Effect of Microstructure, Mechanical and Tribological Properties of Al5005 Reinforced Titanium Carbide (TiC)

Pramod Nayak P. G[1] , Shiva Pratap Yadav[2] , Manish Nayakp [3]
P.G. Student, Department of Mechanical Engineering, NITTE Meenakshi Institute of Technology, Bangalore, India[1]
Assistant Professor, Department of Mechanical Engineering, NITTE Meenakshi Institute of Technology, Bangalore , India[2]
Assistant Professor, Department of Mechanical Engineering, Girijabai Sail Institute of Technology, Karwar , India[3]
Machine Design

Abstract

The current work describes the fabrication of Al5005 composites reinforced with TiC with different reinforces of TiC (3% , 6% and 9%).Liquid metallurgical route was used to fabricate composites. Various tests such as microstructure, hardness and compression tests was conducted as per ASTM standards. The results obtained were compared with as-cast alloys and conclusions were drawn based on the obtained results.

Keywords:- Stir Casting, Al7005 ,TiC, Hardness, Compression

I. INTRODUCTION

MMCs initially appeared to enhance execution for cutting edge military frameworks. They were not completely created till mid 1970s and their applications spread in the 1980s. In the ongoing decades, inquire about on MMCs in understanding the handling, microstructure and property assessment to different designing applications has been quick creating because of their adaptability in fitting their physical, mechanical and different properties as requested in a large portion of the applications [1-6]. Be that as it may, MMCs are yet to be abused financially. In the present situation, MMCs made of magnesium compounds, aluminum amalgams, titanium combinations and lithium are the significant ones discovering applications in car, aviation and other related enterprises.

II. Related work

Bhargavi Rebba et al. studied the aftereffects of a test examination on the mechanical properties of molybdenum disulphide (MOS_2, likewise called moly disulphide) powders strengthened in aluminum combination (Al-5005) composite. MOS_2 powders of roughly 40μm molecule measure were fortified in an aluminum combination lattice to deliver composite examples of proportions, 1, 2, 3, 4 and 5 weight % through mix throwing system.

Sijo M T et al. studied the Aluminum silicon carbide metal grid composites are utilized in different fields like aviation, air ships, submerged, car, substrate in hardware, golf clubs, turbine cutting edges, brake cushions and so on. A few manufacture procedures are accessible

for the creation of aluminum silicon carbide metal grid composites (Al-SiC MMC). Among the different techniques, mix throwing course is basic, more affordable, and utilized for large scale manufacturing [7-13].

2.1. Summary of literature review

- At the point when the fortifications are included, the particulate fortifications structure cores which results in more prominent number of grain development. Consequently, the development is confined further, which results in more prominent quality.
- Blend regular throwing strategies the significant preferred standpoint of blend throwing process is its relevance to large scale manufacturing. Contrasted with other creation strategies.

Xiao Hong Wang has investigated the role of texture on initiation and expansion of corrosion pits for a D16T aluminium alloy drilling pipe in 3.5% NaCl solution by immersion and electrochemical tests. The results revealed that the surface parallel to the extrusion direction has typical brass [110] <112> and copper [112] <111> grain orientations, and the surface perpendicular to the extrusion direction has typical [112]<110>,[111]<112> and [001<100> grain orientations. The <211> orientation sub-grain and sub-grain/deformed grain were found to be responsible for the initiation of circular corrosion pits.

