Visual Abstract

Study on micro - nano sized Al_2O_3 particles on mechanical, wear and fracture behavior of Al7075 Metal Matrix Composites

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ABSTRACT. Having Low density and being Light weight with better mechanical properties, aluminum is the most significant material and is universally used in highly critical applications like navy, aerospace and particularly in automotive applications. This research work is aimed to investigate the effect of micro and nano Al_2O_3 (Alumina Oxide) to aluminium (Al) on the mechanical and wear properties of the Al composites. The micro - nano composites with 1, 2, 3 and 4 % of Al_2O_3 particulates in Al are fabricated using stircasting processes. It was found that an increase of Al_2O_3 both as micro and nano particulates content resulted in improved hardness, enhanced tensile strength and high wear resistance. However, nano Al_2O_3 reinforced MMCs have better hardness, improved tensile strength and higher wear resistance as compared with micro-sized Al_2O_3 reinforced MMCs. Grain refinement of composite and nano composite materials as compared with pure Al were observed in the microscopic structures. Analysis of wornout surface and tensile fracture surface was studied by SEM analysis to examine the nature of wear and tensile fracture mode of composite samples.

KEYWORDS. Al7075; Al_2O_3; Micro; Nano; Hardness; Tensile; Wear loss.

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INTRODUCTION

Due to the high strength, low density and better wear resistance, aluminum (Al) composites are the most useful materials for several engineering applications. In particular, aluminum alloys are used in several components manufactures namely, engine blocks, pistons, brakes, engine blocks, impellers, and valve components. The main reasons for considering these Al alloys used in above-mentioned applications possess excellent weldability, castability and good corrosion resistance. Mechanical properties are significantly influenced by the chemical composition, microstructure and solidification process [1]. Different types of particles are used as reinforcements such as Al_2O_3, TiC, SiC, B_4C, ZrO_2, fly ash and etc., with Al combination to obtain high wear resistance and strength. Among these, ceramic particulates are broadly used as the support in the development of materials as they possess high strength and modulus. Increase in the content of particulates in the Al matrix leads to improvement in the rigidity of the produced composites. In aluminium composites, ceramic particles help in providing improved hardness, higher wear resistance and acts like a lubricating film on the contact surface and also provides to low thermal expansion. Ceramic particles help in the development of mechanical properties and wear resistance of the material [2]. Mainly, Al alloy-based composites applicable in aerospace, automotive and also other engineering applications are relatively popular due to their better mechanical behavior. Properties of alloy can be improved upon by adding micro and nano hard ceramic reinforcements. Al composites have gained specific attention for automobile applications as possibly advanced essential materials in the last two-three decades due to their better properties and accessibility of the low cost production methods. The technique used to manufacture a composite depends on the chemical properties and mechanical characteristics of the reinforcements and matrix, the particulate size and the desired particle configuration [3 - 5]. The MMCs (Metal Matrix Composites) of micro and nano-composites can be produced by using three different processes like liquid state, solid state and solid-liquid mixed process. Stir casting, spray casting and squeeze castings are liquid state techniques. Friction stir casting and Powder technology are solid state techniques used in matrix composite fabrication. The semi-solid forming and compo casting are considered as liquid-solid (semi solid) mixed methods used in the manufacture of MMCs. Among the numerous composite fabrication methods, casting techniques and powder metallurgy are more common compared to other manufacturing techniques. Although stir casting methods are cheaper, straightforward and more manageable, the inherent non-wettability of the hard ceramic in the Al melt is difficult. Some techniques are based on employing mechanical parameters in fabrication to improve the wettability, such as stir-casting [6]. The main drawbacks of stir casting process are agglomeration of reinforcing particulates due to the insufficient heat and unbalanced material flow throughout the stirring process [7, 8]. Particulates agglomeration is not only owing to the high wt. % of reinforcing ceramic micro/nanoparticles, but also due to non-wettability of these particulates by the melt and the inherent tendency of these particulates to absorb each other. Numerous studies have been conducted to overcome this challenge. The researches in the matrix of Al composites reinforced by hard ceramic nano particulates, especially Al_2O_3, have received much attention because of extensive use of these types of materials in the aerospace applications [6]. Al_2O_3 is one of the regularly used reinforcing materials for Al metal matrix composites. Alaneme and Bodunrin [9] studied the mechanical characterization of Al alloy 6063 - Al_2O_3 composites fabricated by stir-casting method. MMCs having 6 - 18 wt. % of Al_2O_3 were produced. It was found that MMCs had less porosity levels and good uniform distribution of the Al_2O_3 particles with in the base matrix. The ultimate tensile strength (UTS) and hardness enhanced with increasing in wt. % of Al_2O_3 content while the fracture toughness decreased with increase in wt. % of alumina content. L Singh et al. [5] produced the MMCs containing Al with 3 to 9 wt. % of Al_2O_3 particulates by stir-casting technique. It was found that the hardness of composites enhanced with increase in wt. % of Al_2O_3 content, but decreased with increasing in particulates size. Velavan et al. [10] in their investigation, used Al 7075 powder of 60 μm (mesh size) and reinforcing particulates like SiC (2, 4, 6 %) and Al_2O_3 (2 %) of particle size < 51 nm to produce hybrid composites. From the outcomes it was witnessed that the grain boundaries showed no pore cavities in the composites and also confirmed that the sintering was effective. The silicon carbide particulates had fine granular structure and also precipitated with the grain boundaries of the Al matrix. The separation at interfaces showed outstanding sintering and therefore reduction in size of grains was observed due to the addition of nano-sized hard ceramic particles and also due to presence of secondary reinforcements (Al_2O_3) within the parent material. This acted like a heterogeneous nucleation throughout process and it restricted the grain growth which showed the motion of dislocations. S. Mula et al. [11] studied the structure of a nanocomposite of Al with 2 % nano sized Al_2O_3 particulates. Nearly 57% increase in the tensile strength and 92% increase in the hardness were found from the results. These developments in the tensile strength and hardness were due to reinforcing by only 1.4 wt. % of nano-sized Al_2O_3 particulates in the matrix. Huda et al. [12] developed Al7075 composite reinforced by 0 - 5 wt. % of Al_2O_3 particulates by using stir-casting technique. From the outcomes it was observed that, the wear rate and mechanical strength of the produced MMCs considerably improved by addition of Al_2O_3 nano particulates. These material properties were significantly enhanced as the wt. % of hard reinforcements increased from 1% - 5%. The enhancement of 26.3% and 14.3% was observed for hardness and tensile strength of composites respectively. Al-Jafaari [13] studied the effect of Al7075 reinforced with Al_2O_3 nanocomposites produced by stir-casting process. It was witnessed that the tensile strength of MMCs significantly enhanced by 8% at 0.3 wt. % of Al_2O_3 content. The higher tensile strength of nano composite could be attributed due to the reason that Al_2O_3 particulates act like an obstacle to the movements of the dislocation. C. Kannan and R. Ramanujam [14] investigated the microstructural and mechanical characterization of Al7075-based mono and hybrid nano composites manufactured through stir-casting techniques. The composites were produced with reinforcement of 2, 4 wt. % nano sized Al_2O_3 particulates and 4 % SiC particulates. In comparison with as-cast, hardness enhanced by 63.7% and 81.1% for mono and hybrid nano composite. Sajjadi et al. [15] examined the aluminum composites reinforced with micro and nano Al_2O_3 particulates. It was observed that the hardness of MMCs samples improved with increasing wt. % of Al_2O_3 particles. Some studies confirmed that, the smaller nano sized particulates provided better as compared to micro-sized particulates. Recent studies found that, the reinforcing the nano particulates considerably increased mechanical properties of composites, whereas the ductility was retained [16]. The microstructural characterization and mechanical behavior of MMCs are highly influenced with respect to parameters like uniform distribution, particles size and wt. % of micro - nano sized reinforcing particulates. Among these parameters, uniform dispersal of reinforcements determines the micro-graphical structure and mechanical behavior of MMCs is influenced by the factors due to matrix material and fabrication technique. Wettability and distribution of particulates are two major glitches to be avoided while reinforcing micro or nano sized particulates into the Al matrix through stir casting method. Whereas, these two factors can create unfavorable effects on mechanical behavior of both composites / nano composites if they have not been taken proper care of at processing stage. The wettability is very poor for nano sized reinforcement particulates. Also, it is very difficult to achieve uniform dispersal of nano particulates in a base matrix by stircasting technique [17]. In the literature survey, there is mention of several studies which have examined the effect of micro or nano- sized reinforcing particulates on the mechanical behavior of Al composites at various wt. % of hard ceramic reinforcements. Generally, it is very difficult to equate the MMCs with micro / nano- sized particulates. Due to this reason, the research studies have been done to examine the influence of micro - nano particulates on the microstructures, mechanical and wear characteristics of Al-based composite/nanocomposite reinforced with varying wt. % of Al_2O_3 particulates by using stircasting technique. In the present research, the two types of Al_2O_3 particles like micro size (30-50 microns) and nano size (30-50 nm) were used in the reinforcing phase for the fabrication of Al matrix composite and nano composite. The stir-casting method is selected in the present research work, since it is one of the best inexpensive methods of processing of Al composites. The fabricated composite and nanocomposites were further studied for microstructure, mechanical and wear properties.

