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Study of Comparison of Mechanical Properties of Al7075 with Al7075 Reinforced with Nano and Micro Particles of Al_2O_3 at Varying Percentagevia Stir Casting Route

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***Abstract*: Al7075-Al_2O_3 materials are formed by adopting stir casting technique on Al7075 by adding reinforcements of Al_2O_3 in the form of nano and micro particles at varying wt. %. In present study Al7075-Al_2O_3 metal matix composite developed in three different compositions of micro and nano particles. The Fabrication of composite are carried out by liquid metallurgy route via stir casting technique. Casted composites machined to make the samples for mechanical testing. Tensile strength test and Hardness Test are conducted on different machines. Improved results are found after testing. Future scope is also given for research scholar.**

***Keywords*: Metal Matrix Composite, Aluminum, Alumina.**

Introduction:

In the recent years, the demand for light weight, low cost and high quality performance materials has increased. Many researchers have tried to develop new materials that meet these requirements. One of the newly developed materials is Aluminium metal-matrix composites (AI-MMCs). Basically, there are three types of MMCs: particle reinforced, whisker reinforced and continuous fiber MMCs. Metal-matrix composite (MMCs)are widely used in industry because of their excellent mechanical properties. Nowadays, there are various MMCs used especially for automotive and engineering applications. This is because of their high strength, high elastic modulus, low co-efficient of thermal expansion, light weight, low thermal shock, good wear resistance and many more advantages. These combinations of these properties are not available in a conventional material. These mechanical properties also depend on the composite particles for the reinforcement of the Aluminium. Most of the alloys that are used as matrices are light alloys, particularly those based on Aluminium alloys.

Aluminium Alloys

Aluminium became a common structural material because of its attractive properties like its light weight, ease of fabrication and machinability, high resistance to atmospheric corrosion, good thermal conductivity, high metallic luster and nonmagnetic and non-sparking properties. Selecting the right alloy for a given application entailsconsiderationsofitstensilestrength,density,ductility,formability, workability, weld ability andcorrosion resistance. Aluminium alloys are alloys in which Aluminium (Al) is the predominant metal. The typical alloying elements are Copper, Magnesium, Manganese, Silicon andZinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of Aluminiumisusedforwroughtproducts,forexamplerolledplate,foilsand extrusions. Cast Aluminium alloys yield cost effective products due to its low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast Aluminium alloy system is Al-Si, where the high levels of Silicon (4.0% to 13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required. Wrought Aluminium alloys are used in the shaping processes: rolling, forging, extrusion, pressing, stamping. Cast Aluminium alloys are come after sand casting, permanent mould casting, die casting, investment casting, centrifugalcasting, squeeze casting and continuous casting. Aluminium alloys are classified as shown in Figure 1.

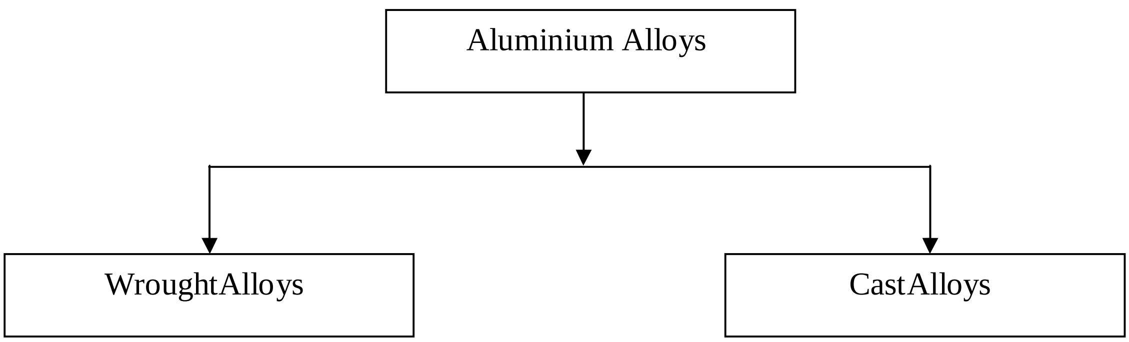

Figure 1 ClassificationofAluminium Alloy

Physical and thermal properties of Aluminium alloy 7075

Table 1Physical properties of Aluminium alloy 7075

Physical properties	Unit
Melting Point	Approx. 635°C
Modulus of Elasticity	70-80 GPa
Poisson's Ratio	0.33
Density	2.81 gm/cm^3

Thermal properties

Co-efficient of Thermal Expansion (250°C) is 25.2µm/m°C
Thermal Conductivity: 130W/mK

Stir casting

Stir casting set-up mainly consists a furnace and a stirring assembly as shown in Figure 2. In general,thesolidificationsynthesisofmetalmatrixcomposites involvesameltof the selected matrix material followed by the introduction of a reinforcement material into the melt, obtaining a suitable dispersion. The next step is the solidification of the melt containing suspended dispersions under selected conditions to obtain the desired distribution of the dispersed phase in the cast matrix. In preparing metal matrix composites by the stir casting method, there are several factors that need considerable attention, including the difficulty in achieving a uniform distribution of the reinforcement material.

