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Reciprocating Wear Studies on Al 6061 Alloy Reinforced with TiB_2 additions

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ABSTRACT:

MMC's provide combination of improved mechanical properties of metal matrix materials including high toughness, ductility reinforcement particles accounts for high stiffness and hardness. They also exhibit good corrosion resistance and wear resistance property compared to all other materials. Aluminium alloys are commonly used as piston materials as they exhibit good wear resistance properties. In the present study, successful attempts were made to produce Al6061 alloy reinforced with TiB_2 additions. By use of stir casting method Al6061 was reinforced with TiB_2 additions weight percentage (3% 5% 7% 9%). Less information is available with respect to Mechanical properties and wear properties of Al6061 alloy reinforced with TiB_2 additions. The study is mainly aimed in developing improved properties with respect to the piston material. The results of present investigation indicate that increased percentage of TiB_2 additions increases the UTS and hardness values, further wear resistance properties. The results of investigation are quite encouraging in take up the studies on materials in further way.

Keywords: Al6061, stir casting, reciprocating wear, hardness test and wear studies.

1. INTRODUCTION

Aluminium matrix composites (AMC's) are light weight composites and have vast applications in field of aerospace and automobile components and has combination of properties such as high stiffness, high stability, reduced density, high corrosion resistance[1,2,5,6,7,8,11,14,17]. Metal matrix composites (MMC's) are most widely used in automobile engines due to their high strength to weight ratio [3, 4, 9, and 10]. MMC's are relatively isotropic and have advantages such as high elastic properties [12], high thermal conductivity, high electrical conductivity, and high wear resistance. MMCs can be produced through techniques like powder metallurgy [13], stir casting, plastic deformation, friction stir processing and other techniques. Mass production of MMCs can be done by stir casting method.

MMCs provide a combination of improved mechanical properties of metal matrix, including high toughness and ductility, and reinforcement particles such as high stiffness and hardness. Aluminium alloys are most widely used as a metal matrix material in both research and industrial applications due to their high strength to weight ratio [15]. Due to high performance of workability, gases dissolved during melting process porosity occurs in high rate on Al alloys By modification of microstructure, cold working, heat treatment, composition and by adding reinforcement materials the drawback on porosity can be minimized.[16]

Aluminium alloy Al6061 is lightweight material with low density, high thermal conductivity, and low wear resistance. Alloy Al6061 is reinforced with TiB_2 to overcome drawback of low wear resistance, as reinforcement material exhibits high young's modulus [18], high hardness, high electrical conductivity [19], high wear resistance [20] and good thermal stability.

The objective of Present investigation is aimed in improving mechanical properties and wear property of alloy Al6061 reinforced withTiB2 additions with different weight percentages of reinforcement materials (3% 5% 7% 9 %) additions by use of stir casting method. Reciprocating wear studies for different conditions has been carried out to evaluate the wear resistance properties. Castings with different % reinforcement additions are made. Property evaluation with respect to mechanical properties and wear has been carried out. The results of the investigation are quite encouraging to take up further studies on this material.

2. MATERIALS AND EXPERIMENTATION

2.1 Materials

Table 1 shows details of composition of Al 6061 alloy used.

Table 1: Composition of alloy AL6061

Elements	Si	Fe	Cu	Mn	Ni	Pb	Zn	Sn	Mg	Al
Percentage	0.48	0.7	0.35	0.15	0.05	0.24	0.25	0.001	0.902	Balance

2.2 Fabrication process

Stir casting method was adopted to prepare the composites through casting. Stir casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with molten matrix metal by means of mechanical stirring.

For the development of the composites, melting was carried out using 2 kg capacity induction furnace as shown in figure 1. The charge material having the following composition in the form of ingots were loaded into the furnace. Al6061 alloy was melted at 750^0C in a graphite crucible resistance furnace. To this material, degassing tablets (Powdered form) was added. The slag and other impurities were skimmed off. At the temperature of 800^0C the preheated TiB_2 material was added in weight percentages (3%5%7%9%) into molten metal for with stirring was carried out at 400rpm for duration of 5 mins. The molten metal was poured into precoated and preheated seamless tubes immediately and are allowed to solidify. . The castings were ejected out of the molds. Samples were prepared for characterization of the composite.

Fig.1 Melting of Al6061

2.3 Tensile test

A Bench type tensometer was used to measure tensile strength of the specimen. The tensile test specimens were prepared as per ASTM E8 standard. Figure 2 and 3 shows details of tensometer and specimen for tensile strength testing. Fig, 4 shows necking and breaking of specimen when specimen breaks. From the UTS, %elongation values are carried out.

