FABRICATION AND MECHANICAL BEHAVIOUR OF AL6061-TiB2 BY POWDER METALLURGY TECHNIQUE

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ABSTRACT

Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever-increasing demand of modern-day technology, composites are most promising materials of recent interest. The present research work involves the study of Al 6061-TiB2 composite through powder metallurgy. This method involves formation of reinforcements within the matrix by the chemical reaction of two or more compounds which also produces some changes in the matrix material within the vicinity. Titanium Diboride (TiB2) was the reinforcements in the matrix of Al 6061 {Al 97%-TiB2 3%, Al 94%- TiB2 6% and Al 91%- TiB2 9%} alloy which can be suitable for space, aircraft and automotive components at elevated temperatures. The mechanical properties in terms of hardness and impact test were carried out. The sample of Al 6061 alloy was also casted and tested for comparison.

Keywords: Powder Metallurgy Technique, Micro Hardness, Micro Structure, wear resistance, FESEM.

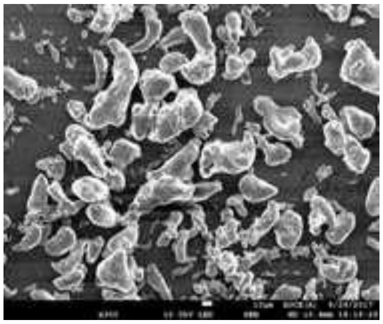
1. INTRODUCTION

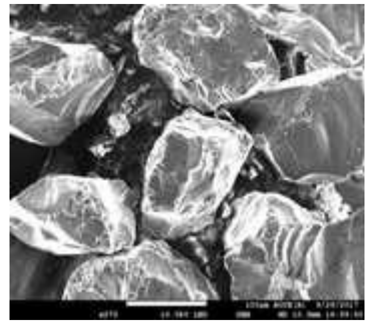
A material or a particle having less than 100nm (at least one dimension) is known as Nano material. Nano term itself having the big meaning because in almost all industries like medical, electronics and more over in mechanical engineering industries Materials with structure at the Nano scale often have unique optical, electronic and mechanical properties. The properties like thermal conductivity, electrical conductivity optical and more over crystal are depends on the size of the particle. By viewing the Nano in the broad sense the following are important for the classification of Nano particles area a) <5 nm for catalytic activity, b)<20 nm for making a hard magnetic material soft, c)<50 nm for refractive index changes d)<100 nm for achieving super Para magnetism, mechanical strengthening or restricting matrix dislocation movement. By the point 4 of above size had a great influence of mechanical properties. Nano particles addition results in a significant improvement in, ultimate tensile and yield strength of composites. It was also found that the addition of to the matrix alloy increases the hardness[1] To improve the ductility and fracture toughness of the traditional composites, the new class of materials known as Metal Matrix Nano composites (MMNCs) are developed by reinforcing particles in the Nano meter scale [3,4] The reinforcement of micro/ Nano particles in the AMC's has improved mechanical properties due to the reinforcement of high strength and high modulus particles like Nano sized Sic, Al_2O_3, B_4C, ZrO_2, Graphite, $FeTiO_3$. Aluminum Metal Matrix Nano Composites (AMNCs) are widely used for high performance applications such as automotive, military, aerospace and electrical industries. Recently some researchers have highlighted the real possibility to produce composites characterized by excellent mechanical properties, which can be further improved by optimizing the particle dispersion. These MMCs also exhibit remarkable wear resistance. In terms of hardness, mechanical strength, creep behavior and damping properties they also proved to be excellent composite material are having very good properties compared to base materials. Although among all types of composite materials MMC (metal matrix composite) had great importance in all the aspects and had a wide variety of applications in aerospace automobile sectors, military technology, sports guards, and food processing industry. Metal matrix composites reinforced with Nano particles or Nano-tubes are not yet being employed in relevant commercial applications due to their very recent development. However, Nano particle dispersed MMCs show higher mechanical properties than micro-particles reinforced composites. No evidence of decrease in thermal and electrical conductivity [5,6] the particle distribution plays a very important role in now-a-days metal matrix composite had wide area of research and having great applications due to strength factor [7]. Aluminum has a several series that is like Al 1100, 2011, 2024, 3003, 5052, 6061, 6063 and 7075. MMCs using several metallic materials as matrix have been studied by many researchers. Among all, the most interesting metals for industrial applications are Al, Mg, Ti, Cuand their alloys [8-15] Nano sized reinforcements can significantly improve mechanical strength, creep resistance at elevated temperature, better machinability and higher fatigue life without affecting ductility [16-18]. Improvement in the properties of MMCs is attributed to the hardening mechanism, fine particle size, uniform distribution, inter particle spacing and thermal stability at high temperature following work presents hardness measurement and density measurement of a composite and hybrid composite. In former case the matrix material is Al 2024 and reinforcement is B_4C in the Nano form and the latter case which is hybrid composite Al 2024, B_4C and graphite. Among the entire aluminum series Al 2024 was taken due to their applications in aerospace structure, rivets, valve bodies and miscellaneous applications. B_4C is the second hardest materials, it was taken in the Nano form and graphite is used as lubricant purpose and to improve machinability properties of composite. Coming to manufacturing methods of composites are electroplating, electroforming, stir casting, liquid infiltration, squeeze casting, spray deposition and powder metallurgy. In the following work powder metallurgy is taken due to low wastage, suitable for mass production work, good surface finish is obtained and low cost of production.