- Wettability between the two main substances.
- Porosity in the cast metal matrix composites.
- Chemical reactions between the reinforcement material and the matrix alloy.

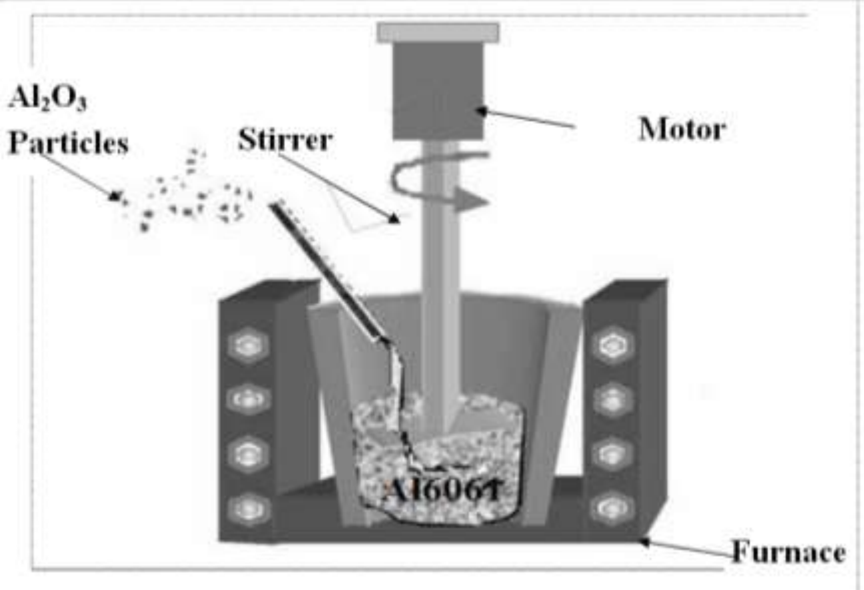

Figure 2 Stir casting process.

In order to achieve the optimum properties of the metal matrix composite, the distribution of the reinforcementmaterialinthematrixalloymustbeuniform and thewettabilityorbonding between these substances should be optimized. The porosity levels need to be minimized.

Objective:

- Study the Mechanical Properties of Al7075 with Al7075 Reinforced with Nano and Micro Particles of Al_2O_3 at Varying Percentage Via Stir Casting Route.

Methodology:

Preparation of samples

In this study, Al7075 Aluminium alloy is used as the matrix material while micro and nano particles of Al_2O_3(aluminia) 1.5wt%, 3wt% and 4.5 wt. % of each are used as the reinforcements. The average size of micro and nano Al_2O_3particles are supplied by nanoshellare 40µm and less than 70nm respectively. For manufacturing of the MMCs, 1.5wt%, 3wt% and 4.5 wt. % of micro and nano Al_2O_3particles are used. The stir casting furnace is used for producing the MMC composites. Initially, Al7075 alloy charges into the crucible and heated to about 900°C, which is above the liquidus temperature of the Al alloy. Then, the mixer is lowered into the melt slowly to stir the molten metal. The micro and nano Al_2O_3particles arepreheated in muffle furnace at temperature of 900°C for aperiod of 1 to 3 hours before being mixed with the Al alloy melt. The reinforcement particles feed into the molten metal manually by a spoon. After the completion of particle feeding, the mixing is too continued for further 15 min. Then the molten mixture is poured in the pre-heated mould. The casting billets are of 120 mm height and ϕ12 mm diameter.

