Processing and characterization of mechanical and wear behavior of Al7075 reinforced with B₄C and nano graphene hybrid composite

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Abstract
The present investigation aims to establish the mechanical and wear behavior of Aluminum 7075 (Al7075) reinforced with Boron Carbide (B₄C) (28 μm particle size) and Graphene (Gr) nano Particle (100 nm particle size) composites. These composites were prepared by stir casting process and also based on 5, 10 and 15 weight percentages (wt%) of B₄C particles and 0.1, 0.2 and 0.3 wt% of Gr. Al7075 is reinforced with B₄C and Gr particles for production of MMC. The mechanical properties like tensile strength, hardness, flexural, impact test and also wear properties like coefficient of friction and wear rate were investigated. The test results revealed that the tensile strength, flexural strength and hardness increased with increasing the wt% of B₄C and Gr along with increase in toughness up to certain limits (10% B₄C). Wear rate noticed with Gr reinforced with Al7075%-10%B₄C composite is lower compared to other Al6061%-10%B₄C-Gr with various Wt% composites. On comparison, the Al7075%-10%B₄C-0.2%Gr composite shows better wear rate compared to other composites. TGA/DTA analysis shows that increase in % of B₄C and Gr 17% increased the ignition period of the composites. The coefficient of friction and the specific wear rate were obtained in terms of sliding distance at various loads in the range of 5 N, 10 N and 15 N. It was found that when B₄C content in composites increase, the wear resistance also increases monotonically with hardness. In addition, the hybridization of two reinforcements enhanced the wear resistance of composites, especially in case of high sliding speeds.

1. Introduction

Aluminum Matrix Composites (AMCs) are a class of advanced materials reinforced by ceramic particles or fibre. They generally have enhanced properties, like increased specific strength with stiffness, low thermal expansion coefficient, improved tribological properties and high temperature strength compared to unreinforced alloys [1–4]. In this regard, the applications of AMCs have been extended for use as structural materials in weight-critical applications like aerospace, automotive, tower, furniture, pipelines, marine, defense industries and canoes where strength, wettability and corrosion are required [5, 6]. The Al alloys are very attractive due to their high damping capacity, low density and capability to be strengthened with the precipitation, better corrosion resistance, and high electrical and thermal conductivity. The common reinforcing materials used in Al alloy matrix are SiC, B₄C, Al₂O₃, WC, ZrB₂, TiB₂, Si₃N₄, TiC, graphite and Gr [7–10].

The alloys of Al7000 series possess increased strength at room temperature over the entire classes of Al alloys and thus acquire the ability to act as an excellent candidate matrix for the composites [11]. Al7000 series Al get
uniformly dispersed and they are extremely fine precipitates that become an obstacle to the dislocation movement form in the matrix of Al over heat treatment. This offers better strengthening and durability [11]. Therefore, Al7075 alloy was selected as a model system in this work to analyze the effects of stir casting-strengthening of Al7075-B4C composites. Al alloys exhibit a number of physical and mechanical properties but display extremely poor resistance. The reinforcement of Al alloys with hard ceramic particles, solid lubricants, short whiskers and fibers results in advanced MMC with precise balance of physical, mechanical, and tribological properties [12]. Boron carbide (B4C) is one of the preferred phases of reinforcement in Al MMCs due to its lightweight, high stiffness, high hardness, (HV ~30 GPa, density ~2.51 g cm⁻³, shear stiffness ~193 GPa) and an elastic modulus of about 427 GPa for B4C [13–15]. AMC is reinforced with 10% vol. of boron carbide through which the elastic modulus can be significantly increased. Hence Al-B4C composites possess the potential to join high hardness and stiffness of B4C with Al ductility without affecting the aim of producing a material of stiff low density. The applications of B4C–Al composites are limited and are used as armor plate materials, structural neutron absorber, and also as substrate material for computer hard disks [16].