For making composite to be homogeneous distributions of reinforcement is full out of pellets it should be pre-mixed in ball milling machine. For that purpose, planetary ball milling machine of single jar is used. Density measurements are carried out by Archimedes principle. Hardness values were taken by Vickers hardness testing machine of indenter size 0.25 inch

1. MATERIALS AND MEASUREMENT

Powder metallurgy technique was for the fabrication of both non-hybrid composite and hybrid composites are fabricated. In former case Al 6061, TIB_2 is used. In this case al 2024 is used with the size of 50 µm was supplied by M.S material suppliers Pune and the elemental compositions were shown in table 1, Nano size TIB_2 was received from Praswani Material Suppliers Delhi material suppliers of 100 nm size and graphite is purchased from Vijay Prakash Gupta & Sons New Delhi. The particles size and density of all the used powders were shown in Table 2. All the powders are measured in simple balance had accuracy of 0.001 grams. Totally 6 compositions are measured with a total quantity of 50 gram to fabricate 4 numbers of samples in every composition to conduct various tests





1(a)*Al 6061* 1(b) TIB_2

Figure 1 SEM images of received

Table 1 Compositions of Al-6061

COMPOSITIONS	WEIGHT PERCENTAGE
Copper	3.8-4.9
Chromium	0.10
Ferrous	0.5
Magnesium	1.2-1.8
Manganese	0.3-0.9
Silicon	0.5
Titanium	0.15
Zinc	0.25
Aluminum	90.7-92.6
Others	Reminder

Investigation on Micro Structure and Mechanical Properties of Al-2024 Reinforced with Nano B4C and Graphite

Table 2 Particles Size and Density of Materials

Material	Density	Size of particles
Al -2024	2.78	80 µm
TIB_2	4.52	100nm

2. EXPERIMENTAL PROCEDURE

2.1 pre-mixing of powders

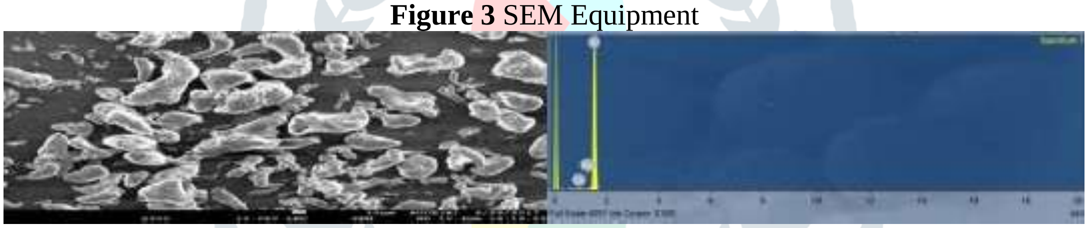
The required composite powders were measured in a simple balance then these powders were well mixed in a planetary ball mill [RETRSCH PM 100, German Made]. The milling process was carried out by choosing different milling parameters like speed 400 rpm, ball to powder ratio 10:1. The entire process was carried out in an inert (organ) atmosphere for about 30 minutes.

