 ISBN: 978-81-910765-1-6

Evalution in Mechanical Properties of Aluminium Metal Matrix Reinforced with Titanium dioxide Composite via Stir casting

R.Ganesh.M.E/Assistant Professor
1.M.Hariharasudhan,2.P.Vinayaga moorthy
Indra ganesan college of engineering Trichy
Email id-hsudhan990@gmail.com

***Abstract:* In this present scenario metals are used for the Industries, Marine applications, Infrastructure and other daily utilities. So in the current demands of advanced engineering applications Aluminium based nano composites are the new generation of metals. Researchers have been observing thatthe addition of nano sized titanium dioxide (tio2) particles with aluminium metal matrix leads towards superior mechanical properties, physical properties and interfacial characteristics of nano composites. The image of scanning electron microscope of aluminium metal matrix nano composites indicate that the nano Titanium dioxide (Tio2) reinforcing particles are uniformly distributed in the metal matix. This paper tries to review the fabrication techniques and mechanical properties of aluminium/tio2 based metal matrix composites.**

***Key words:* Aluminium Metal Matrix Nano Composite, Fabrication Technique, Scanning Electron Microscope, Mechanical,Metal Matrix Composite,TIO2.**

I. INTRODUCTION

There is a tremendous demand for advanced engineering materials with high strength, light weight, and increased resistance to wear in aerospace, civil and sliding components of automobile sectors. This leads to the development of aluminium matrix composites (AMCs). Aluminium is principally reinforced with hard phases such as SiC, TiC, TiB2 and Al2O3 and soft phases like graphite (Gr) and MoS2.Aluminium metal matrix composite filled with nano particles featuring physical and mechanical properties very different from conventional metal.

The nano particles can improve the base material in terms of Tensile strength, compressive strength, hardness, wear resistance, damping properties, porosity, corrosion resistance and mechanical properties. The Exploitation of reinforcement of nano particles on metal matrix depends on the type of primary and secondary processing, matrix composition, size, volume fraction, morphology of reinforcement and heat treatment. Among all the investigated nano particles reinfor Titanium dioxide was found to be most effective in enhancing the strength properties of Auminium when incorporated via ingot metallurgy process. Fabrication methods can be broadly classified into Two types, solid state processing and liquid state processing. In liquid state processing mechanical and electromagnetic stirring and ultrasonic based dispersion is uses for the proper distribution of nano particle that have some advantages than solid state of processing that are high productivity, flexibility, easy to control on matrix structure and better bonding between matrix and particles etc. In solid state of processing mostly preferred method is powder metallurgy in which, the main drawback of liquid state processing technique can be overcome that is non-uniform dispersion of nano particles but this uniform dispersion of nano particles makes it costly and lengthy process.

A.Fabrication Technique:

Processing of Aluminium metal matrix nano composite

1)Solid state

2)Liquid state

1)Solid state: In solid state Diffusion Bonding, Electroplating, Powder Metallurgy, Spray Deposition, Immersion Plating, etc.

2)Liquid state: In Liquid state processing includes Stir Casting, Squeeze Casting, Melt Infiltration, Compo Casting and Melt Oxidation processing etc.

But Powder Metallurgy, Stir Casting , High Energy Ball Milling, Squeeze Casting, Mechanical Alloying ,Spark Plasma, Ultra sonic cavitation based solidification and Laser Deposition mostly used. The nano particles have tendency of agglomeration and clustering because of electrostatic, high surface energy, adhesiveness due to the moisture present. Out of these fabrication technique some are discuss below that are mostly prefer for reinforcement of ceramic nano particlesmetal matrix.

