ISSN: 2456-9348
Vol (03) _Issue (03) Impact Factor: 4.520

iJETRM
International Journal of Engineering Technology Research & Management

# EXPERIMENTAL INVESTIGATION ON SINGLE AND DUAL REINFORCEMENT IN ALUMINUM METAL MATRIX COMPOSITES MANUFACTURED BY STIR CASTING- A REVIEW

Abhimanyu Mallick
K.Logesh
A.Manimaran
M.Venkatasudhahar
Department of Mechanical Engineering, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu, India
abhimanyu.mallick@gmail.com
klogesh7@gmail.com
mullaimaran@rediffmail.com
kmrflowers@gmail.com

**ABSTRACT**
Aluminium Metal Matrix Composites (Al MMC) are impotent class of martials used in various application such as aerospace, automobile, agriculture machinery and other industrial applications because of their essential materials properties such good wear resistance, low density and high strength as compared to any other composite materials. In this study, deals with the addition of reinforcements i.e., single and dual nano particles to the Aluminium matrix in various proportions. Aluminium metal matrix composites manufactured by stir casting will be reviews with different combinations of reinforcement in aluminium matrix and how the proportion of reinforcements has effected the composites material properties in details. Also this work deals to study the fabrication of metal matrix composite by cost effective stir casting techniques and study the Tensile test, Hardness test, Wear resistance test & Microstructural analysis of composites. The application of Al MMCs are also marked comprehensibly in this work.

**KEYWORDS:**
Aluminium Metal Matrix Composites, Wear resistant properties, Stir casting, Nano particles.

## INTRODUCTION

Aluminium Metal Matrix Composites are increasing importance because of its unique combination for low density, good corrosion resistance and excellent mechanical properties. Aluminium MMCs are great extent used in automobile, aircraft, aerospace and various industrial application [1]. Aluminium Matrix Composites (AMC) are commonly reinforced by, silicon carbide (SiC), aluminium oxide ($AL_2O_3$) and carbon (C). The form of reinforcement are in the flakes, fibers and particle. Aluminium matrices are mainly Al-Si, Al-Cu, 2xxx, 6xxx and 7xxx alloy [2-4]. The distribution of particle play impotent role in the properties of Al MMC. Fibers are important reinforcement that satisfied to fabricate the desired composite.

Reinforcement with $Al_2O_3$ particulate has very good comprehensive strength and wear resistance of Al MMC. Boron carbide ($B_4C$) is the one of hardest material. Reinforcement with boron carbide increase the hardness but not increase the wear resistance significantly [5]. The zircon increase the wear resistance in Aluminium MMCs and usually used as hybrid reinforcement [6]. The fly ash also increase importance as reinforcement due to low cost and easily available in the in the thermal power plant and it increase effect of electromagnetic shielding in Al MMC. hBN is mixed into ceramic to provide the self-lubricating properties and carbides to gaining resistance against thermal shock and corrosion [7]. The hBN is used as solid pressure media because of its effective at transmitting pressure.

iJETRM
International Journal of Engineering Technology Research & Management

## STIR CASTING METHOD

The stir casting method is liquid state processing in which the matrix material will be melted and the reinforcement materials will be added to it and stir with graphite made stirrer by suitable mechanism. The stir casting is generally adopted in promising route and practiced commercially. The advantages stir casting is its simplicity, cost effective and can be applied to large production quantity effectively. The main disadvantage of stir casting is to obtained particle wettability in molten liquid metal and homogenous dispersion of the reinforcements.

