DEVELOPING OF HYBRID COMPOSITE OF AL-6068 AND AL-7075 BY REINFORCING TIO2/ BN BY STIR CASTING PROCESS AND FINDING MECHANICAL AND WEAR BEHAVIOR OF THE HYBRID COMPOSITION

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Abstract

In the Current work, hybrid composites were prepared by reinforcing nanoparticles into the aluminum alloys (Al 6068 and Al 7075). The Al 6068 and Al 7075 aluminum alloys are reinforced with TiO_2 and BN by a stir casting process. The wear behavior and mechanical properties were investigated by performing hardness test and tensile test and compressive test and wear test was conducted under the dry sliding conditions. And performed the microstructural study to know the bond formed between the alloy and reinforcements. The samples are prepared as per ASME standards, and stirring speed (650 rpm), stirring time(15 min), % weight of reinforcement (3%), and stirring temperature ($750^0{}_C$) is considered as process parameters to fabricate the samples to perform mechanically and wear properties. The samples are fabricated by the combination Al 6068+TiO_2, Al 6068+BN, Al 6068+TiO_2+BN, Al 7075+TiO_2, Al 7075+BN, and Al 7075+TiO_2+BN. And the mechanical test was performed and studied the results obtained, and also the wear behavior of the hybrid composite was recorded and finally the analyzed the bonding between alloy and reinforcements of the composite materials by the SEM images.

Keywords: SEM (Scanning Electron Microscope), Hybrid Composition, Stir casting, Nanoparticles.

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1. INTRODUCTION

In the present industries like automotive, aircraft industries are working on the high strength and corrosion-resistant materials which are less weight, namely alloys like aluminum alloys and alloy steels, coming to alloy steels there are good in structural and strength but weight is more compared with aluminum alloys, but the aluminum alloys are less in weight and have good strength but it will not achieve the requirement of present engineering applications so it was reinforced and prepared hybrid composite to encounter the present applications. In aircraft industries two dissimilar materials are used in building the frames and body structures of the aircraft by using welding process or riveted joints in this regard need to identify the mechanical strengths of the two dissimilar for aircraft applications.

A new composition was developed for aerospace applications with Al 6068 and Si_3N_4, AIN and Zrb_2 reinforcements by stir casting process and performed hardness test, tensile test, compression test and wear behavior and also studied the microstructures. By increasing the wt% of reinforcements the mechanical properties are also increasing and also observed improved in wear rate [1]. Investigated the mechanical and tribological characteristics of Al6068 with Boron carbide as reinforcement by stir casting process. And consider the input process parameters for wear are applied load (20, 30 and 40N), sliding speed (1.25, 2.51 and 3.76 m/s) and sliding distance (400,600,800 M) with this parameters A16068-10 wt % B_4C MMC was showed increased in wear rate at different loads. And the SEM images presents the proper distribution in MMC [2]. Al6068 is reinforced with SiC_P particles by stir casting process and observed the mechanical properties of new MMC by considering size of reinforcements 7 and 33 μm, wt% 5 and 10, Stirring temperature 750^0 C and stirring speed 700 rpm. The mechanical properties tensile strength was improved by increasing the weight of reinforcement and hardness also but the impact strength was reduced by increasing the weight percentage [3]. Comparative study of mechanical properties of Al 7075 and MMC Al 7075/TiB_2/12_P by stir casting process. In this study the composite material shown better results than base metal. The tensile and hardness was increased by the TiB_2 wt% [4]. By using the Stir casting method Al7075 is reinforced with 5% of Baggage-ash and observed a slight increase in tensile strength, compressive strength, and impact strength. And also developed hybrid composite by adding Baggase-ash and Graphite to Al7075 it recorded the superior in mechanical and microstructural properties compared to al7075 [5]. Hybrid Nano composites were developed by ultrasonic stir casting method by reinforcing the Sci and B4C to Al7075 alloy. And observed that the 1.5% SiC and 0.5% B4C reinforcement shows an increase in tensile strength [6]. To improve the mechanical properties likely tensile and compressive strength of Al7075 alloy, reinforced with Al7075-5%TiC+5%SiC MMCs, after reinforcing the TiC and SiC the tensile strength and compressive strength was increased to 32% and 10.5% respectively [7]. Al6063 reinforced with a changing weight fraction of TiB2 and Gr were fabricated using the stir casting process. And achieved the required Hardness, Tensile Strength, and Impact strength, and wear resistance, in this 4% of TiB2 exhibited superior properties among all composites [8]. The tensile strength of the hybrid Al7075/Tio2/BN has shown improvement of tensile strength up to 27% and Al7075/5% Tio2/2%B has increased hardness up to the value 83.34 Vickers hardness [9]. The researchers have introduced the ultrasonic stir casting method for developing nano-reinforcement metal matrix composition, which can regulate the temperature and stirring speed of molten metal and also reinforcements evenly distributed. The A356-SiC-Al2O3 metal matrix improved the tensile strength, yield strength, and elongation were gradually increased based on the weight of nanoparticles reinforced into the molten metal [10]. The objective of the current work is to compare the mechanical, wear properties of two dissimilar alloys by adding reinforcements TiO_2 and BN for aircraft applications.