Fig.2 Bench type tensometer **Fig.3 Tensile test specimen**

The specimen was fixed to shackles of the tensometer, loading of the specimen was carried out by the regulating computerized inputs. When the specimen break at a point, maximum load and breaking load values are noted down.

Fig.4 breaking of specimen

2.4 Hardness test

Pre- Hardness test specimens across cross section of the specimen were made, measurement was carried out using Brinell hardness tester (5 mm diameter ball indenter, 100 kg load was applied for 30 seconds duration) and the average BHN value has been considered for analysis. The above procedure was followed for carrying out the hardness of the base alloy reinforced with TiB_2. Dimension of the specimen are shown in figure 5 (20mm diameter and 10mm height). Figure 6 shows the Brinell hardness tester used in the Present study.

Fig.5 Hardness specimen **Fig.6 Brinell hardness tester**

2.5 Wear Testing

Wear tests were carried out under dry reciprocating wear conditions using tribometer conforming to G133-05 specifications. Figure 7 shows the details of the specimen and figure 8 illustrates the tribometer used for

wear studies. Cylindrical specimen measuring 15 mm height and 8mm diameter were made to slide against a stationary EN32 steel wear plate of dimension 40x40x5mm.

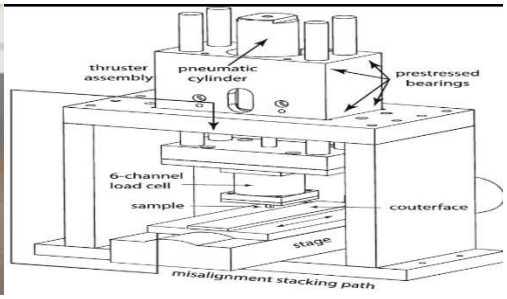


Fig.7 wear test specimens Fig.8 Linear reciprocating tribometer

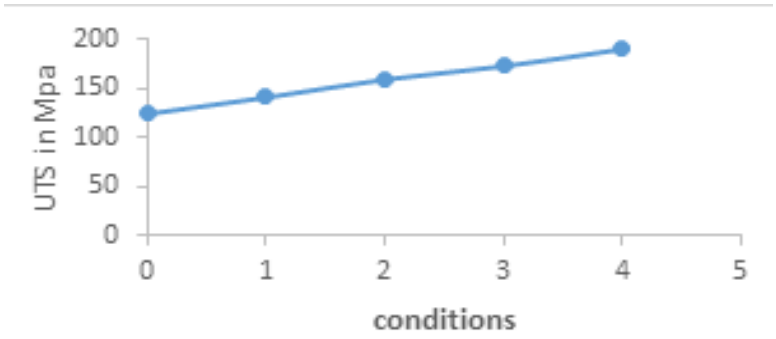
3. RESULTS AND DISCUSSION

3.1 Tensile testing

Tensile test were carried out on alloy and alloy with different amounts of TiB_2 additions. Ultimate tensile strength and percentage elongation were assessed for above conditions. Figure 9 shows the variation of UTS values for different percentage additions of reinforcement.

Al6061 alloy	Wt % of TiB_2	UTS value in MPa
Base alloy	0	124
Al6061	3	140.8
Al6061	5	159.1
Al6061	7	176.6
Al6061	9	197.7

Table 2.Tensile test values for different conditions.



Al6061
1.Al6061+3%TiB2
2.Al6061+5% TiB2
3.Al6061+7% TiB2
4. Al6061+9% TiB2

Fig.9 variation of UTS values for different reinforcement conditions

It can be observed from above graph that the base alloy exhibits the lowest value when compared with alloy reinforced with different additions. Base alloy reinforced with 9% wt addition exhibits maximum UTS value. Increasing value of UTS is observed with increased addition of TiB_2.An increase of (40%) is noticed with alloy reinforced with 9% TiB_2 additions.

3.2 Hardness testing

The Brinell hardness re-analysis carried out on base alloy and the alloy with different percentages of TiB_2 additions. The test were carried out on applying 100 kg load and three readings across the cross section were recorded and average of three readings were considered for an analysis.

Al6061 alloy	Wt % of TiB2	Hardness value(BHN)
Base alloy	0	36
Al6061	3	55.29
Al6061	5	57.94
Al6061	7	60.7
Al6061	9	63.66

Table.3 hardness values for different conditions.

