IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X
PP. 12-14
www.iosrjournals.org

A Review on Metal Matrix Composites

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Abstract :*MMC shows such specific strength, specific modulus and other properties which are required. The luminous MMC's shows at variety of applications. But instruction of reinforcement in aluminum matrix changes its machinability. A simple aluminum slab can be easily machined with reasonably good surface finish with good material removable rate. But with reinforcement like SiC, Zerconium or ceramics in Aluminum matrix changes its machinability. Thus specific parameters for machining of MMC required to be determined for better machining and to get good surface finish.*
Keywords : *Infiltration, MMC, FML-GLARE*

I. Introduction

Metals and alloys are conventional used for various engineering applications but these materials have predetermined fixed values of die, Y and other material constants. These are isotropic materials which limits their performance. But modern advancement in technology require very specific properties and other can be given less importance.

FML are newly developed material for advance aerospace applications due to their high specific mechanical properties like fatigue resistance. The adhesive bonding provided for FML-GLARE plays an important role on determining its properties. Manufacturing of FML thus play an important role in properties of material thus produced. FML with a very good adhesion between glass fibers and aluminum shows fatigue resistance whereas FML with poor adhesion show very poor fatigue resistance.

II. Literature Review

C.Sarvananan et.al. has studied the existing methods of manufacturing of Metal Matrix Composites. These are classified basically into liquid state and solid state methods[1]

Liquid state manufacturing of MMC:-

1. Stir Casting: - In this matrix material is heated to liquid state so it will melt. Then this melt is cooled to semi solid state, at this stage preheated particles are added and the slurry is again heated to liquid state and mixed by stirring
2. Composite Casting: - Composite casting is a liquid state process in which reinforced particles are added in semisolid state melt and it will agitated. This will result in better distribution of particles.
3. Squeeze Casting: - In this technique reinforced material is forced into molten metal by movable mould part (ram) which forces the molten metal to penetrate into a preformed dispersed phase, placed in the lower mould part.
4. Spray Deposition: - This technique typically consists of winding fibers onto a foil-coated drum and spraying molten metal onto them to form a mono tape. The source of molten metal may be powder or wire feedstock which is melted in a flame, arc or plasma torch.
5. In-situ Fabrication of Metal Matrix Composites: - In-situ synthesis process the reinforcements are formed in the matrix by controlled metallurgical reactions. During the process one of the reacting elements is usually a constituent of molten matrix alloy and other reacting element may be either externally added fine powder of gaseous phases. For better coherent property and homogeneous distribution this method is preferred.
6. Ultrasonic assisted casting: - This process combines solidification processes with ultrasonic cavitations based dispersion of nano-particles in metal melts. It can produce hotspots of transient micro size having temperatures of about 5000 degree celcius.This strong impact coupling with such high temperatures potentially break the nanoparticle clusters and clean the surface.

Solid state fabrication of Metal Matrix composites:-

1. Powder metallurgy : - Powder metallurgy is a process of blending fine powdered materials. Pressing them into desired shape. and then heating the compressed material in a controlled atmosphere to bond the material(sintering). It consists of four steps (1)powder manufacture (2).mixing and blending (3).compacting(At room temperature) (4).sintering (At atmospheric pressure.)

2. Diffusion bonding :- It is a common solid state processing technique for joining similar or dissimilar metals. In this process bonding is achieved by inter diffusion of atoms between two clean metallic surfaces at an elevated temperature. This principle enables the process to be carried out on variety of metal matrices and control of fiber orientation and volume fraction
3. Friction Stir Process:- It is used to get fine-grained microstructure which uses same principle as friction stir welding(FSW). Friction stir process has been basically advanced as a grain refinement technique, It is a very attractive process for also fabricating surface composites.

B C Kandpal et.al. work has added some other MMC manufacturing processes such as [2]

1) Infiltration:-It is a liquid state method of composite materials fabrication, in which a preformed dispersed phase(ceramic particle) is soaked in ala molten matrix metal, which fills the space between the dispersed phase inclusion. The motive force in this process maybe capillary force or the dispersed phase or an external force applied to the liquid matrix phase.
2) Chemical Vapor Deposition Technique (CVD) :-This involves coating individual fibers in a tow with the matrix material needed to form the composites followed by diffusion bonding to form a consolidated or structural shape. It is a vaporized component decomposes or reacts with another
3) vaporized chemical on the substrate. The processing is generally carried out at elevated temperatures.