2. EXPERIMENTAL WORK

2.1 Material Used

In this work considers the Al 6068 and Al 7075 as the base alloys and TiO_2 and BN consider as the reinforcements for fabricating the hybrid composite material Al 6068 and Al 7075. And the chemical properties and mechanical properties of alloys are tabulated in table no.1 and table no. 2 respectively [1 & 4].

Table.1: Composition of Al6068 and Al7075

Alloy Elements	Cu	Si	Mg	Ti	Fe	Ni	Cr	Al
Al6068	2.3	0.18	1.6	0.07	1.1	1.0	-	93.7
Al7075	0.25	0.6	1.0	-	-	-	0.2	97.9

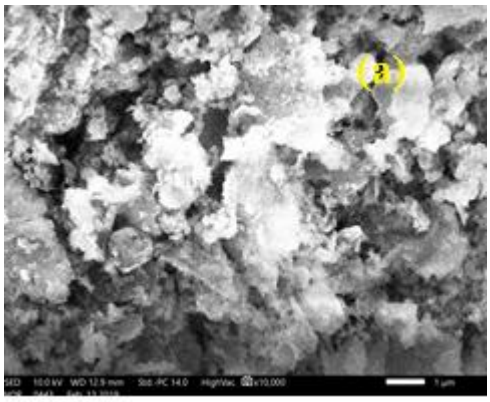
Table.2: Mechanical properties of Al6068 and Al7075

Alloy	Tensile Strength(Mpa)	Hardness (BHN)	Compressive Strength (Mpa)
Al6068	440	140	112.36
Al7075	310	95	108.36

The reinforcements TiO_2 and BN are added with 3% of the total weight. And the mechanical properties of reinforcement are tabulated in table no 2 and Sem images of TiO_2 and BN are shown in Figures no.1 and 2.