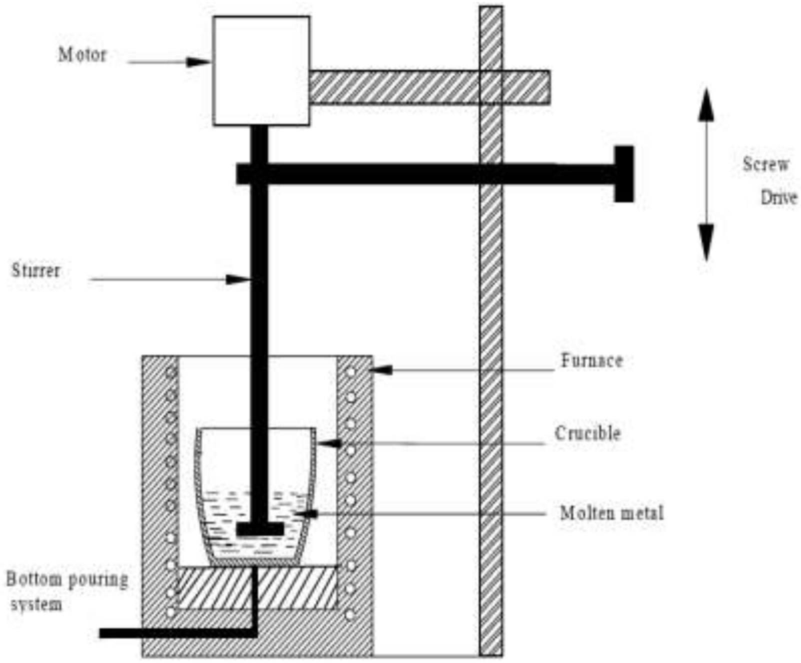

Figure3Graphicalrepresentationofstircasting

Mechanical Testing:
Tensile Strength

The tensile test is generally performed on flatspecimens. The dimension of the specimen is ϕ12mm diameter and 30mm lengthand a uniaxial load is applied through both ends.

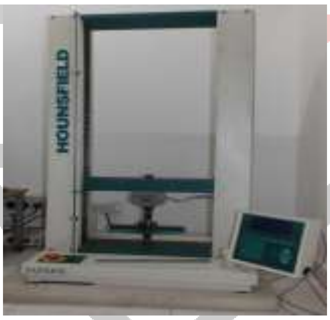

Figure 4Universal Testing Machine

In the present work, this test is performed on the universal testing machine Hounsfiled H25KS (Figure 4) at a crosshead speed 5mm/min and the results are used to calculate the tensile strength of composites materials. The test is repeated three times on each composites type and the mean value is reported as the tensile strength of that composites.

Tensile strength test

The tensile tests are used to assess the mechanical behavior of the composites and matrixalloy.Thecompositeandmatrixalloyrods aremachinedtotensile specimens with a diameter of Φ12 mm and gauge length of 60 mm and 50mm clamping length. Ultimate Tensile Strength (UTS) is the maximum stress that a material can withstandwhilebeingstretchedorpulledbeforenecking,whichiswhenthe specimen's cross-section starts to significantly contract.

Table2 Comparison of tensile strength and %age elongation

Composite composition	UTS(MPa)	Elongation(%)
Al7075	220	6.21
Al7075 + 1.5% Al_2O_3 (Micro)	225	5.34
Al7075 + 3% Al_2O_3 (Micro)	241	4.81

Al7075 + 4.5% Al_2O_3 (Micro)	253	3.97
Al7075 + 1.5% Al_2O_3 (Nano)	233	5.07
Al7075 + 3% Al_2O_3 (Nano)	242	4.71
Al7075 + 4.5% Al_2O_3 (Nano)	240	4.02