EXPERIMENTATIONS

Materials

In present research, Al7075 has been used as the base matrix. Two different types of Alumina Oxide (Al_2O_3) particulates i.e., micro and nano-size were used as a reinforcements for the production of composite and nanocomposite. Al7075 (rod) was purchased from Perfect Metal Works, Bangalore, Karnataka. Al_2O_3 particulates (micro and nano-size) were purchased from Prince Chemical Bangalore, Karnataka. The stircasting facility was provided by M/s Aluminium Fabrications, Bengaluru.

Fabrication of Composites/Nanocomposites

Stir-casting method helps to enhance the wettability in MMCs by evading the development of oxide and gaseous layers on surface of melt and also prevents agglomerations of the particulates in the base matrix. In this method, the fluidity can be continued, like cleaning the molten melt from the oxides and decreasing the rate of heat transfer by the mold box. The MMCs were reinforced by 1, 2, 3 and 4 wt. % of Al_2O_3 particles of micro size (30-50 microns) and nano size (30-50 nm). The casting facility was provided by M/s Aluminium Fabrications, Bengaluru. The MMCs were produced by a stircasting technique. Coke furnace was used to melt the Al7075 alloy at 850ºC. The preheated reinforcement was added into the Al melt. Degasifier tablets were used to remove the gases from the molten melt. While adding hard reinforcements, the stirring process was done at 150±5 rpm for the duration of 3 min and the ready composite melt was poured into the metal die. Then the composite samples of 20 mm diameter and 200 mm long were separated from the die. Composites were machined by using CNC machining process to prepare test samples. The tensile test specimens were prepared as per the

ASTM E8 standards of size (12.5 mm diameter and gauge length of 50 mm). The composite samples used for testing purposes are depicted in Fig. 1.

