



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

 ijirset@gmail.com

 www.ijirset.com

Investigations on Mechanical behavior of Al6061 - Redmud Composites

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ABSTRACT: The paper is the result of investigations made on microstructure and mechanical behavior of 2.5, 5, 7.5, and 10 weight percentage of nano sized Red mud particulate reinforced to Al6061 alloy composites. Al6061 matrix composite having Red mud was fabricated by liquid stir casting method. The microstructure of the composites was examined by scanning electron microscopy. Further, mechanical behavior of Al6061 alloy, Al6061-2.5, 5, 7.5 and 10 wt. % Red mud composites were studied. Tensile properties like hardness, ultimate tensile strength; yield strength, percentage elongation and compression strength were evaluated as per ASTM standards. Micro structural observation revealed uniform distribution of Red mud particles in the matrix. The analysis disclosed hardness, ultimate tensile strength, yield strength and compression strength of composites increased due to increase in percentage of nano boron carbide particles and percentage elongation of the composites decreased with increase in Red mud particulates in base alloy matrix.

KEYWORDS: Al6061 Alloy, Redmud Particulates, Ultimate Tensile Strength, Yield Strength, Stir casting, Percentage Elongation

I. INTRODUCTION

Aluminium based metal matrix composites (AMCs) have found greater applications in the field of automotive, aircraft industries owing to their low density and concomitant high wear resistance, strength, corrosion resistance, stiffness and thermal conductivity [1, 2]. AMCs are fabricated by incorporating micro and nano sized ceramic particles, such as SiC, Al₂O₃ and B₄C, into the aluminium matrix. Boron carbide is a superior reinforcement material due to its high hardness, low density, high strength, high wear and impact resistance, high melting point, low coefficient of thermal expansion and good chemical stability [3]. Pankaj et al. synthesized the A356-B₄C (4 wt %) and graphite particulate metal matrix composite by stirring process and reported that hardness was higher in case of 7.5wt. % of Red mud and shown improvements in ultimate and yield tensile strength with addition of Red mud and graphite particulates [4]. Krishna Dama et al. investigated the effects of adding micro size Red mud particles to ZA27 alloy on the mechanical properties, observed that the hardness, ultimate tensile strength and yield strength of alloy increased as the level of addition of B₄C particulates increased in steps of 2.5wt. %, 5wt. %, 7.5wt. % and 10wt. %. Further, researchers concluded that the percentage of elongation decreased for the same % wt. with the addition of Red mud [5]. Several methods are currently used to fabricate the metal matrix nano composites (MMNCs), viz mechanical alloying [6, 7] high-energy ballmilling [8], spray deposition, powder metallurgy, nano-sintering and various casting techniques [9]. The conventional mechanical stir casting method can be used to disperse Red mud particles in molten aluminium without agglomeration and clustering. Recent studies, Jiang et al. investigated for the best anticorrosive property by preparing and characterizing nickel Red mud composite coating, Harichandran et al. investigated the mechanical properties of Red mud particle reinforced aluminium metal matrix composites and stated ductility, impact energy were better with Red mud reinforcement along with significant increase in wear resistance up to 10% of Red mud. Further researchers like A. Alizadeh, Morteza etc., have investigated the influence of nano particles reinforcement on the mechanical and microstructural properties of MMC's. The present research work is aimed to investigate the mechanical behavior of Al6061 alloy with 2.5, 5, 7.5 and 10 wt. % Red mud composites.

II. EXPERIMENTAL WORK

A. *Material:* The current study used Red mud as reinforcement and Aluminium 6061 as matrix material with chemical composition (using optical emission spectrometer-BAIRD - DV 6E) as shown in the table 1 below.



Table 1: Elemental composition of Al6061

Elements	Al +	Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Sn	Ti	Cr
percentage by wt	Rem	1.22	2.20	0.09	0.16	0.05	0.01	4.62	0.02	0.02	0.06	0.24

B. Preparation of Al6061– Red mud Composites:

The nano composites containing 2.5, 5, 7.5 and 10 wt. % Red mud particulates were prepared from two step stir casting process technique. Initially the required amount of nano Red mud and the cast iron die are preheated to a temperature of 300°C-400°C. On the otherpart, the calculated amount of Al6061 was weighed and placed in a graphite crucible inside an electricfurnace and heated to temperature of 750°C. After the complete melting of Al6061, the degassingpowder known as Solid HexaChloro Ethane (C2Cl6) [10] is introduced into the molten melt so that the unwanted adsorbed gases are forced out from the melt. The molten melt is disturbed by dipping azirconium coated mechanical stirrer to form a clear vortex by stirring mechanism at a speed of 300rpm. Once the vortex is formed then the preheated nano ceramic particles along with the proper proportion ratio of K2TiF6 is introduced into the molten melt in steps of two stages by a constant feed rate, which involves in dividing the entire weight mixture of Red mud and K2TiF6 in two equal weights. At every each stage the continues stirring process is carried out before and after the pouring of mixture of Red mud and K2TiF6 to avoid clustering of particulates and to have uniform homogenous distribution of particulates in the melt. After continues stirring, the entire molten metal was poured into preheated cast iron die. The prepared nano composites were machined as perthe standards for characterization purpose.