Figure 2 High Speed Ball Milling

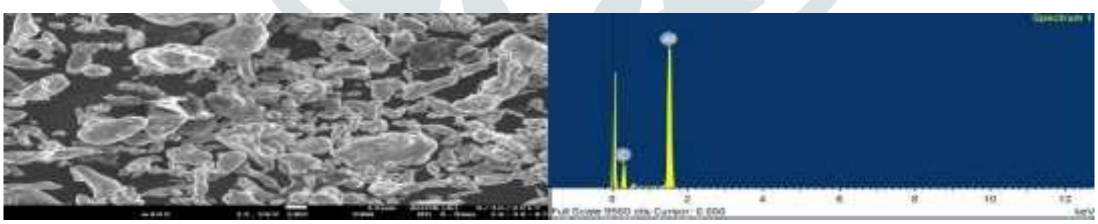
2.2 SEM ANALYSIS

Scanning electron microscope (SEM) is one the type of electron micro scope which scans the sample with focused beam of elections. SEM can give the information about sample contains with less than 1(one)Nano meter accuracy. The following gives the SEM images for Al -6061, Al 6061, Al -606&TIB_2 and Al6061& TIB_2.All the spectrum reports were taken from Jyothi Spectro analysis laboratories and report shown in digital form

Figure 3 SEM Equipment



Spectrum Analysis of Al 6061



Spectrum Analysis of Al 6061 3% TIB_2

Figure 4 FESEM Powder Mixtures

3. FABRICATION OF PELLETS

Die is made from hardened steel of grade 760 and super finishing obtained from lapping process for the better surface finish of specimens. Dimensions of die 15 mm diameter, 80 mm length, for effective compression billets of 10mm length and same diameter arranged which gives excellent cross-sectional finish which shown in fig 5.

For each run, the die was filled with same quantity of well pre-mixed powder then a punch was placed over the die and the powder was compressed in a CTM (fig4) by applying a pressure of 400Mpa then maintaining this pressure for about for about 5 Sec. For the purpose of compression, the use of compression testing machine (CTM) which can be operated by either manual or electrical. CTM had a dial that can be control of load variations from slowly applied progressive to impact load. For the purpose of compression pre-mixed powder is filled in the die and placed against the upper jaw of CTM against with die rod which shown inn fig 7.

A load of 400Mpa was applied gradually, that load is maintained at the for the time of 30 sec, for better result, then it was ejected from the die by applying the nominal pressure with the aid of CTM which shown in fig 7

Figure 7 Pellets from CTM

3.1. SINTERING

The pellets produced are only raw materials in the form of 15 mm diameter and certain length only, to perform various operations (to conduct tests) of these pellets had to be converted to as specimens. For that purpose, every pellet had to be gone sintering process. During the process of Sintering makes the strongest bond between matrix and reinforcement that can be done with aid of muffle furnace. The sintering temperature depends on the melting point of either matrix or reinforcement which is low. For the both hybrid composite and non-hybrid composite the sintering temperature was maintained about 580^0c for the time duration of 3 hours [soaking]

Figure 8 Muffle Furnace

Figure 9 Pillets in Muffle Furnasce

The specimens after sintering operations are red brick color and they were further trimmed on its cross sectional area with aid of double disc polishing machine which shows in fig.10(both polished and no polished in 2 nob's)

Figure 10 Specimens after Sintering

3.2. MICRO STRUCTURE STUDY

All the specimens which are sintered followed to disc polishing machining of 360 mm diameter of double disc are covered along grains size papers are 240, 600, 800 and 1000-grit silicon carbide papers used. These specimens were also polished with aid of elevated cloth which is (striped on the one of the discs) along with diamond paste for obtaining mirror finish and gives clear image for and distribution of particles Al-2024, Gras follows