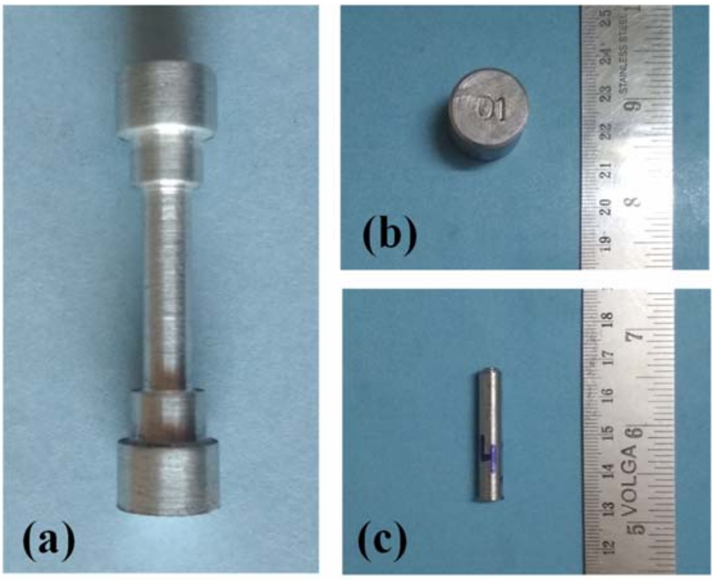


Figure 1: (a) Tensile test specimen (b) Hardness test specimen (c) Wear test specimen

Characterizations of Composites/Nanocomposites

The composite and nanocomposites test samples were polished by using 500 grit size emery sheets. The test specimens were polished by velvet disk to achieve adequate finish on the specimen surface. The dispersal of hard particles with in the matrix was examined by optical microscope. Tensile tests were carried out according to the ASTM E8 standards. The tests were conducted by using UTM at a load of 400-410 KN. Three tensile test samples of similar compositions were tested and the average values were considered and the variation of tensile strength values was less than 5 %. For each trials Hardness of composite and nanocomposites were studied according to E92 standards by using Vickers micro hardness testing apparatus. Here, 12 mm diamond-shaped indenter was used under load of 1 kg for the duration of ½ minute on the test samples. Hardness of the composite and nanocomposites was examined at 3 different places to obtain indentations on the test samples. The average value of micro hardness was determined. The pin-on-disc test equipment was used to examine the wear loss of composite and nanocomposites. The tests were carried out according to the ASTM G99 standards under the constant sliding speed of 2.1 m/s and load of 2.5 kg against the EN-32 hard steel disc for time duration of 30 minutes. The three wear test samples of similar compositions were tested and the average values are considered and the variations were less than 5 %. Initial weights of composite and nanocomposites samples were measured by digital weighing machine. The test samples were vertically fixed rigidly and made to be contact with rotating hardened steel disc. The test was conducted by bringing surfaces of the specimen in contact with the surface of flat hard steel disc. Finally, the samples were removed and acetone (organic solvent) was used to clean the tested sample surface. The wear behavior of composite and nanocomposites was studied by determining the difference between initial and final weights.

MICROSTRUCTURAL OBSERVATIONS

Fig. 2 depicts the microscopic images of Al7075, composite and nanocomposite samples. The Fig. 2(a) shows the base matrix material microscopic image without any presence of reinforcements. The micrograph shows images free from casting defects or any voids. The presence of Al and Al_2O_3 particulates is observed in the micrograph image of micro-composite sample (Fig. 2(b)) with 4 % of micro size Al_2O_3. The matrix phase shows proper dispersal of reinforcements. Here, the particles are free from agglomeration and clustering due to the stir casting method adopted to manufacture the composites. Micrograph image of 4 % nano-sized Al_2O_3 reinforced nano composite specimen (Fig. 2(c)) reveals the presence of Al in light (color) portion, whereas the dark portion depicts the agglomeration of nano Al_2O_3. The dispersal of Al_2O_3 nano particulates in Al matrix is a vital requirement for increase of the mechanical strength and wear characteristics of the composites [18]. Reinforcing micro and nano Al_2O_3 particulates in the Al matrix enhance the grain refinement. The microscopic study revealed that the grain around Al_2O_3 is much finer compared to the grains around Al_2O_3 free matrix alloy. Therefore, Al_2O_3 particulates can induce the recrystallization of Al alloy by accelerating particulates nucleation among the reinforcement and matrix phase. The Al_2O_3 micro/nano particulates can defer the crystal growth of grains during the casting process. The microscopic image reveals that nano Al_2O_3 reinforced composite induces improved grain refinement when compared with the micro Al_2O_3 reinforced composite [19, 20]. Due to the nano size of particles, it is very difficult to distinguish with matrix material and also very difficult to observe the grain boundaries of the reinforced particles.