Figure 1. (a) Boron Nitride Nanoparticles

(b) Titanium dioxide Nanoparticles



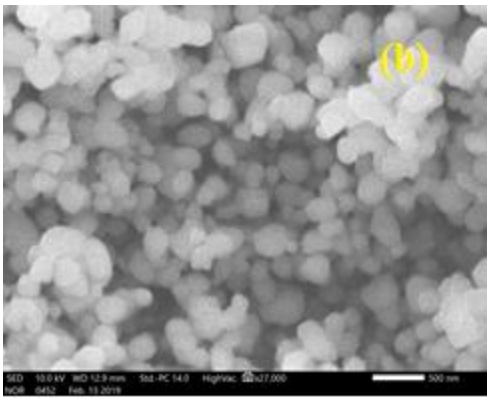


Figure No.2. SEM Images of (a) BN Nanoparticles (b) TiO_2 Nanoparticles

2.2. 3. Composition Preparation

The composition was fabricated by stir casting procedure were shown in figure no.3[21], and considering the stirring temperature as 750^0 C, Stirring speed 650 rpm, Stirring time 15 min, weight % of reinforcement add is 3% and reinforcements are TiO_2 and BN is considered as the process parameters to fabricate the hybrid composite samples[12]. The samples are Al 6068+TiO_2, Al 6068+BN, Al 6068+TiO_2+BN, Al 7075+TiO_2, Al 7075+BN, and Al 7075+TiO_2+BN.

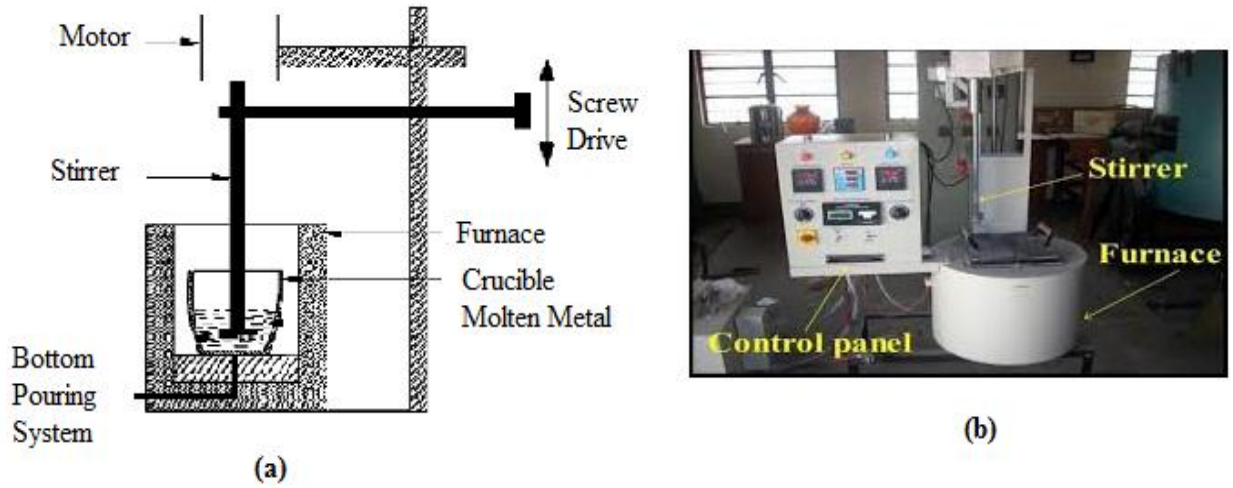


Figure No.3. Stir casting Machine Setup

3. EXPERIMENTAL PROCEDURE

The specimens were fabricated as per ASTM E8M stands with the components discussed above and the specimens were fabricated by preheating the al alloys and reinforcements up to 350^0 C to remove the moister present in the materials figure no.4. The base alloys are taken into the graphite crucible and placed in the electric furnace and heated up to 750^0 C temperature the base material turns into molten metal then the reinforcements are added to the molten metal by packing in the aluminium foil and started stirring for 15 min and 650 rpm stirring speed and concerning the above combination by pouring into the cast iron mould of dimensions 100*100*10mm are shown in figure no.5 [14]. The fabricated samples are tested and studied the wear behavior and mechanical properties of the new hybrid composition. The mechanical properties conducted on fabricated samples are tensile test, hardness test, and compressive test. The tensile test is performed on a computerized universal testing machine, and the compression test also, the hardness test was performed on Brinell hardness test machine. The wear rate of the specimens was tested by using a pin on the disc developed by Windom. And the microstructures of samples were seen in the scanning electron microscope (SEM) to know the bonding between the base material and reinforcement. The results attained from the experiments were explained in detail in results and discussions.