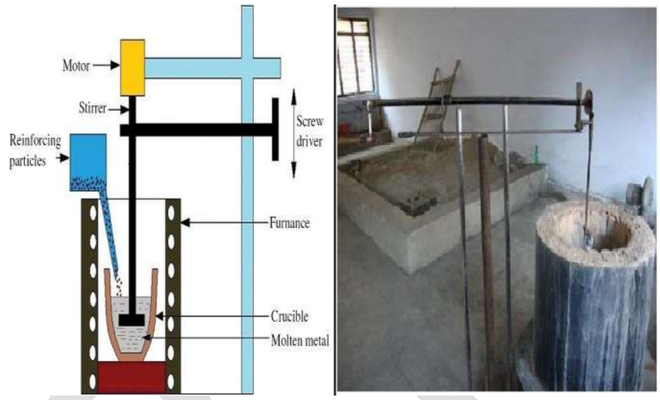
II.EXPERIMENTAL PROCEDUR

A.Metal matrix method

The matrix material in present study is Al. The reinforcing material selected is Titanium oxide TiO2 of different composition. The Titanium oxide is varied by 4%, 8%, 12% and 16% weight of Aluminium .The Aluminium alloy was used as the base matrix. This is melted at 585°C which is slightly more than 30°C above the liquids temperature. The reinforcing material used is TiO2 powder of 4%, weight of Aluminium . The stir casting technique is adopted to fabricate the specimens in which a stir casting is created in the melt of the matrix alloy through a mechanical stirrer coated with aluminate and rotating at 550 rpm. The composites are fabricated with 4-16 weight % of the TiO2 particle in steps of 2 weight %. The TiO2 particles are added to the melted Aluminium. Aluminium alloy is first preheated at 2000 for 2h before melting and TiO2 is added to melted material which improves the wetting properties by removing the absorbed hydroxide and other gases. The composite melt is thoroughly stirred. The composite slurry is then reheated to a fully liquid state and mechanical mixing is carried out for 20 min at 200 rpm average stirring speed. Finally, the composite slurry is poured in permanent metallic mould. The composites are then cast in permanent moulds. Al alloy composites containing various TiO2 contents, namely 4%, 8%, 12% and 16% by weight of Aluminium and similarly the composites are fabricated with 4-16 weight % of TiO2. The TiO2 particles are added to the melted Aluminium , were fabricated and tested and their properties. All tests are conducted in accordance with ASTM Standards. Tensile tests are performed at room temperature using a Tensile Testing Machine

B. Experimental Setup:

Initilly Al was melting with the help of Crucible furnace .The furnace was heated for the reinforcement materials as Sic and Tio2 gradually raised the temperature up to 857 0C slightly more than the liquid temperature maintained at particular period of time. Vortex technique is used to disperse the reinforced matrix of Sic and Tio2 particle size 5- 30μm was used in FCC structure. This reinforcement material preheated at 200-350 0C of vortex was created to mix with the liquid metal at a rate of 150 g/min. To increase the wet ability of base material a small amount of ceramic was used. After the melting process, composite material has fully stirred and to create a good binding capacity. Totally four specimens are prepared along the cylindrical die. It was machined named by universal testing machine .



Gauge length (G)= 7 mm ,
Distance between shoulders (B)=10mm,
Length of reduced section (A)=9mm,
Diameter of reduced section (D_1)=14mm
Grip diameter(D_2)= 19mm,
Radius of curvature (R)=4mm

III.RESULT AND DISCUSSION

Various tests have been conducted on fabricated metal matrix composites samples to analyse the strength characteristics of aluminium / TiO2 metal matrix composite. Mechanical properties such as tensile strength, compressive strength and torsional strength have been determined on fabricated metal matrix composite. The tensile strength is carried out at room temperature on Tensile testing machine. Compressive strength is carried out at room temperature on Compressive testing machine. Torsion test is carried out on a hydraulic Torsion testing machine.

A.Tensile strenth

For evaluating the tensile strength the five samples were taken which are reinforced with the differenTiO_2 compositions they are

Fig.2: Tensile specimen

Fig.3:Amsler tensile testing machine

1. Pure aluminum
2. Aluminium with 4% Tio_2
3. Aluminium with 8% Tio_2
4. Aluminium with 12% Tio_2
5. Aluminium with 16% Tio_2

The results show that the effect of TiO_2 content on tensile strength, compressive and Torsion strength of aluminium /TiO_2 metal matrix composite. Figure 1 clearly shows that the effect of TiO_2 content on tensile stress of aluminium alloy composites. It can see that as the TiO_2 content increases the tensile strength of the composite material increases monotonically by signification amount if other factors are kept constant.
Increase in tensile strength is due to the uniform distribution of TiO2 particles and strong bonding with

 ISBN: 978-81-910765-1-6

aluminium matrix.

