Effect of Coconut Shell Ash and Cow Dung Ash on Mechanical Properties of Al Metal Matrix Composites. Properties

Vidhya B[1], Jayasheel I Harti[2], S. V. Prakash[3]

1 Research Scholar student ,East Point College of Engineering and Technology, Bangalore

2 Assistant Professor, East Point College of Engineering and Technology, Bangalore

3 Professor and Head of the Department, East Point College of Engineering and Technology, Bangalore

Abstract –Hybrid composites have superior tribo-mechanical properties compared to a single reinforced Al-MMC. Hybrid composite with micron synthetic ceramics and Agro/industrial waste particle reinforcement provided improved mechanical properties. Hybrid composite was more durable against wear and corrosion. The stir casting process has fewer defects like formation of agglomeration and non-homogeneous distribution of elements inside the matrix besides, the simplicity in composite manufacturing makes it as a mostly appropriate method for the fabrication of composite materials.The use of Agri Industrial waste particles as a reinforcement will improve the machinability, increase the hardness and strength of the composite, and improve wear and corrosion resistance. The AMMC finds applications in industries, automation and space research. Aluminum based metal matrix composites improves UTS, hardness, YS and further good percentage of reduction in density and percentage of elongation with the upsurge in the weight percentage of reinforcement particulate. The composites are used in automobile sectors especially in transportation due to low fuel consumption, less emission and low noise pollution which ultimately controls the environmental pollution.The specific modulus and specific strength of Aluminium alloys could be considerably enhanced by developing composites based on these alloys. The particle-reinforced Aluminium based metal matrix composites are of interest due to their ease of fabrication, lower costs and isotropic properties. In the present work The Al4008-CSA & CDA Composites is fabricated by using Bottom pouring stir casting techniques with weight % of 0, 4, 8&12 and 4 wt. % of magnesium is added in order to increase the wettability of the composites and Microstructure and Mechanical properties like Hardness and Tensile Properties are evaluated according to ASTM Standards.

Keywords –Al4008, CSA & CDA Particles, Hardness, Ultimate Tensile Strength, Yield Strength, Elongation.

1. INTRODUCTION

The profit of MMHCs (Metal Matrix Hybrid Composites) from industrial point of view with apprehending improvements in mechanical properties, wear life, corrosion behaviour, fatigue life, environment profits like noise resistance and monetary benefits like easy machinability. The accumulation of reinforcement particulate such as tungsten carbide, silicon carbide, titanium carbide, aluminium oxide, boron carbide and graphite will enhances wear resistance, corrosion resistance and mechanical properties of the base metal.

Cow dung, sometimes referred to as cow pats, cow pies, or cow manure, is an animal byproduct of the bovine family. These species include yaks, water buffalo, bison, and domestic cattle (sometimes known as "cows"). The undigested remnant of plant materials that has passed through the animal's digestive system is known as cow poo. Mineral-rich faecal matter is the consequence. Greenish to blackish in hue, it frequently darkens quickly after being exposed to air. It's common to utilise cow dung, which is often dark brown in colour, as manure (agricultural fertilizer). Cow dung has the potential to dry out and remain on the pasture, creating an area of grazing space that is unappealing to livestock if it is not recycled into the soil by species like earthworms and dung beetles. Any waste liquids with oil and grease qualities can be cleaned with cow dung.

Agricultural waste is coconut shell ash. The garbage is created in large quantities worldwide and is hazardous to both the environment and human health. Therefore, utilising them in an efficient, convenient, and environmentally beneficial manner has always been difficult for scientific applications. This project's work primarily focuses on the manufacturing of metal matrix composites utilising coconut shell ash, as well as the evaluation of the characteristics and machining of coconut shell ash-reinforced aluminium metal matrix composites, as well as microscopic examination of the machining.

Aluminium and its alloys, apart from their low density (one third of steel), have good damping characteristics, dimensional stability and excellent machinability, characterized by low power requirements, excellent surface evenness and small fragmented chips. Further, aluminium is the third abundantly available metal in the earth crust and available at relatively low cost. It is easy to fabricate this metal and its alloys by a number of conventional techniques. As the automotive and aerospace industries uses more and more lightweight materials to improve their fuel efficiency and reduce their emissions, the demand for aluminum alloys is growing rapidly.