Sener Karabulut et al [1]: The hardness, TRS (transverse break quality), also prolongation conduct technique for AA7039 strengthened for particulates of SiC, Alumina, REDMUD were investigated to clarify those impact of reinforcement substance. 3 composite AA7039 reinforced with 10% wt. of Redmud, REDMUD, Sic produced with solid metallurg technique.

Hardness, elongation, drilling behaviour, TRS tested for above composites. Useful interfacial holding might have been attained between Aluminium alloy7039, reinforced component. AA7039 composite strengthened with Redmud for 10% exhibited results with elevated hardness, elongation, TRS, prolongation among investigated examples. Crack surface dissection revealed uncovered cracks on crack surface for AA7039/REDMUD, 7039/SiC. The Redmud-reinforced composite exhibited better bonding against with the REDMUD, Sic reinforced composites. Better surface was achieved for AA7039/Redmud composite for drilling. Chip formation was affected by mechanical & morphological properties of work materials.

K. Umanath et al [2]: This paper displays those wear self-destructive considerations and conduct from claiming Al6061-T6 discontinuously fortified with silicon carbide (SiC),aluminum oxide (Redmud) composite. ASTM standard specimens were prepared. Those examinations conducted utilizing an pin for circle wear analyzer. Experimental connection to estimate wear, utilizing variance analysis (ANOVA), statistical analysis were done. The Outcomes demonstrated that the wear safetyof the 15% mixture composite is superior to that of the 5% composite. Those crack surfaces for composites indicates ductile tear ridges and cracked Redmud particles demonstrating both flexible, fragile crack system.

T. Rajmohan et al [3]: Hybrid metalgrid composites comprise about three constituents-a metal or a compound grid, two reinforcements on different forms, fortified together in atomic level in composite. In spite of their higher particular properties of quality, stiffness, those non homogeneous, anisotropic way joined together with abrasive reinforcements render their machining difficulty. In this work, surface integument of machining drilled hybrid composites been examined. Penetrating tests in changing shaft speed, bolsterrate, different drill materials.

will investigate impact for distinctive cutting parameters related to surface, level of deformity for penetrated surface due to infiltrating.. Materials utilized for examination were Al356/10SiC (wt %) metal grid, Al356/10SiC-3mica (wt%) mixture composites. The composites are created utilizing stir casting. Drilling tests on CNC center utilizing carbide, polycrystalline jewel (PCD) drills were done .Surface unpleasant for raising shaft speed reduces, increases with increasing feed rate. Machined surface is analyzed by electron microscopy (SEM). SEM pictures of the machined surfaces show the vicinity for grooves also pits. Micro hardness profiles demonstrate that those subsurface harm will be restricted to the top of 100-250 µm.

M. Ramulua et al [4]: Metal grid composites been found quite advantageous in number of engineering applications including the purchaser merchandise. However, machining these materials will be extreme because of abrasive qualities of reinforced particulates. In this study drilling investigations on Redmud aluminum-based MMC have been directed by utilizing diverse drills (high-speed steel, carbide-tipped, and polycrystalline jewel (PCD) drills) to process holes in 10%, 20% volume (Redmud)p/6061. Those drilling strengths were recorded utilizing dynamometer. Surface finish assessed by surface profilometer. Tool wear geometry inspected utilizing optical SEM. Those penetrating forces were assessed in terms of drilling forces, chip formation, drilled-hole nature, tool wear. It might have been discovered that PCD drills outperformed the greater part different drills as far as drilled-hole quality with less force. Exceptional outcomes attained with those PCD drills in line with other comparative investigations for other methods.

A.Pramaniket al [5]: Surface integrity, machining forces, friction angles, chip formation, shear, are significant elements to understand machinability about metal grid composites (MMCs). However, due to those complexity of reinforced components for ceramic particles, an unreasonable appraisal of the machinability about MMCs will be still a troublesome issue. This work investigates tentatively the impacts of support particles on machining MMCs. The major discoveries are: (1) the surface remaining focuses on the machined MMC would be compressive; (2) the surface unpleasantness may be controlled by feed; (3) molecule pull-out impacts those unpleasantness at low feed; (4) particles encourage chip breaking and effects generation of residual stresses; and (5) shear, rubbing angles depend fundamentally for feed independent of speed.

