TechnoChem

International Journal of TechnoChem Research
ISSN:2395-4248 www.technochemsai.com
Vol.02, No.02, pp 127-132, 2016

Stress-Strain Analysis of AA6063-5AND7.5 Wt. % TiC Nano Composites

S.Saravanan[1], K.Kaviya[2], M.Ravichandran[3]*, P.Senthilkumar[4]

[1]Department of Mechanical Engineering, St.Joesph's College of Engineering and Technology, Tanjore -624 204, Tamilnadu, India
[2]Department of Civil Engineering, Parisutham Institute of Technology and Science, Tanjore - 624 204, Tamilnadu, India
[3]Department of Mechanical Engineering, Kings College of Engineering, Pudukkottai - 622 507, Tamilnadu, India.
[4]Department of Mechanical Engineering, K.S.R College of Engineering, Tiruchengode - 637 215, Tamilnadu, India

Abstract : The Aluminium matrix composite reinforced with 5 and 7.5 wt. % TiC nano particles was prepared by stir casting route. The high strength AA 6063 was selected as matrix material. This composite is expected to be used in aerospace, automotive and similar engineering industries. The addition of 5 and 7.5 wt. % of nano TiC as the particulate in the matrix of AA6063, the microstructure can be greatly changed. Hence the detailed study of the micro structure of the composites was carriedout. The microstructure of AA 6063 - 5 and 7.5 wt. % TiC nano composites were analyzed using optical microscope and reported. The stress-strain analysis was done using ANSYS software and it was correlated with the microstructure of the composite.
Key Words: AA 6063, TiC, OM, ANSYS, AMNCs.

1. Introduction

The advances on industries are required for light weight and high strength materials in the field of material science. The use of aluminium in light vehicles has increased dramatically with the need to the automobile weight and improves fuel efficiency. Aluminum based metal matrix composites (MMCs) have been extensively synthesized for aerospace, automotive and military applications [1]. These material having a lower density, higher thermal conductivity and high coefficient of friction compare to others. The reinforcement particulate such as TiC, TiB_2, TiO_2 [2,3] Al_2O_3, AlN, SiC, and ZrB_2, has added to conventional materials to produce MMC [4]. The new properties are derived from structure features in the size of 1-100 nm, as nano particulates. It can improve the mechanical properties of the matrix by promoting the hardening mechanisms than micron size particles [5]. The term Aluminum matrix nano composites (AMNCs), can overcome those disadvantages associate with the conventional AMCs. The properties of AMNCs would be improved considerably even with lower volume fraction of nanoparticles and improved performance at elevated temperature. The processing technique for preparation of composite materials the liquid state processing especially stir casting is used for synthesis of AMNCs because of their simplicity and scalability [12].Gopalakannan et al. fabricated metal matrix nano composite (MMNC) of AA 7075 reinforced with 1.5 wt. % SiC nano particles by a novel ultrasonic cavitation method [6]. The Al-TiC and Al-TiB_2 composites and composite powders with up to 40 vol. % of fine reinforcement were reported [7, 8]. Tong [9] has investigated in situ produce Al-TiC composites with refined microstructures and enhanced dispersion hardening of the reinforcing phases. The synthesized TiC particles possess a metastable FCC crystal structure with an atomic composition of TiC08 and a lattice parameter of 0.431 nm.

Lin et al. [10] performed a preliminary study on the fabrication of in situ TiC particulate reinforced Ti matrix composites by means of the CAC. Rai et al. synthesized Al-10 TiC in situ composite by the reaction of molten Al with K_2TiF_6 and graphite powder at 1200^0C. In stir casting process the presence of TiC, and the TiC particles were segregated towards the grain boundary. TiC particles can be synthesized in situ by several ways such as salt reaction with the molten Al, addition of Al-TiC powder compact or by the reaction of CH_4 gas with the melt [11]. Ramulu et al. carried out experimental investigations on the effect of surface roughness on mechanical properties of a 15 vol. % SiCp/A336 aluminum metal matrix composite [13]. Akshay Dvivedi et al. investigated the machinability of an AA6063-SiCp metal matrix composite developed using the melt stir squeeze quench casting route and was characterized for density, porosity and electrical conductivity [14].