III. Methodology

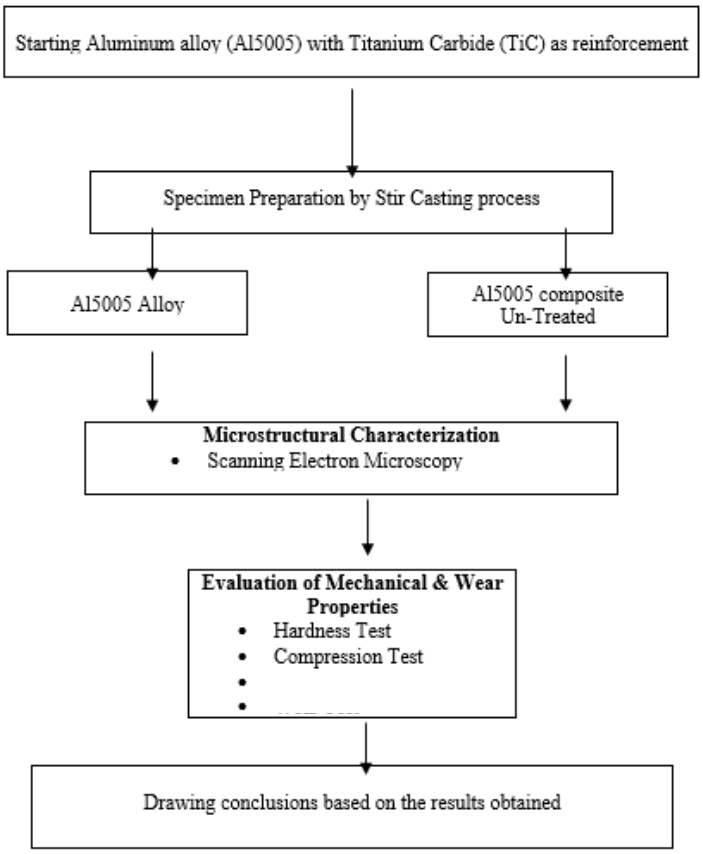

Fig 1 Flow Chart of Experimental Work

IV. Experimental results

A. Material Selection And Sample Preparation

- Aluminium 5005 as Matrix Material

Table 1: Chemical composition of Al5005 alloy (weight percentage)

Si	Fe	Cu	Mn	Mg	Cr	Zn	Others	Balance
0.28	0.07	0.18	0.18	0.85	0.08	0.19	0.12	Aluminium (98.5)

Figure 2: Al5005 Billet

- Titanium Carbide (TiC) as Reinforcement Material

Table 2: physical properties of Titanium Carbide (TiC) used in present study

Properties	Density	Melting Point	Elastic Modulus	Poisson Ratio
Values	4.93g/cm^3	4820 ^{0}C	400 GPa	0.19

Figure 3: Titanium Carbide (TiC) Sample

- Designation of Titanium Carbide (TiC) Reinforced Alloy

Table 3: Designation of TiC/5005-Alloy

S/No	Alloy/Composite Designation	Notation
1	As-Cast Al5005 alloy	T_c
2	Al5005 alloy + 3%Titanium Carbide	$3T_c$
3	Al5005 alloy + 6%Titanium Carbide	$6T_c$
4	Al5005 alloy + 9%Titanium Carbide	$9T_c$

B. Fabrication of Specimens

- Stir Casting Process

Procedure, the vital entity is to make great drenching among the particulate support dispersions in these cast composites might likewise be an issue because of connection between suspended ceramic particles and moving solid liquid interface in the midst of establishing. This procedure has real preferred standpoints that the generation cost of MMCs are low. A few papers propose a twostep blend throwing procedure to improve homogeneity of the fortifications in the composite.

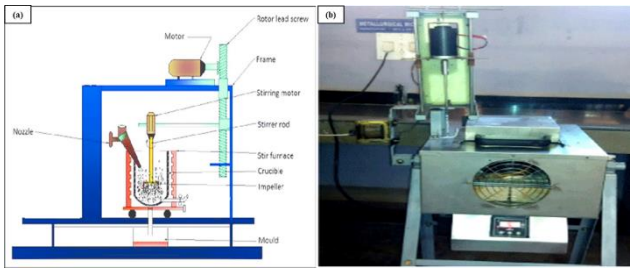

Figure 4 (a): Line diagram of Stir-Casting Process (b): Schematic Representation of Stir-Casting Process

C. **Microstructure Characterizatio***n*

- Sample Preparation for Microstructure Characterization

The microstructure of composites is carried out using an optical microscope. Here, Keller's reagent is used as an etching agent. In this project study, sand papers of Grit size 220µm, 400µm, 600µm, 800µm& 1000µm and also Grade 1.0, 2.0, 3.0, 4.0 &5.0 are respectively used for polishing purposes to obtain mirror surface for microstructure analysis.