K.M. Shorewardi et al [6]: Three aluminum metal grid composites considering supporting particles for SiC, Redmud, REDMUD (0-20 %) Volume changed. The stir-molding process taken after high temp expulsion was been utilized, always a standout around expense compelling mechanical systems. An adequate interfacial reaction product or layer might have been viewed throughout Al-SiC interface for components held for more than 30 minutes. No reaction result might have been viewed Previously, Al-Redmud likewise Al-Boron carbide interfaces throughout the determination of SEM. On the diverse hand, two discretionary phases (alumina stage holding boron, aluminium, carbon) were found in the aluminum grid away from interface over Al-REDMUD components. Beginning with split surface analysis, the composite showed up remarkable interfacial considering contrasted for remaining composites.

Sener Karabulut et al [7]: AA7039/Redmud MMCs were generated from powder metallurgy, impact for milling parameters on surface unpleasantness, cutting force utilizing a uncoated carbide embed were investigated. Those processing tests were performed by Taguchi configuration utilizing L18, 21 x 32 with blended orthogonal array. Those impacts of cutting elements on surface unpleasantness, cutting force, were dictated utilizing variance analysis (ANOVA). Those dissections comes about indicated that material structures have been powerful element for surface unpleasantness, while feed rate might have been the prevailing element influencing cutting energy. Surface unpleasantness qualities were essentially progressed between 196% and 312% in milling, Redmud particle-reinforced. Aluminum compound composite in contrast with AA7039 aluminum. ANN regression investigation was applied for anticipating surface unpleasantness and cutting drive. ANN might used to foresee surface unpleasantness, cutting energy for mean squared slip equivalent to 2.25%, 6.66% individually

A. Baradeswaran et al [8]: This study investigated individual effect for red mud on wear activity for Al 7075-Redmud-5%wt red mud mixture composite. The individual's examination uncovers the invariability of red mud in composite for gaining wear reduction.

Al6061 strengthened to Redmud-red mud were investigated. Those work material produced with liquid metallurgy span. Ceramic particles with strong lubricating materials were joined with aluminium alloy to decline wear resistance, coefficient of friction. Al6061/Redmud/red mud mixture composite could have been primed for 5% red mud particles, 2, 4, 6, 8 wt.% about Redmud. Those hardness, flexible strength, flexural caliber, compressive strength of Al6061-Redmud-red mud mixture composites was increased with increased weight percentage for ceramic phase. Wear properties for mixture composites considering red mud exhibited excellent wear-resistance properties.

T. J. A. Doe1 et al [9]: This study investigated tensile examination for room heat situation for MMCs, on Al6061 alloy of reinforcement SiC for three apparent sizes 5, 13, 60 pm. Above grid agedness states were studied, peak aged, equivalent underaged, overaged matrix condition based on micro harnesses timations. Those effects from agedness state on the flexible properties of the composites were on unreinforced material. Composites considering 5 pm, 13 pm particles both required a greater amount staggering 0.2% confirmation anxiety in addition

unbending nature qualities again unreinforced matter. Composite specimen reinforced to 60 pm element obliged decrease 0. 2% confirmation tension In addition unbending nature in the under aged also peak time of reptiles condition. An additional staggering 0.2% stress in averaged form contrasted for individuals robust compound. Every single standout amongst composites necessary cut down pliability again the unreinforced material, to the material considering 5 pm SiC continually adaptable in addition that reinforced for 60 pm SiC facilitating inside and out low ductility. Failure appears to be will happendue to inner part damage withparticles fracture. Such harm initiates voids which create additionally prompt reduced pliability again these composites. Broad 60pm particles split undoubtedly to low associated stresses, provoking diminished 0. 2% confirmation tension and premature frustration contrasted for exchange composites. Little 5 besides 13pm particles harm few simply, subsequently those specimen might tough over those robust material.

A. Saravanakumaret al[10]: This displaywork, antest examination is made on the impact for shaft speed, feed rate, wt % of alumina molecule in reducing surface unpleasantness throughout drillingfor Al6061-Redmud-Grmixturecomposite. Tincoveredstrongcarbideboringapparatus

fromclaiming 6 mm breadthwill be utilized for penetrating thosecomposite. Taguchi'stest plan particular idea may be utilized for upgrading the outline parameters for three levels to finer surface finish. The test conclusions, microstructure for machined surface uncover that the penetrated tests toward least feed rate demonstrates superior execution around surface unpleasantness. Thewt %foraluminaalso need itsimpact onminimizings urfaceunpleasantness emulated by spindle speed same time penetrating the created specimens.