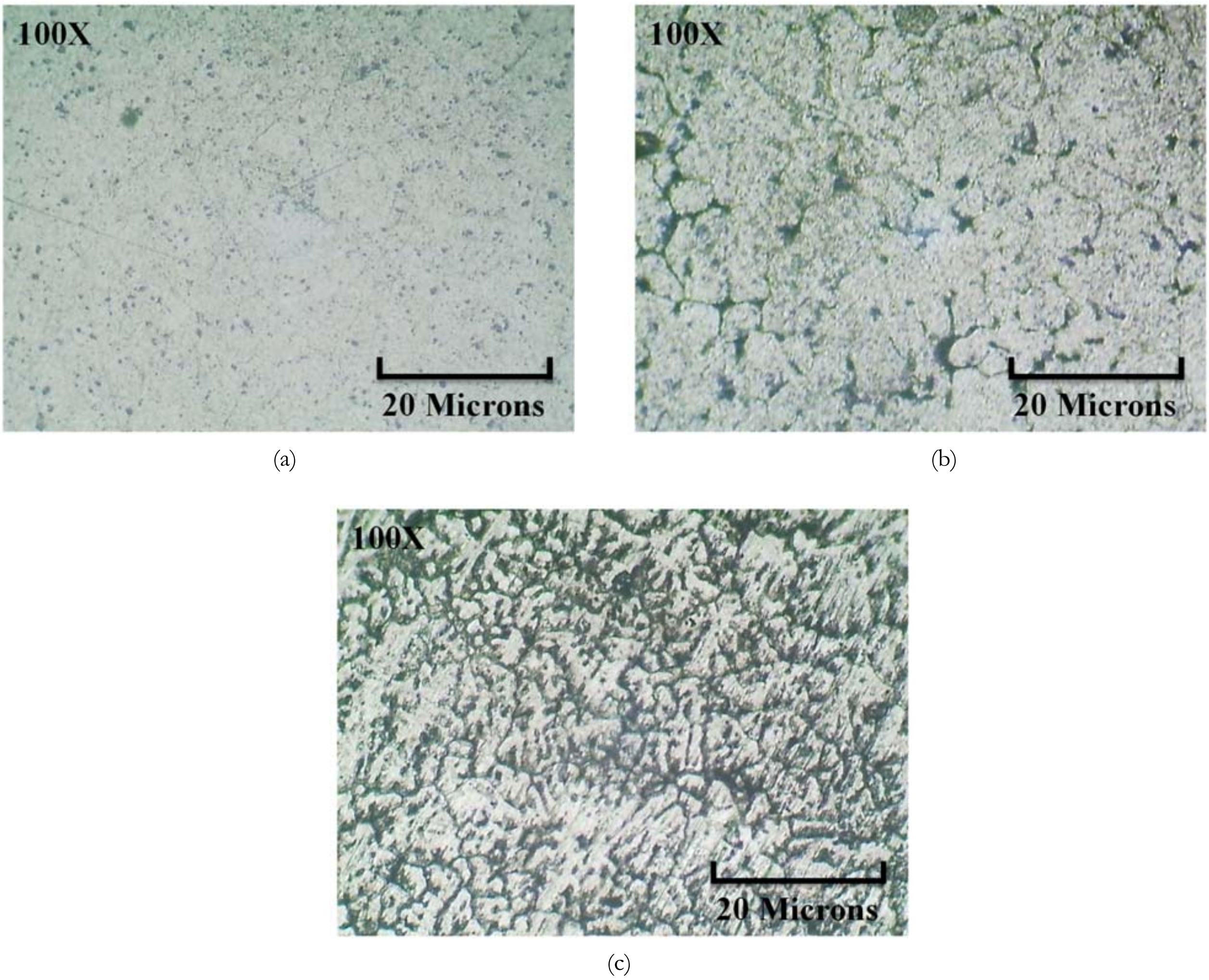


Figure 2: Microstructure images of: (a) Base alloy (b) Micro composite (c) Nano composite

Hardness

The outcomes of hardness for all the composites produced by stircasting are shown in Fig. 3. From the Fig it is seen that the composite/nanocomposites reinforced with hard ceramic particulates (Al_2O_3) exhibit improved hardness values compared to Al alloy. In addition, the composite reinforced by nano-sized Al_2O_3 particulates exhibit improved hardness when compared to MMCs reinforced with macro sized Al_2O_3 particulates. A comparatively better hardness values are revealed for 4% of Al_2O_3 particles in both composite and nanocomposites. Research by Dash et al. [21] revealed enhanced hardness for Al composite reinforced by nano-sized Al_2O_3 particles when compared to Al MMCs reinforced with equal wt. % of the micro sized Al_2O_3 particulates. The hard nano particulates are more closely bound and uniformly distributed with in the matrix. So, higher stress is necessary for the movement of dislocations once they encounter these hard particulates. Thus, the uniformly dispersed nano sized particulates may be attributed to better dispersion strengthening by the appropriate particulates dislocation interaction. Therefore, the MMCs reinforced with nano sized particulates possess higher hardness. The improved hardness of nano-composites may also be attributed due to the presence of hard intermetallic phases and improved grain refinements [22 - 24]. In addition, as the wt. % of nano particulates increases, the agglomeration of nano particles also increases because of insufficient processing time of the molten melt. The hardness of nano composites at higher wt. % of nano particles is not affected due to this.