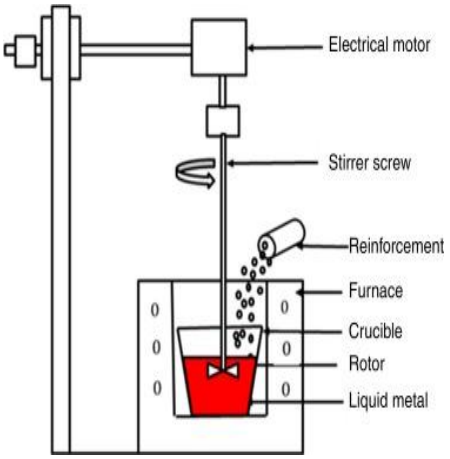


Fig.1. Stir Casting Process

Courtesy: https//www.researchgate.net/

## SINGLE REINFORCEMENT Al MMCS

The reinforcement such as $ZrO_2$, $Al_2O_3$, SiC, $B_4C$, CNT, Graphene, BN etc. is used single in the aluminium metal matrix composite to enhance the properties of materials is called the single reinforcement Al MMCs . The tensile strength is increased with increasing the content of $ZrO_2$ at 750°C which is the result of increasing dislocations density and their pile-ups behind the uniform distributed $ZrO_2$ particles [2]. The Increasing $ZrO_2$ volume percent resulted in an increase in ultimate tensile strength of the composite, however decrease the tensile strength containing 15 vol% $ZrO_2$, mainly due to the formation of porosity in the composite by air entrapped in high temperature casting [3].

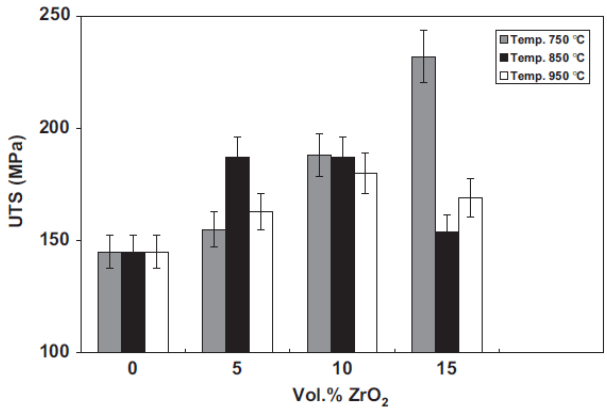


Fig. 2.The UTS results of the Al alloy and the composites specimen's containing5, 10 and 15 vol% $ZrO_2$ fabricated at750, 850 and 950°C [3].

iJETRM
International Journal of Engineering Technology Research & Management

The aluminium A356 reinforced with 3 wt. % of $Al_2O_3$ not increase in the tensile strength but significantly increase hardness [4]. SiC particle reinforced with Al MMC is increased tensile strength, density and hardness of composite but decrease in impact toughness [8]. The impact properties of Al and SiC particle reinforced in Al MMC with different temperature conditions [9]. The impact properties of composites was affected due to clustering and cracking of particles, also weak reinforcement bonding with matrix. Experimentally investigation found that Al-$Al_2O_3$ composites has better wear rate as compared with Al-SiC composites [10]. The wear properties of A356 reinforced with 25SiC in Al MMC has compared with the grey Cast iron slipping over friction material used in automobile. It has been noticed that the wear resistance of the composite is better than the grey cast iron and most suitable material used in brake drum [11]. However, this composite cannot be used for lining material due to of the presence hard particles of SiC. The mechanism for tool wear of cutting tool made by SiC composites shows that the main damage due to abrasive wear and brittle failure The main factors affecting in tool life are the weight % volume of SiC particulates and its size in the composite [12]. In the experimental investigation, the effect of volume fraction of $Al_2O_3$ reinforcement varying from 5-30% in Aluminium matrix and found that the fracture toughness of the Al MMC has decrease while increase in weight % volume of $Al_2O_3$ particulate. The fracture toughness decrease due to increase spacing on inter-particle of nucleated micro voids [13]. The experimentally investigation for characterization of A359/$Al_2O_3$MMC by using electromagnetic stir casting technique. The electromagnetic stirring action effects increase in tensile strength and hardness of Al MMC due to micro grain size and better particulate matrix interface bonding [14]. Al MMC wear resistance has increased with the increase weight volume of fly ash while reduce the corrosion resistance by increasing in fly ash content [15]. Carbon nano tube are taken much interest for next generation materials for industries application due to unique properties such as five time lower density and hundred time higher strength as compared with conventional material [16].