III. METHODOLOGY

The fabrication of Al6061-Redmud composites will be carried out by liquid metallurgy route via stir casting technique. The major components of the casting process consist of electrical resistance furnace; zirconium coated steel impeller and cast iron permanent mould. The power rating of electrical furnace will be 60kw and maximum temperature limit is 1200 degree Celsius. The mechanical stirrer used for stirring the molten alloy during the preparation of composites with high temperature and to prevent migration of ferrous ions from the stirrer material into Al6061 alloy melts.

Calculated amount of the Al6061 alloy ingots are charged into the furnace for melting. The melting point of Aluminium alloy is 660 °C. The melt superheated to a temperature of 750 °C. The temperature will be recorded using achrome-alumel thermocouple. The molten metal is then degassed using solid hexachloroethane (C2Cl6) for 3 min. A stainless steel impeller coated with zirconium is used to stir the molten metal to create a vortex. The stirrer will be rotated at a speed of 300rpm and the depth of immersion of the impeller was 60 percent of the height of the molten metal from the surface of the melt. Further, the Redmud particulates are preheated in a furnace upto 300°C will be introduced into the vortex. Stirring is continued until interface interactions between the reinforcement particulates and the matrix promotes wetting. Then, Al6061- 2.5,5 and 10 wt. % Redmud mixture are poured into permanent cast iron mold having dimensions 125mm length and 15mm diameter.

The micro structural study was carried out on the investigating composites using scanning electron microscope and EDS. Samples around 15 mm diameter cut from the castings and are polished properly. Keller's reagent is used to etch the samples. Further, based on the microstructural study compression, fatigue and wear properties are evaluated as per ASTM standards.

IV. EXPERIMENTAL RESULTS

TENSILE STRENGTH

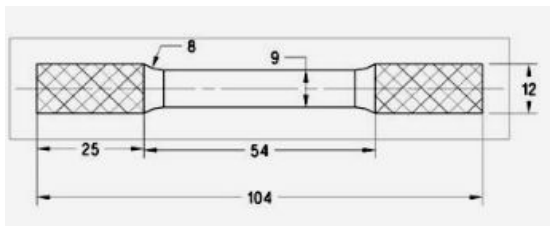


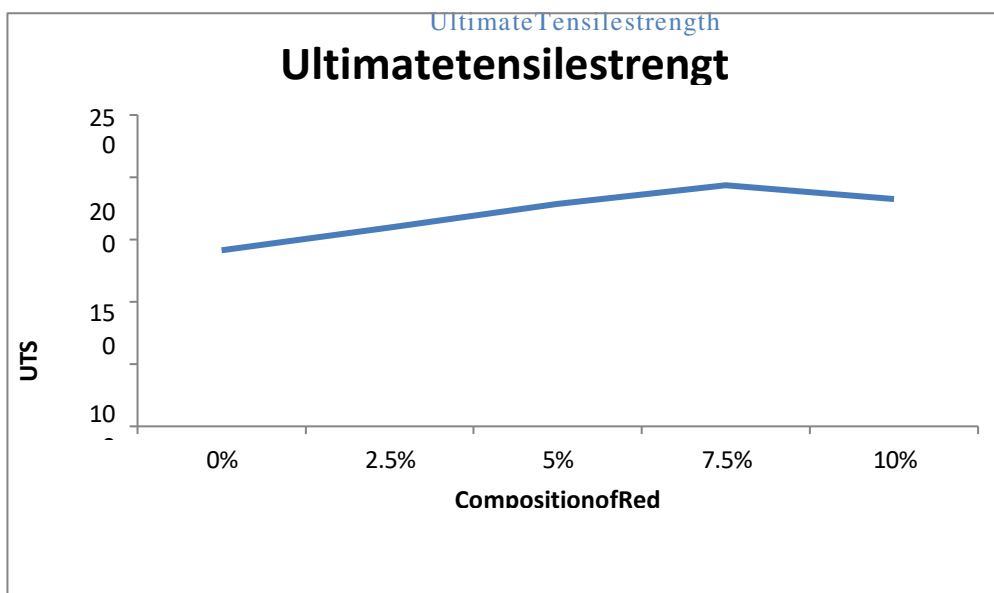
Figure 1: Tensile specimen and its dimensions in mm.