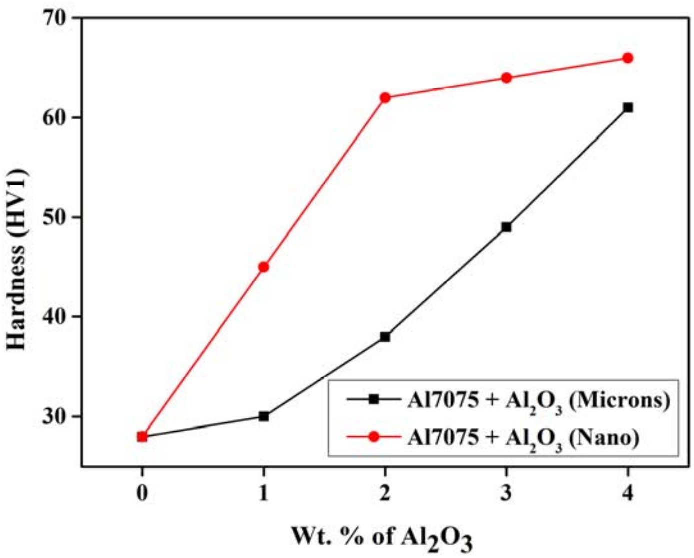


Figure 3: Hardness of micro Vs nano composite samples

TENSILE STRENGTH

The outcomes of tensile strength for composite - nano composites are depicted in Fig. 4. When compared to the Al alloy, the composite and nano composites possess better tensile strength. The results exhibit that the UTS is enhanced by increase in the wt. % of Al_2O_3 particulates content. This improvement in tensile strength was found may be due to the existence of hard ceramic particles of Al_2O_3 in the Al matrix, which tends to enhance the tensile strength of Al composite. The tensile strength enhanced with an increase in the wt. % of Al_2O_3 content which is attributed to be low degree-of-porosity and uniform dispersal of Al_2O_3 particulates. This remark conforms with the outcomes of most hard particulates reinforced in the MMCs. Abhishek et al. [25] investigated the mechanical characteristics of composites reinforced by hard ceramic particles. The results revealed that, the solidification of composites increased based on the quantity of reinforcements in the base matrix. Generally, this is because of the intricacy involved in adding hard ceramic particulates which creates obstacles to dislocation of movement over the matrix material. It is also found that the tensile strength of the nano-particles reinforced MMCs is higher than micro-sized particle reinforced composites due to better interfacial bonding strength among the particles and the base matrix. It is known that the addition of Al_2O_3 nano particulates into the base material provides better heterogeneous nucleation at the time of solidification resulting in refined grains. Therefore, the improvement of the tensile strength can be ascribed to the grain size [12]. Other researchers suggested that the different strengthening mechanisms for the MMCs like load sharing, grain refinement, particulate strengthening and thermal mismatch strengthening were caused by nano-particulates. Out of all these strengthening mechanisms, the effect of load sharing is very minimal and improvement in UTS is mainly because of the grain refinements based on Hall-Petch theory concept and the restriction towards the movement of dislocation with in the base matrix due to nano-particulates rendering to "Orowan" mechanism concept. Improved strength of nano-sized particulates reinforced composites could also be ascribed to the difference in the CTE (coefficients of thermal expansion) of matrix and nano-particles when it is cooled under the room temperature (27°C). Whereas these nano-composites were prepared by stir casting method, due to this reason grain refinement and reduction of porosity were attained. This may be the main reason for increase in tensile strength of stir cast nano-composites [26 - 29]. In addition, it was observed that the UTS of nano sized particulates reinforced composites remain unaffected when the wt. % of nano-particulates was more than 3%. Higher wt. % of nano-particles reinforcements led to higher agglomeration with in the composite due to high content of nano-particles [30 - 32].

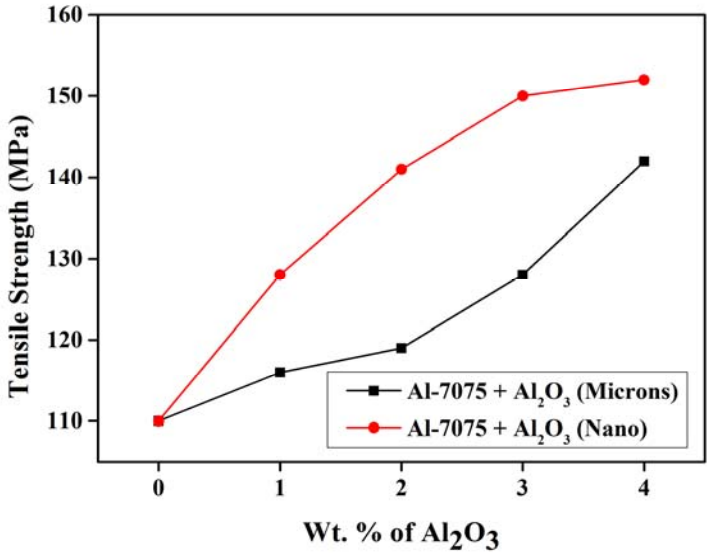
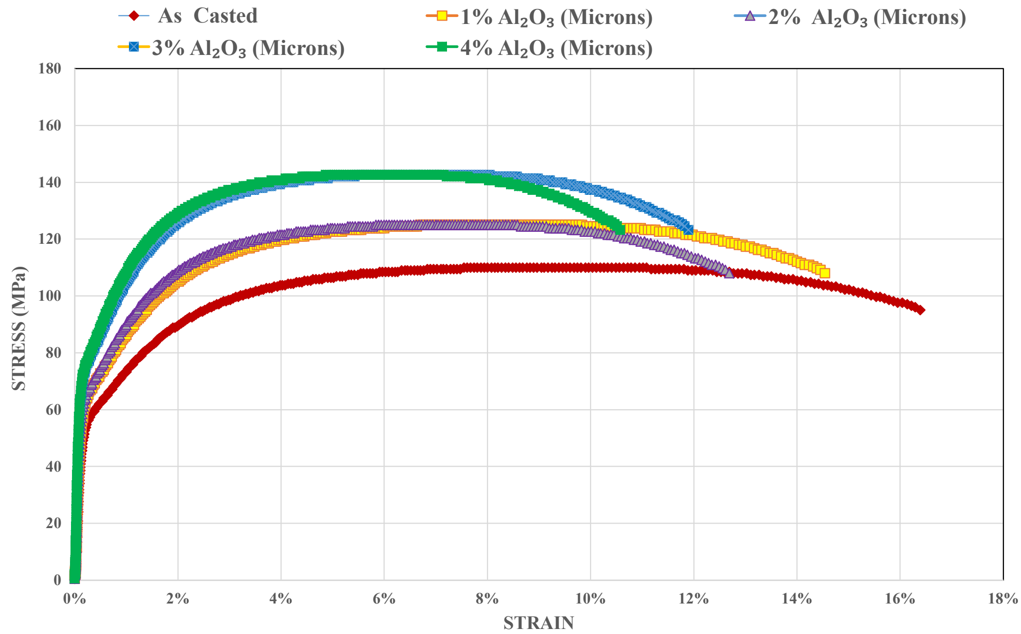