2. Materials and Experimental Method

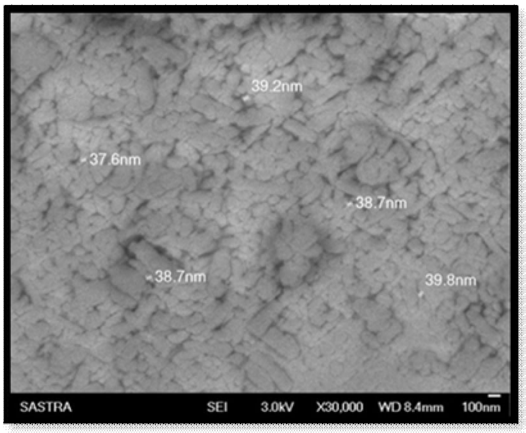
A typical chemical composition and properties of AA6063 and TiC is provided in Table 1 & 2. The SEM image of nano TiC powder is shown in Fig.1 and the size of the nano particles is marked in the image. The required quantity of AA6063 and TiC particles are taken in order to make the 5 & 7.5 wt. % of TiC composites. The stir casting techniques was used to prepare the nano composites. Initially AA6063 was melted in a crucible by heating it in a furnace at 750°C for 3 to 4 hours. The nano TiC particles were preheated at 1000ºC to make their surfaces oxidized. The furnace temperature was first raised above the liquidus temperature of Aluminum near about 750ºC to melt the AA6063 completely and then it was cooled down just below the liquidus to keep the slurry in semi solid state. The preheated nano TiC was added at this temperature and stirring of slurry was performed for 3-5 minutes with motor controlled stirrer. The composite slurry was then super heated to 720^0C and a second stirring performed by mechanical stirrer to improve the distribution of the nano TiC particles in the molten of AA 6063. The molten composite was then cast into prepared cast iron molds. The experimental setup for synthesizing AA6063-TiC composite is shown in Fig. 2. The presence of reinforcement through out the specimen was inspected by cutting the casting at different locations and under microscopic examination. The specimen surfaces were prepared by grinding through 600 to 1000 mesh size girt papers and for velvet cloth polishing is done to get fine surface finish. After that the specimens were etched using Keller's reagent ($HCl+HF+HNO_3$), the microstructures were observed using optical microscope.The uniaxial tensile test is simulated as per the sequence of steps in the finite element analysis. The ANSYS 12.1 software used to analysis the stress distribution of AA6063-TiC nano composite. In this analysis the physical properties such as element type assolid 8 Node 183 asymmetric. The modeling of rectangular component dimension is shown in Fig.3. The rectangular component is converted into cylindrical component by using asymmetric constraint. It is followed by meshing of component for the element edge length of 1mm. After generation of modeling the load and constraints are defined. Then the results plotted to the given data to obtain the stress behaviour of the desired load conditions.

Table: 1 Chemical composition of the AA 6063.

AA 6063	Si	Cu	Mn	Mg	Zn	Ti	Al
Weight (%)	0.44	0.02	0.03	0.56	0.66	0.02	Bal.

Table: 2 Properties of AA 6063&TiC powder.

Properties	**AA6063**	**TiC**
Density kg/m^3	2700	4935
Yield Strength MPa	48	120
Melting point °C	650	3200



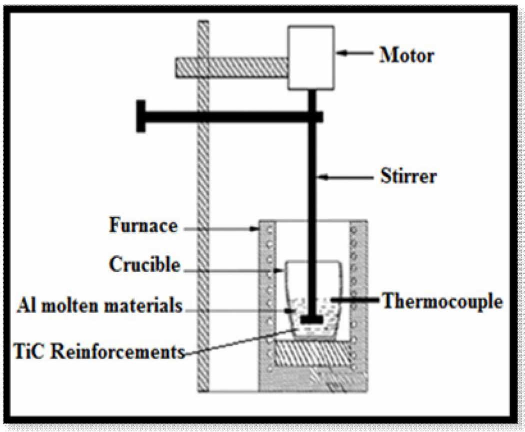
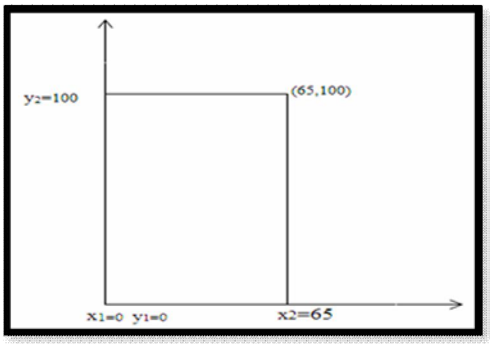


Fig.1 SEM image of nano TiC powder.Fig.2 Experimental setup of stir casting process.