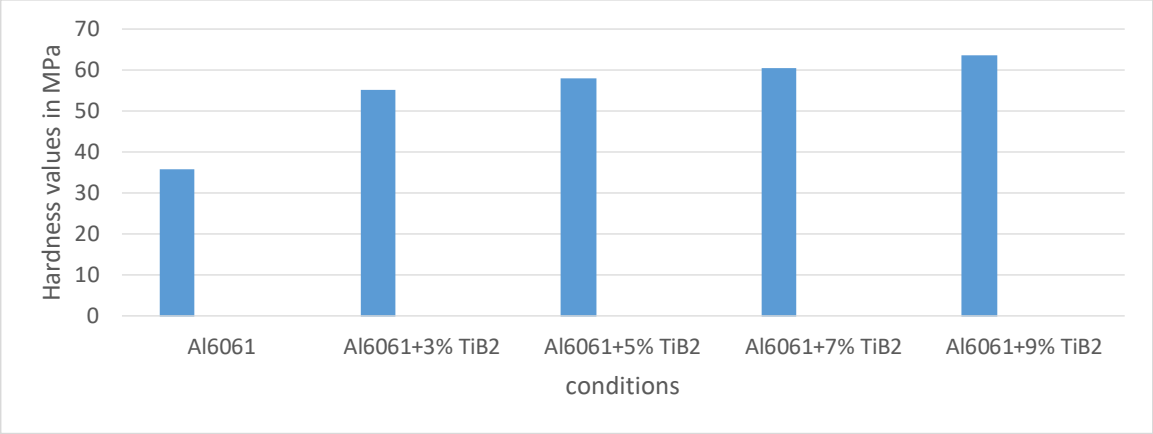


Fig.10 variation of hardness values for different reinforcement conditions.

It can be observed that the base alloy exhibits low hardness value. And the specimen reinforced with 9% of reinforcement possess maximum value of hardness.9% addition exhibits maximum value of hardness. An increase of 43.4% in hardness value is noticed for alloy reinforced with 9% TiB_2 additions.

3.3 Wear studies

Wear studies under reciprocating motion were carried out using the Linear Reciprocating type tribometer confirming to G-133 specification in dry condition. The counter plate material was made of EN32 steel. Specimen is in the form of pin and was made to reciprocate against the stationary wear plate. The parameters considered for the wear study are Load, Frequency and Duration of testing. Weight loss method has been employed in the study. The test is conducted by varying load on constant frequency of 10Hz. The load variation was made from 2N to 20N The test was conducted for a duration of 20 minutes for each variant.

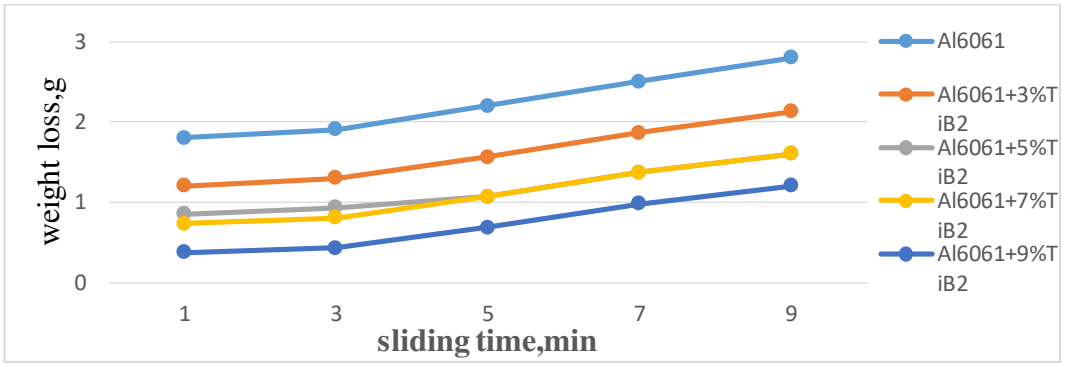


Fig.11 Variation of Weight loss for 1N load and 10Hz frequency for varying sliding time.