Figure 4. Preheating

Figure 5. Molten metal pouring in mould

4. RESULTS AND DISCUSSIONS

The obtained results was explained in detail in the following.

4.1. Tensile Test

The specimens were fabricated as per ASTM E8 standards, shown in figure 6. The hybrid MMC was showed better results compared with base alloys represented in graph no.1. The hybrid MMC

Al6068+TiO2+BN recorded a higher value of 497.96 Mpa and the lower value recorded at Al7075+TiO2 is 376.89 Mpa. In combinations of Al6068+TiO2+BN and Al7075+TiO2+BN are also performed Better results than single reinforcements add combinations, which was shown in graph no.1 and figure no 7 [15].

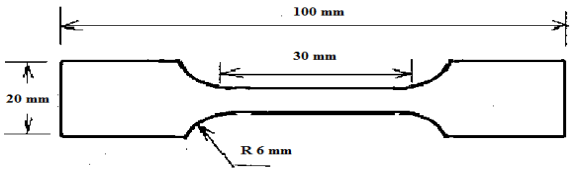
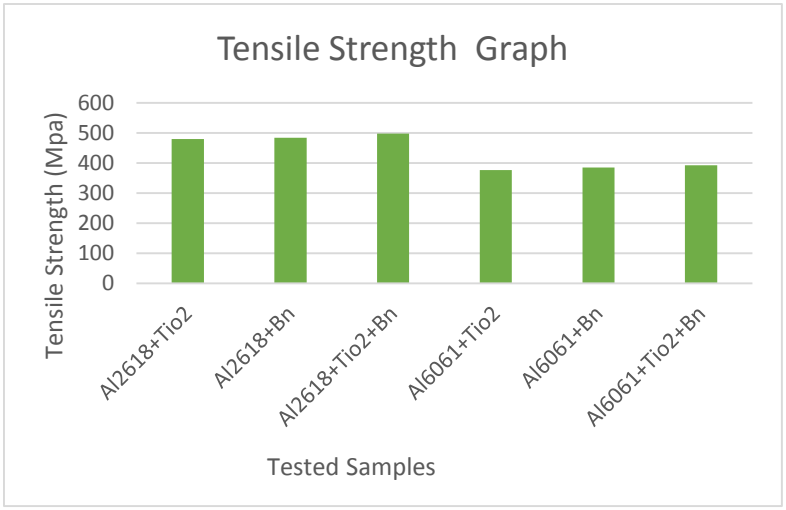


Figure No. 6. Dumbbell shape for tensile test

Figure No.7. Tensile test Samples

Graph no.1 Tensile Strength



4.2. Hardness Test

The Brinell hardness test was implemented on the prepared work pieces. From obtained results it is analyzed that the hardness was improved in the new reinforcement, the 189.63 BHN is the highest value recorded for combination Al6068+TiO2+ BN and the lower value obtained is 102.54 BHN for the combination Al7075+TiO2 and the composition was improved up to 135.53% and it the higher value than base alloy. And results were shown in graph no.2 and figure no 8.