## DUAL REINFORCEMENT Al MMCS

Two different particulate reinforce to the matrix for fabrication the composite is called the dual reinforcement composite. This composites are fabricating to achieve the required properties of composites material with addition of two different reinforcement such as Al- $Al_2O_3$ - $Si_3N_4$ Al-$Al_2O_3$- Graphite, Al-$Al_2O_3$-SiC & Al-$Al_2O_3$-h-BN and so on.

The impact of metal (Al) mixed dual size particle reinforcements ($Al_2O_3$ (mm) & $Si_3N_4$ (nm)) and the domination of silicon nitride nano particle in the composite system. Tensile characteristics were much influenced by pre mixed $Si_3N_4$ nano particles and its volume fraction in composites. The composites with dual reinforcement have shown superior tensile behavior than single reinforcement [17].

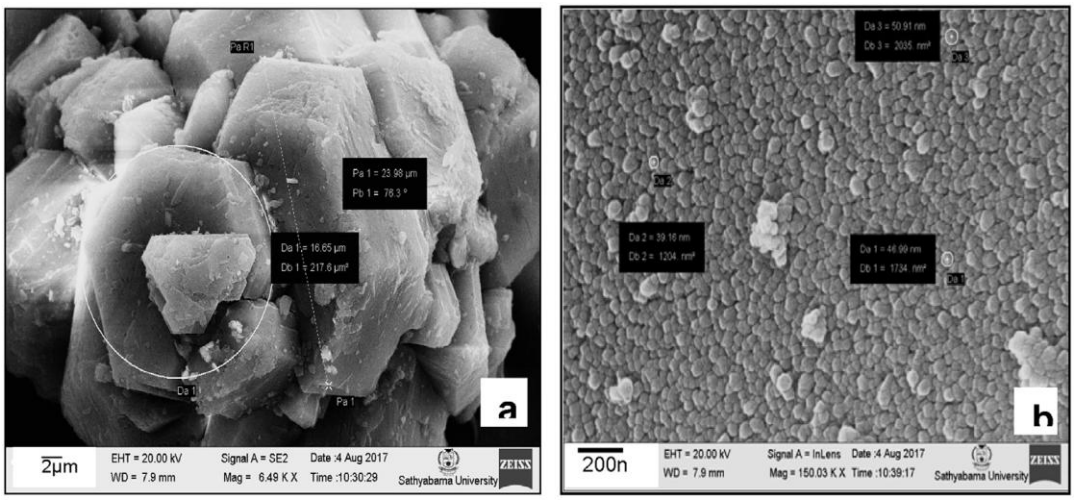


Fig. 3. SEM micrographs of a) micron $Al_2O_3$ particles and b) nano $Si_3N_4$ particles [17]

iJETRM
International Journal of Engineering Technology Research & Management

Composites material reinforced with $Al_2O_3$ and SiC in aluminum metal matrix has increase physical and mechanical properties. This composite material is one of Lightweight materials and can be used in automobile components [18]. The interest in use of hexagonal boron nitride particles (h-BN) as reinforcement for aluminium has been growing considerably due to its self-lubricating property, thermal and chemical stability. The dual reinforcement of $B_4C$ (2 wt. % and 4 wt. %) and h-BN (2 wt. %) particles composites shows improvement in elongation and impact energy. The wear properties of the dual reinforcement composites, containing 4 wt.% $B_4C$ and 2 wt. % h-BN, exhibit the superior wear resistance properties compared to the unreinforced aluminium matrix and composites[19]. Reinforcement of $Al_2O_3$ microspheres in Al 6061-Mg-Si alloy with the different volume fraction varying from 5%-30%. The composite fabricated with powder metallurgy is better fatigue strength as compared with stir casting process shows in the experimental investigation [20]. In the experimental investigation composite fabricated with Al-Cu alloy matrix with Zircon, alumina and sand particles have better wear resistance compared with un-reinforced alloy. However, zircon reinforced composites found better resistance of wear than that of alumina reinforced composite due to better particle matrix bonding [5].