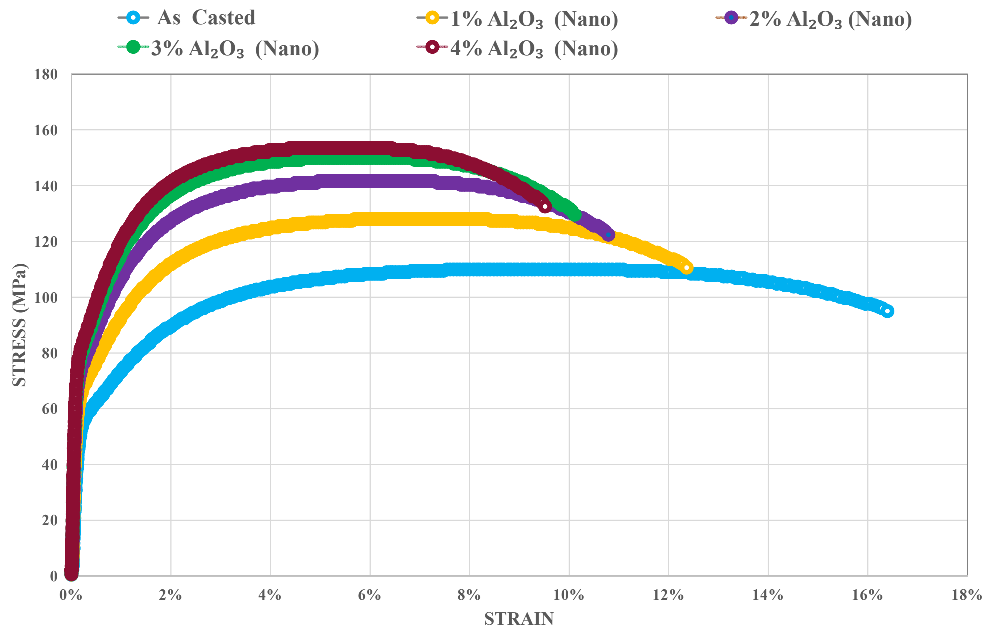
Figure 4: Tensile strength of micro Vs nano composite samples

Stress-strain graphs of the micro and nano composites are depicted in Fig. 5 (a & b). The main features of these curves are that the tensile strength increases when the fracture strain is decreased with increasing particulate content. It is observed that the monolithic alloy has the highest plastic strain and also exhibits the least resistance to plastic deformation from its comparatively lower flow stress when compared with the composite and nano-composites. It is observed that all the MMCs provide better strength when compared to the base alloy. This is due to the grain refinements and the strengthening of particles. The improvement of strength in the MMCs is generally due to the mismatch strengthening and high load bearing caused by the nano-sized particulates. It is inferred that could be due to difference in the CTE among the matrix and the reinforcements. Due to the thermal-mismatch stress, there is a chance of increase in dislocation density within the base material at the time of cooling from the solidification temperature. Dislocations might cause stress at interface of the particulates and the base matrix. The stress generally depends on the temperature from which the MMCs were cooled. High temperature led to increased stress at an interface generally, which made the plastic deformation harder and resulted in increased strength of the composites. When it is compared to the base matrix, the improvement in the strength revealed in the MMCs is due to the presence of the hard particulates as an obstacle that restrict the motion of dislocation with in the matrix. The increase in wt. % of micro particles might increase the dislocation density with in the base matrix of MMCs, which can be designated as a dislocation strengthening. The dislocations trapped by the hard ceramic nano sized particles led to increase the tensile strength of the nano-composites during tensile tests [26, 31, 33].
The SEM analysis of the tensile fracture surfaces for a composite and nano composites is illustrated in the Fig. 6 (a & b). The fractured surfaces of the test samples indicates distributed shallow portions and dimples with different sizes with in the MMCs and also confirms the high ductility witnessed in the tensile test studies. It is observed that there are more number of large sized dimples which are linked together along with the boundaries, presenting an increased amount of clustering along with the grain boundaries. Of-course, in these MMCs, due to the utilization of the sufficient reinforcement with a better strength, the fracture particulates are not likely to occur. Also, due to the better strength within the base metal, de-cohesion of the matrix and particulates interface is more likely than fracture of the base matrix during the tensile strength test. Hence, nucleation of micro voids at the matrix and particulates interface and their development is the fracture mechanism. This is caused due to the merging the micro voids and the shear among them within a base matrix. Deep and stretched dimples are formed due to the nucleation of micro voids, their resultant growth in the structure and lastly their coalescence, which is affected by shear-stress. The Al_2O_3 particulates have a substantial effect on the fractured surfaces of the MMCs. The existence of hard particulates in the core of maximum dimples means that the matrix and particulates interface and particles agglomeration provided proper sites for development of cracks and as well as propagation. The crack propagation is produced due to decohesion at the base matrix and particulates interface as a weak place within the structure. Comparison among the fractured surfaces of two different composites such as micro and nano-sized particulates shows that particle size is decreased and number of cavities has increased while their sizes are

decreased. Generally, this phenomenon is affected by reducing the distance among particles and also increasing the matrix and particle interface as a suitable place for the nucleation of cracks or cavities. Hence, interface debonding was the main cause for deprived ductility of the MMCs in the present research work. Moreover, nano-sized Al_2O_3 particle clusters are the foremost causes for the rapid failure and also it shows no effect on the mechanical strength of the MMCs at higher wt. % of reinforcements [31, 34, 35].