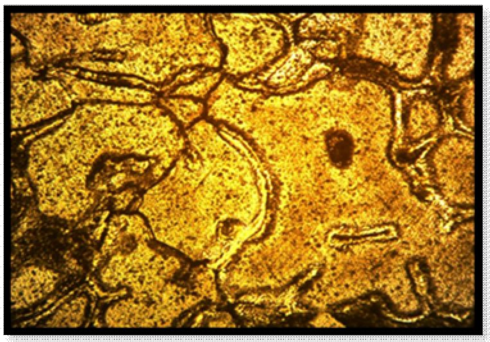


Fig.3 Dimension of FEA model.Fig.4Optical micrographof AA6063-7.5%TiC at 100x.

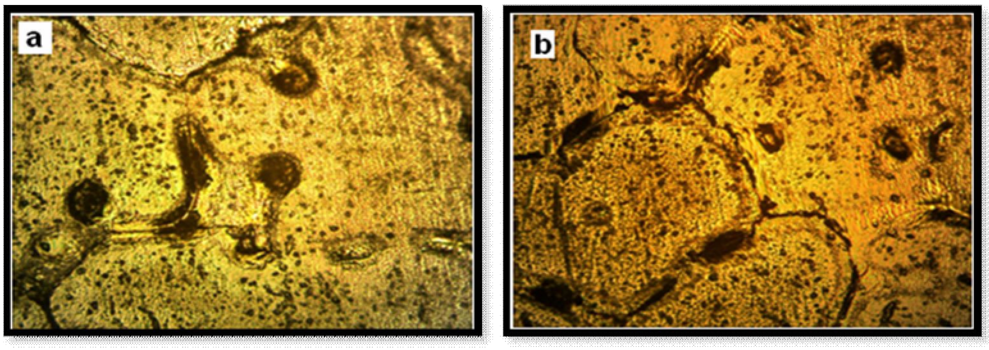


Fig.5 Optical micrographs of AA6063-5%TiC nano composite at magnification of 200x.