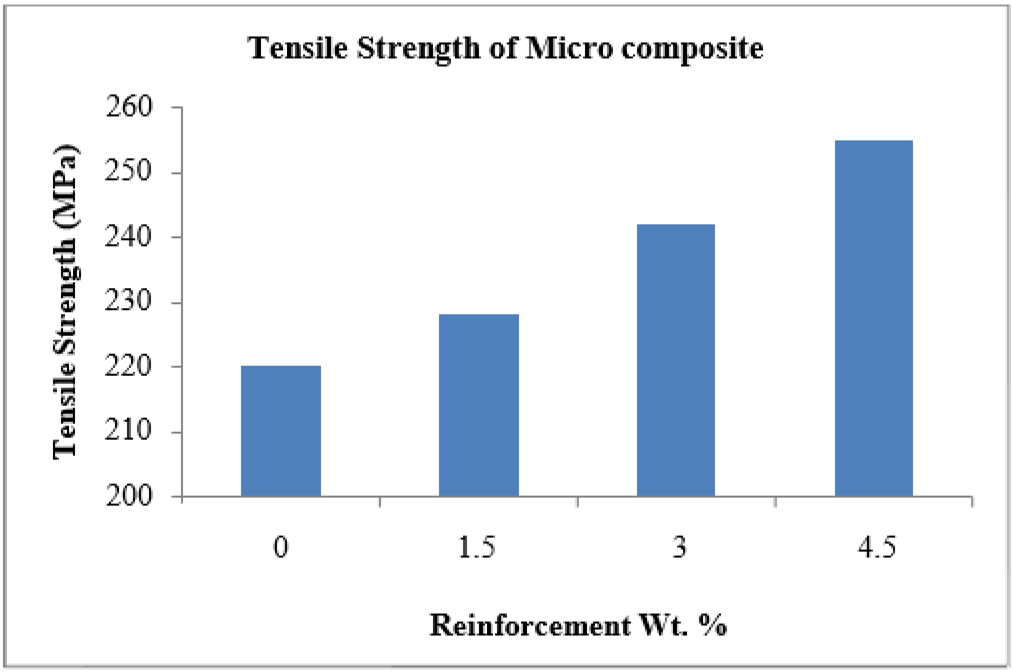

Figure 5 Tensile strength of composite with wt. % variation of micro Al_2O_3

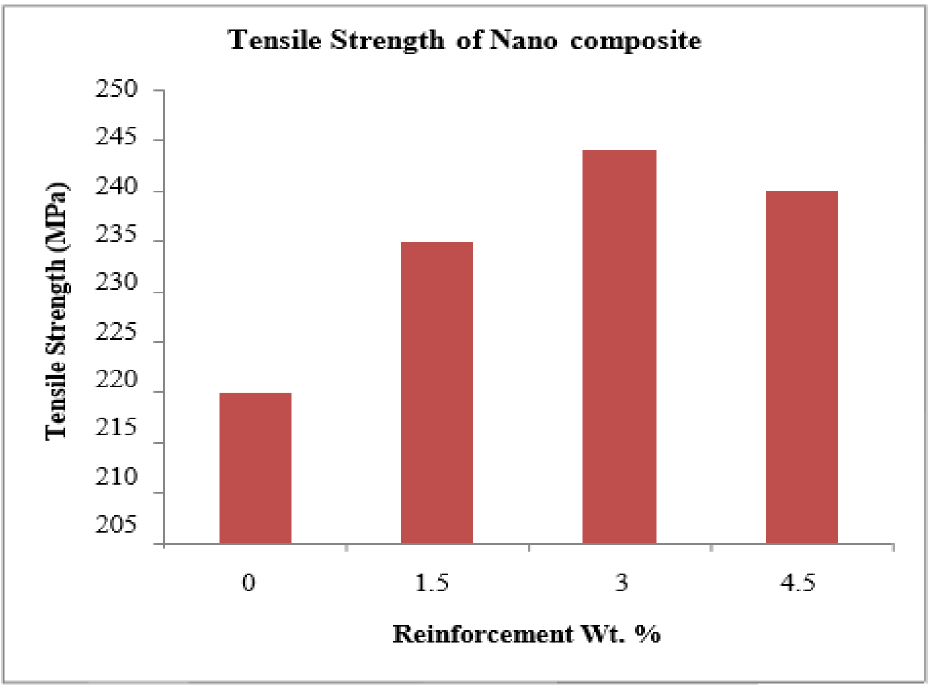

Figure 5 Tensile strength of composite with wt. % variation of nanoAl_2O_3

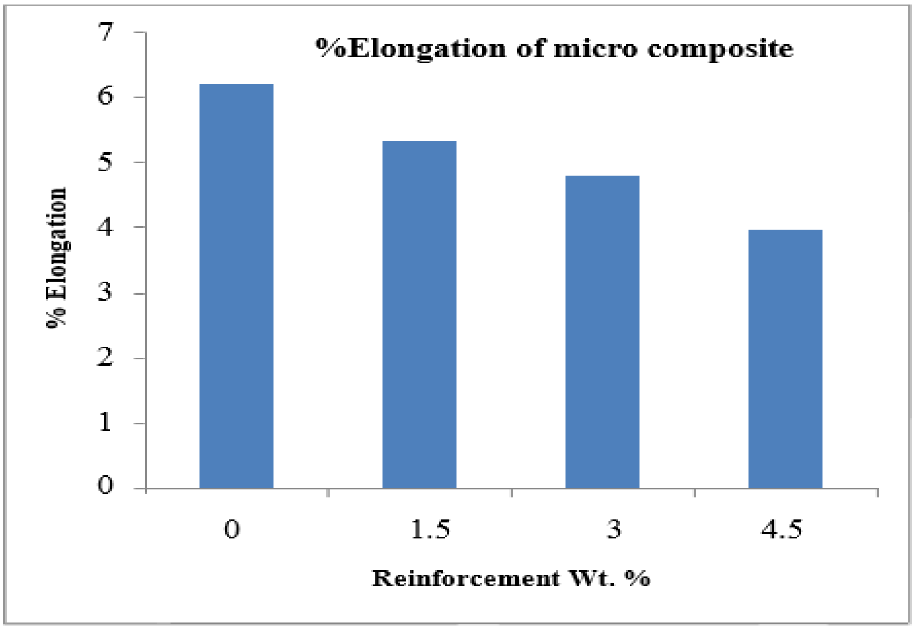

Figure 6 %Elongation of composite with wt. % variation of Micro Al_2O_3

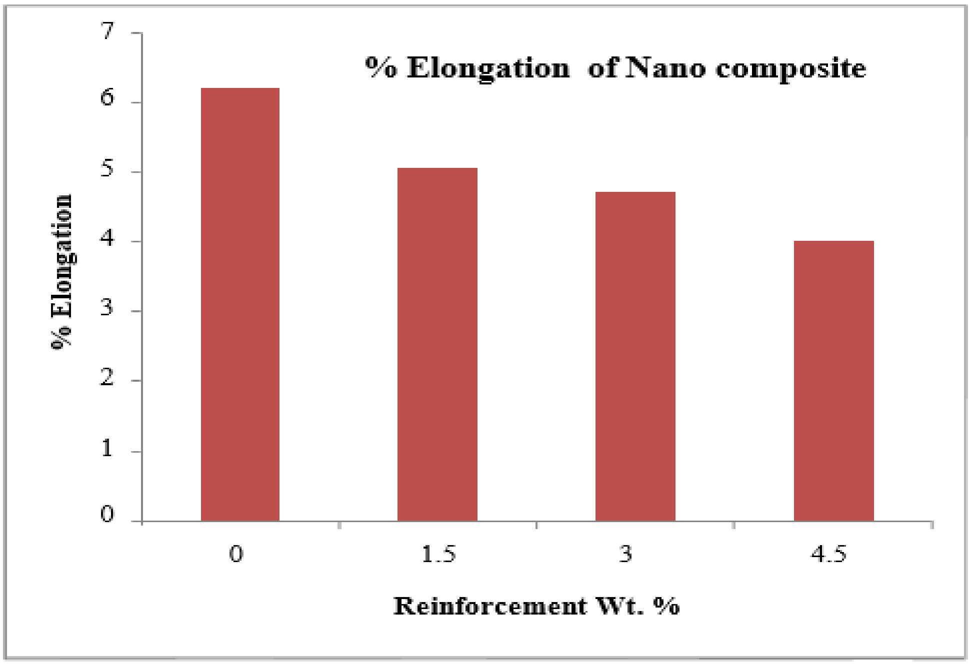

Figure 7 %Elongation of composite with wt. % variation of nanoAl_2O_3

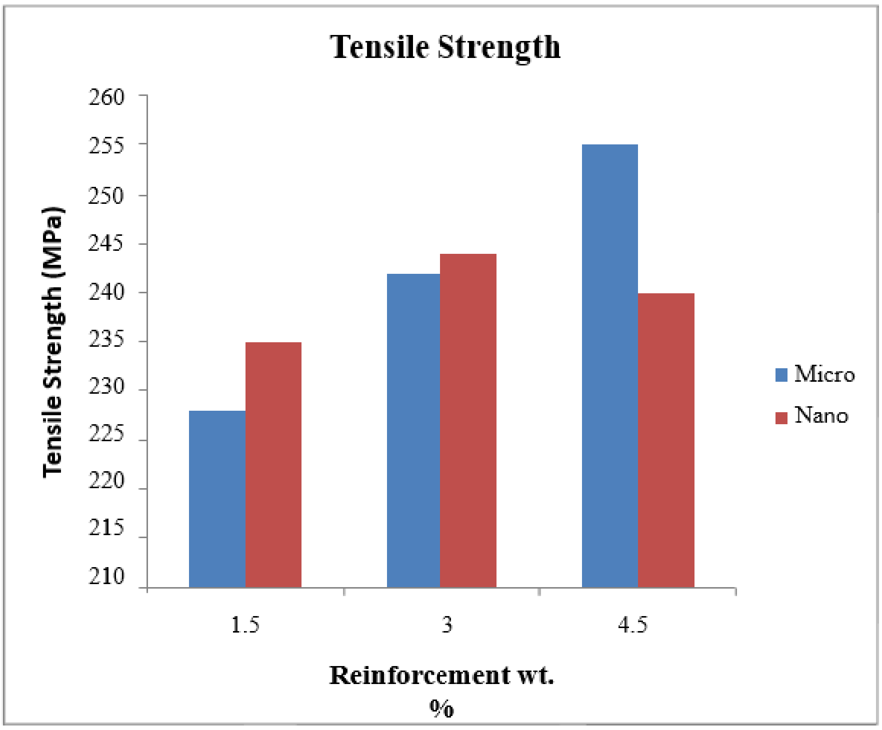

Figure 8 Comparison of ultimate tensile strength micro and nano composites

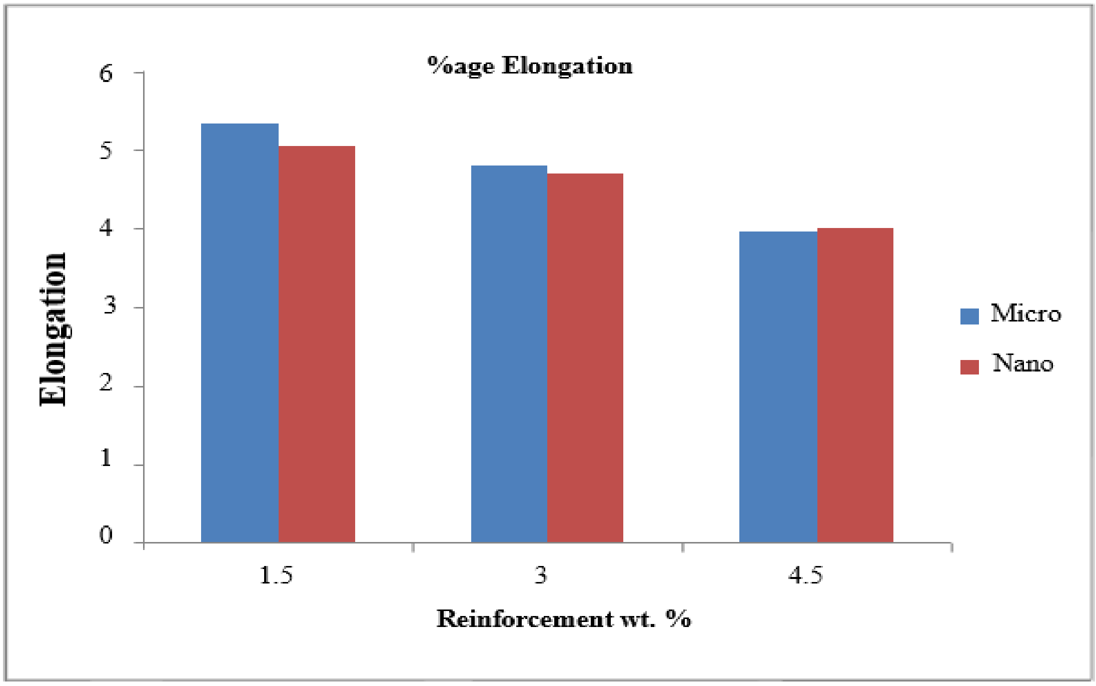

Figure 9Comparison of %age elongation formicro and nano composites