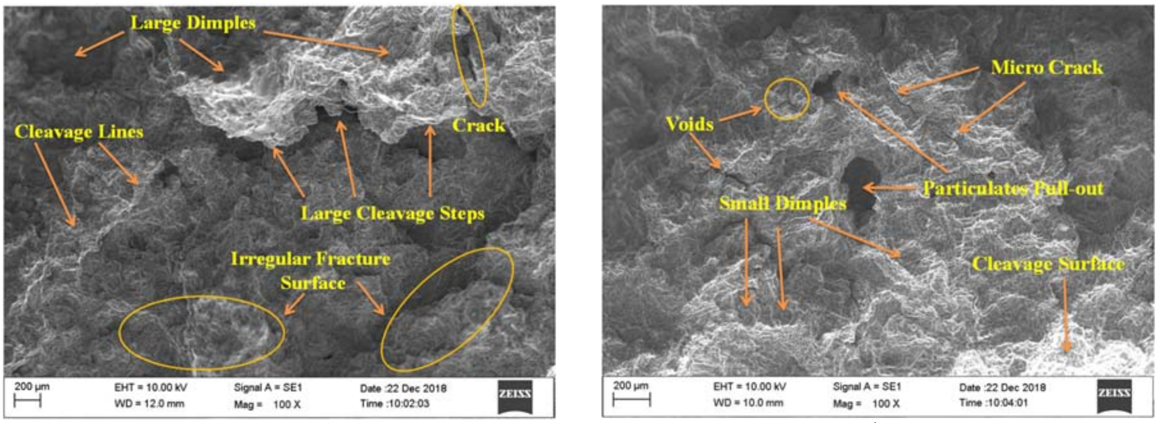


(a)



(b)

Figure 5: Stress strain curve of (a) micro composite (b) nano composite.



(a) (b)

Figure 6: Fracture images of the tensile specimen (a) micro composite (b) nano composite

WEAR BEHAVIOR

The adding of hard ceramic Al_2O_3 particles in to the aluminium is thought to considerably enhance the high wear resistance of the MMCs. Fig. 7 shows the wear behavior of Al7075 reinforced micro / nano Al_2O_3 particulates. The wear rate is completely correlated with the load for composite and nanocomposites containing up to a 4% of micro and nano Al_2O_3 particulates. Wear rate of the nano-sized particle reinforced composites shows improved wear resistance when compared to micro-sized particulate reinforced MMCs.

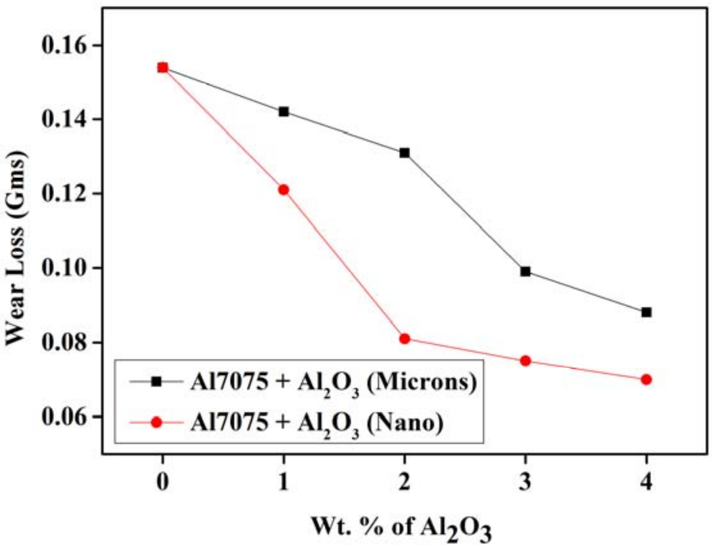
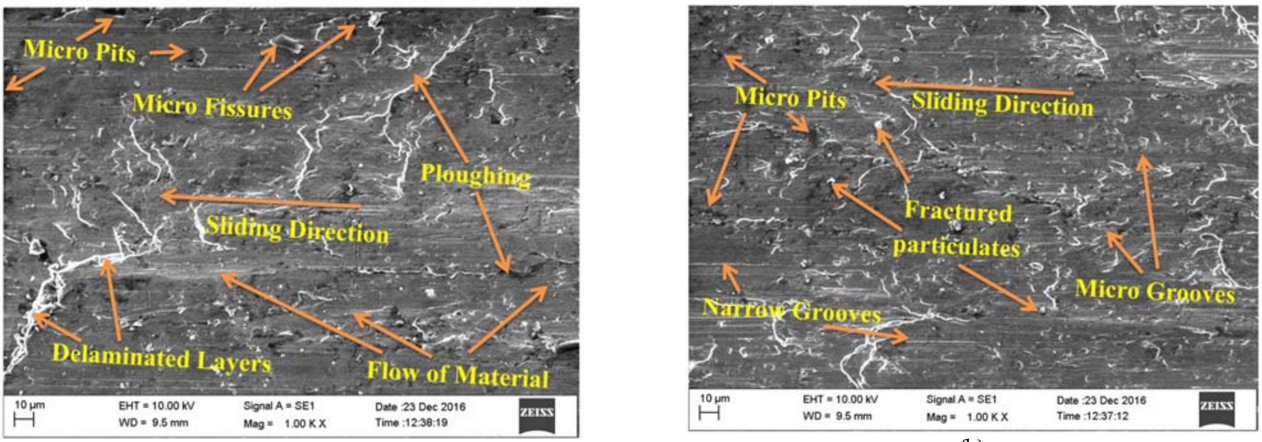


Figure 7: Wear behavior of micro Vs nano composite samples

The enhancement of the high wear resistance of the nanocomposites when compared to composites is generally due to the grain refinement. However the wear loss of the as-cast is higher when compared to composite and nano composites. It is known that the wear behavior strongly depends on the reinforcements. However, the wear loss decreases upto a certain wt. % of reinforcement and then remains unaffected due to various factors such as wettability and agglomeration of nano reinforcement particles. This leads to reduction in the wear resistance of nano-composite at higher wt. % of reinforcement content. Normally, the wear loss is inversely correlated to the material hardness. Generally, the decrease in the hardness is due to the high porosity and also heterogeneous dispersal of the hard particles in the Al matrix. Therefore, the wear behavior of the micro and nano composites reinforced with 4% by weight remains unaffected.