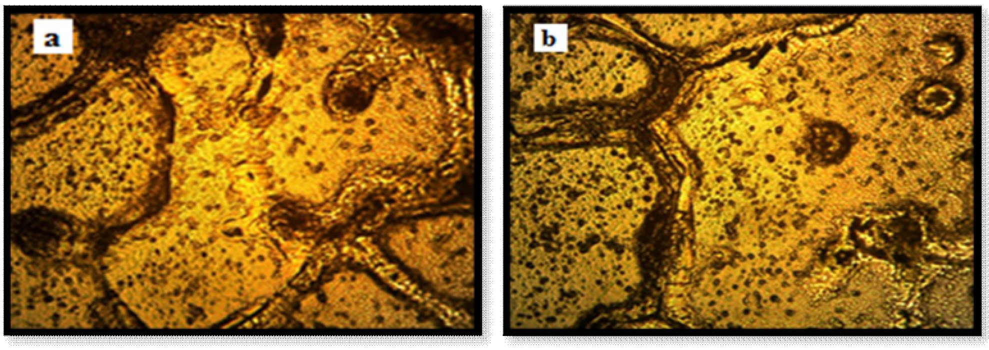
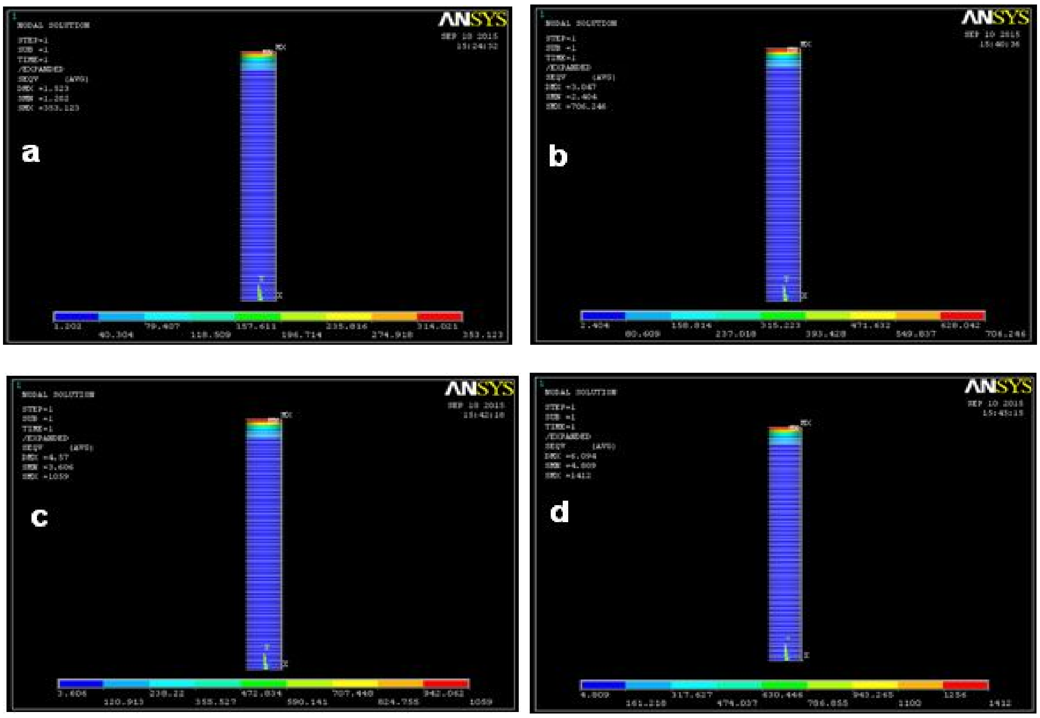


Fig.6 Optical micrographs of AA6063-7.5%TiC nano composite at magnification of 200x.

3. Results and Discussion

The stress induced during tensile load was analyzed by using ANSYS 12.1 software. The effects of weight percentage of TiC on the tensile stress of the composites are analyzed with the optical microstructure. In this analysis, a nano TiC particulate reinforced AA6063 composited was used. When the load is applied to the AMNCs, the reinforcement particle of the TiC is considered to deform elastically and the matrix deformation is assumed to be elastic-plastic [15]. The properties of AA6063-TiC compositessuch as Youngs modulus and Poisson ratio are taken from experimentalanalysis.The uniaxial tensile load is applied on the model and the results were computed for stress-strain relationship in the software itself. The tensile stress-strain behaviour of the models was subjected to an applied stress with the increment of2kN. The average strains are calculated from the deformed model, which is defined as strain rate. The stress increase for the increasedin applied load. When the tensile load is applied on the model, the stress distribution is not uniform because of the irregular shape of the particles and their distribution nature. The stress distribution analysis of 5 and 7.5 wt. % TiC composites is shown in Fig.7&8. The elastic response of the AMNCs was not much affected by the clustering since the elastic response is derived from the matrix. The maximum stress field was found at the interface region and the maximum strain was found at the maximum region. In addition, an increase in the weight % of TiC particles in the matrix exhibits an increase in the tensile strength of the composites. The initiation of crack at the face and matrix yielding, it would be better to have the stress distribution at lower stress level. The plastic stress accumulation is more near the region of particle due to interface decohesion or particle (Fig. 5(a) &6(a)) which depends on the magnitude of the applied stress. Lack of plasticity due to the constraint on the matrix region, the large dimensions of the particle facilitate a greater degree of stress transfer from the matrix to the particle (Fig. 4). The plastic deformation of the matrix initiated after interface decohesion leads to the redistribution of stresses and an increasing strain of the matrix, which results in lowering of the overall stress as shown in microstructure(Fig.5(b) &6(b)).



