A Comprehensive Review of the Characteristic Behavior of Aluminium Metal Matrix Composites

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Abstract:

This paper presented comprehensive review of literature of past years research work already done in proposed field is present. The work is done by reviewed of research Papers, Articles , Magazines, references books etc. The present work focus on fabrication techniques, mechanical properties and surface texture of aluminium matrix composites (AMCs) reinforced by silicon carbide (SiC).The varying SiC content in AMCs is (0, 5, 10, 20 Wt. %) were fabricated by stir casting process. Mechanical properties Hardness, Tensile Strength, Toughness and Microstructure of composites were analyzed. This composites show that the reinforcement of silicon carbide into Al matrix increased tensile strength and hardness, maximum tensile strength show at 20 Wt. % SiC reinforced in AMCs. With increasing the percentage of SiC in composites increase the porosity into the composites and also decrease the ductility.

1.Introduction:

The metal matrix composites are combinations of two or more different materials with at least one being a metal and another material such as a ceramics or organic compound. When at least three materials are present it is called Hybrid composites. To achieve optimum combination of properties in composites. It should produced by controlling the morphologies of constituents the properties of any composites depend on the chemical composition or on the properties of constituent phase geometry including particles, Size shape and orientation in the matrix [1,2].The metal matrix composites (MMCs) is a advance materials that can be used for wide applications within, Aerospace, Automobile, Defence industries, Nuclear power plant, Electronics, Bio-medical, Sporting industries etc. Al composites are mainly reinforced using hard materials like, Silicon carbide(SiC), Alumina (Al_2O_3),Boron nitride (B_4N), Boron carbide (B_4C), AlN, TiB_2 and organic reinforcements are also used like fly ash [3].These reinforcement can provide advantageous properties over base metal alloy these include improved thermal conductivity, Abrasion, Low density, high toughness, higher fatigue endurance, durability, machinability, resistance, creep resistance, dimensional stability, strength-to-weight ratios. They also better high temperature performance. [4].There are different fabrication process are used for preparation of aluminum metal matrix composites (AMMCs).The widely use common process are stir casting, powder metallurgy, squeeze casting. Stir casting method is generally used for the reinforcement because of its wider availability to other methods. Stir casting processes also enhance the bonding strength between the reinforced particles and matrix because of its better stirring action. The major problem with the stir casting is segregation or dusting of reinforced particles because after wetting some particles sink of float due to density difference during solidification. Due to this many casting defects like porosities, blow holes and inclusion may arise. The objective of this study is to observe the characteristic behavior of silicon carbide reinforcement in aluminum matrix composites on tensile strength, hardness, toughness, microstructure effect on different composite compositions.

2.Literature Review:

Balasivanandha Prabu et al. [5] : Studied that better stir process and stir time the content of silicon in aluminium alloy is high Al-silicon carbide MMC material with 10% of silicon carbide by using a varying stirring speed and time. The scanning electron microscope (SEM) and optical microscope was used for examine the microstructure of

composites. The various effects on microstructure and strength has been studied due to stirring speed and time. By increase in stirring speed and time resulted in uniform distribution of particles, the mechanical properties hardness of composites is also affected by stirring speed and stirring time. The most uniform value of hardness was achieved at 580 rpm with 12 min. stirring. Above this speed the properties decreases again. The ample of scope of research in area of decision making for processing parameters such as speed and time.

Dora siva Prasad et al. [6] : Studied that hybrid metal matrix composites with up to 8 % rice husk ash and silicon carbide particles could be manufactured by using double stir casting process. The matrix showed uniform distribution of rice husk ash and SiC. With the increase of reinforcement percentage hardness and porosity also increases but density decrease with increase in rice husk ash and SiC content the yield strength and ultimate tensile strength increases. The most significant property of aluminium silicon carbide composites with aerospace industries is its strength to weight ratio, which is 3 times greater than mild steel. [7]

Hashim et al, [8] : Have identified four technical difficulties in stir casting: difficulty of achieving a uniform distribution of the reinforcement materials; wet ability between the two main substances; porosity in the cast metal matrix composites; and chemical reactions between the reinforcement materials and the matrix alloy. These difficulties need to be overcome in order achieve a MMC with a broad range of mechanical properties. They have also identified the important processes variables that affect the mechanical properties of MMC. The holding temperature, stirring speed, size of the impeller and the position of the impeller in the melt are to be considered in the production of cast metal matrix composites.