Table 1: Shows the tensile result

Sl. No.	Sample	UTS (MPa)	YS (MPa)	% Elong
1	Al6061 Alloy	141.38	121.3	13.18
2	Al6061-2.5% Redmud	159.85	139.25	12.23
3	Al6061-5% Redmud	178.91	148.24	11.08
4	Al6061-7.5% Redmud	193.5	158.47	10.11
5	Al6061-10% Redmud	182.6	147.3	10.04

ULTIMATE TENSILE STRENGTH



Graph1: showing the variations in ultimate tensile strength of 6061Al before and after addition of different wt. % of Redmud particulate

COMPRESSION STRENGTH

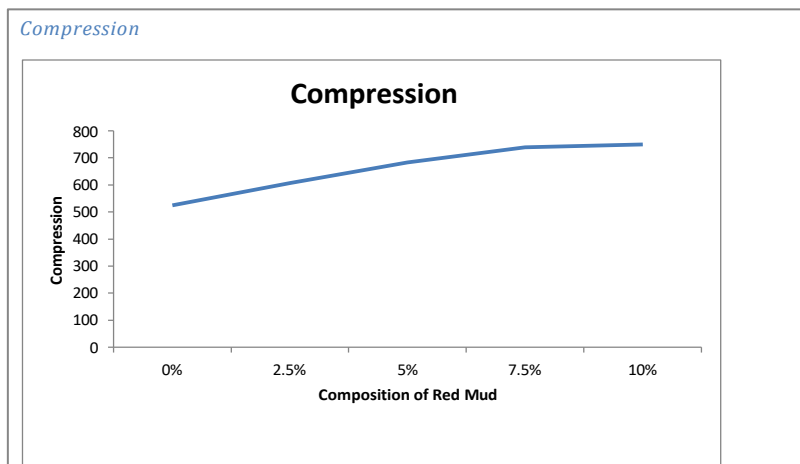
A majority of parts of structures, machines or devices are invariably subjected to uniaxial compression load. The behaviour of a material under simple uniaxial compression is called compression behaviour. The test performed for this purpose is referred to as compression test.

Among the various mechanical testing, compression testing is one of the most important and widely used. One can obtain important information concerning the materials ductile properties, the character and extent of plastic deformation, ultimate strength and toughness. The response of materials to other type of loading can sometimes be explained or predicted on the basis of their behavior under simple compression. So much information can be obtained from a single test justifies its extensive use not only in engineering materials research but also in engineering industries for quality control and design purpose. Different materials respond differently to uniaxial compressive forces. The compressive curves correspond to these responses have discussed in below:



Table2: Shows theCompression results

Sl. No.	Sample	CS (MPa)
1	Al6061 Alloy	480.16
2	Al6061-3% Redmud	553.28
3	Al6061-6% Redmud	625.76
4	Al6061-9% Redmud	686.96
5	Al6061-12% Redmud	699.03



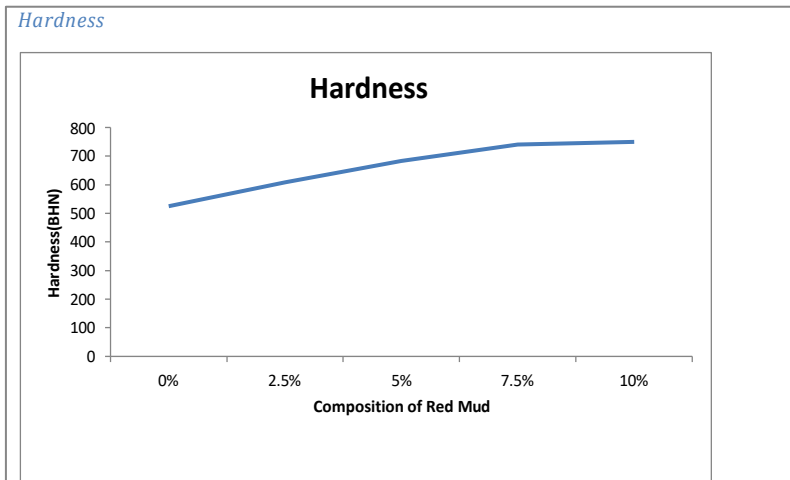
Graph2: showing the variations in Compression strength of 6061Al before and after addition of different wt. % of Redmud particulate

The compression strength of Al6061 alloy and various wt. % of Redmud composites. From the graph as weight percentage of Redmud reinforcement increases from 3 to 12 wt. %, This increase compression strength is mainly due to high compression strength of Redmud particulates. The compression strength of Al6061 alloy increased from 553.28 MPa to 699.03 MPa by adding 12 wt. % of Redmud particulates in the matrix.