Figure 11 (a) Al 6061 (b) Al 6061&6% TIB_2

4. HARDNESS MEASUREMNTS

Micro Vickers hardness testing equipment of ASTM E-384 of standard diamond indenter with diameter of indention is 0.25 inch had been used for the testing of specimens. The load applied during the equipment is all about 5 kg for the duration of 10 Sec of time. The hardness has increased with the increase of TIB_2 of the competent and in the case of hybrid composite there is an increase in the hardness as the percentage as increase of TIB_2 an

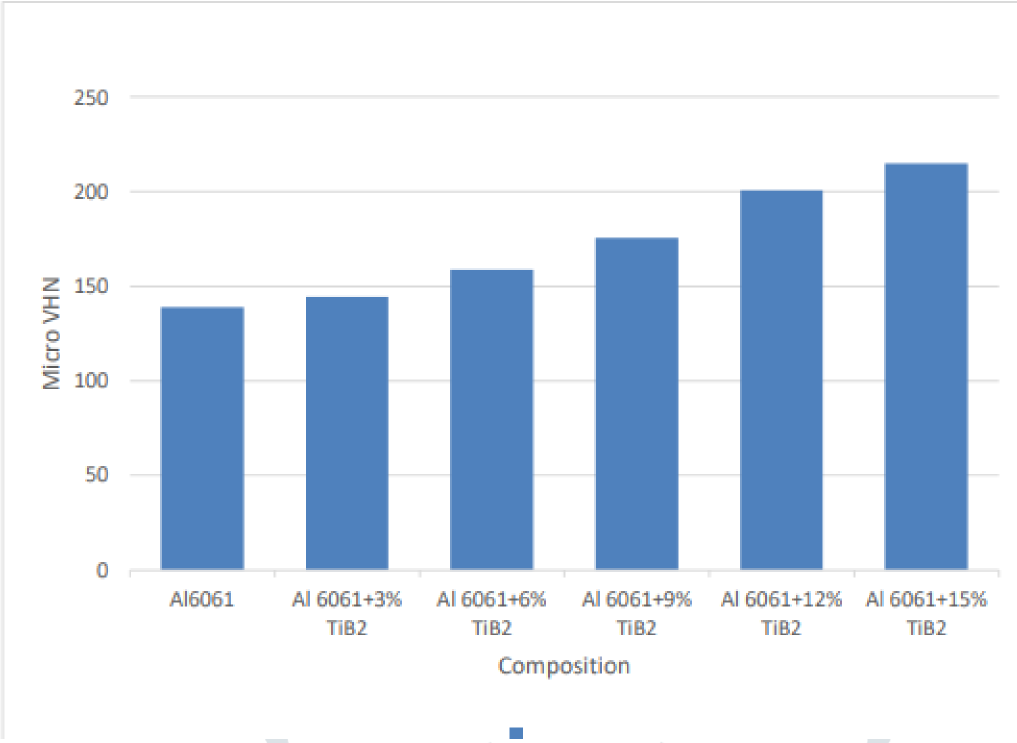
Highest value of hardness is obtained at 15% of TIB_2