## CONCLUSION

Several researches confirmed in order to strengthen the Al MMCs properties such as mechanical and tribological behavior corresponding to its applications. The main conclusions arrived from the previous works are summarized as follows.

-Dual reinforcement with aluminium metal matrix composite has more advantages for preparing the low density, superior strength, and hardness over the single reinforcement composite material and base metal. Hence trend has been increased to use dual reinforcement in many applications fields including, structures of aeronautical, automobile and marine.

-The single reinforcement with aluminum metal matrix trend shows that it is only increase the certain properties of composite material, however the dual reinforcement has improve the materials in multi directional i.e. increase hardness as well as better lubrication properties.

- Al MMCs reinforced with SiC have higher wear resistance properties as compared with $Al_2O_3$ reinforced Al MMCs.

- Al MMCs reinforced with SiC are best materials for use in brake drums due to high wear resistance, however this composite not suitable for brake linings application because of this will damage the brake drum.

- The fracture toughness of the Al MMC has decrease while increase in weight % volume of $Al_2O_3$ particulate.

- Al MMCs reinforced with Zircon sand improves the compressive strength and wear resistance of the composites material.

-The hBN reinforcement is used as solid pressure media because of its effective at transmitting pressure.

- Hexagonal boron nitride particles (h-BN) as reinforcement for aluminium has been growing considerably due to its self-lubricating property, thermal and chemical stability.

- Aluminium reinforced with flyash improves the wear resistance, while corrosion resistance is reducing.

- The composites with dual reinforcement have shown superior tensile behavior than single reinforcement.

## REFERENCES

[1] D.L. Mc danels (1985) " Metall Tans." A16-1105.

[2] Hai Su, Wenli Gao, Zhaohui Feng and Zheng Lu (2012) " Processing, microstructure and tensile properties of nano-szed $Al_2O_3$ particle reinforced aluminium matrix composites" Materials and Design 36, 590-596.

[3] Hossein Abdizadeh, Reza Ebrahimifard and Mohammad Amin Baghchesar (2013) "Investigation on mechanical properties and fracture behavior of A356 aluminum alloy based $ZrO_2$ particle reinforced metal-matrix composites' Ceramics International 39, 2045–2050.

[4] Z. miskovic, and I. bobic, (2006) "The Structure and Mechanical Properties of an Aluminium A356 Alloy Base Composite with $Al_2O_3$ Particle Additions" Tribology in industry, Volume 28, No. 3&4,

[5] Barbara Previtali, Dante Pocci and Cataldo Taccardo, Composites: Part A 39 (2008) 1606.

[6] Sanjeev Das, Siddhartha Das and Karabi Das (2007), Composites Science and Technology 67, 746.

[7] R. Haubner, M. Wilhelem, R Weissnbacher (2002) Boron nitride- properties, synthesis and application, Struct Bond 102,1-45.