Figure 5: Emery papers of Different Grit size

- Surface Preparation

The specimens will be properly grinded, polished and etched for microscopy exploration as per ASTM ideals.

- Polishing and Etching

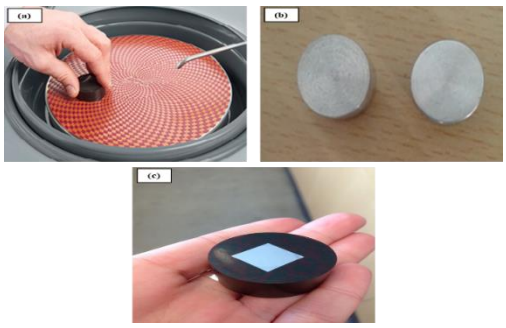

Figure: 6 (a) Polishing or Grinding Machine (b) Specimens before polishing (c) Specimen after Polishing

- Hardness Test

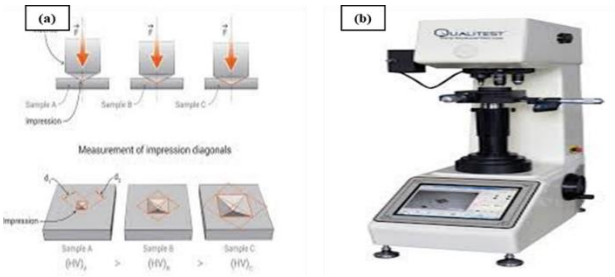

Figure 7 (a): Vickers Hardness Test indentation (b): Vickers Hardness Tester

Table 4: Specification of Vickers hardness testing Machine

Make	M/S FINE TESTING MACHINES
Model No	FMV-1
Magnifications	125X, 250X & 625X
Maximum test height	115 x 70 mm.
Gross weight	80 kgs(approx.)
Hydraulic oil used	Servo-system-32
Load range	10 grams to 1000 grams
Mains supply	220V AC, 50Hz, 1-Phase

Vickers' hardness trial route, also deduced a smaller scale hardness test approach, is ordinarily used in lieu slim areas, or connotation toil. The 'Vickers' system trusts on structure. 'Micro hardness test 'framework, `ASTM E-384`, picks a level of using a vital stone indenter surveyed altered done solidity regard. A quadrangular vile encompassed huge stone is used for testing.