The reinforcement particles have increased bonding strength with matrix which supports the applied load better to prevent initiation of cracks. The hardness, strength and wear resistance increases for Al alloy with the addition of Sic reinforcements [17]. However, the inherent drawbacks of B4C, such as low impact toughness, machine component difficulty, poor processing ability and high brittleness may severely limit its use in many applications. Therefore, improving the toughness and strength of B4C has become an active topic of research. Mechanical properties of B4C ceramics has been significantly improved by adding carbon nanotubes and Gr-based fillers [18–20]. Gr is the thinnest of all materials but exhibits incredible strength which is about 200 times more than steel. Graphite is a single sheet of nano graphite powder which is formed with carbon atoms that are linked in hexagonal shapes and bonded covalently to three other atoms of carbon. Gr has similar structure as that of carbon atoms that are linked in hexagonal shapes to develop carbon nanotubes, but it is mostly flat and sometimes cylindrical. Gr possesses extraordinary thermal, electrical, and mechanical characteristics arising from its unique structural nature [21]. It is a two-dimensional carbon material showing unique combination of mechanical and thermal properties. In particular, have both superior tensile strength of 130 GPa and Young modulus of 1 TPa. The addition of 0.22% of Gr to Al increases its crack resistance to 50% and shows hundred million increases in electrical conductivity [22].

When incorporated into polymer or ceramic matrices, these properties revolutionize to exhibit remarkable improvement in their strength and stiffness. The limitations in the synthesis and the production of Al7075 reinforced with Gr are due to poor agglomeration and dispersion, and the individually exfoliated Gr in the matrix of Al [23]. Gr has significant mechanical characteristics that make better reinforcement in the MMCs hypothetically. It possesses exclusive thermal and optical properties that make it striking fillers for production of multifunctional composites especially to gain excellent toughness (0.5-1 TPa) and tensile strength (130 GPa) of Gr make it as an effective reinforcement to stiffen and strengthen the metal. B4C and Al₂O₃ are two reinforcing materials commonly used in AMC [24]. The change in the hardness values (HV) of Al6061-Graphene composites sintered over different sintering temperatures. AMCs produced with TiB₂ shows better tensile strength, hardness and wear resistance as compared to the unreinforced Al6061 [25]. Most of the researchers have acknowledged that Al reinforced with Gr composite exhibits superior wear properties over the base alloys due to the presence of Gr particle. Based on the literature study, this work is planned accordingly to conduct experimentation on reinforcement of B4C and Gr with Al7075 alloy using stir casting method. This research work mainly focuses on the study of hybrid composites characterisation by micro structural analysis and probes into the mechanical properties like hardness, tensile strength and thermo gravimetric analysis[26–28].

1.1. Processing

In this present study Al7075 rod has been utilized as the material of matrix and the chemical composition of Al7075 matrix alloy [2] is shown in table 1. Al matrix was reinforced with B4C and Gr. Thus Al-B4C & Al-B4C–Gr with selected compositions (wt %) of sample were prepared [6]. The schematic and experimental setup of stir casting is shown in figures 1(a), (b).

Table 1. The Chemical composition of Al7075.

| Element | Zn | Mg | Ca | Cr | Fe | Ti | Mn | Al |
|---------|----|----|----|----|----|----|----|----|
| Weight % | 5.2 | 2.4 | 1.4 | 0.78 | 0.28 | 0.10 | 0.04 | Balance |

Al7075 was purchased in cylindrical rod form and cut into pieces as per requirements of the crucible. The rods were situated in a graphite crucible and melted at 650 °C for a period of 2 h. The addition of B4C particles was done by adding weights of 0%, 5%, 10%, 15% and were fed into preheating chamber at 900 °C in order to
improve the wettability of B₄C in molten stage [6]. During this condition, the preheated particles of B₄C were mixed and 5 grams of degasser is added to the crucible. The stirrer starts mixing both molten alloy and B₄C. The composite slurry was reheated again to transform itself into a fully liquid state and the mechanical mixing was performed for about 20 min at an average stirring speed of 400 rpm. Now the molten metal is fed into the mould of permanent iron die to produce composites of 300 mm length and 50 mm diameter. The experimental procedure is repeated with the compositions Al7075%-10%B₄C-Gr (0, 0.1, 0.2 & 0.3%). To ensure uniform dispersion of reinforcement particles into the matrix alloy, two stages of stirring was employed with a gap of 15 min. The agitation of melt starts and the 10% B₄C particles of size 28 μm that are preheated and various wt% of Gr (0, 0.1, 0.2 & 0.3) are introduced. The fabricated samples are shown in figure 2.