Formulation:

$\sigma_t = P/A$

$A = (\pi/4)D^2 = 153.86$ mm^2 (which is constant for all samples)

Where,

σ_t =Tensile strength(Mpa)

P=Load(TON)

A=Cross-section area(mm^2)

Therefore for

1. Sample (p_1)=1.568 TON, σ_{t1}=101.32 Mpa
2. Sample (p_2)=1.863 TON, σ_{T2}=121.33 Mpa
3. Sample (p_3)=2.264 TON, σ_{T3}=147.14 Mpa
4. Sample (p_4)=2.642 TON, σ_{T4}=171.71 Mpa
5. Sample (p_5)=3.263 TON, σ_{T5}=212.50 Mpa

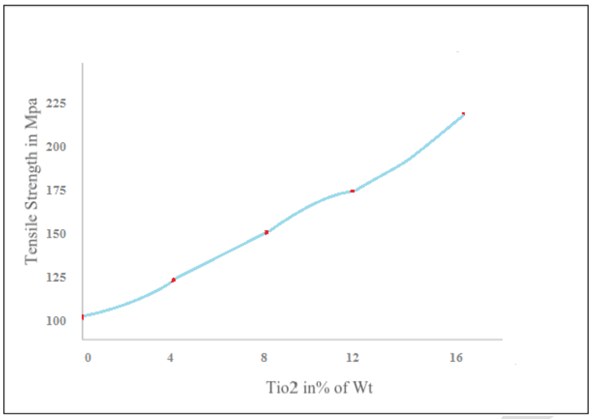


Fig:4.Tensile strength

A compression test determines the characteristics of materials under crushing loads. The sample is compressed and deformation at various loads is noted. Compression Test conducted requires the testing of 5 Specimens prepared by stirr casting of aluminium metal matrix and TIO_2composite at different composition 4%,8%,12%,16%. Specimen Specifications: L/Deff 1.6 for to assure a geometrical dimensional factor and homogeneous deformation.

L = Length of the Specimen 25

Deff = Effective Diameter of the Cross Section of the Specimen

Hence if Deff =15 mm

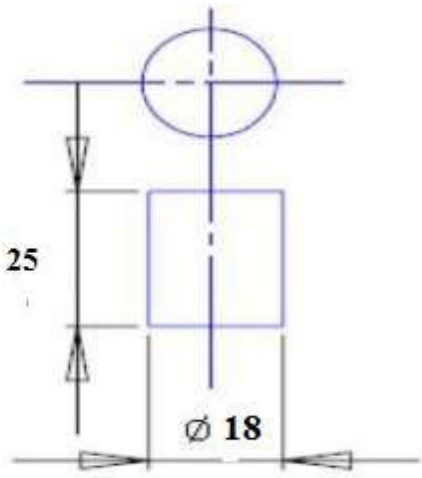


Fig.5: Compressive testing specimen

Formulation:

$\sigma_C = P/A$

A= Area of specimen

$A = \pi r^2$

$= 3.14*9^2$

= 254.34 mm^2 (this would be same for every specimen)

Therefore for,

1. Sample (p_1)=24034.5 N, σ_{c1}= 94.49 N/mm^2
2. Sample (p_2)=25497.2 N, σ_{c2} = 100.24 N/mm^2
3. Sample (p_3)=28439.2 N, σ_{c3} = 111.81 N/mm^2
4. Sample (p_4)=33342.6 N, σ_{c4} =131.09 N/mm
5. Sample (p_5)=41187.9 N, σ_{c5}=161.94 N/mm^2

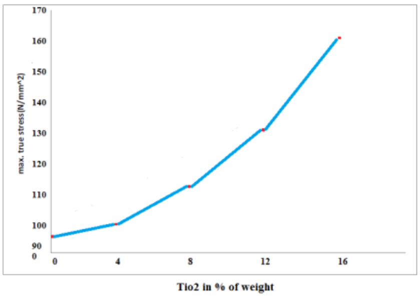


Fig:6,Compressive strength

C.Torsional Strength:

Torsion tests twist a material or test component to a specified degree, with a specified force, or until the material fails intorsion. The twisting force of a torsion test is applied to the test sample by anchoring one end so that it cannot move or rotate and applying a moment to the other end so that the sample is rotated about its axis. The rotating moment may also be applied to both ends of the sample but theends must be rotated in opposite directions. The forces and mechanics found in this test are similar to those found in a piece of string that has one end held in a hand and the other end twisted by the other.The purpose of a torsion test is to determine the behavior a material or test sample exhibits when twisted or under torsional forces as a result ofapplied moments that cause shear stress about the axis.for the experiment the same type samples of aluminium metal reinforced with TIO_2 atdifferent % Measurable torsional fatigue life,These values are similar but not the same as those measured by a tensile test and are important inmanufacturing as they may be used to simulate the service conditions, check the product's quality and design, and ensure that it was manufactured correctly.