Figure 14 Hardness Readings Position

Table 4 Hardness values for specimens

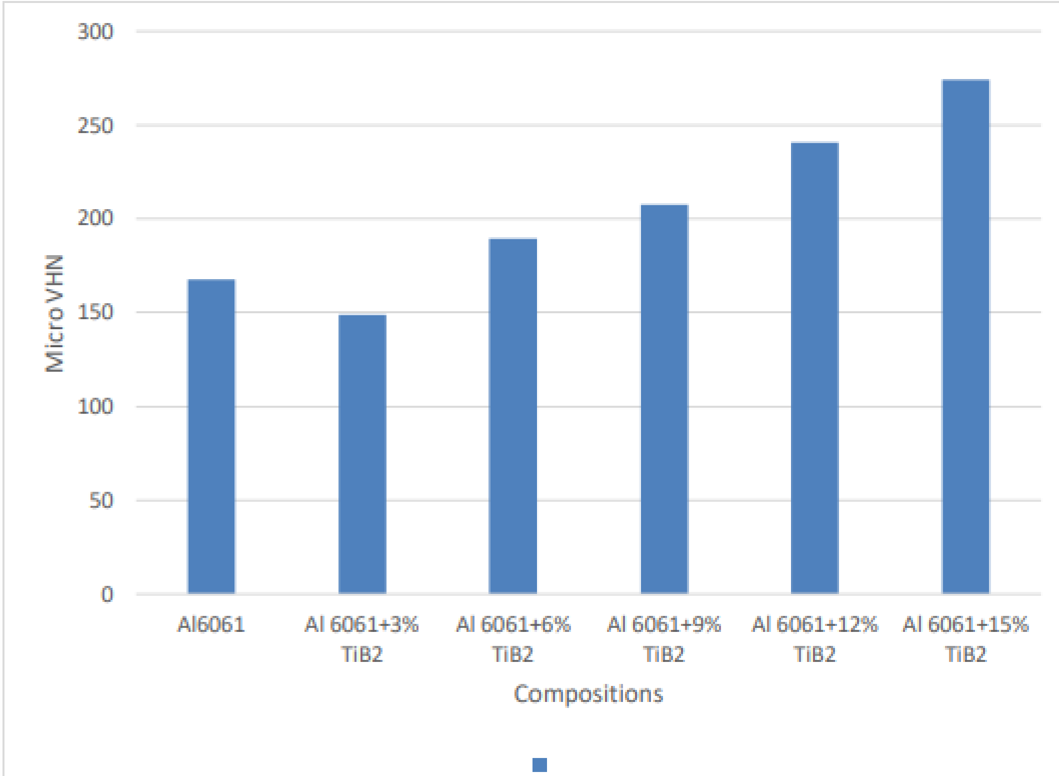
composition	D1	D2	VHN	D1	D2	VHN	Micro VHN
Al6061	82.31	82.40	135.20	81.75	135.20	142.70	138.957
Al 6061+3% TiB2	94.32	94.25	111.09	82.68	111.09	137.50	144.507
Al 6061+6% TiB2	80.15	80.06	157.750	80.71	80.01	159.950	158.850
Al 6061+9% TiB2	75.96	76.20	174.069	79.71	161.60	176.089	175.679
Al 6061+12% TiB2	73.84	78.06	199.438	79.09	153.00	201.638	200.538
Al 6061+15% TiB2	65.37	73.77	214.049	73.34	84.19	216.069	215.059