Figure 4, 5 show variation of tensile strength with increase in percentage of Al_2O_3particulates.Tensile strength of the micro composite material increases as the content of Alumina particulates increase from 0 to 4.5 wt. %. It is observed that the tensile strength of the micro composites are higher than that of their base matrix it is also observed that the increase in the filler content contributes in increasing the tensile strength of the composite. Also from the Figure 8 it is observed that the tensile strength of the Al7075- Al_2O_3nanocomposites is higher than that of the micro composites up to 3 Wt.% ,dew agglomeration of the nano particles in the composite occurs at higher Wt. % of the reinforcement results decreasein the tensile strength.

As the percentage of reinforcement increases in Al7075 thetensile strength also increases but ductility decreases. The reduction in ductility can be attributed to the presence of ahard ceramicphasethatisprone tolocalizedcrackinitiation and increased embrittlement effect due to local stress concentration sites at the reinforcement matrix interface.

Rockwell 574 Hardness Tester

The Rockwell 574 Hardness Tester is used for checking of the hardness of the composite samples are made of minimum thickness of ϕ12mm diameter. And Rockwell 574 hardness tester is used for hardness calculations, 100kgf is indentation loadused with 1/16 inch diameter (1.588mm) of indenter and tests conducted withsteel sphere indenter. LCD display showed the harness results.