### 1.2. Testing of samples

The specimens of four tensile test samples were made cylindrical as per ASTM standard (E8/E8M-13a) and were tested in a FIE servo controlled universal Testing Machine (UTM) (UNITEK 94100-100 kN, FIE Pvt Ltd, Yadrav) with 8.33 × 10⁻⁶ m s⁻¹ cross head speed at the room temperature [8] trial and the error analysis was calculated to find the average tensile strength value. Vickers micro Hardness tests that were carried out on at three locations on each sample surfaces with hardness tester on the basis of ASTM-E384-10. The specimens were metallographically polished for conducting the hardness test [6]. Flexural test were carried out on four samples using UTM in accordance with ASTM E190-10. Impact tests were carried out on an izod impact tester (CEAST Resil Impactor) in accordance with ASTM D256-10 [8].

The dry sliding wear characteristics of the composite specimen (pin) size of diameter 8 mm and height 30 mm and track radius 120 mm is determined with computerized wear testing pin on the disc machine (DUCOM, TR-20LE-PHM-400) in ASTM: G99. The slider disc is made up of 0.95 to 1.20% carbon (EN32) hardened steel with hardness of 65 HRC and has a diameter of 165 mm. A track diameter of 100 mm has been...
used in all the experiments. The initial surface finish of the steel disc has been 1 μm. The Wear Rate (WR) of composites was analyzed as a function of applied load, sliding velocity, and the sliding distance [26]. It is estimated with the difference in specimen weights using equation 1 for a constant sliding distance of 3000 m.

Thermal analysis of Al-B4C and Al-B4C-Gr composites was conducted using differential thermal analysis in a simultaneous thermal analyzer NETSCH—STA 449 F3 Jupiter. The samples in form of burrs were kept inside the analyzer [13]. The crystallization behavior reported that the peak temperature touched throughout analysis was diverse amongst 620 °C up to 1000 °C with rate of 20–40 mm min⁻¹. B4C particles are very dense with random distribution due to its high melting point. Moreover, increasing the B4C particle size will increase the composite’s densification. By increasing the B4C and Gr particle size from 50 μm to 70 μm, composite densification increases. The distance between the reinforcement particles increases the required tension for moving the dislocations among the reinforcements, leading to increased composite strength [25, 27].

2. Results and discussion

2.1. Characterization
The images of Scanning Electron Microscopy (SEM) and Transmission electron Microscope (TEM) was generated from EVOLS15, Carl Zeises at 9.0 ks, 15.0 kV and JEOL 2200FS with omega energy filter (JEOL Ltd, Tokyo, Japan) for TEM which were utilized in the investigation of the fracture morphology with increased magnification views of tensile tested specimens of Al7075 and its various wt% reinforced composites are shown in figures 3(a)–(d). The Energy Dispersive x-ray Spectroscopy (EDX) is used with SEM to scan the composites to analyze the elements and its percentages that are present at random areas of the composites [3]. Al and various wt% of Al7075 samples were tested with the use of Bruker D8 advance x-ray diffractometer to identify the phases of crystalline material and the formation of carbide during consolidation. It discloses the fact that Al7075 alloy has voids that are uniformly distributed.

Figures 3(b)–(d) shows that the distributions of B4C were analyzed and found to be non-uniform. The evidence of ductile fracture is present in the fracture morphologies. However the ductile fracture is very high in the alloy of Al7075 and is marginal in the composite. It proves that the percentage of elongation lowers when the percentage of B4C increases [6]. This is because of the hard nature of B4C particle. Figures 3(c)–(d) shows the Al7075-B4C-Gr composite with uniform distribution. It disclosed the fracture in ductile mode with de-cohesion of the reinforcing particles. The fracture of composites can be readily observed, leading to associated micro voids and particle pull-out in most cases. They were less and small and present in the dimples with B4C particles harbored well. This proved the better bonding of matrix and the B4C particles. The results of SEM depict some grain boundary structure and porosity which may be the reason for one of the factors stated above [8].

Figures 3(e)–(f) shows the TEM image of Al7075 and B4C and Gr particles. It precipitates the grain boundary of microstructure of Al-B4C-Gr composites at room temperature for several hours. In this analysis the depletion of each element related to the matrix material and the aging results predicted that copper and zinc aged with the matrix. Figures 4(a)–(d) presents the optical microscope of variations in B4C-Gr particles in the composite. It is noted that uniform distribution of layers and extrusion over the reinforcement particles. The particles are distributed with no evidence of crack and some porosity is found in the castings [14].