Particle-reinforced metal matrix composites is isotropic discontinuously reinforced compositeswhich have either hard or soft particles or their mixtures embedded in a ductile metal or alloy matrix in order to reinforce the desired matrix properties. The PMMCs are of particular interest due to their ease of fabrication by conventional methods at lower costs. PMMCs combine metallic properties (ductility and toughness) with the special characteristics of particle reinforcements, often leading to greater strength, higher wear resistance and higher elevated temperature properties depending on the nature of particles.

Stir-casting techniques are currently the simplest and most commercial method of production of MMCs. This approach involves mechanical mixing of the reinforcement particulate into a molten metal bath and transferred the mixture directly to a shaped mould prior to complete solidification. In this process, the crucial thing is to create good wetting between the particulate reinforcement and the molten metal. Non- homogenous Microstructure can cause notably particle agglomeration and sedimentation in the melt and subsequently during solidification. Non-homogeneity in reinforcement distribution in the cast composites could also be a problem as a result of interaction between suspended ceramic particles and moving solid-liquid interface during solidification. This process has major advantage that the production costs of MMCs are very low.

2. LITERATURE SURVEY

According to the investigation done by Manoj Singla et al [1], the Sic Particles have been reinforced to Aluminium Matrix alloy by Stir casting technique, varying from 5% to 30% in steps of 5% being used for casting composites which was stirred at 600 RPM speed for about 10 Minutes. The results shows increase in overall properties as the Wt. % of SiC Particles increases, but the microstructure study reveals as the Wt. % of SiC Particles increases the clustering & agglomeration has also increases as well as the ductility decreases.

K.V. Mahendra et al [2], carried research work using Aluminum with 4.5% Cu has matrix material and fly ash having SiO_2 (58.41%), Al_2O_3(30.4%), Fe_2O_3(8.44%) has reinforcement, and the creation of the composite was conceded thru stir casting route. The matrix materials were melted in an electric furnace to 850°C and melt was degassed at around 800°C via Hexa-Chloro -Ethane (C_2Cl_6, 0.5 wt. %) degasser. The particles were added while stirring the molten metal to form a vortex. Under the stirrer, the degassed molten metal was poured and swirled at about 600 rpm for about 12 minutes. The developed composites shows increased properties compared to base metal alloy.

A. Dinesh et al [3], carried research work on resistance to wear of hybrid Aluminum metal matrix composites using Al2219 grade aluminium, SiCp of 45 microns size varying from 0 -15 wt% in step of 5% and a fixed quantity of 3 wt% of graphite were used as reinforcement. The investigator, observed that sliding distance has (34.35%) influence on the wear, the load (23.24%), plus sliding speed (21.5%). Owing to the interfaces sliding speed plus load (6.96%) and sliding speed and distance (3.57%) influence of the wear.

T. P. D. Rajan et al [4], performed Fabrication plus characterization of Al-7Si-0.35Mg/fly ash MMC, and reported in their research work that the assimilation of untreated fly ash particles in Al (356) alloy via liquid metallurgy route results formation of agglomerates and porosity and these agglomerates turns in to macro pores. Even occurrence of Mg in the matrix, which endorses wetting, has not abetted much in breaking the agglomerates. Better dispersion and distribution of fly ash particle achieved by using coated fly ashes and hence agglomerates plus porosity were reduced besides subsequently more number of discrete fly ash particles was observed in the matrix.

S. Charles et al [5], carried out property analysis and mathematical modeling on hybrid composites, consisting of LM10 Aluminum, SiCp of 10 , 15 and 20%,and Fly ash 10%., investigator observed that addition of dispersoids particle increases the hardness and wear resistance. From the microstructure examination he observed fairly uniform distribution of the reinforcements in the matrix. Andrew W.

S Raghu et al. [6] showed the effect of Nano Particles on the Composites which is synthesized by using bottom pouring Stir Casting method. The LM0 Al Alloy is used as Matrix and Nano TiO_2 Particles are used as reinforcement with wt% of 0, 4 8 and 12. The Microstructure study reveals the uniform distribution of TiO_2 Particles, as the percentage increases clustering and agglomeration are seen. Hardness and Tensile properties have been increased nearly 15 to 20% compared to the same composition of Micron Sized Particulate Composites.