Z.Fan et al. Studied various manufacturing processes of MMC's and find out they exhibits extremely low ductility and the processes used are non economical for producing engineering components. To overcome these problems to a certain extent he suggested a novel rheo-process. They carried out this experiment on Al alloy and SiC reinforcement. They discovered that the rheo-process is based on intensive shearing of liquid metal containing particulate clusters. Novel rheo-process is successfully carried out to fabricate metal matrix composites with uniform microstructures and without formation of particulate agglomerates.[3]

Peter Tatarko et al. has performed Spark Plasma Sintering for joining CVD-SiC coated and uncoated fiber reinforced ceramic matrix with pre-sintered Ti_3SiC_2 .joining parameters were carefully selected to avoid the decomposition of Ti_3SiC_2 and the reaction between the joining filler and the CVD-SiC coating. He discovered while that diffusion bonding occurred during joining of the observed coated composites, a combination of both solid state reaction and diffusion bonding was observed for the uncoated C_f/SiC composites, no reaction between the Ti_3SiC_2 and CVD-SiC was observed. The infiltration of the joining filler into the surface cracks in the CVD β-SiC coating allowed the filler to be more uniformly integrated with the matrix material all along the interface.[4]

Xinchen Xiong et al. has performed ultrasonic vibration treatment for improvement of particles distribution of in-situ 5 vol% TiB_2 particulates reinforced Al-4.5Cu alloy matrix composites. And discovered that TiB_2 particles are uniformly distributed throughout the bulk melt after treated by ultrasonic vibration of 240 s.The tiny agglomerations formed by TiB_2 particles smaller than 100nm are also broken by ultrasonic vibration. By this experiment the ultrasonic vibration treatments are successfully introduced into composites fabrication .Large agglomerations in the melt are eliminated at the very early stage of ultrasonic vibration treatment. after this process yield strength of composites is improved by 114% and 61% comparing with base metal and untreated composite, respectively.

Mikhail Tashkinov. Performed statistical approach on micro-scale modeling of phase-level elastic fields of SiC reinforced metal matrix multiphase composites. He worked on developing a instrument on statistical mechanics as well as their application in studying micro structural behavior of MMC. He did study od multiphase TiC+SiC and Al+SiC MMC. He varied the microstructural parameters for obtaining the variations in the stress and strain fields. By this experiment he investigated that the possible variations of the mechanical and geometrical properties of the microstructure allows to asses their influence on stress strain field. This property of microstrure to influence the stress strain field can be used in optimizing MMCs.[6]

S. Kumar et al. have done a grey relational analysis of aluminium based composites machined by wire electrical discharge machining. In their work analysis has made to optimize parameters such as peak current, pulse on time, wire feed rate and weight percentage of reinforcement that affect the responses like kerf width and surface roughness. They have found that the inclusion of reinforcement particles in the composite increases the surface roughness of the machined area. An increase in the pulse duration also increases the surface roughness.[8] Lal et al. have conducted experiments in the $Al7075/Al_2O_3$/SiC hybrid composite through Wire-EDM to determine the effect of the process parameters, and found that the pulse on time is the major contributing factor.[7]

G. Ugrasen et al. studied Wire EDM the machining performance on metal matrix composites for accuracy, surface roughness and volumetric material removal rate. The analysis was done by Taguchi's technique. Their results based on ANOVA methods show that the most effective parameter on surface roughness, volumetric material removal rate and accuracy is current.[8]

Study on titanium carbide reinforced steel metal matrix composite was done by **Probir Saha et al.** They have used a Neuro-Generic technique to evaluate the results. Their results show that the process parameters namely pulse on-time and average gap voltage have great influence on the cutting speed and the kerf width. The optimization results show that it may be possible to achieve significant improvement in the cutting speed value for the same kerf width which was obtained through experiments.[9]

M. Nataraj et al. have done analysis of Al6061 based hybrid metal matrix composite for Wire EDM machining. They have considered current pulse on time and pulse off time as inputs and measured the metal removal rate, tool wear rate and surface roughness with respect to it. The results show that pulse off time has less effect on MRR and surface roughness. The optimum parameters they came across are 1.40 Amps of current, 30µs pulse on time and pulse off 7µs for maximizing the metal removal rate and minimizing the surface roughness.[10]

S. Gopalakannan et al. performed analysis of varience to investigate the influence of process paraeters and their interactions viz. pulse current, gap voltage, pulse on time and pulse off time on material removal rate, electrode wear rate and surface roughness. The analysis was done on Al 7075-B_4C MMC using response surface methodology. The results show that two main significant factors that affect the MRR are pulse current, pulse on time. The MRR first increases with an increase in pulse on time and then decreases if further increase in pulse on time is done.[11]

H. K. Kansal et al. have studied the Powder Mixed electrical discharge machining to determine the inter relation between pulse on time, pulse off time, duty cycle, peak current and concentration of dielectric fluid. MRR increases with the concentration of dielectric, however more improvement in surface roughness is still expected at higher concentration level in dielectric.[12]

B. Mohan et al. have done the study on controlling the electrical process parameters, and empirical relationships between process parameters and optimization of process parameters in EDM process. The study found that peak current and pulse duration are dominating the performance measures EDM process.[13]

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