V. RESULT AND DISCUSSION

A. MICROSTRUCTURAL CHARACTERIZATION OF AL 5005 ALLOY AND ITS MMC'S USING SEM

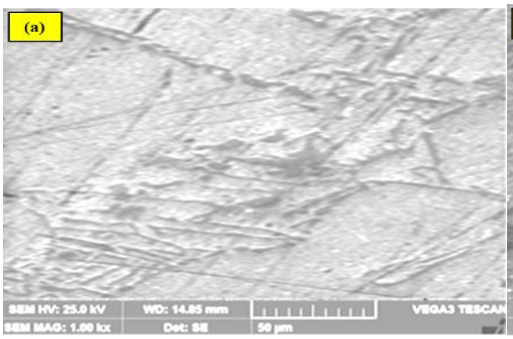

Figure 5.1(a):SEM Micrograph of as-cast Al5005 alloy

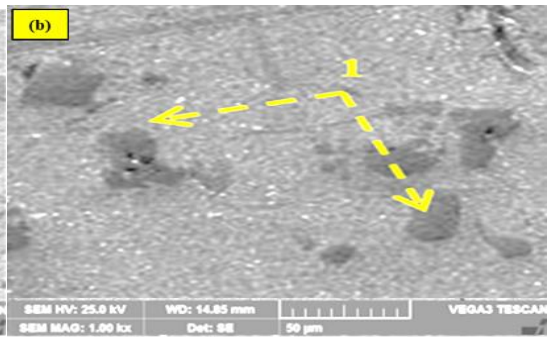

Figure 5.1(a):SEM Micrograph of as-cast Al5005 alloy + 3% TiC

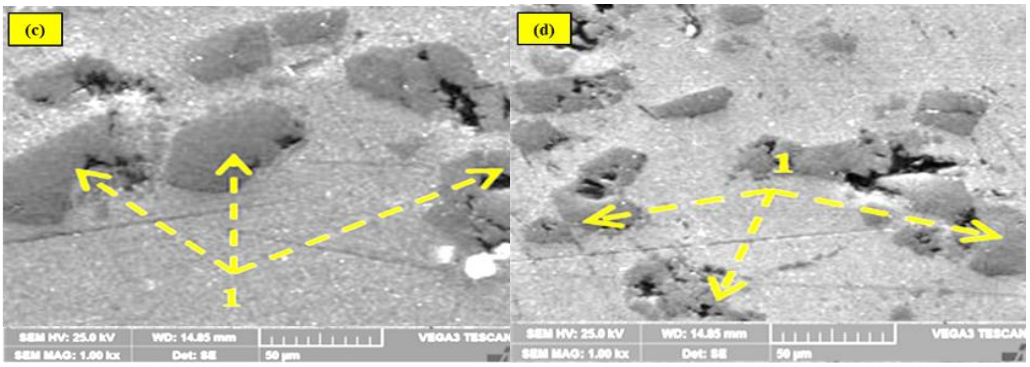

Figure 5.1(a):SEM Micrograph of as-cast Al5005 alloy + 6% TiC

Figure 5.1(a):SEM Micrograph of as-cast Al5005 alloy + 9% TiC

The microstructure clearly shows a truly consistent circulation of fortification (TiC) in all cast amalgamated frameworks with negligible absorption in the lattice amalgam. Microstructure comprises fine incentives in a strong arrangement of dendritic aluminium. There is no isolation or porosity in the area. We can see that the spikes in the middle are fairly dispersed. The turbulent district shows the medium and the silver tone shows the dispersion of TiC particles. It shows a well spread twitch particle area within the Al5005 matrix. This was due to the effective stirring action and the use of acceptable parameters for stir casting in the casting process. Typically, the increase in the weight share of composite enhancements leads to consistency problems [14-17].

B. Hardness Test results of Al5005 alloy and its composites

Table 5: Hardness Test results of Al5005 alloy and it's composite

S/No	Alloy/Composite Designation	Notation	Hardness (VHN)	% Increase In Hardness
1	As-Cast Al5005 alloy	A5005	90.2	--------
2	Al5005 alloy + 3%Titanium Carbide	A5005-3T_c	96.1	6.54 %
3	Al5005 alloy + 6%Titanium Carbide	A5005-6T_c	99.4	10.19 %
4	Al5005 alloy + 9%Titanium Carbide	A5005-9T_c	103.8	12.86 %

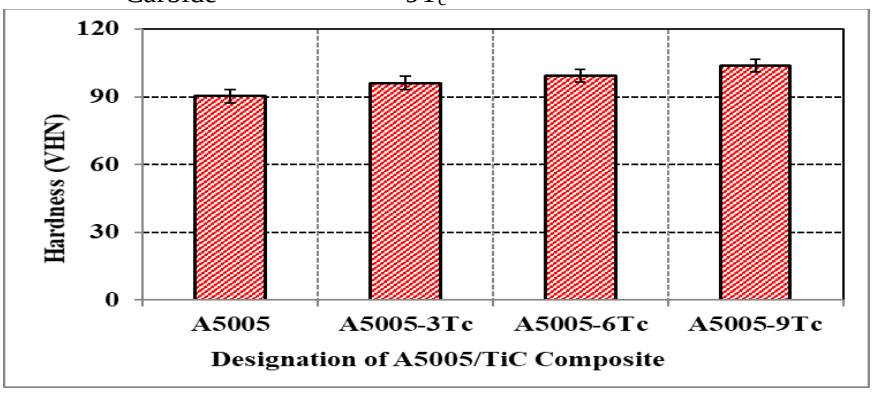

Figure 8: Hardness values of Al5005 alloy and it's Composite

The figure shows linear increases in hardness of 3Tc, 6Tc and 9Tc in comparisons to the as-cast alloy due to the addition of the medium fortifying. This is due to the stentorian capacity of the medium material bolstering [14-17].