Vijaya Ramnath et al. [7] discussed about the mechanical properties of aluminum alloy reinforced with alumina and boron carbide metal matrix composites. Composites were fabricated by stir casting method and test samples were prepared and tested to

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 07 | July - 2022 Impact Factor: 7.185 ISSN: 2582-3930

find the various mechanical properties like tensile, flexural, impact and hardness. The results shows the improvement in overall properties compared with the base metal alloy. The internal structure of the prepared composite was observed by using scanning electron microscopy.

3. EXPERIMENTAL SET UPS & METHODS

Processing of Al2219-TiC Particulate Composites by Using Bottom Pouring Stir Casting Furnace:

A stir casting furnace cum bottom pouring set-up has been used in this research work for solidification processing of all the different Al2219-TiC composites with a maximum melting capacity of 1 kg. The schematic diagram of the experimental set-up is as shown in Fig. 1.

Fig. 1: Schematic diagram showing experimental set-up for stir casting used for solidification processing of cast composites and unreinforced base alloys.

Approximately 1000g of Al4008 aluminium was melted to a preferred processing temperature in a clay-graphite crucible inside the muffle furnace. Before any addition, the surface of the melt was cleaned by skimming. The weighed amounts of elemental TiC particles were preheated to about 400°C and the rate of addition of particles was controlled at an approximate rate of 0.2-0.3 g/s. A four pitched blade stirrer (45° pitch angle) was used to disperse the TiC particles in the melt. The speed of the stirrer was kept constant at 600 rpm. The temperature of the melt was measured by using a digital temperature indicator connected to a chromel-alumel thermocouple placed at a depth of 15-20 mm inside the melt. During stirring, the temperature of the slurry was maintained within ±10°C of the processing temperature. A magnesium lump of 4wt% was enclosed in aluminium foil and charged into the melt-particle slurry before the addition of CSA & CDA particles. When thepreferred time of the stirring elapsed, the stirrer was stopped and taken out from the crucible. Then, the graphite plug at the bottom of the furnace was removed and the slurry of melt-particle was poured into a pre-heated permanent type mold of split type, having a size of 40x40x 150 mm kept below the plug. The cast composite ingot was immediately cooled by immersion in to water bath.

CDA & CSA as a Reinforcement Material:

Cow dung ash's chemical composition is high in calcium, potassium, and nitrogen. The ratio of carbon to nitrogen is comparatively high. Cow dung ash typically contributes up to 30%.Agricultural waste is coconut shell ash. The garbage is created in large quantities worldwide and is hazardous to both the environment and human health. Therefore, utilising them in an efficient, convenient, and environmentally beneficial manner has always been difficult for scientific applications.