The analysis of the specimens was performed on EDAX to know the availability of various elements that are present in the composites, with the study of homogeneous distribution of B4C and Gr in parallel as depicted in figures 5(a) and (b). The carbon, oxygen and the aluminium peaks of samples represent the dispersion of B4C in the matrix of Al. In addition with the SEM images, the porosity lowers when the wt% of Gr reinforcement increase with increased concentration of nano particle [13].

2.2. Tensile test
The variation in ultimate tensile strength of Al7075 reinforced with wt% B4C of (0, 5, 10 and 15%) is shown in figure 6. The tensile strength increases when the reinforced wt% of B4C particles increases. It is noticed that higher tensile strength is produced using the composite with Al-15% B4C which is 25% greater than unreinforced Al7075 alloy. From the results shown in figure 6(b), it is understood that the study of mechanical behavior of Al7075%-10% B4C — 0.1, 0.2&0.3% of Gr shows variations in tensile strength and increases with varying reinforcement content of Gr Nano Particle. Al-10%B4C — 0.1 Gr is 45.2% higher as that of Al base alloy. The ultimate tensile strength (MPa) reaches its maximum with increased wt% of Gr Nano particles and suddenly decreases when the wt% of Gr increases beyond 0.2%. The Gr addition normally affects the strength, and it is evident that the mechanical strength decreases with addition of Gr and for the improvement of mechanical strength, the B4C particles are added [13].
It is noticed that this goes on increasing with addition of Gr. This is due to the fact that MMHC gets tougher and tougher with the addition of increased B₄C particles. It stays persistent until the matrix could store the particle without any distortion \[17\].

2.3. Stress-strain relationship

Figures 7(a)–(f) depicts the Stress-strain curves, which represents that the value of stress increases with the addition of B₄C particles and the ultimate tensile strength also increases with the increase in B₄C particle. In addition, the tensile test proves that as the reinforcement amount increases, the tensile strength increases, with degradation in ductility \[15\].

Tensile stress of compositions of Al-B₄C, Al-B₄C-Gr is shown in figures 7(c)–(f). The considerable enhancement of mechanical characteristics of composites when compared to Al7075 is attributed to B₄C particles in matrix, and it increases when the wt% of B₄C increases. Beyond this, there is a sudden increment as a result of better bonding phase and hard characteristics of B₄C. But, the elongation of the composite materials is less compared with the unreinforced specimens of standard benchmark. The deformation of the plastic of base metal matrix is very rapid as that of the composites produced with reinforcement \[13\]. Hence, ductility should be very less for the composite when compared to the unreinforced material. The tensile strength increases with

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Figure 3. SEM of (a) A17075, (b) A17075%-5%B₄C, (c) A17075%-10%B₄C-0.2 Gr, (d) A17075%-10%B₄C-0.3 Gr, (e) TEM image of A1%-10%B₄C and (f) A1%-10%B₄C-0.2 Gr.
The mechanical characteristics are further enhanced due to the transference of stress from AMC to the reinforced B₄C particles [16].

### 2.4. Micro hardness test

Figure 8(a) depicts the changes in micro hardness with the variation in the content of reinforcement of B₄C. The Al possesses the least value of hardness, and the hardness of hybrid composite, Al-15% B₄C is 20% higher than Al-17075%-10%B₄C-0.2 Gr.

**Figure 4.** Optical Microscope of (a) Al7075%-10%B₄C, (b) Al7075%-10%B₄C-0.2 Gr, (c) Al7075%-15%B₄C-0.2 Gr and (d) Al7075%-15%B₄C-0.3 Gr.

**Figure 5.** EDAX distribution (a) Al7075:B₄C Composite (b) EDAX distribution of Al7075:B₄C-Gr Composite.

increase in B₄C content and with addition of Gr nano particle.
Figure 6. Tensile strength (a) Al7075–B₄C (b) Al7075%–10%B₄C–Gr.

Figure 7. Graphical representation of tensile behavior of Al7075 with their composites (stress with displacement) (a) Al (b) Al-5%B₄C (c) Al-10%B₄C (d) Al-15%B₄C (e) Al-10%B₄C–0.1 Gr (f) Al-10%B₄C-0.2 Gr.
base alloy. The micro hardness of Gr reinforced Al-B4C is shown in figure 8(b), the enhancement hybrid composite hardness was due to the uniform distribution of the composites of B4C. Increased hardness of the B4C reinforcement particles and the higher density leads to the enhancement in hardness [18]. The hardness is increasing for Al7075%-10%B4C-0.2 Gr, which is 37% greater than the base alloy. It is observed that the hardness lowers with increased Gr content in the composite of Al-B4C beyond 0.2%Gr. In general, the usage of Gr Particles affects the hardness due to high carbon content. Similarly Gr addition enhanced the hardness up to a particular proportion mainly by the transference of hardness from Al to the reinforced particles B4C [19].