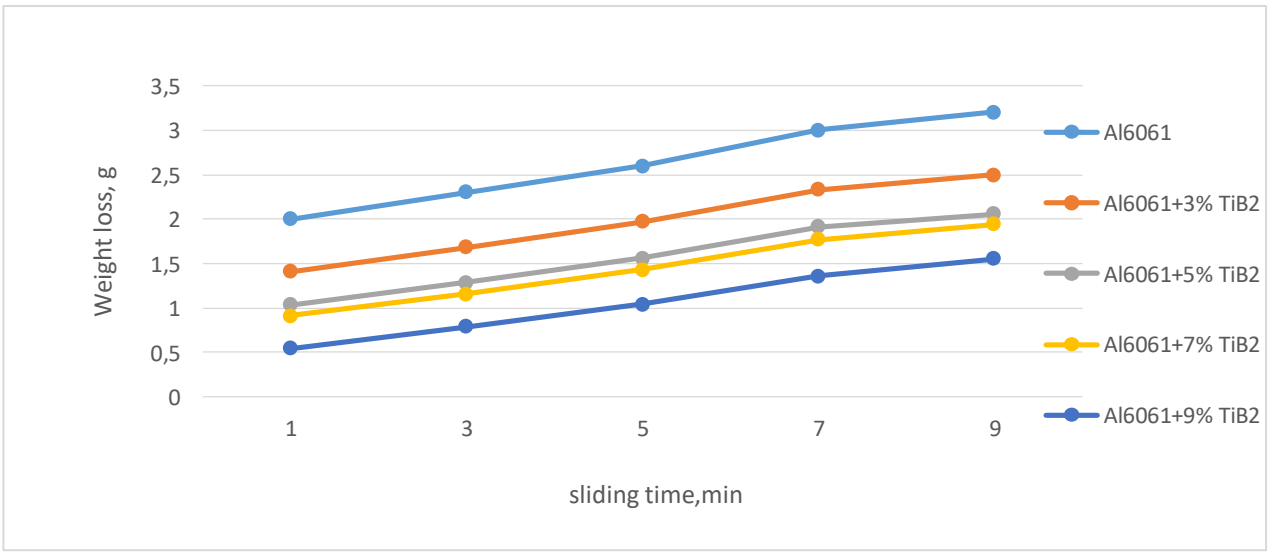


Fig.12 Variation of Weight loss for 5N load and 10Hz frequency for varying slidingtime.

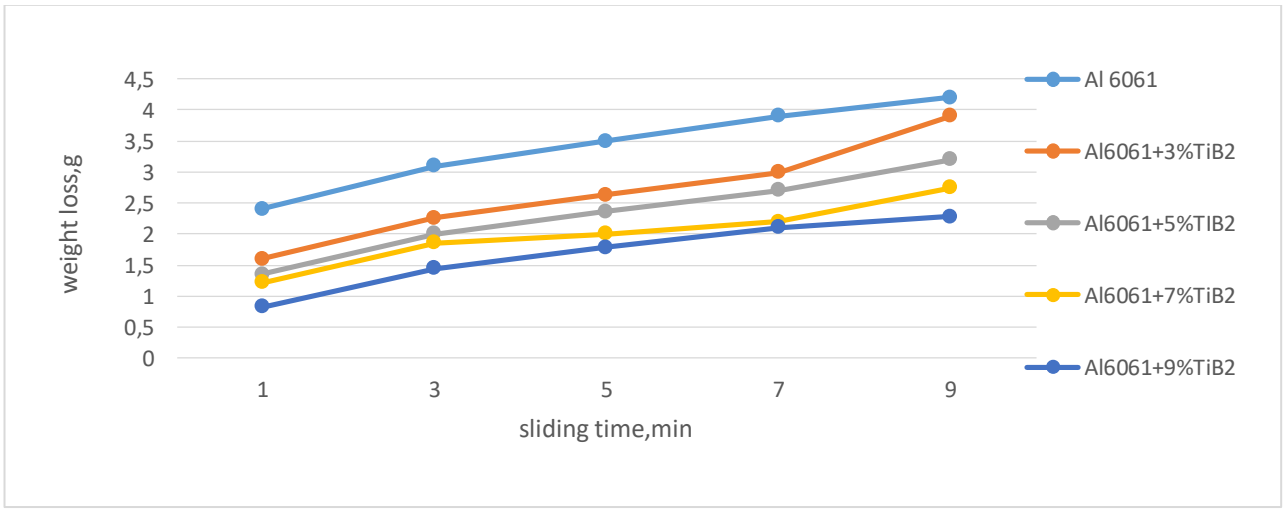


Fig.13 Variation of Weight loss for 10N load and 10Hz for varying sliding time.