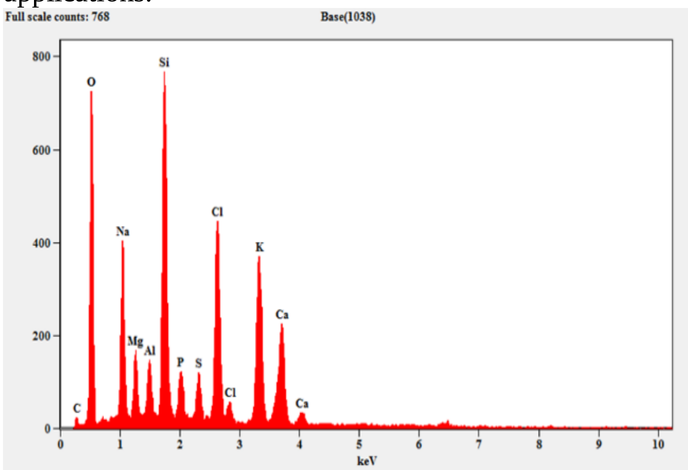


Fig. 2: EDS Analysis of CDA

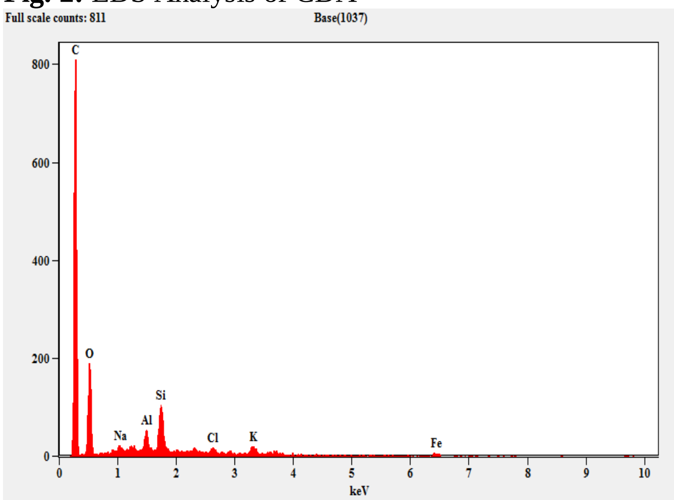


Fig.3:EDS Analysis of CSA

Al4008 Alloy as a Matrix Material:

Aluminium 4008 alloy was selected, for the purpose of matrix material. It is a flexible extruded alloy that may be heat treated and has a range of strengths from medium to high. This alloy is widely used in the aerospace and automobile industry.

Table1: Chemical Composition of Al-4008.

Content	Percentage Composition (%)
Aluminium	92.87
Magnesium	0.084
Silicon	6.703
Iron	0.161
Copper	0.033
Zinc	0.040
Titanium	0.010
Manganese	0.041

Scanning Electron Microscopy:
Metallography is the study of the microstructure of materials. Analysis of the microstructure of the material determines whether the material has been properly processed and the mechanical properties depend on how the TiC particles are distributed in the composite and therefore constitute a crucial step in determining the reliability of the product and determining the reason for failure of material. Field emission scanning electron microscopy (FE-SEM), Carl Zeiss, German model: Neon 40.

Hardness Testing:
The Brinell hardness test method as used to determine BHN, as defined in ASTM E10, the hardness of prepared nano composites are assessed using ball indenter of diameter 10mm at an applied load of 500kg. The Brinell hardness of the cast composites and cast unreinforced alloys were studied on the samples. The load was applied with a ball indenter for about 180 seconds on a sample and then the diameter of indentation was measured with the help of travelling microscope. For each indentation, an average of two diameters measured perpendicular to each other was used to find the corresponding hardness. On each sample, at least three indentations for hardness measurement were made at different locations and the average of these readings is reported as the hardness value of the material. The formula used to calculate BHN is given by: $BHN = 2P/(D-\sqrt{D^{2}-d^{2}})$.
Where,
P= Load Applied in Kg.
D= Steel Ball Indenter diameter in mm.
d= Impression made by steel ball indenter in mm.

Tensile Testing:
The tensile tests were carried out at ambient temperature for the cast unreinforced alloy, composites. The shape and dimension of the tensile specimens, conforming to ASTM–E8M specification, is shown schematically in Fig. 4. At least four tensile specimens machined out from each segment of each cast composite and unreinforced alloy, were tested under uniaxial tension in a UTM and the average of ultimate tensile strength, yield strength and percentage elongation is reported as the tensile property of the material.

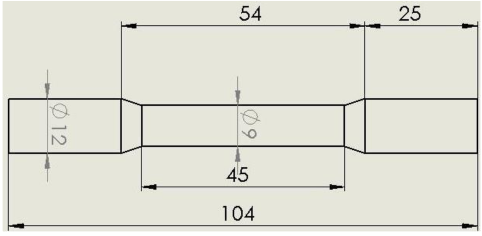
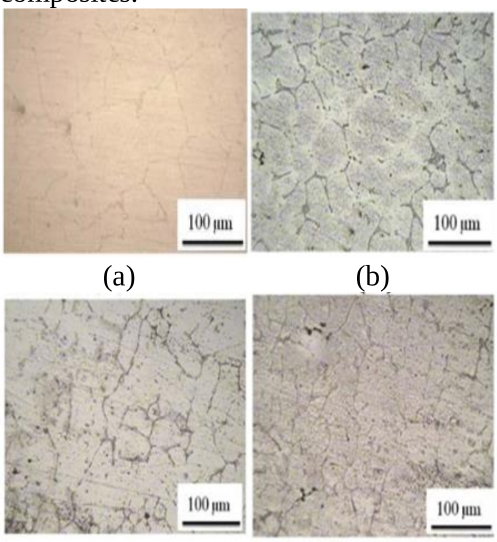


Fig. 4: The Tensile Specimen.