C. Tensile Test results of A5005 alloy and its composites

Table 6: Tensile Test results (UTS) of Al 5005 alloy and it's composite

S/No	Alloy/Composite Designation	Notation	UTS (MPa)	% Increase In UTS
1	As-Cast Al5005 alloy	A5005	185.2	--------
2	Al5005 alloy + 3%Titanium Carbide	A5005-3Tc	191.6	3.45
3	Al5005 alloy + 6%Titanium Carbide	A5005-6Tc	198.4	7.12
4	Al5005 alloy + 9%Titanium Carbide	A5005-9Tc	207.9	12.25

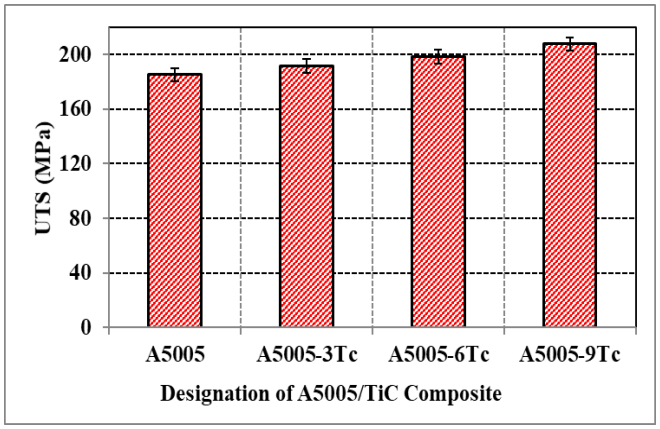

Figure 9: Tensile Test values (UTS) of Al5005 alloy and it's Composite

From this figure you can see a linear increase in strength (UTS) of 3Tc, 6Tc and 9Tc as compared to the as-cast alloy due to the addition of the medium. This is due to the storage capacity of the material for bolstering [18-24].

References

[1] B Sajjan, L Avinash, S Varun, KN Varun Kumar, A Parthasarathy "Investigation of Mechanical Properties and Dry Sliding Wear Behaviour of Graphite Reinforced Al7068 Alloy-"Applied-Mechanics-and-Materials-,867,(2017),-10-1.

[2] L Avinash, T Ram Prabhu, A Parthasarathy, KN Varun Kumar, B Sajjan " Wear and mechanical behaviour of Hypo-eutectic Al-7% Si-0.5% Mg alloy (A357) reinforced with Al_2O_3 particles", Applied Mechanics and Materials ,829,(2016), 66-72.

[3] A Parthasarathy, L Avinash, KN Varun Kumar, B Sajjan, S Varun "Fabrication and Characterization of Al-0.4% Si-0.5% Mg-SiCp Using Permanent Mould Casting Technique-"Applied-Mechanics-and-Materials,-867,(2017),34-40.

[4] L Avinash, T Ram Prabhu, S Bontha "The Effect on the dry sliding wear behavior of gravity cast A357 reinforced with dual size silicon carbide particles" Applied Mechanics and Materials, 829,(2016),83-89.