Figure 10Wilson hardness tester

Hardness test

Hardness is considered as one of the most important factors that govern the wear resistance of any material. The determination of the Rockwell hardness of a material involves the application of a minor load followed by a major load. The minor load establishes the zero position. The major load is applied, then removed while still maintaining the minor load. The depth of penetration from the zero datum is measured from a dial, on which a harder material gives a smaller number. That is, the penetration depth andhardness areinversely proportional. Thechief advantage of Rockwell 574 hardness tester is its ability to display hardness values directly. Rockwell 574 Hardness Tester was used for checking of the hardness of the composite samples and values are directly shown on LCD in HRB scale.

Table3 Comparison of Hardness

Composite composition	**HRB**
Al7075	46.50
Al7075 + 1.5% Al_2O_3 (Micro)	52.72
Al7075 + 3% Al_2O_3 (Micro)	55.53
Al7075 + 4.5% Al_2O_3 (Micro)	57.61
Al7075 + 1.5% Al_2O_3 (Nano)	53.33
Al7075 + 3% Al_2O_3 (Nano)	57.64
Al7075 + 4.5% Al_2O_3 (Nano)	58.81

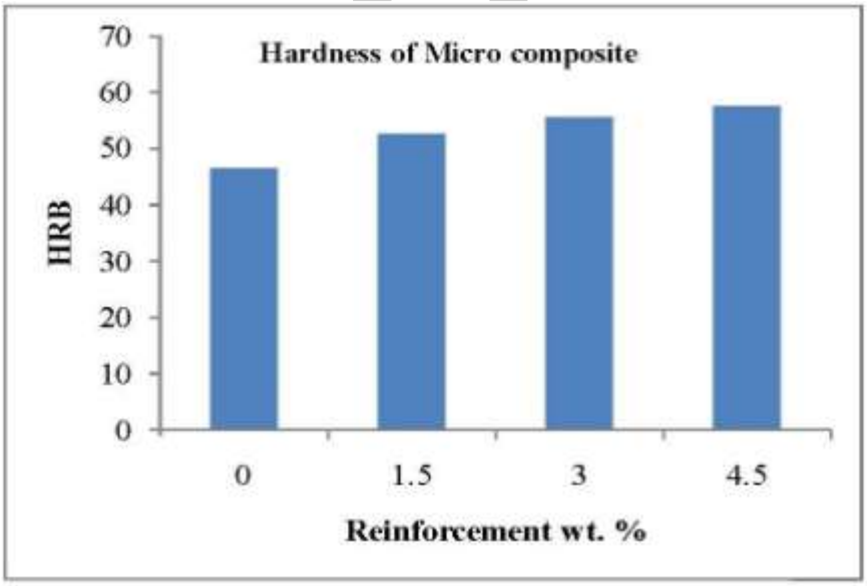

Figure 11 Hardness of composite with wt. % variation ofMicro Al_2O_3

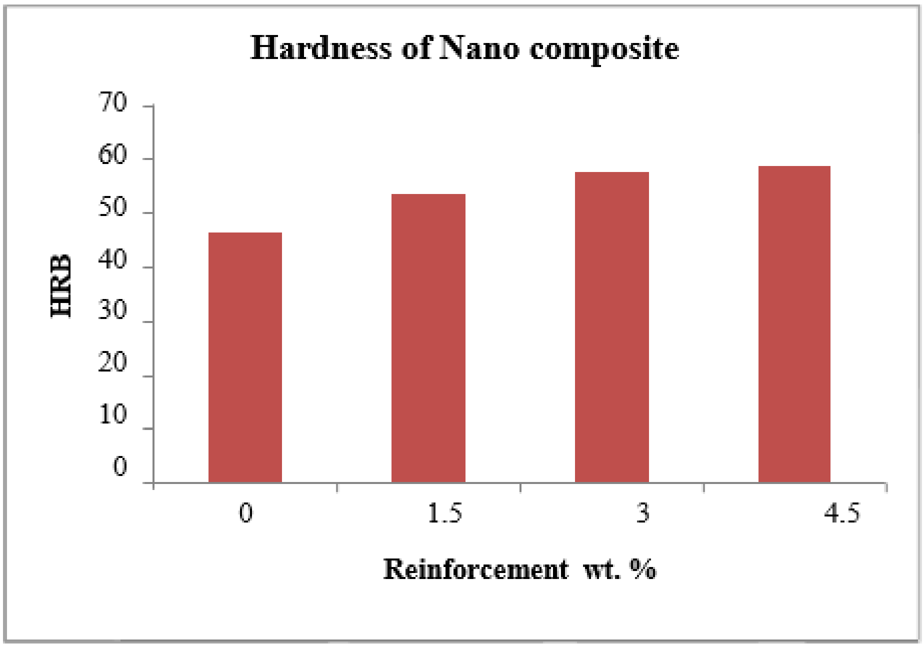

Figure 12 Hardnessof composite with wt. % variation ofNano Al_2O_3

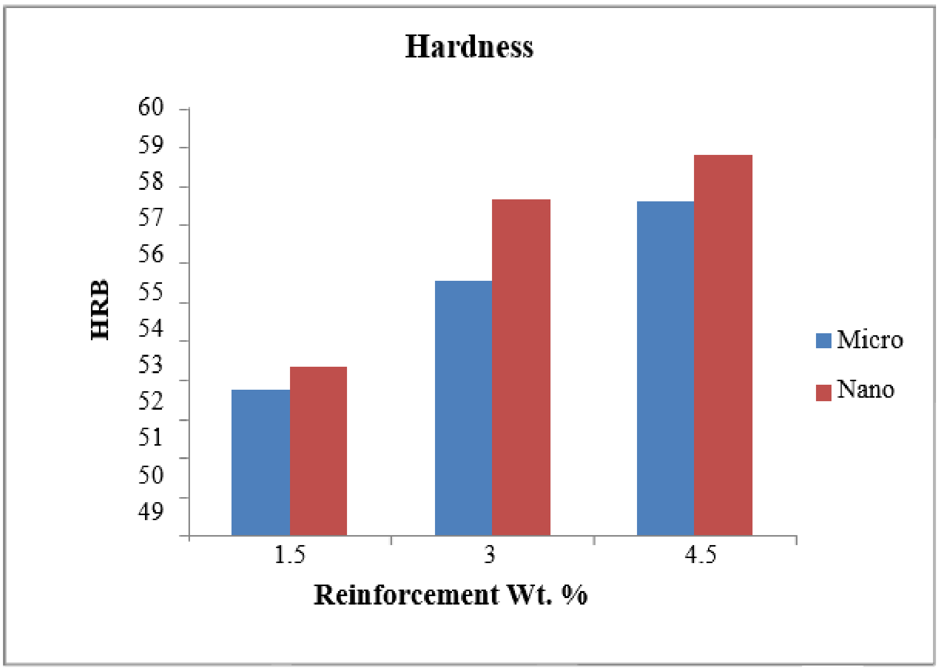

Figure 13 Comparison of Hardness micro and nano composites

It is observed that the hardness of the composite is greater than that of its cast matrix alloy. The composites containing higher filler content exhibits higher hardness. Hardness of the Al7075–Al_2O_3composite material increases as the content of Al_2O_3increases from 0 to 4.5 wt. %. The improvement in the hardness can be attributed to the fact that the Al_2O_3possess higher hardness and its presence in the matrix improves the hardness of the composite.