Alaneme & Aluko (2012) [9] : Has Pay attention on double stir-casting technique to cast the Al(6063) scrape and SiC and reinforcements of SiC in 3,6.1,9.2and12 % volume into the furnace. And melt at temperature 750°C.Then molten metal allowed to cool at 580°C.They found this stage dehydrated borax mixture and silicon carbide was added into the molten metal and stirred for 15-20 minutes.

Gopalkrishan & murugan (2012) [10] : Studied the fabrication of MMC by modified stir casting method for improved specific strength, temperature wear resistance, hardness. Al-TiC composites is having a good potential and composites was fabricated in argon gas atmosphere by using modified stir casting process. The specific strength of the MMC increased with addition larger % of TiC.

Nhar et al [2004] [11] : Fabricate Al-SiC composites by using liquid stir casting and semi-solid stir casting methods. The speed range of stirring is 200 to 500 rpm. The 30 µm sized silicon carbide particles were used by 10% volume the main purpose was to fabricate uniformly distributed homogeneous composites. Faster rate of solidification.

Rajan et al [2007][12] : Pay attention the effect of different stir casting methods on the structure and properties of fly ash particles reinforced Al-Si-Mg composites. Molten metal stir casting, compo-casting and modified compo-32 casting followed by squeeze casting route were studied. Newly modified compo-casting provide uniformly distributed minimum porosity composites.

Nabil Fat Halla et al. [1988][13]: Compared the mechanical properties and microstructure of modified and non-modified stir cast aluminium composites A-S7go_3 and A-S_4G the stir cast structure partially improved the mechanical properties in comparison to those of traditionally cast alloys. By the addition of 0-0.2% strontium in the form of Al-5 mass % Sr master alloy. During stir casting enhanced the eutectic silicon into very fine spheroidal morphology, the phase particles also showed the same morphology as stir cast composites. This structure show the highly improvement in mechanical properties. In various fabrication techniques stir casting is one of the most low cost and highly efficient techniques to produce a composites.

Rama rao et al[14] : Manufactured aluminium boron carbide composites by liquid state metallurgy method with different particulate weight ratio. The variation in weight is 2.5, 5, 7.5 %.X-ray diffraction method is used for phase identification of boron carbide SEM (scanning electron microscope) is used for microstructure analysis. Toughness,

hardness and compression carried out for mechanical properties result shows with the increase amount of composites decreases but hardness is increased. With the increase of weight percentage of boron carbide in composites the compressive strength increases.

Jayaseelan et al. 2010 [15] : Have compared extrusion characteristics of Al-SiC fabricated by two methods compared materials fabricated by powder metallurgy. Stir cast material give fine microstructure and high hardness as compared material fabricated by powder metallurgy. And also have higher strength.

3.Silicon Carbide Reinforced AMC:

Tamer ozbenet al. [16]: Studied the machinability and mechanical properties Al-MMC reinforced by SiC particles. With the increases weight percentage SiC hardness, tensile strength and density of Al MMC increased while toughness decreased.

Sedat ozdenet al.[17] : Studied the impact behaviour of aluminium matrix and reinforced SiC particles under variable temperature condition the study result show the impact behaviour of composites was affected by segregation of particles, cracking, and weak bonding between matrix and reinforcement. The effect of temperature on impact behaviour test were not very significant on all materials.