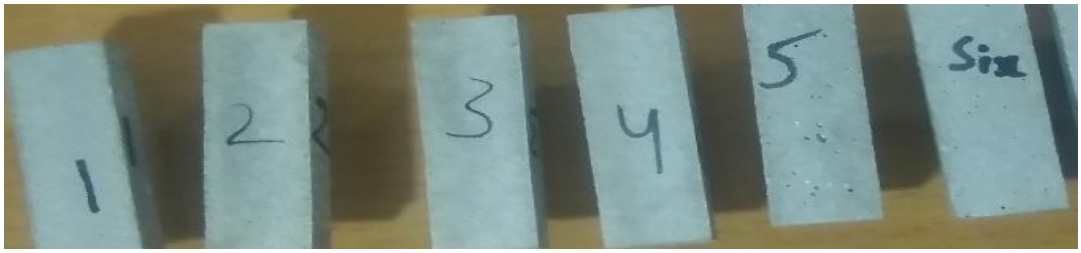
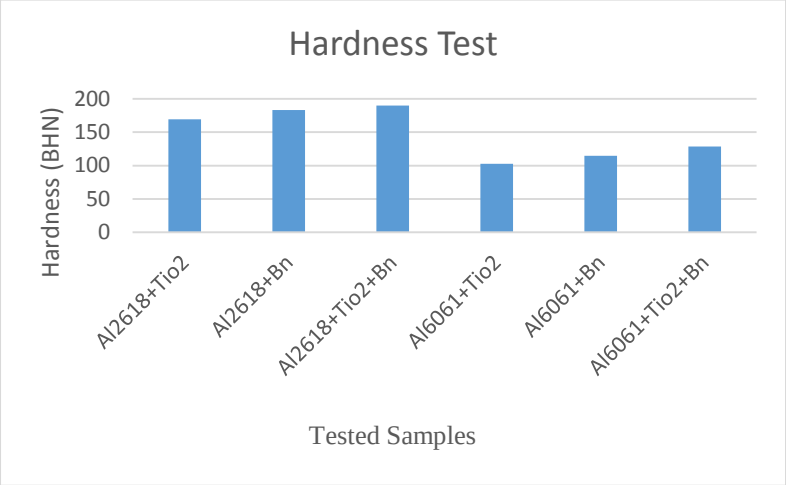


Figure no.8. Hardness test samples

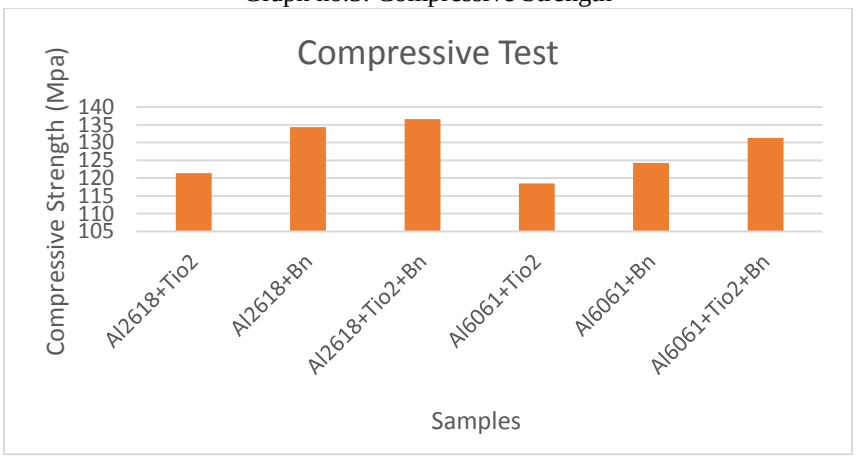
Graph no.2 Hardness Test



4.3. Compressive Strength

The Samples were fabricated as per standards and the test was conducted on the computerized universal testing machine (UTM). The Al6068+TiO2+ BN combination recorded a better value than the remaining one 136.56Mpa and the lower value recorded is 118.5 Mpa at Al6068+TiO2 and the strength was improved by 121.6% and the results were shown in graph no.3.

Graph no.3. Compressive Strength



4.4. Microstructural Studies

The samples were fabricated with dimensions 10*10*10 for scanning. The scanning was performed under scanning electron microscopy (SEM) with 1000X magnification. And it is observed, the reinforcements were uniformly distributed in all combinations. By observing clearly that the reinforcements add BN +Tio2 having greater bonding with the base alloys so that way these combinations are recorded the better results in the mechanical properties. The BN partials were achieved good porosity with to alloys so the values with BN reinforcement had obtained good results corporately tio2 in mechanical properties but coming to wear behavior of MMC tio2 add composition has greater values than BN values. Tio2 was providing good lubricating properties on the surface and the hardened nature of reinforced particles. The SEM images are shown in figure no.9 [16 & 17].