HARDNESS STRENGTH

TABLE 3: Shows the hardness results

Sl. No.	Sample	BHN
1	Al6061 Alloy	53.18
2	Al6061-3% Redmud	60.26
3	Al6061-6% Redmud	71.36
4	Al6061-9% Redmud	79.64
5	Al6061-12% Redmud	77.36



Graph3: showing the variations in BHN of 6061Al before and after addition of different wt. % of Redmud particulate

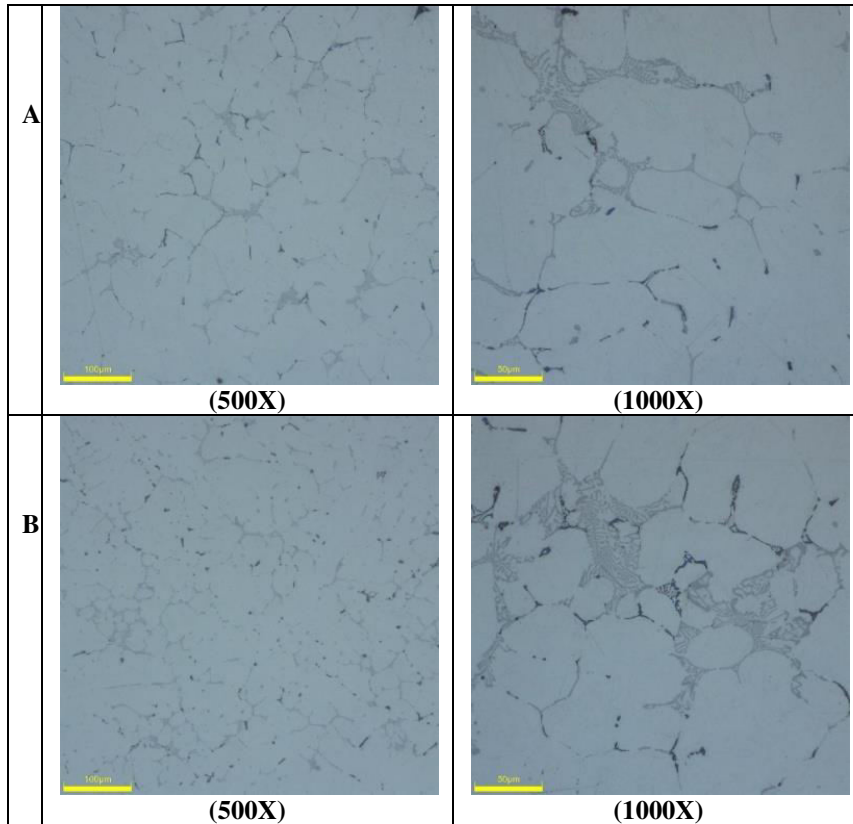
it is observed macro-hardness of increasing linearly with increase in weight percentage of Redmud particles. this may be attributed because of escalation in occurrence of hard Redmud particles in the aluminium matrix and high hardness of Redmud particles. incorporation of reinforcement particles in the aluminium matrix enhances their surface area and the size of aluminium matrix grains reduced. the occurrence of these hard surface areas of Redmud particles offers huge resistance to the plastic deformation which results into augmentation of the hardness of fabricated.

MICROSCOPIC ANALYSIS

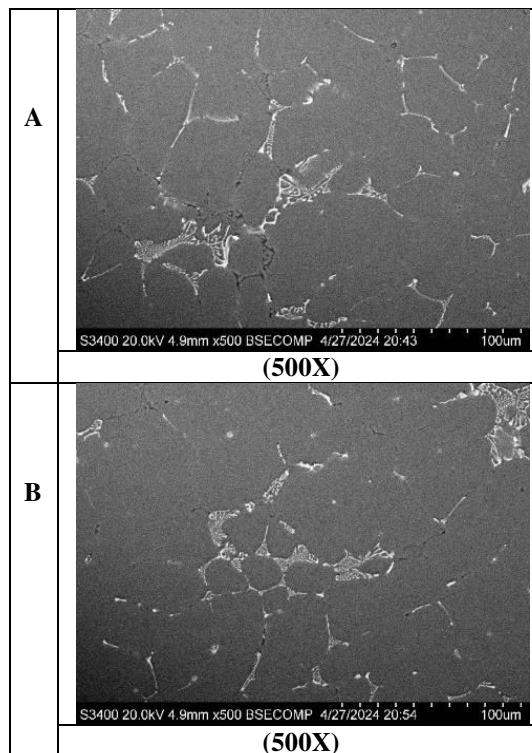
Microscope was used to examine the casted surfaces of the test samples. In present study, OLYMPUS Microscope BX51M with Clemex Image analyzer was used for the analyzing material characterization of surface of the materials. Microscopic images of different casted specimen such as 0%, 3%, 6%, 9% and 12 wt% of Redmud were analysed with a magnification of 1000X and 3000X.



