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A REVIEW ON PREDICTING THE FABRICATION OF ALUMINIUM METAL MATRIX COMPOSITES

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ABSTRACT

Light and strong aluminium metal matrix compositesare widely used in aerospace,automobiles,farm machinery and many other industrial applications due to their low density and mechanical properties,better corrosion resistance,wear resistance low thermal co-efficient of expansion low density and high strength as compared between the conventional metals and alloys.

Particular,particulate reinforced metal matrix composites (MMCs) have recently found special applications because of their specific strength specific stiffness at room or evaluated temperatures. It is proved that the elastic properties of metal matriccomposites are strongly influenced by micro structural parameters of the reinforcement such as shape, size, orientation, distribution and volume fraction.

In thecurrent study deals that provide a literature review on the overall manufacturing techniques employed in the fabrication process.

Keywords: metal matrix composites (MMCS), Desirable properties, Aluminium alloys, Metals.

INTRODUCTION

Current scenario, determining the possible to develop new structural materials with higher strength to weight ratios is one of the biggest challenges in the automotive and aerospace industry. Properties like high specific strength, stiffness, better wear resistance and improved elevated temperature properties compared to the conventional metals and alloys are the key reasons for the increasing attention towards Metal Matrix Composites. A variety of processing ways have been established for the production of reinforced composites. Stir casting is one of the most universally used approaches to manufacture particle reinforced composites.

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CLASSIFICATION OF LIQUID STATE FABRICATION OF METAL MATRIX COMPOSITES

Fabrication of Aluminium Matrix composites: Uniform distribution of the reinforcement phases to achieve adefect-free microstructure is one of the key challenges in processing the composites. The reinforcing phases in the composite can be either particles or fibers, based on the shape. The relatively low material cost and suitability for automatic processing has made the particulate-reinforced composite preferable and classified as two main groups.

(i). Liquid state processes: Liquid state processes include stir casting, compo casting, squeeze casting, spray casting and in situ (reactive) processing, ultrasonic assisted casting.

(ii). Solid state processes: Solid state process includes powder metallurgy (PM route), high energy ball milling, friction stir process, diffusion bonding and vapor deposition techniques. Type and level of reinforcement loading, the degree of microstructural integrity desired, etc., are some of the factors that influence the selection of the processing routes.

LIQUID STATE PROCESS

Squeeze Casting : Squeeze casting is a hybrid of low pressure casting and high pressure casting, and it has the potential to completely eliminate the gas defects associated with high pressure die casting, and to enable heat treatment of the castings. In squeeze casting, the die is filled slowly with metal to maintain laminar flow. Once the cavity is full, the pressure on the melt is increased to over 100 MPa and maintained to feed the casting to compensate for shrinkage until the casting has solidified. Die design for squeeze casting is different from that for die casting, and includes thick gates and a large shot end biscuit to ensure that the gates do not freeze before the casting in the cavity has solidified and to ensure feeding the shrink during solidification.

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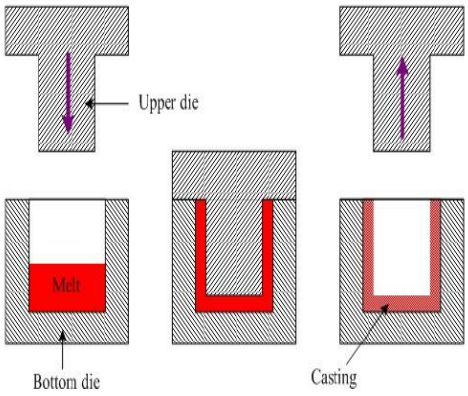

Fig.1 Squeeze casting process.

G. N. Lokeshet. al. studied the effect of hardness, tensile, compression and impact properties as well as density.The Al-4.5% Cu (by weight) alloy was chosen as base matrix casted by both stir and squeeze casting. Fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste is used as reinforcement. The Al-4.5wt%Cu reinforced 3, 6, 9 and 12wt%fly ash composite was squeeze casted with an applied pressure of 120MPa. The results showed that hardness tensile compression and impact values were increased by increasing weight percentage of fly ash reinforcements during squeeze casting. Porosity and other casting defects such as shrinkage cavities were minimized due to pressure applied during solidification. Increase in weight percentage of fly ash composites caused to increase porosity even in squeeze casting but lesser than gravity cast matrix alloy. Microstructure shows the absence of micro porosity, and grain refinement interfacial bond between matrix and reinforcement. (GN Lokesh, 2013)

Stir casting: stir casting is a liquid state method for the fabrication of composite materials, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. Stir Casting is the simplest and the most cost effective method of liquid state fabrication. The stir casting set-up is shown in

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Fig.2.

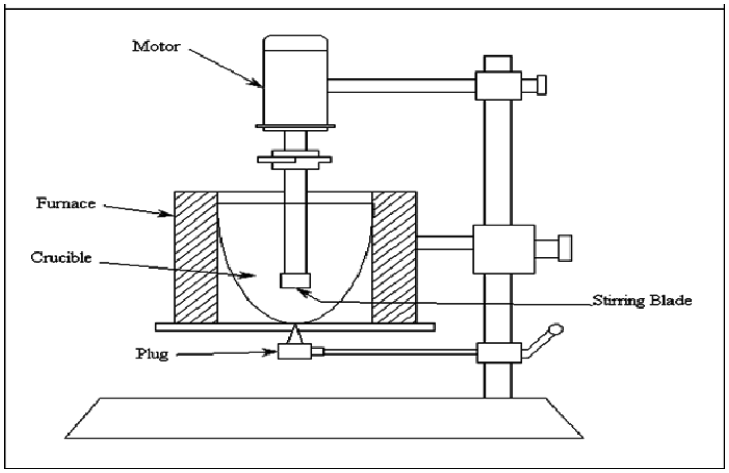

Fig.2 Stir Casting Process.