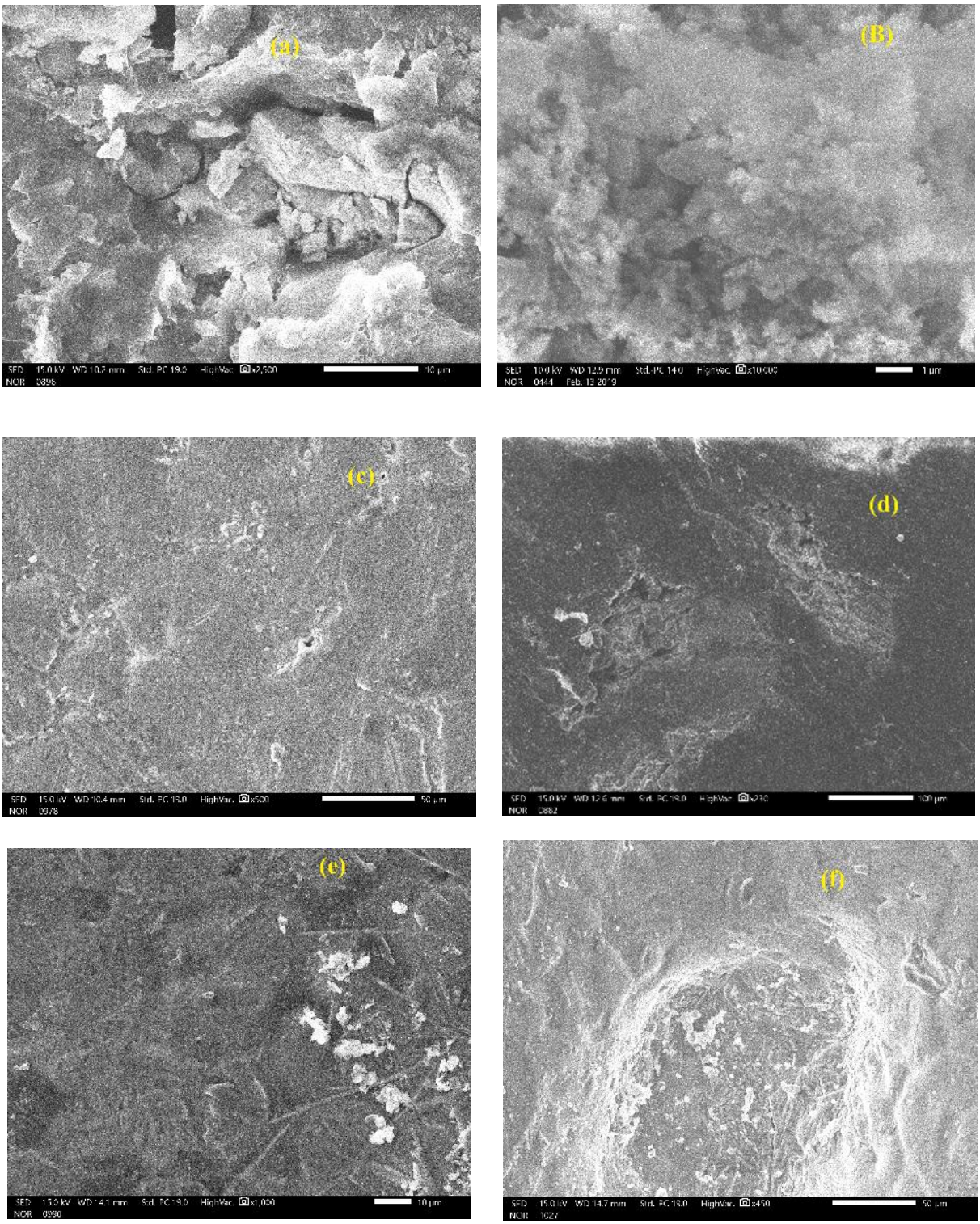


Figure No.9. (a) Al 6068+TiO_2, (b) Al 6068+ BN, (c) Al 6068+TiO_2+ BN, (d) Al 7075+TiO_2, (e)Al 7075+ BN, and (f) Al 7075+TiO_2+ BN