Figure 15 Graphical representation of hardness values



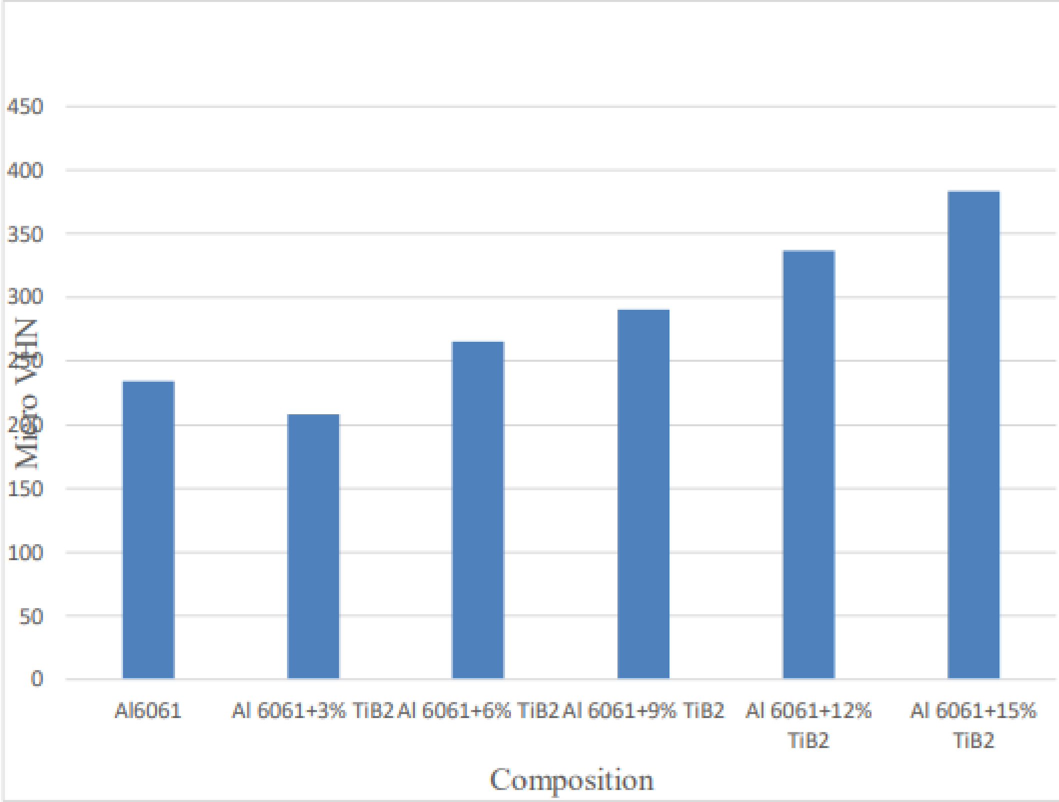
Heat Treated Hardness at 2 hours

composition	D1	D2	VHN	D1	D2	VHN	Micro VHN
Al6061	82.31	82.40	162.20	81.75	135.20	172.70	167.45
Al 6061+3% TiB_2	94.32	94.25	133.09	82.68	111.09	164.50	148.795
Al 6061+6% TiB_2	80.15	80.06	187.750	80.71	80.01	190.950	189.35
Al 6061+9% TiB_2	75.96	76.20	204.069	79.71	161.60	211.089	207.579
Al 6061+12% TiB_2	73.84	78.06	239.438	79.09	153.00	241.638	240.538
Al 6061+15% TiB_2	65.37	73.77	289.049	73.34	84.19	259.069	274.059



