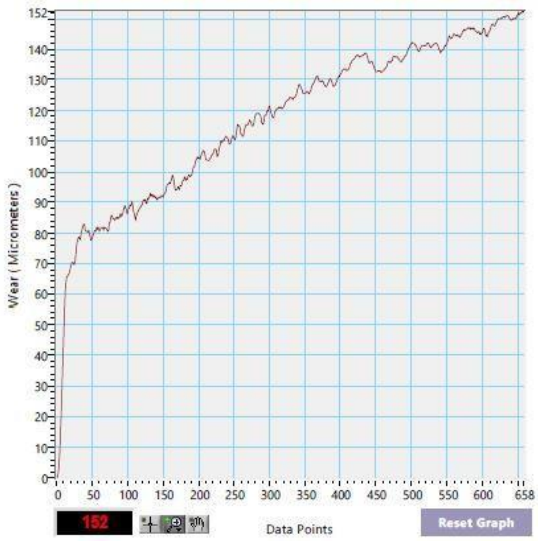
4.3 Wear results

Wear results are shown in table 5. From the table 5, it is observed that, minimum wear rate was occurred at 3 wt% reinforced composite material with 20 N load, sliding speed 500 rpm. The minimum wear rate was 152 μm. Maximum wear rate was occurred at 1 wt % reinforced composite material and the wear rate was 206 μm.

Table -5: Wear test results

S.no	Load N	Sliding Speed RPM	Track Diameter mm	Hybrid Reinforcement %	Wear Rate μm	Friction Force N
1	20	500	100	1	173	8.3
2	20	500	100	2	206	9.1
3	20	500	100	3	152	5.8

Fig -7: Wear Rate at 152μm



The figure 7 show the graph obtained at minimum wear rate.

5. CONCLUSION

The composites were successfully fabricated by stir casting process. Lower tensile strength 150.43 MPa was obtained at 1 % reinforcement. Highest tensile strength 184.75 MPa was obtained for 3% reinforcement material. Tensile strength was increasing with the increase in reinforcement percentage. Maximum Hardness value of 202.6 HV was obtained at 3 % of reinforcement material and the minimum hardness was obtained at 1 % of reinforcement. Hardness increases with increase in reinforcement percentage. The minimum wear rate of 152 microns was obtained at 3 % of reinforcement and the maximum wear rate of 206 microns was obtained at 2 % of reinforcement. Based on the test results, Maximum tensile strength, maximum hardness and minimum wear rate was obtained 3 weight % of reinforcement. Hence the optimal reinforcement percentage is 3 %.

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