Manufacturing and Machining Challenges of Hybrid Aluminium Metal Matix Composites

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Abstract: Manufacturing which involves material removal processes or material addition processes or material transformation processes. One or all the processes to obtain the final desired properties for a material with desired shape which meets the required precision and accuracy values for the expected service life of a material in working conditions. Researchers found the utility of aluminium to be the second largest after steel. Aluminium and its metal matrix composite possess wide applications in various applications in aerospace industry, automobile industry, Constructions and even in kitchen utensils. Hybrid Al-MMCconsist of two different materials, and one will be from organic origin along with the base material. In this paper an attempt is made to bring out the importance of utilization of aluminium and the challenges concerned in manufacturing and machining of hybrid aluminium MMC.

Keywords: HAMCs, Machining, Stir casting, WEDM

1. INTRODUCTION

Al-MMCreveal greater hardness, strength, toughness, specially made hybrid materials of aluminium. Hybrid materials are those materials which consists of two or more different materials, one is of organic origin. In this paper reinforcement choice by different researchers is chosen and method of casting. Ganesan Pandi, Saravanan Muthusamty [1] concluded that the reinforcement affects the mechanical, tribological and machining properties. Identified that graphite, alumina and fly ash alters the mechanical and tribological behaviour and affects the machinablity.

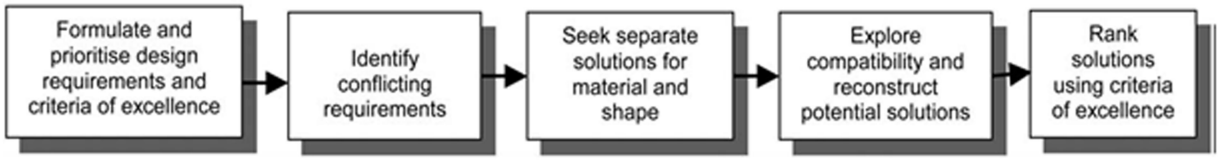

Fig.1 Steps for Hybrid (M.F.Ashby, Y.J.M.Brechet [3])

2. CASTING

The oldest known casting is cast in Mesopotamia dates back to 3200 B.C. In 2000 B.C Iron was discovered, 700 B.C cast iron in china, 500 A.D cast crucible steel. Vannoccio biringuccio is the first man to manuscript the foundry process, the father of the foundry industry. In 19th century Cupola is introduced, in 20th century first electric arc furnace is used. Rohatgi, P., Asthana, R. [19] reported that in India Aluminium with graphite, alumina and silicon carbide castings were first produced at Inco Limited and at the Indian Institute of Technology (IIT) at Kanpur (India) using stir-casting technique. Discovery of rheocasting at the Massachusetts Institute of Technology (MIT) by Merton Flemings. Jaswinder Singh, Amit Chauhan [4] concluded that Hybrid aluminium matrix composites (HAMCs) are realistic in automotive industries. HAMCs produced by stir casting method have been found to be even with microstructure. The limitations of ceramic reinforcement composites are overcome by HAMCs and reported that the particulates like fly ash, rice husk ash and mica addition reduces the density comparatively with ceramic particulate. Suggested replacement of conventional materials with HAMCs. J.David Raja Selvam, D.S.Robinson Smart and I.Dinaharan [5] investigated fly ash particles into semi solid aluminium MMC enhanced the wettability. Kiran Kumar Ekka and SR Chauhan, Varun [6] investigated HAMCs consisting of cenosphere, SiC and Al_2O_3 and reported that cenosphere acts like a solid lubricant that reduces wear rate. R.J.Friel. R.A.Harris [7] experimented on hybrid form of manufacture, referred as ultrasonic additive manufacturing. J.David Raja Selvam, D.S.Robinson Smart and I. Dinaharan [8] experimented using stir casting of aluminium, SiC and Fly ash and concluded that both micro and macro hardness of the composite increased and 23 percent increase in tensile strength. G Elango, BK Raghunath, K.PalaniKumar and K.Tamizhmaran [9] experimented and investigated on LM25 reinforced with SiC and TiO_2 and concluded that abrasive wear mechanism is owing to hard ceramic particles on the damaged surface. S A Mohan Krishna, TN Shridhar and L Krishna Murthy [10] produced composite reinforced with SiC and graphite particles by stir casting and also