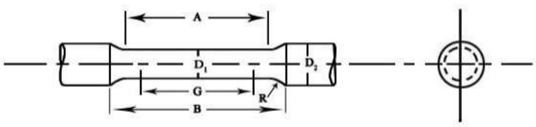


Fig.7: Tensile specimen

Guage length (G)= 7 mm , Distance between shoulders (B)=10mm,

Length of reduced section (A)=9mm, Diameter of reduced section (D_1)=14mm

Grip diameter(D_2)= 19mm, Radius of curvature (R)=4m

Fig.8:Amsler torsion testing machine

Formulation:

The formula to calculate average shear stress is force per unit area.

$$\tau = F/A$$

where:

τ = the shear stress;

F = the force applied;

A = the cross-sectional area of material with area parallel to the applied force

Therefore,

A= Area of specimen

$$A = (\pi/4)D_2$$

=153.86 mm_2 (which is constant for all samples)

Torsional strength of specimen

$\tau_{max} = Tr_0/J = 16T/\pi d_3$

Where,

τ_{max} = maximum shear stress

T = Torque

r = Radius of reduced section

J = polar moment of inertia

So for,

1. Sample (T_1)=2600 Kgfmm , τ_1 =47.31 Mpa
2. Sample (T_2)=2800 Kgfmm , τ_2 =51.00 Mpa
3. Sample (T_3)=3200 Kgfmm , τ_3 =58.29 Mpa
4. Sample (T_4)=3500 Kgfmm , τ_4 =64.99 Mpa
5. Sample (T_5)= 3700 Kgfmm , τ_5 =67.40 Mpa

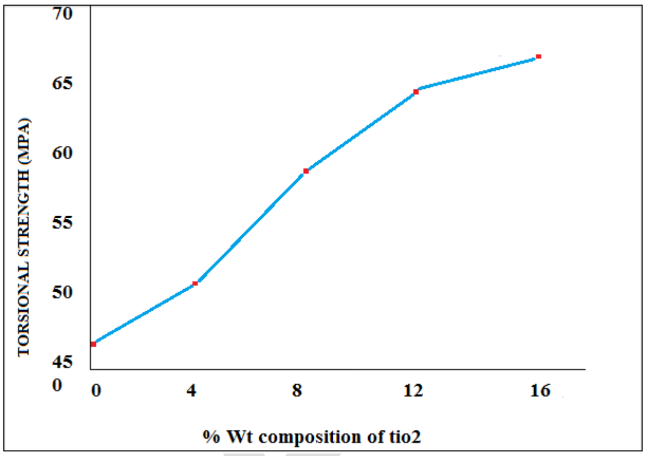


Fig. 9: Effect of content on Torsional Strength of material TiO2

IV.CONCLUSION

The present investigations of mechanical behavior of Aluminum metal matrix revealed that the tensile strength, compressive strength and Torsional strength is greatly influenced by the Titanium Dioxide (TIO_2) content/ weight fraction of reinforcement in matrix. A reinforced composite shows more tensile, compressive strength and Torsional strength than unreinforced epoxy. With increase in 4%,8%,12%,16% of weight fraction of (TIO_2) over pure Aluminum, the following conclusion can be made….

- Stir casing is an easy and accurate method of fabricating aluminum composite with Titanium Dioxide (TIO_2).
- The percentage increase of reinforcement increases the tensile, compressive and torsional strength of the composite.
- Tensile, compressive, and torsional strength increases with the increase in % 0f the reinforcement but between 12%-16% reinforcing of tio_2 tensile strength increases tremendously. This concludes that higher the percentage of the tio_2 higher the strength of the composite.
- The uniform distribution of TiO2 particles and strong bonding with aluminium metal matrix are the causes for increase in tensilestrength, compressive and torsional strength of the composite.
- Table showing the reinforcement conclusion

 ISBN: 978-81-910765-1-6

SPECIMEN	% increase in tensile strength of (AL) due to reinforcement of (TIO_2)	% increase in compressive strength of (AL) due to reinforcement of (TIO_2)	% increase in torsional strength of (AL) due to reinforcement of (TIO_2)
Pure aluminium (Al)	σ_{t1}=101.32 Mpa	σ_{c1}= 94.49 Mpa	τ_1 =47.31 Mpa
AL + 4% OF TIO_2 (by wt.%)	σ_{T2}=121.33 Mpa	σ_{c2} = 100.24 Mpa	τ_2 =51.00 Mpa
AL + 8% OF TIO_2 (by wt.%)	σ_{T3}=147.14 Mpa	σ_{c3} = 111.81 Mpa	τ_3 =58.29 Mpa
AL + 12% OF TIO_2 (by wt.%)	σ_{T4}=171.71 Mpa	σ_{c4} =131.09 Mpa	τ_4 =64.99 Mpa
AL + 16% OF TIO_2 (by wt.%)	σ_{T5}=212.50 Mpa	σ_{c5}=161.94 Mpa	τ_5 =67.40 Mpa
AL + 16% OF TIO_2 (by wt.%)	σ_{T5}=212.50 Mpa	σ_{c5}=161.94 Mpa	τ_5 =67.40 Mpa