4. RESULTS & DISCUSSIONS

Microstructure Analysis:
Figure 5 (a) - (d) shows the Scanning Electron Microscope micrographs of as cast Al4008 alloy and its composites. The microstructure clearly shows the uniform distribution of the CSA & CDA particles in the developed composites. The porosity was less in the developed composites because of good wettability between the matrix and reinforcement particles which are observed from the SEM images. The SEM image shows that for the 12 wt. % composite has more clustering and agglomeration than the 4 and 8 Wt. % composites.



(c) (d)

Fig.5: Showing the SEM microphotographs of (a) as cast Al4008 alloy (b) Al4008-4 wt. % CDA & CSA (c) Al4008-8 wt. % CDA & CSA (d) Al4008-12 wt. % CDA & CSA.

Hardness:
The hardness increases gradually as the CDA & CSA particles increases in the composites. In fact, the hardness of a composite depends on the hardness of the reinforcement and matrix. The increase in hardness is principally owed to the fact that the coefficient of thermal expansion (CTE) of the ceramic particles is lesser than the coefficient of thermal expansion of the aluminum alloy and because of sudden quenching with

water. Therefore, a large quantity of dislocations is produced at the particle-matrix interface during solidification, which further increases the matrix hardness. The greater the amount of particle-matrix interface, the more is the hardening owing to dislocations. The hardness value of Al4008 with 4 wt. % TiC is nearly 6.36% increased as compared with the unreinforced alloy Al-4008, respectively for Al4008 with 8% CDA & CSA and Al-4008 with 12% CDA & CSA the increase in hardness is 12.73% and 17.22% with Al-4008alloy.

Fig.6: Variation in Hardness of Al4008 with wt. % of CDA & CSA particulates Composites.

Tensile Properties:

The average tensile properties i.e. yield strength, ultimate tensile strength and percentage elongation of synthesized composites have been measured and compared with those observed Al-4008 aluminium alloy. The variations of yield strength, ultimate tensile strength and percentage elongation with increasing CSA & CDA particle content are shown in Figs.7, 8, and 9 respectively. In cast composites, the yield stress increases from 102.14 MPa in Al-4008 aluminium alloy to 114.38, 127.71 and 139.55 MPa in composite containing about 4, 8 and 12 Wt. % of CSA & CDA. UTS also enhances monotonically with increasing CSA & CDA particle content in cast composite, UTS for Al-4008 alloy is 125.35 to 136.22, 148.58 and 157.84 MPa in composite containing about 4, 8 and 12 Wt. % of CSA & CDA particles. The ductility of cast composites decreases with increasing CSA & CDA content which can be seen in figure 9 because of the Chemical Constituents present in the CSA & CDA particles.

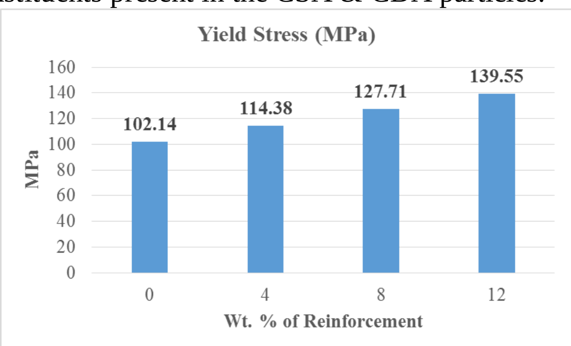


Fig.7: Yield Strength of the Developed CSA & CDA Particulate Composites.

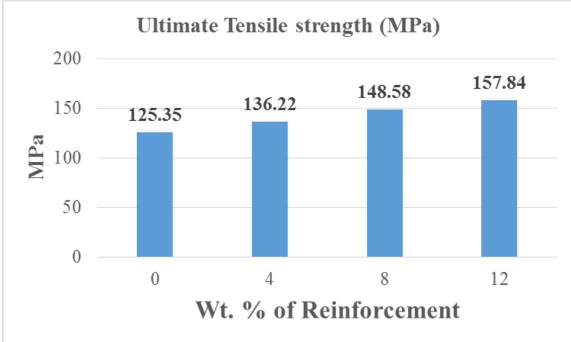


Fig.8: Ultimate Tensile Strength of the Developed CSA & CDA Particulate Composites.