investigated the thermal conductivity behavior of hybrid composite with varying proportions of reinforcements using laser flash technique. JSS Babu, A Srinivasan and CG Kang [17] developed nano - microhybrid reinforced MMC. GB Veeresh Kumar, ARK Swamy and A Ramesha [11] identified that cast iron and bronze MMC are being replaced by aluminium MMC due to low density And higher strength to weight ratio, used Tungsten carbide (WC)-Graphite in Al6061. Rheocasting, stir casting involve liquid shear induced by either mechanical or electromagnetic means to create vortexing flows. Muhammad hayat jokhio, Muhammad ibrahim panhwar and Mukhtiar ali unar [13] experimented on aluminium MMC matrix with the adding up of Copper, Zinc and Magnesium and Al_2O_3 using stir casting method and also tabulated the results shown in (Fig.2) of strength and elongation processed by either stir casting or vortex method. For small freezing range MMC stir casting need low power consumption [19].

Author Name	Country	Reference	Matrix Composition	Reinforcement	Process Used	Strength	El
Jokhio	Jamshoro Pakistan	[28, 29]	Al-Cu-Zn-Mg	Particulate "Al_2O_3" 48µm	Stir Casting	297MPa	17%
Kok	Turkey	[7]	Al-Cu 2024	10% "Al_2O_3" Max	Vortex	112 MPa	Not Determined
Yilmaza	Turkey	[14]	Si.46 MM .17	"Al_2O_3" 20µm 15 Val%	Stir casting	195 MPa	Not Determined
Srapppa and Rohatgi	India	[8]	Al- 11.8% Si 1-4% "Al_2O_3"	"Al_2O_3" 53-63µm	Vertex	157Mpa with 1% "Al_2O_3"	6%
						118 Mp with 4% "Al2O3"	2.5%
Stefanos Skolianos	Greece	[19]	4.5% Cu, 1.5% Mg	"Al_2O_3" 50µm 20 24 2%	Stir casting	194 MPa	Not determined
Azim, et all	Egypt	[21]	2024 4.12 Cu and 1.94 Mg	"Al_2O_3" 50-150µm 10% "Al_2O_3"	Vertex	132 MPa	3.2%
Rupa Das Gupta and Humaira Meenai	India	[15]	7075 Al-Cu-Mg-Zn Cu 1.6, Mg 2.5, Zn 5.6	Si Cp 40 µm 15 wt%	Stir casting	As cast alloy 63 MPa T6 100 MPa	1.13 1.56%

Fig.2 Comparison table Process, Al_2O_3 strength and elongation (Muhammad hayat jokhio [13])

P. Manimaran, C. Karthik Kumar, R. Bharanirajan and I. Premnauth [21] investigated hybrid composite of Al8011 aluminium MMC reinforced with B_4C and red mud processed by stir casting method. Prasanna, S. C., Ramesh, C., Manivel, R. and Manikandan [22] conducted experiments using different proportions of SiC, Fly Ash and Neem leaf ash in aluminium using stir casting method. Ritesh Raj, Dineshsingh G. Thakur [20] experimented using modified stir casting equipment and concluded that the particles of B4C distribution is homogeneous. Biswajit Das, Susmita Roy, R.N. Rai, S.C. Saha and Priyanko Majumder [23] developed

aluminium copper MMC reinforced with TiC particulates by stir casting method. S G Kulkarni, J V Menghani and Achchhe Lal [24] investigated mechanical properties of A356 with alumina and fly ash and revealed that compressive strength and microhardness are increased.