V.REFERENCE

1] G.S. KATAIAH, DR. D.P.GIRISH, “The mechanical properties & fractography of Aluminum 6061 – TiO2 Composites “International Journal of Pharmaceutical Studies and Research, Vol-I, 2010, pp.17-25.

[2] T. RAJMOHAN, S.RANGANATHAN, T.S.A. SURYAKUMARI, “Experimental Study on fabrication of Hybrid (Al+TiO2+Gr) Metal Matrix Composites”, International Journal of Advanced Engineering Applications, Vol-7, 2014, pp.11-14.

[3] CHINTA NEELIMA DEVI, V.MAHESH AND N.SELVARAJ, “Tensile and Impact behavior of Al-Sic-Zn-Cu Metal Matrix **Composite “Research Journal of Engineering Sciences,Vol-3,2014,pp-17-22.**

[4] M.VAMSI KRISHNAA, ANTHONY.M.XAVIOR, “An Investigation on the Mechanical Properties of Hybrid Metal Matrix Composites”, Procedia Engineering, Vol-97, 2014, pp-918-924.

[5] ANTONY VASANTHA KUMAR, J. SELWIN RAJADURAI, “influence of rutile (tio2) content on wear and microhardness characteristics of aluminium-based hybrid composites synthesized by powder metallurgy trans”. Nonferrous met. Soc. China 26(2016) 63−73.

[6] AMAL E. NASSAR, EMAN E. NASSAR, “Properties of aluminum matrix Nano composites prepared by powder metallurgy processing”. Journal of King Saud University Engineering Sciences 2015.

[7] GANESH KHANDOORI, DR. K.K.S MER AND CHANDRAVEER SINGH, “Sliding behavior of aluminium metal matrix composite reinforced With titanium oxide” International Journal of Recent Scientific Research Research Vol. 6, Issue, 5, pp.4197-4203, May, 2015.

[8] B.STALIN, S.ARIVUKKARASAN AND C.SELVA GANESAN,”Evaluation of Mechanical Properties of Boron Carbide and Titanium Dioxide Reinforced with Aluminium Alloy Metal Matrix Composites”. International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.55 (2015).

[9] M.RAMACHANDRA, A. ABHISHEK, P. SIDDESHWAR, V. BHARATHI “Hardness and Wear Resistance of ZrO2 Nano Particle Reinforced Al Nanocomposites Produced by Powder Metallurgy” Procedia Materials Science 10 (2015) 212 – 219.

[10] A. FATHY, A. WAGIH, M. ABD EL-HAMID , AHMED A. HASSAN “The effect of Mg add on morphology and mechanical properties of Al–Mg/10Al2O3 nanocomposite produced by mechanical alloying” Advanced Powder Technology (2014) .

[11] J. SAFARI A, G.H. AKBARIA, A. SHAHBAZKHANC, M. DELSHAD CHERMAHINID “Microstructure and mechanical properties of Al–Mg/Al2O3 nanocomposite prepared by mechanical alloying” Journal of Alloys and Compounds 509 (2011) 9419– 9424.

[12] G. SIVAKUMAR, V. ANANTHI, S. RAMANATHAN “Production and mechanical properties of nano SiC particle reinforced Ti−6Al−4V matrix composite” Trans. Nonferrous Met. Soc. China 27(2017)82-90.

[13] M. G. BADER, T. W. CLYNE, G. R. CAPPLEMAN AND P. A. HUBERT, ―The Fabrication and Properties of Metal-matrix Composites Based on Aluminium Alloy Infiltrated Alumina Fibre Preforms, Composites Science and Technology, Vol 23, pp.287- 301, 1985.

[14] S. BARNES AND I. R. PASHBY, ―Machining of Aluminium Based Metal Matrix Composites‖, Applied Composite Materials, Vol 2, pp.31-42, 1995.

15] A. M. S. HAMOUDA AND M. S. J. HASHRNI, ―Mechanical Properties of Aluminium Metal Matrix Composites under Impact Loading, Journal of Materials Processing Technology, Vol 56, pp.743-756, 1996.