Conclusions:

1. Hardness & Tensile strength ofthe composites are found to be higher than that of basematrixwhile%ageelongationdecreasesastheweightpercentageof reinforcement increases.
2. It has been concluded that nano composites are better in hardness, tensile strength and specific wear rate. It is also observed that micro and nano composites have better wear resistance than Al7075.

Scope for Future Works

1. Some MMCs can be manufactured by using other manufacturing techniques like powder metallurgy etc. and particles

size can be further varied and then results can be compared with stir casting technique.

References:

[1] G.S. Kataiaha, Dr. D.P.Girish(2016)" The mechanical properties &fractography of Aluminium 6061 – TiO_2 composites", "International Journal of Pharmaceutical Studies and Research" E-ISSN 2229-4619, 9-12, Vol 3.

[2] Indumati B.Deshmanya, Dr. G.K. Purohit(2012) "Modelling tensile behavior of stir cast AMCs using factorial design of experiments", "Chemistry and material research" ISSN 2224-3224 Vol 2 No 1.

[3] K.Gunasekaram, D.M.Akalam, S.S. Anandbabu, N. Deepak kumar, D. Arunprasath(2016) " The effect of various reinforcement on Aluminium alloy (Al7075) – A review" , "ICSSLCET" , Vol. : 02 , ISBN : 978-81-929866-6-1.

[4] L. Ceschini (2006) "Tensile and fatigue properties of the AA6061/20% volume Al_2O_3 and AA7005/10% volume Al_2O_3 composites", "Composites Science and Technology" 66, 333–342.

[5] M. Kok,(2005) "Production and mechanical properties of Al_2O_3 particle-reinforced 2024 Aluminium alloy composites", "Journal of Materials Processing Technology" 161, 381–387.

[W1] http://en.wikipedia.org/wiki/Aluminium

[W2] http://www.alueurope.eu/about-Aluminium/properties/

[W3] https://www.researchgate.net/