[5] AK Mullah, L Avinash, VR Kabadi "Study of Mechanical and Tribological Properties of CSAp Reinforced LM25 MMC " Journal of Material & Metallurgical Engineering 8 (2), 28-32

[6] S Praveen, Y Sumanth, N Darshan, N Manas, L Avinash "Effect of Solutionizing and Ageing on Mechanical Properties of AL2024 Reinforced Alumina Particulate " Journal of Material & Metallurgical Engineering 8 (3), 8-12
[7] Bhargavi Rebba, Surappa MK. Aluminium matrix composites: challenges and opportunities. Sadhana 2003; 28(1–2):319–34
[8] Atul kumar, Zuoyong Dou, GaohuiWu, Xiaoli Huang, Dongli Sun and Longtao Jiang // Composites: Part A 38(2007) 186!.
[9]. Sijo M, M. Ramachandra, and K. Radhakrishna // Wear 262(2007) 1450.
[10] Himanshu Kala, Charles S and Arunachalam, V. P. (2004). "Property Analysis and Mathematical Modeling of Machining Properties of Aluminium Alloy Hybrid (Al-Alloy/SiC/flyash) Composites Produced by Liquid Metallurgy and Powder Metallurgy Techniques. "Indian Journal of Engineering and Material Science, 11, 473-480`.
[11] Arora.A , Basavarajappa S, Chandra Mohan, G., Subramanian, R., Chandrashekhar, A. (2006). "Dry sliding wear behaviour of Al2024/ SiC metal matrix composites." Materials Science, Poland, 24, (2/1), 357-366`.
[12] Deepak C Patil ,W. Kaczmar, K. Naplocha (2008)"Wear behavior of composite materials based on 2024 Al-alloy reinforced with alumina fibers", an Institute of Production Engineering and Automation, Wroclaw University of Technology, Poland`
[13] K. Kanthavel, K.V., Radhakrishna, K. (2007). "Castable composites and their application in automobiles", Proceedings I Mech E 221(Part D): J. Automobile Engineering, 135-140`.
[14] S.Magibalan and H.J. Rack, "Dry Sliding Wear of Discontinuously Reinforced Aluminium Composites: Review and Discussion", Wear, Vol.189, Pp.1-19, 1995`.
[15] Kapil Kumar, M.K. Surappa and S. Brusethang, "Effect of reinforcement volume fraction and size distribution on the tribological behavior of Al – Composite", Wear, Vol.206, Pp.1248 – 1255, 2006`.
[16] `Preetham Kulkarni, S.K. Sheshadri and K.J.L. Iyer, "A survey of aspects of wear of metals", Indian Journal of Technology, Vol.29, Pp. 179 – 185, 1991`.
[17] Inampudi Narasimha Murthy F.D. Moriniere, R.C. Alderliesten, R. Benedictus Energy distribution in Glare and 2024-T3 Aluminium during low-velocity impact (International Congress of the Aeronautical Sciences) Structural Integrity Group, Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, The Netherlands`
[18] Cun-Zhu Nie, Dhirendra Verma, Sudhir Kumar "Processing and Tensile Testing of 2024 Al Matrix Composite Reinforced with Al2O3 Nano Particles" (2014) (AIMTDR 2014) December 12th–14th, IIT Guwahati, Assam, India`
[19] Preetam Kulkarni, (2015) "Evaluation of Mechanical Properties of AL 2024 Based Hybrid Metal Composites" IOSR-JMCE, e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 12, Issue 5 Ver. IV, PP 108-122
[20] Inampudi Narasimha Murthy, Nallabelli Arun Babu, Jinugu Babu Rao (2014) "Comparative Studies on Microstructure and Mechanical Properties of Granulated Blast Furnace Slag and Fly Ash Reinforced AA 2024 Composites" Journal of Minerals and Materials Characterization and Engineering, , 2, 319-333
[21] Cun-Zhu Nie, Jia-Jun Gu, Jun-Liang Liu, Di Zhang,(2007) "Production of Boron Carbide Reinforced 2024 Aluminum Matrix Composites by Mechanical Alloying" Materials Transactions, Vol. 48, No. 5 , pp. 990 to 995
[22] H.J. PARK, K.H, N.S. Cho and S.W. Kim titled "A study of hydrostatic extrusion of copper clad aluminium tube"
[23] C.S. Ramesh and Naveen Noronah on "A review on hot extrusion on metal matrix composites (MMC's) in March 2014.
[24] Anand Babu Varadala on 'No access equal channel angular extrusion of Al5083 alloy with Copper Shielding' published in 'Emerging materials research' in August 2018.