3. Bamboo Leaf Ash

Shridhara K T, Hanumnthal S, Annoji Rao TM [25] experimented with aluminium hybrid MMC and concluded that hardenss of hybrid metal matrix composite is higher than aluminium-copper alloy and also discussed that distribution of particulates in the uniform due to stir casting. K. K. Alaneme , E. O. Adewuyi [26] observed that bamboo leaf ash hybrid composite fracture toughness and elongation was better-quality than single reinforced composite. Himanshu Kala, K.K.S Mer, Sandeep Kumar [27] reviewed about stir cast aluminium based composite with addition of alumina, SIC and B_4C which improved the hardness, tensile strength, yield strength while ductility decreased. Discussed about organic reinforcement of coconut ash, rice husk ash which improved mechanical properties and tribological behaviour of the hybrid composite and concluded that Al MMCs with organic reinforcements very limited work is reported and suggests for further investigations. K. Kanthavel, K.R. Sumesh, P. Saravanakumar [28] reported about applications in aerospace and automotive, and also reported that alumina has good tribological properties but the limitation is about the lubrication and concluded that the introduction of MoS_2 a solid lubricant improved the tribological properties and beyond 10% there was no change in tribological property. Authors recommended for the scope of work in potential to optimise the composition and tribological property using design of experiment G. Miranda et.al. . [29] concluded that reinforced hybrid composites showed higher ultimate tensile strength and good ductility than unreinforced Al-SiC. Keneth Kanayo Alanemea, Idris B. Akintundea, Peter Apata Olubambib, Tolulope M. Adewalec [30] fabricated hybrid aluminium matrix composites with alumina and rice husk ash suitable for low cost high performance composites. Kenneth Kanayo Alaneme, Tolulope Moyosore Adewale, Peter Apata Olubambi [31] investigated Al- Mg – Si hybrid composite reinforced with rice husk and SiC and reported the findings of corrosion and wear when subjected to 3.5% NaCl solution the composites was corrosion resistant and the comparative results of Al- Mg – Si and SiC and Al- Mg – Si – SiC and rice husk ash showed that Al- Mg – Si – SiC and rice husk ash is good at corrosion and wear resistant. Dora Siva Prasad, Chintada Shoba, Nallu Ramanaiah [32] investigated the mechanical properties of aluminium

hybrid composites of SiC and rice husk ash and concluded that decrease in density of hybrid composites and increase in porosity and hardness due to increase in reinforcement percentage. K.K. Alaneme , B.O. Ademilua, M.O. Bodunrin [33] concluded that beyond certain limit of percentage of bamboo leaf ash in Al-MMC the ultimate tensile strength, hardness and percent elongation of the hybrid composites decreased. Aminullah, Eti Rohaeti, Irzaman [34] experimented using bamboo leaves ash which consists of silicon in it other than rice husk. Production of high purity silicon from bamboo leaves for the applications of sensors in satellite technology and bamboo leaves are abundant in many parts of the world. [35] Kammuluri.Baburaja, Kambagowni VenkataSubbaiah, Ramakotaiah Kalluri sumptuously presented the fabrication, machining and analysis of hybrid materials of aluminum.

4. Conclusion

In this paper the importance of hybrid aluminum MMC for custom required applications are addressed and the challenges to overcome machining difficulties that may exist due to the modified physical properties that enhance the properties of aluminium and also concerns the monetary matters involved in production and manufacturing of Hybrid metal matrix composite of aluminium. Sustainable metal matrix composite, where bio origin bio waste material like Bamboo leaf ash, Rice husk ash, Corn cob ash and Fly ash is introduced in the metal matrix of aluminium. Environmental concerns are also addressed for future improvement of hybrid MMC. Use of organic particles in aluminium MMC can provide sustainable materials for engineering applications and eco friendly materials.

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