2.5. Flexural strength

It is noticed that the flexural strength of the composite with Al7075- B4C, increases with the increases wt. % of B4C in MMGs as show in figure 9(a). It is noticed that flexural strength is increases with increase with B4C content in Al alloy. The maximum flexural strength is showed at Al–15% B4C which is 20% greater than base alloy. Due to increases of carbon content in B4C, the ability to resist the rupture gets increased [19]. The flexural strength represents the highest Al–15% B4C–0.2 Gr flexural strength experienced within the material at its moment of rupture. It is noticed that the flexural strength for Al7075%-10% B4C–0.3 Gr was % less as compared with Al7075–B4C–0.2%Gr composite in figure 9(b). In addition, the constituents of reinforcement acts as a major factor that control the Al–B4C–Gr hybrid composites strength, which is brittle and hard, that results in dispersion hardening of the matrix [20].

2.6. Impact strength

The impact strength increases with increasing Wt% of B4C (5 &10%) and decreases to more than 10% of B4C particles with Gr as shown in figure 10. This is because of the brittleness of increased carbon content in the B4C particles. A10705%-15%B4C & more wt. % B4C is not advisable. Though 15% B4C has improved mechanical properties, it is brittle in nature and hence cannot be used for further studies. By increasing the reinforcement particle size, Impact strength and ductility get decreased simultaneously [20].

The toughness that increases for B4C content with 0.1 Gr is 2 J & for Al-10%B4C –0.2 Gr is 3.5 J and it is noticed that decrease for Al7075%-10%B4C –0.3 Gr is 2.8 which is less than 0.2% Gr composite. This is due to brittleness of high carbon content present in the Gr nano particles. A10705%-10%B4C-0.3 Gr is not advisable for further applications.
2.6.1 Wear study

Dry Wear behavior of Al7075 alloy, Al7075-B4C composite and Al7075-B4C-Gr hybrid composites were conducted on ASTM pins. Figures 11(a)–(c), confirm that when the sliding distance increases, the specific wear rate lowers. When comparing the entire composites, the increase in B4C percentage, led the specific wear rate to minimum [12].

This is because of the asperities fragmentation and the material removal which, in turn, was the result of ploughing and cutting of asperities that penetrates hard over softer surfaces. When time progresses, frictional heating increases and at greater levels they soften the surface [16]. The asperities were initially rigid and strong leading to reduced wear rate due to the hard characteristics of the reinforcement material. Figure 11(a) shows

![Figure 10. Impact strength of Al-10%B4C - Gr composites.](image)

![Figure 11. Wear rate of Al-B4C (0, 5, 10 and 15%) composite at different loads (a) 5 N (b) 10 N (c) 15 N.](image)
increase in sliding distance of 1000 m to 3000 m that decreases the specific wear rate. When the sliding distance is increased further, the specific wear rate becomes constant or minimum for all composites. This was also the result of the formation of oxide layer during sliding. The oxide layer behaves like a layer of protection to control the increase in specific wear rate. Figure 11(b) shows Al-15%B4C and the specific wear rate of composites being higher compared with 10wt. % of B4C [16].

Figures 12(a)–(c) depicts the comparison of the specific wear rate of various composites during 5 N, 10 N and 15 N loads with hybrid composites. This confirms the decrease in specific wear rate with increased sliding distance of over 2000 m. Among the entire hybrid composites, Al7075%-10%B4C−0.3 Gr composite has minimum value. The comparison with figures 12(a)–(c) depicts that the specific wear rate for Al7075 alloy 10%B4C-0.2 Gr, decreases when the sliding distance is increased further from 1000 m to 3000 m. Constant specific wear rate was maintained for all composites. The coefficient of friction decreased when the sliding distance increases [9]. The extreme development in the coefficient of friction was over the values of 0.2 to 0.4. It confirms that the B4C particles were pulled out and slide over the surface of contact, and thus decreases the coefficient of friction. Thus, during sliding, the B4C particles are removed and crammed among the surfaces that increase the coefficient of friction. Al7075%-15%B4C gives lower coefficient of friction when the sliding distance increases. Hence, it clearly shows that the development of B4C particles reduces the coefficient of friction of composites and leads to good particle matrix interface, improved dispersion, good bonding and lower heat development between the surfaces [26].