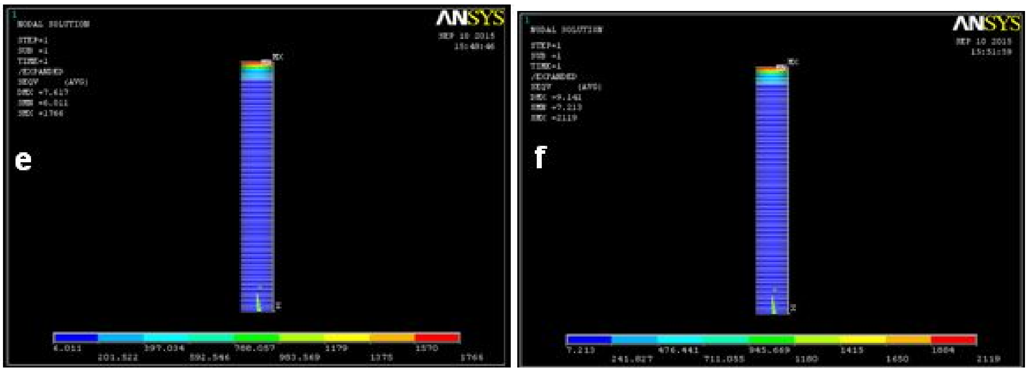


Fig.7 Stress distribution of 5 wt.%TiC on loads(a).2kN (b).4kN (c).6kN (d).8kN (e).10kN (f).12kN.