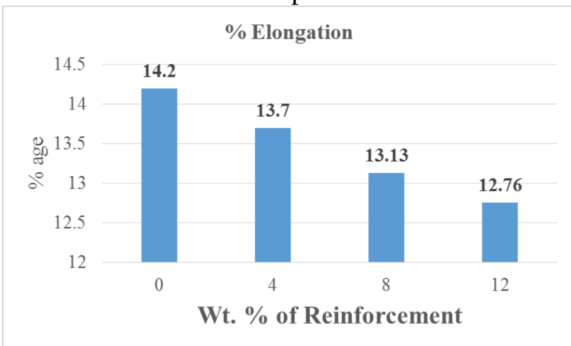


Fig.9: Percentage Elongation of the Developed CSA & CDA Particulate Composites.

5. CONCLUSIONS

i. The microstructure analysis displays that CSA & CDA particulate have been uniformly distributed in the composites but care has to be taken for increasing CSA & CDA wt. %age to minimize agglomeration and clustering.

ii. The Brinell hardness increases with increase in CSA & CDA particles in the composites.

iii. The Yield Strength and Ultimate Tensile Strength will also increase as the CSA & CDA particles increases in the composites due to progressive bonding of particles to matrix during plastic deformation and the CSA & CDA particles will act as barriers which prevent plastic deformation of the matrix.

iv. The ductility decreases as the wt. % of CSA & CDA particles increases in the composites compared to unreinforced composites.

REFERENCES

1. Manoj Singla, D. Deepak Dwivedi, Lakhvir Singh, Vikas Chawla, Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite,Journal of minerals and material characterisation and engineering, Vol 8, No 6, pp455-467,2009.
2. K.V. Mahendra, K.Radhakrishna. Fabrication of Al-4.5 % Cu alloy with fly ash metal matrix

composites and its characterization. Materials Science-Poland, Vol. 25, No1, 2007.

3. Dinesh. A, S. Basavarajappa and G. Chandramonhan. Dry Sliding Wear Studies on Hybrid MMC's-A Taguchi Technique. International Symposium of Research students on Materials Science and Engineering, December 20-22, 2004, Chennai, India.
4. T. P .D. Rajan, R. M. Pillai., B. C. Pai, K. G. Satyanarayana, P.K.Rohatgi. Fabrication and characterization of Al-7Si-0.35 Mg/fly ash metal matrix composites processed by different stir casting routes. SCIENCE DIRECT.Composite Science and Technology 67 (2007) 3369-3377.
5. S Charles and V.P.Arunachalam, Property analysis and mathematical modeling of machining properties of aluminum alloy hybrid (Al-alloy/Sic/ fly ash) Composites produced by liquid metallurgy and powder metallurgy techniques, Indian Journal of Engineering and Material Sciences Vol 11, December 2004, pp 473-480.
6. Raghu. S, H. M. Nanjundaswamy, Savitha. M and M. Sreenivasa, "Synthesis and Characterization of Mechanical Properties of Nano TiO2 Particle Reinforced Al-MMMC." International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), ISSN (P): 2249-6890; ISSN (E): 2249-8001 Vol. 8, Issue 2, Apr 2018, 981-988
7. B. VijayaRamnath, C. Elanchezhian, M. Jaivignesh, S. Rajesh, C. Parswajinan, Siddique Ahmed Ghias, "Evaluation of mechanical properties of aluminium alloy–alumina–Boron carbide metal matrix composites", Materials and Design, 58, pp. 332–338, 2014.
8. C. R. Prakash Rao, Bhagyashekar M.S, Narendra Viswanath, Machining behavior of Al6061 fly-ash composites, AMME 2014, Procedia Materials Science, 5, 2014, pp1593-1602.
9. Raghu. S, H. M. Nanjundaswamy, Savitha. M and M. Sreenivasa, "Synthesis and Characterization of Mechanical Properties of Nano TiO2 Particle Reinforced Al-MMMC." International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), ISSN (P): 2249-6890; ISSN (E): 2249-8001 Vol. 8, Issue 2, Apr 2018, 981-988
10. Raghu S, H M Nanjundaswamy, M Sreenivasa, "Impact of Different Nano-Sized TiO2 Particles on LM0 Al-Alloy on Mechanical Behaviour of Nano Metal Matrix Composites." Solid State Technology, Volume 63, Issue 1, Sept 2020.