Srivastsan et al .[18]: Investigated the high cycle fatigue and studied the fracture behaviour of 7034/SiC/15P-4A and 7034/SiC/15P-4A metal matrix composites (MMCs).With the increase in temperature strength modulus, ductility and microstructure of composites decreases. Higher fatigue strength achieved with increased the load ratio.

Zhang peng et al.[19]: Investigate the effect of particles segregation on the flow behaviour of Al MMCs reinforced by SiC particles the results show that particles clustering has greater effect on mechanical properties of matrix than the elastic property and also plastic deformation zone is also affected significantly during the tensile deformation test particles segregation higher percentage of particle fracture will experience in microstructure than randomly distribution particles.

Palanikumar and karthikeyan [20] and kylykap et al [21]: Investigate the factors effecting the surface toughness on the machining of Al/SiC particulate MMCs. Process parameter like cutting speed, Feed rate, percentage volume fraction of SiC were optimized to achieve minimum surface roughness normal probability plot response table, response graph and (ANOVA) technique. Surface roughness greater influence by feed rate then cutting speed and percentage fraction of SiC. Low cutting speed high feed rate and low depth of cut is recommended machining conditions high cutting speed and low feed rate produce better surface finish by using coated carbide cutting tool.

4.Mechanical Properties:

Table-1 Hardness & Tensile Strength

Authors	Fabrication Technique	Materials	Hardness	Tensile Strength
Md.Habiur Rahman and H.M mamun,Al Rashed.[2013][24]	Stir casting	Al+0%Sic Al+5%Sic Al+10%Sic Al+20%Sic	24.50 Hv 38.67 Hv 42.3 Hv 45.40 Hv	28.45 MPa 59.36 MPa 50.17 MPa 77.56 MPa

L.Poovazhagan. [2013][25]	Stir casting	Al-AA6061 Al+0.5%Sic+0.5%B_4C Al+1%Sic+0.5%B_4C Al+1.5%Sic+0.5%B_4C	60 HN BHN BHN B 80 100 120	50MPa MPa 19 MPa MPa 0 24 0 21 0
Verma,Agrawal and Awana.(2013)[26]	Stir casting	Al+2.02%Sic+1.67%Cu Al+5.59%Sic+0.015%Cu Al+6.33%Sic+5.97%Cu Al+8.6%Sic+5.82%Cu	55 BHN BHN 48 BHN BHN 95 89	122.44MPa 95.98 MPa 134.9 MPa 138.8 MPa
Mahendra Boopat.(2013)[27]	Stir casting	Al+5%Sic Al+10%Sic	85.3 BHN 87.2 BHN	248 N/mm² 265 N/mm²
P.B Pawar and Abhay.(2014)[28]	Stir casting	Al+0%Sic Al+2.5%Sic Al+5%Sic Al+7.5%Sic Al+10%Sic	28.5 BHN 31.6 BHN 40.3 BHN 47.3 BHN 60.3 BHN	
Manoj single, D.Deepak Dwivedi.(2009)[29]	Stir casting	Al+5%Sic Al+10%Sic Al+15%Sic Al+20%Sic	40.2 BHN 41.1 BHN 43.7 BHN 44.4 BHN	
T.R mohan(2015)[30]	Stir casting	Al+0%Sic Al+5%Sic Al+9%Sic Al+15%Sic		54.3 MPa 57.4 MPa 61.2 MPa 65.1 MPa
K.K Alaneme and A.O aluko (2012)[31]	Stir casting	Al+0%Sic Al+6%Sic Al+9%Sic Al+12%Sic		100 MPa 115 MPa 145 MPa 155 MPa

Neelima Devi(2011) [32]	Stir casting	Al+5%Sic Al+10%Sic Al+15%Sic Al+20%Sic		80.84N/mm² 88.11 N/mm² 94.21 N/mm² 83.00 N/mm²

5.Fabrication Technique of MMCs:

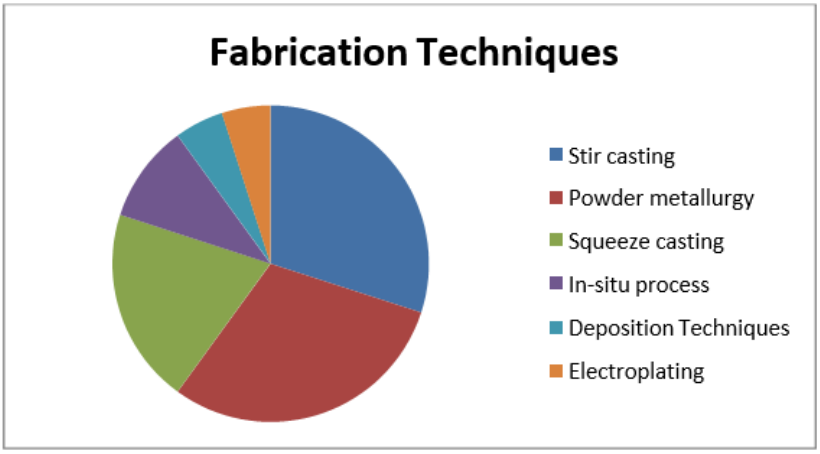

Figure.1

Figure, 1.show the different fabrication techniques, Stir casting, Powder metallurgy, Squeeze casting, In-situ Process, Deposition technique and Electroplating. But stir casting is mostly used because of simple method and low cost.

6.Stir Casting Process:

Stir casting is technique of composite materials fabrication when reinforcement material silicon carbide SiC mixed with matrix materials aluminium with the help of stirrer. The molten composites material is cast by traditional casting method. The distribution of reinforcement material into matrix is not completely homogeneous. There are some clusters due to densities differences. The stir casting technology is relatively simple and low cost for fabrication of MMCs. This can be easily adopted by industries. in recent developed stir casting technique matrix material heated above the melting point, so metal is totally melted and stirrer start rotating. Then pre-heated reinforced material is added slowly after some time molten metal poured into mould wait for solidify it, more homogeneous microstructure obtained by this [34].

Above this stir speed the properties degraded again. Research lead to decision making for processing parameters such as stirring speed and stirring time with microstructure and hardness of composite. [5]

Table- 2. Impact strength

Author	Fabrication technique	Materials	Impact strength
Manoj single, D.Deepak Dwivedi.(2009)[29]	Stir casting	Al+5%Sic Al+10%Sic Al+15%Sic Al+20%Sic	22N-M 24 N-M 30 N-M 36 N-M

Table 1. & 2. show the different mechanical properties, Hardness, Tensile Strength and Toughness with the different composition of Aluminium and silicon carbide.

7.Applications of (MMC):

Aluminium Matrix Composites (AMC) are used for fabrication of aeronautical and aerospace components, automotive parts (pistons, cylinders, head and block, chassis, connecting rods, brake components, clutches), brake rotors for high speed trains, bicycles, golf clubs, electronic substrates, cores for high voltage electrical cables, defence weapons, safety instrument (Bullet proof jacket, Helmet, Bullets carrier).[33]

8.Conclusion:

In this present review paper AMCs is manufactures by using stir casting technique. The variation of SiC content in composites composition Microstructure analyses and Mechanical properties, hardness and tensile strength were studied. The SiC content distribution is partially homogeneous, with increase content of SiC in Al matrix hardness and tensile strength of AMCs is increase compared with unreinforced. The porosity increases with the increase in percentages of the reinforcement where as the density of hybrid of composites decreases and also silicon carbide addition decreases the ductility. The most important property of Al-SiC with reference to the aerospace industry is its strength to weight ratio which is three times more than mild steel. Review shows that much research has been carried out for aluminium matrix composites [AMC] but Titanium, Magnesium and Copper MMC still have yet ample scope for research. Stir casted have scope of highly precise microprocessor based electronics control panels for control of stirrer RPMs, Vibration, Timing.

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