Figure 12. Specific wear rate of Al-10% B4C - Gr (0, 0.1, 0.2 & 0.3%) Hybrid composite at loads (a) 5 N (b) 10 N (c) 15 N.

SEM of wear worn surfaces
The elaborate micro structural analyses of the wear worn surface of Al7075 alloy with their composites were performed with the use of SEM. The SEM analysis was done for the wear worn surfaces of the Al7075 alloy and its composites. The analysis of the wear worn surfaces of Al7075 direction is depicted in figures 13(a)–(f). It has been noticed that the grooves were deeper in case of Al7075 alloys when compared to its composites that are analyzed at 5 N. From the above investigations it is observed that when Al7075 reinforced with B4C (10%), the material Strength and wear resistance is enhanced however because of high carbon content present in high
composition of B₄C, impact strength gets decreases when B₄C content increases with hybrid composites [13]. So it’s not advisable to prefer B₄C more than 10%. It’s preferable to add the reinforcement of B₄C content 10% or less. When Gr added in to the Al7075 matrix there is an improved mechanical and wear properties up to some limitations. But these properties goes decreases when the addition of reinforcement B₄C (10%), Gr (0.2%). It is due to the high carbon content, wettability problem so Gr usage will be restricted not more than 0.2% for the applications [18].

2.6.2. Effect of thermo gravimetric analysis

Figures 14(a), (b) shows the thermo graph of TGA/DTA analysis. It reported that the peak temperature touched throughout the material was diverse amongst 656 °C and 658 °C with 20–40 mm min⁻¹. The thermal stability of graphene added composite increases with that of Al7075-B₄C composites [13]. Interestingly, nano Gr is thermally stable and its residual mass was approximately high in this material. The curve gives a detailed information on the degradation process, maximum intensity of thermal degradation temperatures (DTG), and residual mass, is shown from figures 14(a), (b). It shows that composites with boron and graphene the values are

![Figure 13. SEM of wear worn surface of 15 N(a-b)Al1%-10%B₄C, (c-d) Al-10%B₄C-0.2 Gr, (e)-(f) Al-15%B₄C-0.2 Gr.](image-url)
high than for the without Gr. Moreover, introducing nano Gr into the Al7075 matrix reduced their rate of degradation, which was proven by DTG analysis [5]. Additionally, high amount of residual mass in nano hybrid composites may prevent the thermal degradation of material due to the high surface to the volume ratio and their stability [25]. Al-Gr phase possess better thermal stability, and its point of dissolution is very much greater than 650 °C. Hence Al-B4C-Gr phase with improved thermal stability can be engaged in the prepared composite compositions. In DTA analysis there is mass reduction of about 0.1% in weight due to the reinforcement addition [25].

3. Conclusions

The mechanical and metallurgical evaluation of Al7075-B4C-Gr MMCs was discussed in detail. The following assumptions were identified as follows:

- Based on Al7075-B4C-Gr composites mechanical behavior and resistance to wear, it is observed that the Al7075%-15%B4C composite exhibits tensile strength 25% greater than unreinforced Al7075.
- On evaluation of Al7075-B4C, it was noticed that the tensile strength of Al7075-B4C-Gr (0.1, 0.2& 0.3) MMHCs was increased by 26%, 46%, and 39% respectively. The flexural strength and impact strength of Al7075%-10%B4C-0.2 Gr MMHCs is 30% higher than the unreinforced alloy.
- The toughness of Al-B4C decreases when B4C particles wt. % increases to 15% of B4C.
- For Al-15%B4C composites, 18% lower wear rate was noticed than the unreinforced alloy under all load conditions. It is also seen that the Al-15% B4C composite exhibits better wear rate and mechanical properties with 10% B4C when compared to Al-15%B4C composites.
- Wear rate noticed with Gr reinforced with Al7075%-10%B4C composite is lower compared to other Al6061%-10%B4C-Gr with various Wt% composites. On comparison, the Al7075%-10%B4C-0.2%Gr composite shows better wear rate compared to other composites.
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