Figure shows sample for Characterization analysis



SCANNING ELECTRON MICROSCOPE IMAGES



For both the composite rods, the microstructure shows the grain boundaries, interdendritic network of silicon nitride particles distributed in a matrix of aluminium solid solution throughout the structure. The composite reinforced with

silicon nitride in (b), also presents a microstructure without porosity with uniform distribution of the reinforcing phase (Redmud) and without the presence of agglomerations.

Energy dispersive spectrographs(EDS) of Al6061

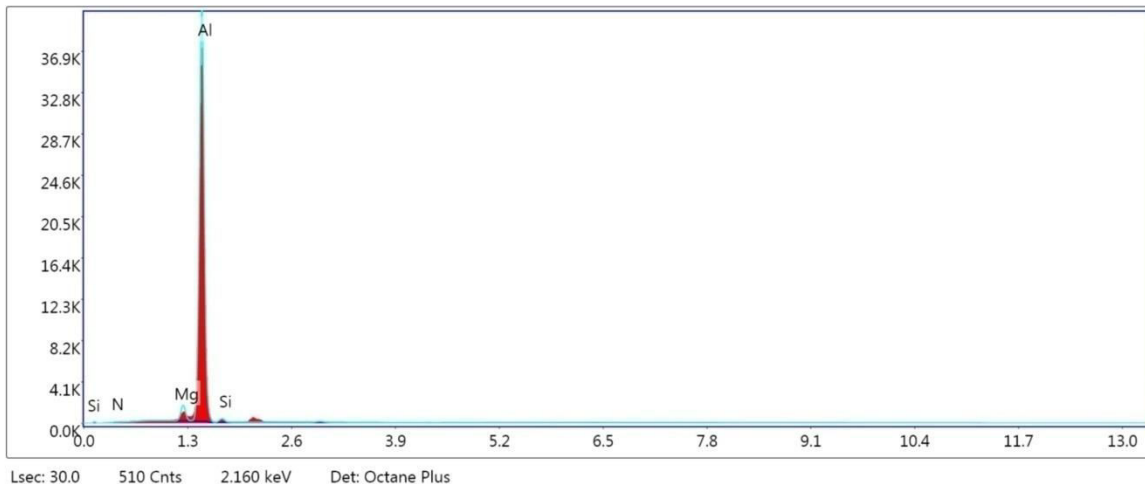


TABLE 4: Shows the EDS results of Al6061

Element	N	Mg	Al	Si
Weight (%)	0.11	2.17	96.51	1.20

V. CONCLUSION

The AMMC with different Weight fraction of silicon nitride is fabricated and various investigations were made.

- Hardness values of the components were found and the hardness of the component increases with the increase in Redmud percentage.
- Tensile strength has been increased at 2.5, 5 and 7.5 wt.% of Redmud, but when the percentage of Redmud is increased further to 10 wt.%, the tensile strength is decreased.
- The microstructure shows the grain boundaries, interdendritic network of aluminium oxide and silicon nitride particles distributed in a matrix of aluminium solid solution throughout the structure.
- There is increase in compression strength with addition of 6 and 9 wt. % Redmud particulates to base Al6061 alloy.

REFERENCES

[1] Abhishek Kumar, Shyam Lal, Sudhir Kumar “ Fabrication and characterization of A359/Al₂O₃ metal matrix composite using electromagnetic stir casting method” Noida Institute of Engineering and Technology, Greater Noida, Uttar Pradesh, India. 7 March 2013

[2] Oskouei , R.N. Ibrahim “An investigation on the fatigue behaviour of Al 7075-T6 coated with titanium nitride using R.H. physical vapour deposition process” Department of Mechanical & Aerospace Engineering, Monash University, Clayton, VIC 3800, Australia

[3] S.A. Sajjadi, H.R. Ezatpour, H. Beygi “Comparison of microstructure and mechanical properties of A356 aluminium alloy/Al₂O₃ composites fabricated by stir and compo-casting processes” Department of Material Science and Engineering, Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran

[4] XIU Zi-yang, CHEN Guo-qin, WU Gao-hui, YANG Wenshu, LIU Yan-mei “Effect of volume fraction on microstructure and mechanical properties of Redmud/Al composites” School of Materials Science and Engineering, Harbin Institute of Technology, Harbin 150001, China 25 July 2011

[5] S.A. Sajjadi a, M. Torabi Parizi b, H.R. Ezatpoura, A. Sedghic “Fabrication of A356 composite reinforced

with micro and nano Al₂O₃ particles by a developed compocasting method and study of its properties” a Department of Materials Science and Metallurgical Engineering, Engineering Faculty, Ferdowsi University of Mashhad, Mashhad, Iran b Department of Materials Science and Engineering, Saveh Branch, Islamic Azad University, Saveh, Iran c Department of Materials Science and Metallurgical Engineering, Engineering Faculty, Imam Khomeini International University of Qazvin, Qazvin, Iran

- [6] C.S. Ramesha, R. Keshavamurthyb, B.H. Channabasappab, Abrar Ahmedb “Microstructure and mechanical properties of Ni–P coated Redmud reinforced Al6061 composites” a Professor, Mechanical Engineering, PES Institute of Technology, Bangalore-560 085, Karnataka, India b Research scholars, Mechanical Engineering, PES Institute of Technology, Bangalore-560 085, Karnataka, India
- [7] Hashim J, Looney L, Hashmi MSJ 2001 The Wettability of SiC Particle in Cast AluminiumMatrix Composites Journal of Material Processing Technology 119 pp. 329-335.
- [8] Ozben T et al 2008 Investigation Mechanical and Machinability Properties of SiC ParticleReinforced AlMMCJournal of Materials Processing Technology 1 98 220-225e.
- [9] Viswanatha B M, Kumar P M, Basavarajappa S 2013 Mechanical Properties Evaluation of A356/SiCp/Gr Metal Matrix Composites Journal of Engineering Science and Technology 8pp. 754-763.
- [10] Meena K L, Manna A, Banwait S S 2013 An Analysis of Mechanical Properties of The Developed Al/SiCMMC.American Journal of Mechanical Engineering 1 pp. 14-19.
- [11] B.A. Parker, D.S. Saunders, and J.R. Griffiths, The QuantitativeEvaluation of Microstructure of a StrontiumModified Al-Si-MgAlloy FollowingProlonged SolutionTreatment, Met. Forum, Vol5, p48-53, 1982.
- [12] J.W. Martin and R.D. Doherty, Stability of Microstructures inMetallic Systems, Cambridge University Press, London, p 210-216, 1980
- [13] C.W. Meyers and J.S. Lyons, Fracture Toughness--Second ParticleInteractions in A357 Alloys, Technology for Premium QualityCastings, E. Dunn and D.R. Durham, Ed., The Metallurgical Society,p 151-179, 1986
- [14] C.Q. Chen and J.F. Knott, Effects of Dispersoid Particles onToughness of High Strength Aluminum Alloys, Met. Sci., Vol 15,p 357-366, 1981
- [15] R.H. Sailors, Properties Related to Fracture Toughness, ASTMSTP 605, American Society for Testing and Materials, p 34-39,1976
- [16] K. Tynelius, "A Parametric Study of the Evolution of Microporosityin Al-Si Foundry Alloys," Ph.D. thesis, Drexel University,Mar1992.
- [17] Anjan Kumar Dr. Sanjay kumar S.M “A Review on Microstructure and Mechanical Properties of Silicon Nitride Reinforced AMMC Using Stir Casting Method” International Research Journal of Engineering and Technology (IRJET) ISSN: 2395-0056 Volume: 05 Issue: 10 Oct 2018.
- [18] P. S. Raghavendra Rao and C. B. Mohan, Study on mechanical performance of silicon nitride reinforced aluminium metal matrix composites, Materials Today: Proceedings, <https://doi.org/10.1016/j.matpr.2020.03.405>.
- [19] K. Gajalakshmi, S. Kathiresan, K.S. Sreenivasan, S. Ravindran, Investigation of microstructure and mechanical properties of silicon nitride reinforced ammc using stir casting method, IOSR J. Mech. Civ. Eng., 61–65 (2014), e-ISSN: 2278- 1684, p-ISSN : 2320–334X.
- [20] Pardeep Sharma, Satpal Sharma, Dinesh Khanduja, A study on microstructure of aluminium matrix composites, 14 May 2015, doi.10.1016.
- [21] M. Wang, D. Wang, T. Kups, P. Schaaf, Size effect on mechanical behavior of Al/ Redmudmultilayers by nanoindentation, Mater. Sci. Eng.: A, (644) (2015) 275– 283.



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