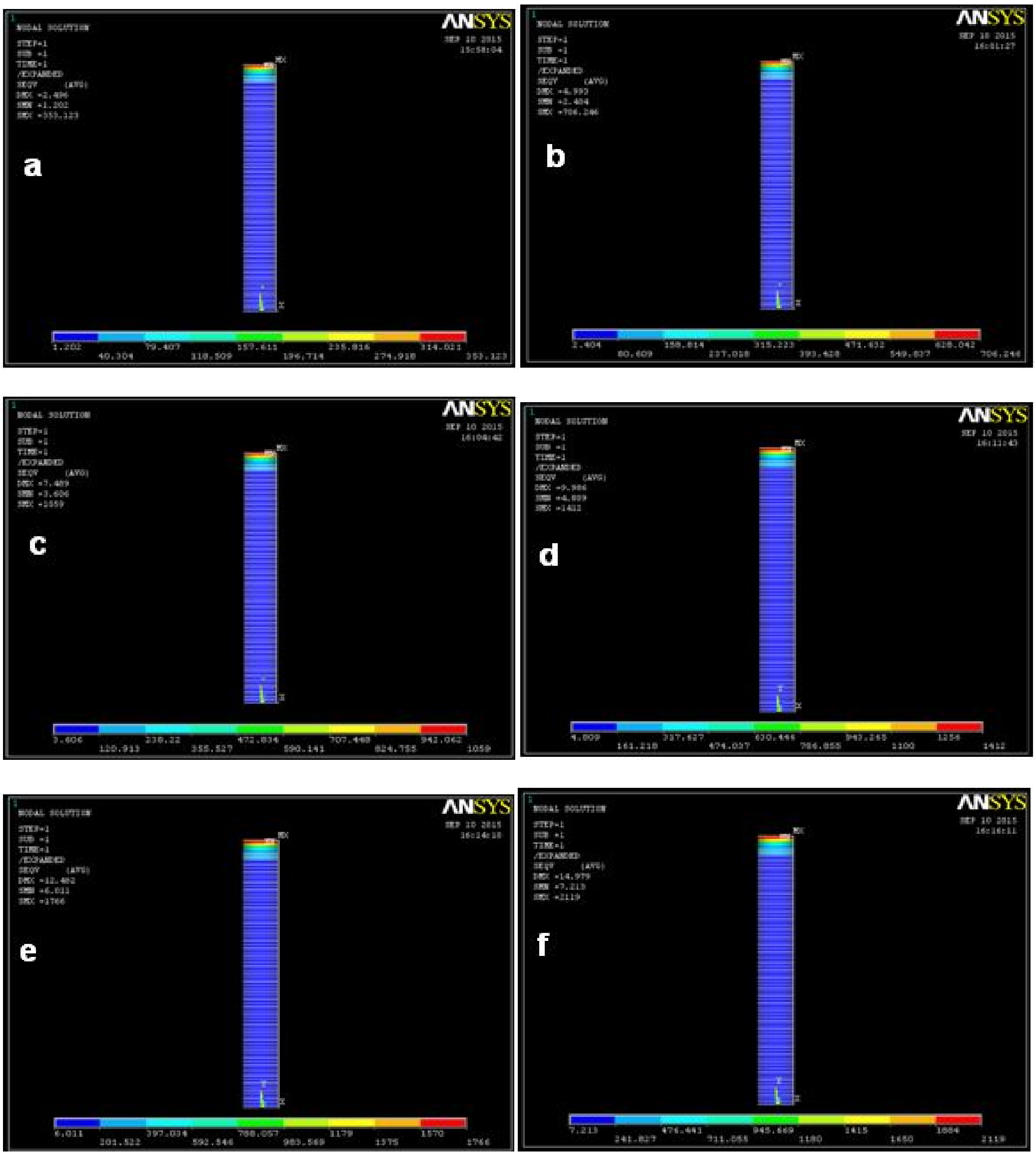


Fig.8 Stress distribution of 7.5 wt.%TiC on loads (a).2kN (b).4kN (c).6kN (d).8kN (e).10kN (f).12kN.

4. Conclusions

The following conclusions are drawn from the above investigation

- AA6063-5 and 7.5 wt. %TiC nano composite have been successfully synthesized using stir casting technique.

- The uniform distribution of the reinforcement is seen in the microstructure of the AA6063-5 and 7.5 wt. % TiC nano composite was carried out using optical microscope.
- From the stress-strain analysis the nanoparticles are very well dispersed in the molted metal and gives improved tensile strength.

References

1. Saravanan Varatharaju, Thyla Pudukarai Ramasamy, Balakrishinan Sreedhara,2014. The abrasive wear behaviour of Cenosphere Aluminum metal matrix composite, Acta Metallurgical Slovaca,l.20;2, pp.177-188.
2. RavichandranM, Naveen SaitA, Anandakrishnan V, 2014. Al-TiO_2-Gr powder metallurgy hybrid composites with cold upset forging, Rare Metals-33;6,pp.686-696.
3. RavichandranM, Naveen SaitA, Anandakrishnan V, 2015. Synthesis and forming characteristics of Al-TiO_2 powder metallurgy composites during cold upsetting under plane stress conditions, Journal of Sandwich Structure and Materials-17:3,pp.278-294.
4. Pramod SL, Srinivasa R, Bakshi, Murty B S, 2014. Aluminum based cast in situ composites: a review, Journal of Materials Engineering and Performance, DOI: 10.1007/s11665-015-1424-2.
5. Garg R K,Singh K K, Anish Sachdeva, Vishal Sharma, Kuldeep Ojha, Sharanjit Singh, 2010. Review of research work in sinking EDM and WEDM on metal matrix composite materials, Int. Jour. Adv. Manuf. Technol. 50;(5-8), pp.799-809.
6. GopalakannanS, SenthilvelanT,2013. Application of response surface method on machining of Al-SiC nanocomposites, Measurement 46;pp.2705-2715.
7. A.R.C. Westwood, 1988. ibid 19B, pp.155.
8. GotmanI, Koczak M J, ShtesselE, 1994. ibid. A187; pp.189.
9. TongXC, 1998. Fabrication of in situ TiC reinforced aluminum matrix composites: Part I-Microstructural characterization, Journal of Materials Science 33; pp.5365-5374.
10. LinY,ZeeR H, ChinBA, 1991. Metall.Trans. 22A; pp.859.
11. Rai R N, RaoAKP, Dutta G L, ChakrabortyM, 2013. Forming Behaviour of Al-TiC in-situ Composites, Mater. Sci. Forum, 765; pp.418-422.
12. SurappaMK, 2003. Aluminium matrix composites: challenges and opportunities, Sadhana28; Parts 1 & 2, pp.319-334.
13. Ramulu M, Paul G, Patel J, 2001. EDM surface effects on fatigue strength of 15 vol. % SiCp/Al metal matrix composite material. Compos. Struct. 54; pp.79-86.
14. Akshay D, Pradeep K, Inderdeep S, 2009.Experimental investigation and optimization in EDM of Al 6063 SiCp metal matrix composite, Int. Jour. Mach Mater., 5(3-4); pp.293-308.
15. Sozhamannan G G, Balasivanandha prabuS, Paskaramoorthy R, 2010. Failure analysis of particle reinforced metal matrix composites by microstructure models, Materials and Design 31; pp.3785-3790.

*****