(a) (b)

Figure 8: SEM analysis of wornout surface of (a) micro composite (b) nano composite

To evaluate the wear mechanisms, the wornout surfaces of composites and nanocomposite specimens were inspected by SEM investigation. SEM images of composites and nanocomposite specimens wornout surfaces for 4% reinforcements are depicted in Fig. 8 (a & b). The wornout surfaces were characterized by narrow grooves, micro-pits and heavy flow of materials. In the SEM image, the dark layer shows the development of narrow grooves. The wornout surfaces of MMCs are concealed by micro pits, fine grooves, signifying that the wear mechanism is delaminating and ploughing. Severe deformation & delamination is witnessed on the wornout surface of MMCs, signifying that the wear behavior is delamination. The load applied on the ceramic particulates, caused wrapping on the composite surface. Generally, these hard ceramic particles acted like a wrapping material on the sliding surfaces which offered better wear resistance.

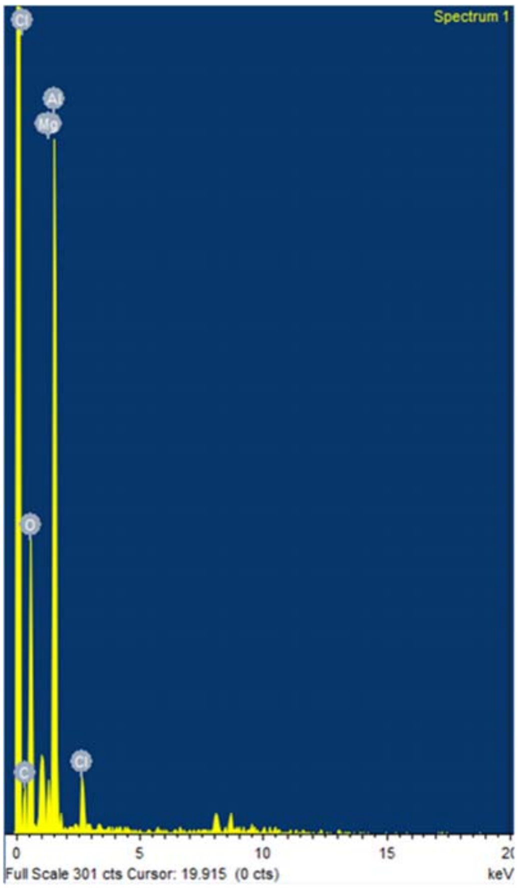


Figure 9: EDS spectrum of nano composite specimen.

The ceramic particles are get deposited in the voids and it is observed that few particles have broken into pieces and some of the particulates are pulled away from the wornout face [18, 36]. It indicates the high rough wear mechanism which is due to the presence of hard ceramic particulates exposed on wornout surface. The microstructure shows that large numbers of narrow grooves were present on wornout surfaces of composite and nano composites. So, these parallel continuous grooves are the evidence for micro ploughing. Wide ploughing can also be seen on the worn out surfaces of composite and nano composites which show prominent wear behavior in the MMCs. The SEM analysis of the wornout surface of nanocomposites depicts the formation of narrow-grooves with dark layers. Generally, this indicates that nano composite exhibits improved wear resistance when compared to the micro sized particulates reinforced Al composites. The chance of debonding of nano particles due to the incessant sliding causes the particles to get slackened from the matrix material and get stuck among the sliding surfaces, whereas it might act like an abrader leading to a short period of wear. Generally, this is the cause for enhanced wear rate [37, 38]. The Energy Dispersive Spectroscopy study of nano particles reinforced composite is shown in Fig. 9. The outcomes reveal that the presence of Al, Mg, C and O within in the interface layer. Smaller volume of O (oxygen) was detected in EDS study due to the formation of the oxide layer within the composites. From the outcomes, it is concluded that oxygen (O) noticed in EDS study is due to the existence of alumina oxide (Al_2O_3) content during composite preparation. The EDS structures have been indexed to the combination of various elements and the other small peaks ascribed to the impurity [39 - 41].

CONCLUSIONS

In this research work, Al7075 reinforced with Al_2O_3 (micro / nano) were effectively fabricated by using stircasting method. The effects of micro - nano sized Al_2O_3 particulates on mechanical and wear behavior were been studied.

- The optical microstructure images revealed that better grain refinement was found in composite and nano composite when compared to as-cast.
- Hardness and tensile strength values were enhanced with increasing reinforcement content with in the metal matrix. It is observed that nano composites exhibit better strength as compared to micro composites.
- The fractured surfaces of the test samples indicated plenty of distributed shallow portions and dimples with different sizes with in the composites which also is in concurrence with the high ductility witnessed in the UTS studies
- The wear rate of composite and nano composite materials was enhanced as compared with as-cast and wear loss decreased up to a certain wt. % of reinforcement and then remained unaffected due to various factors such as wettability and agglomeration of nano reinforcement particles. This leads to reduction in the wear resistance of nano-composite at higher wt. % of reinforcement content.
- The wornout surfaces of MMCs are concealed by micro pits, narrow fine grooves, signifying that the wear mechanisms are delaminating and ploughing. Severe deformation & delamination are witnessed on the wornout surface of MMCs which signifies that the wear behavior is delamination.
- The EDS study reveals the existence of Al, Mg, C and O within in the interface layer. Smaller volume of O (oxygen) was noticed in EDS study due to the progress of the oxide layer within the composites. From the outcomes, it is concluded that oxygen (O) noticed in EDS study is due to the existence of alumina oxide (Al_2O_3) content during composite preparation.

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