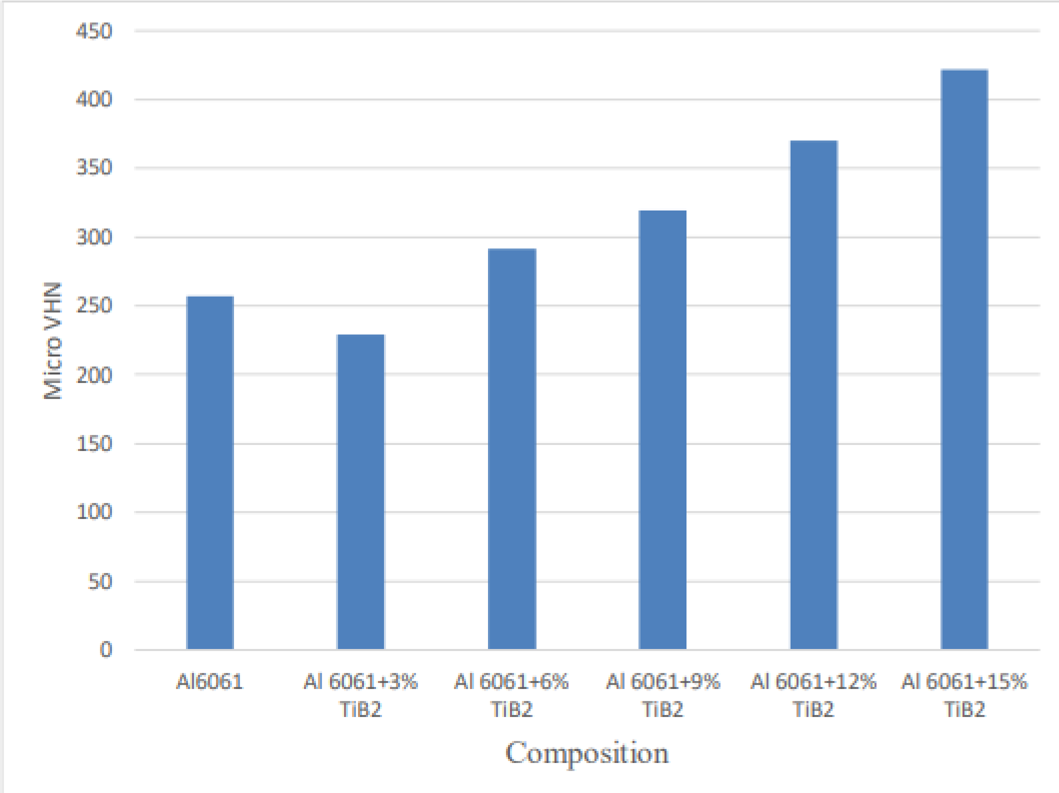
Heat Treated Hardness at 4 hours

composition	D1	D2	VHN	D1	D2	VHN	Micro VHN
Al6061	82.31	82.40	227.08	81.75	135.20	240.8	233.94
Al 6061+3% TiB_2	94.32	94.25	186.326	82.68	111.09	230.34	208.33
Al 6061+6% TiB_2	80.15	80.06	262.85	80.71	80.01	266.950	264.97
Al 6061+9% TiB_2	75.96	76.20	285.67	79.71	161.60	295.089	290.37
Al 6061+12% TiB_2	73.84	78.06	335.217	79.09	153.00	337.638	336.42
Al 6061+15% TiB_2	65.37	73.77	404.667	73.34	84.19	362.069	383.36



Heat Treated Hardness at 4 hours

composition	D1	D2	VHN	D1	D2	VHN	Micro VHN
Al6061	82.31	82.40	249.08	81.75	135.20	264.88	256.98
Al 6061+3% TiB2	94.32	94.25	204.654	82.68	111.09	253.37	229.01
Al 6061+6% TiB2	80.15	80.06	289.13	80.71	80.01	293.59	291.36
Al 6061+9% TiB2	75.96	76.20	314.23	79.71	161.60	324.58	319.40
Al 6061+12% TiB2	73.84	78.06	368.61	79.09	153.00	371.39	370.09
Al 6061+15% TiB2	65.37	73.77	445.06	73.34	84.19	398.26	421.66



5. RESULT AND DISCUSSION

Non-hybrid and hybrid composites are fabricated by using powder metallurgy technique. The reinforments are observed using microscope for various pixels. Weight of all comments are taken in both air and water and density calculated in by using Archimedes principle (shown in table3). The decrease in density is observed in both hybrid and non-hybrid composites compared to base metal matrix composite as the B_4CTIB_2 percentage is increased. While comparison of these two (hybrid and non-hybrid) hybrid composites were having high density than non -hybrid composites. By the aid of micro Vickers hardness testing equipment hardness of the Nano composites was recorded (shown in table 4). With the increasing with the percentage of TIB_2hardness were increased and given the highest value of hardness at 15% of reinforcement of TIB_2 in both the hybrid and non-hybrid composites. As the compression in hardness value (micro hardness number) non–hybrid composites (Al+B_4C)

6. CONCLUSION

By using powder metallurgy technique hybrid composites were fabricated successfully. All the composites were exhibits higher hardness than base material. ¬ Hybrid composites the preference of graphite in hybrid composites will lose the strength because of soft and having much inability. ¬ Micro structure of all composites was shown. ¬ FESEM for the hybrid composites were shown. ¬ By using software-based electro chemical weld tester system was used to carry out potential dynamic polarization tests conducted. ¬ All the composites were shown better corrosive resistive than the base material. ¬ All the hybrid composites were good corrosive resistive than nonhybrid composites because of AL6061 and TIB2 were forums a layer of protection to oxygen reaction. ¬ The studies have revealed that the rate of corrosion is decreased with an increase of reinforcement. ¬ Finally, it is observed that wear rate decreases with an increase of TiB2 reinforcement

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