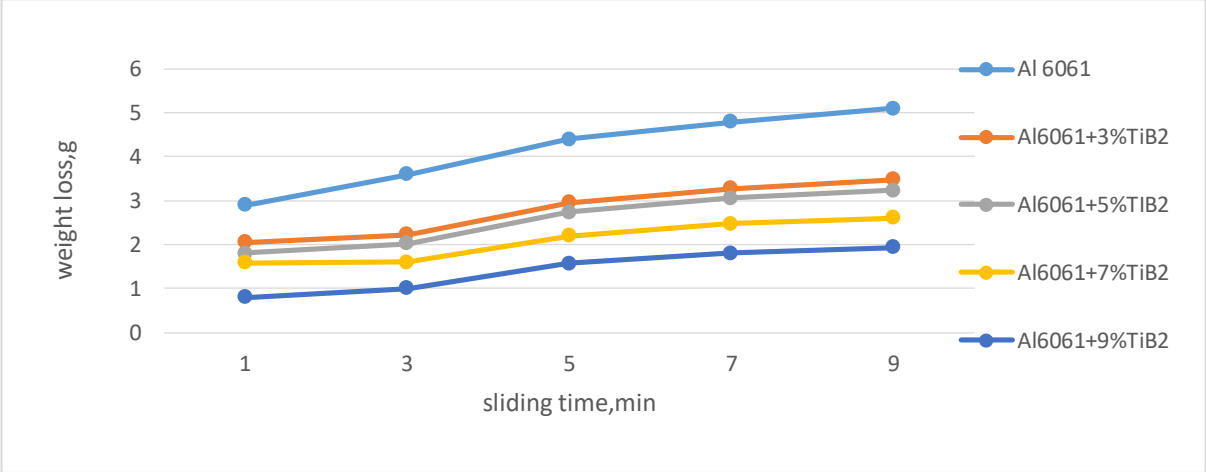


Fig.13 Variation of Weight loss for 15N load and 10Hz for varying sliding time

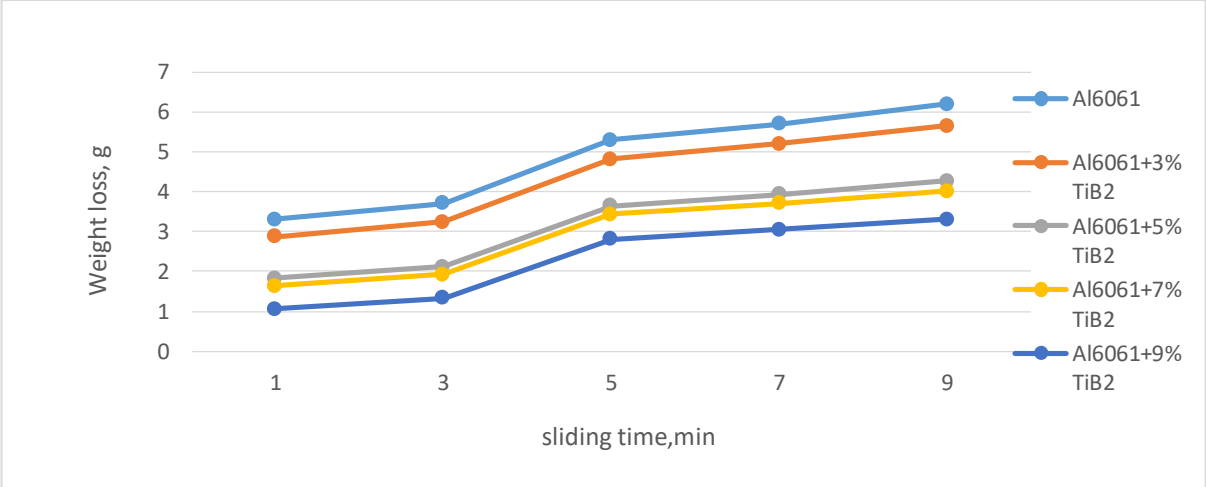


Fig.14 Variation of Weight loss for 20N load and 10Hz for varying sliding time

Fig 11, 12 13 14 shows variation of wear of the specimen for different conditions.it can be observed that from fig that base alloy exhibits more wear. Alloy with 9% TiB2 additions exhibits less wear. This may be attributed to higher hardness values exhibited by specimen for 9% additions.

CONCLUSIONS

Successful attempts were made on fabrication of composite with varying percentages of TiB_2. UTS values have been improved by addition of reinforcement material to base alloy. An improvement of 40% has been observed compared to base alloy. Hardness values were also improved by addition of reinforcement in improvement of 43.4%.

From wear studies carried out on alloy under linear reciprocating condition, the base alloy exhibits more weight loss when compared with samples of reinforcement additions.

The above results indicate that reinforcement addition has an influence in improving the mechanical properties, and when base alloy is reinforced with 9wt% reinforcement it exhibits improved mechanical

properties and wear resistance properties. Hence this material can be recommended as a potential candidate material for application of wear resistance applications.

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