4.5. Wear Behavior

The testing samples were prepared with a size of 8*8*30 mm and the test was completed on a dry-sliding wear testing machine with 100mm tracking disc radius and pin on disc apparatus as per ASTM G99-9 standards. The test is conducted at an ideal load

and rpm for all specimens. And considering the load for the test is 2 kg and 1800 rpm and velocity is 7 m/s [11&13]. The testing samples were cleaned with acetone and weighted by using a digital weight machine which can measure 0.00001 gm also. After measuring weight for all work samples the samples are fixed in a machine and machined for 600 sec and then removed from the machine and once again measured the weight to know the difference between the before and after machining. With the help of a weight change, the wear rate is calculated. The good wear rate is seen in Al7075+TiO2+ BN and also the combination with tio2 had shown better results.

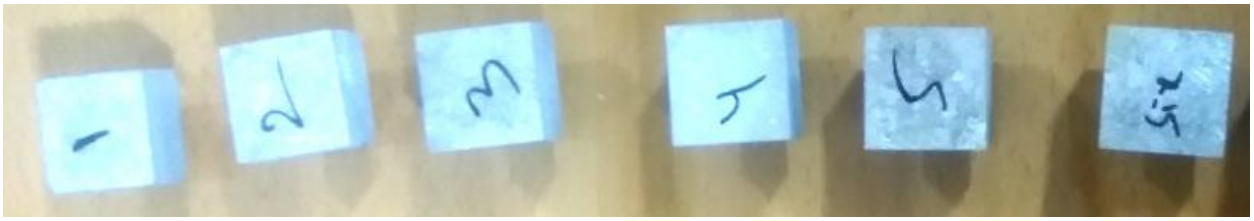
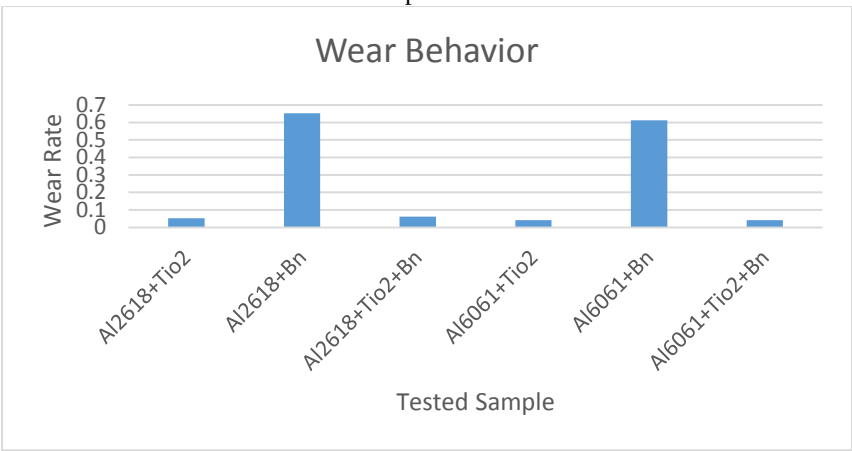


Figure No.10. Wear Test Samples

Graph No.4



5. CONCLUSION

In the presently developed hybrid, MMC was shown to improve in mechanical properties and wear behavior compared with base alloys (Al6068 & Al7075).

The tensile strength was improved above 113.17% compared with base alloys and the reinforcement Tio2+ BN combination showed the best result than single reinforcements and compressive strength was also improved 121.6%. Hardness was also improved up to 135.3% and wear also improved up to 118.2%. It observed that in the SEM analyses the reinforcements were bonding with alloys with good porosity so the wear rate is reduced in the new hybrid composite (Al7075+TiO_2+ BN).

Applications

This hybrid composite can be used for friction stir welding in automobile and aircraft industries. And also can be used in beams and frames in aerospace structures.

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