iJETRM
International Journal of Engineering Technology Research & Management

[8] Tamer Ozben, Erol Kilickap and Orhan Cakir (2008) Materials processing technology 198, 220-225.
[9] Sedat Ozden, Recep Ekici and Fehmi Nair (2007), Composites: Part A 38 (2007) 484.
[10] D. Sujan, Z. Oo, M.E. Rahman, M.A. Maleque and C.K. Tan(2012) *Engineering and Applied Sciences* 6, 288.
[11] N. Natarajan, S. Vijayarangan and I. Rajendran (2006) *Wear* 261, 812.
[12] Quan Yanming and Zhou Zehua (2000), Materials processing technology 100, 194.
[13] B.G. Park, A.G.Crosky and A.K.Hellier( 2008), Composites: Part B 39,1270.
[14] Abhishek Kumar, Shyam Lal, Sudhir Kumar Noida (2013), "Fabrication and characterization of A359/$Al_2O_3$ metal matrix composite using electromagnetic stir casting method", journal of Materials Research and Technology 2(3) 250-254.
[15] M. Ramachandra and K. Radhakrishna (2007) *Wear* 262 (2007) 1450.
[16] H. Kwon, C.R. Bradhury, M. Leparoux (2011), "Functionally grabbed nano particulate reinforced Aluminium matrix composite material" Advance Engineering materials, 13, 325-329.
[17] P.Hariharasakthisudhan, S. Jose (2017) "Influence of metal powder premixing on mechanical behavior of dual reinforcement ($Al_2O_3$ (mm)/Si3N4 (nm)) in AA6061 matrix" Journal of Alloys and Compounds 731, 100-110.
18] D. Sujan, Z. Oo, M.E. Rahman, M.A. Maleque and C.K. Tan(2012) Engineering and Applied Sciences 6 288.
[19] R Harichandran and N. Selvakumar (2017) "Microstructure and mechanical characterization of ($B_4C$ + h-BN)/Al dual composites processed by stir casting, International Journal of Mechanical Sciences 39, 08-12.
[20] B.G. Park, A.G. Crosky and A.K. Hellier (2008) Composites: Part B 39, 1257.
[21] B.Vijaya Ramnath and C. Elanchezhian (2014) "Aluminium metal matrix Composite-Areview" Advance material Science 38, 55-60.
[21] A.Dehghan Hamedan and MShahmiri (2012) "Production of A356-1wt.% SiC nanocomposite by the modified stir casting method" Material Science & Engineering A 556, 921-926.
[23] Hanumanthe Gowda and P. Rajendra Prasadb (2012) "Fabrication of A356 composite reinforced with micro and nano $Al_2O_3$ particles by a developed compo casting method and study of its properties" Journal of Alloys and Compounds 511, 226– 231.
[24] Hanumanthe Gowda,P and Rajendra Prasadb (2017) "Influence of Heat Treatment on corrosion Resistance of A356/RHA/$Al_2O_3$ Based Hybrid Composites", Materials Today: Proceedings 4, 10870–10878.
[25] Hossein Abdizadeh and Reza Ebrahimifard (2014) "Investigation of microstructure and mechanical properties of nano MgO reinforced Al composites manufactured by stir casting and powder metallurgy methods: A comparative study" Composites: Part B 56, 217–221.
[26] Hiratsuka, K.Enomoto,A and Sasada.T (1992) "Friction and wear of $Al_2O_3$ $ZrO_2$ and $SiO_2$ rubbed against pure metals" Wear 153, 361-373.
[27] J. Hashim, L.Looney and M.S.J Hashmi (1999) "Metal matrix composites: production by the stir casting method" Journal of Materials Processing Technology 92-93, 1-7.
[28] K.S. Alhawari and M.Z.Omar (2013) "Wear Properties of A356/$Al_2O_3$ Metal Matrix Composites Produced by Semisolid Processing" Procedia Engineering 68, 186 – 192.
[29] Lava Kumar Pillari, V. Umasankar and G. Chandrasekhar (2016) " Synthesis and characterization of nano hexagonal boron nitride powder and evaluating the influence on aluminium alloy matrix" Material Today: Proceeding 3, 2018-2016.
[30] M. Karbalaei Akbari and H.R. Baharvandi (2013) "Fabrication of nano-sized $Al_2O_3$ reinforced casting aluminum composite focusing on preparation process of reinforcement powders and evaluation of its properties" Composites: Part B 55, 426–432.
[31] M. Karbalaei Akbari and O. Mirzaee (2013) "Fabrication and study on mechanical properties and fracture behavior of nanometric $Al_2O_3$ particle-reinforced A356 composites focusing on the parameters of vortex method" Materials and Design 46, 199–205.
[32] S.T. Selvamani and S.Premkumar (2017) "influence of carbon nano tubes on mechanical, metallurgical and tribological behavior of magnesium nanocomposites" Journal of magnesium and alloys, 2213-9567.