Marlon Jones Louis carried his research work on composite material based on aluminum alloy (Al 2024)reinforced with 10% volume fraction of Silicon Carbide Particulates (SiC) and 5 % volume fraction of Graphite particles produced by stir casting method. The experimental results were compared with the conventional Aluminium 2024 where one can see that the composite material plays a dominant role than the Aluminium 2024 with respect to its strength, ductility and hardness. Dynamic analysis is a very important investigation when it comes to the composite materials, where these can exhibit diversity in material properties as well as shapes. The main idea of this work is to perform analysis which gives the information about cracks and the locations of the damages on composite materials. (marlon, 2014)

In-situ Fabrication of Metal Matrix Composites: In situ fabrication of Metal Matrix Composite is a process, in which dispersed (reinforcing) phase is formed in the matrix as a result of precipitation from the melt during its cooling and Solidification. Different types of Metal Matrix Composites may be prepared by in situ fabrication method

Manas Mohan Mahapatraet. alcarried out research work on addition of reinforcement such as TiC, SiC, Al2O3,TiO2, TiN, etc. to Aluminium matrix for enhancing the mechanical properties has been a well-

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established fact. In-sit method of reinforcement of the Aluminium matrix with ceramic phase like Titanium Carbide (TiC) is well preferred over the Ex-sit method. In the present investigation, Al-Cu alloy (series of 2014 Aluminium alloy) was used as matrix and reinforced with TiC using In-sit process. The Metal Matrix Composite (MMC) material, Al-5%Cu/10%TiC developed exhibits higher yield strength, ultimate strength and hardness as compared to Al-4.5%Cu alloy. Percentage increase in yield and ultimate tensile strengths were reported to be about 15% and 24% respectively whereas Vickers hardness increased by about 35%. The higher values in hardness indicated that the TiC particles contributed to the increase of hardness of matrix. (manas, 2012)

Ultrasonic probe assisted casting: The ultrasonic probe assisted sonication method helps in this case to uniformly distribute the particles in metal matrix. The ultrasonic energy is widely used in the manufacturing for welding, casting and non destructive testing. The ultrasonic cavitation effect is utilized to generate nuclei in casting.

Jain P. K. et. alprepared the composites by ultrasonic cavitation assisted fabrication and investigate the effectof selected nanomaterials (SiC, B4C, CNTs) on the microstructure and mechanical properties of composite, a new method is used to avoid agglomeration and segregation of particles. Then, tensile specimens with different weight fractions of nanomaterials are cast and tested. The microstructure of the composites is investigated by scanning electron microscopy (SEM). (Jain, 2009)

SOLID STATE FABRICATION OF METAL MATRIX COMPOSITES

Powder Metallurgy (PM route): The powder-metallurgy (PM) process, depicted in the diagram below, involves mixing elemental or alloy powders, compacting the mixture in a die, and then sintering, or heating, the resultant shapes in an atmosphere-controlled furnace to metallurgical bond the particles.Most powder-

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metallurgy parts weigh less than 5 lb. (2.27 kg), although parts weighing as much as 35 lb. (15.89 kg) can be fabricated in conventional PM equipment. While many of the early PM parts, such as bushings and bearings, were very simple shapes, today's sophisticated PM process produces components with complex contours and multiple levels, and does so quite economically.

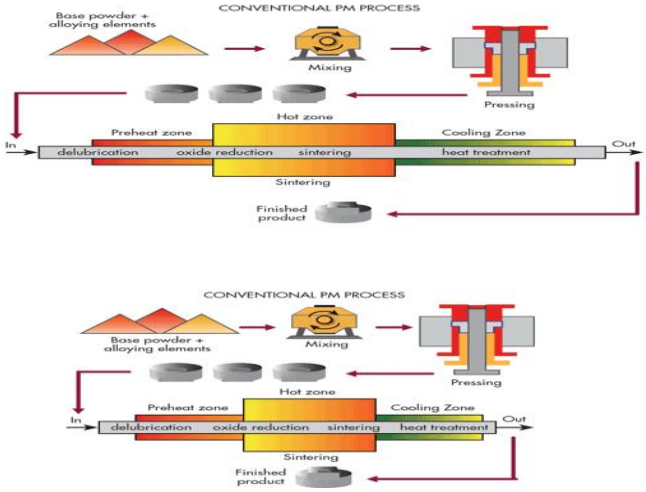

Fig.3 Powder Metallurgy Process.

C.S. Vermaet. al. Al-SiCpcomposites with 5 to 30 weight % of SiCpwere fabricated using powder metallurgyprocess. The density, porosity, hardness, compressive strength and indirect tensile strength of Al-SiCp composites were found to increase with increase in the wt. % of SiCp from 5 to 30 weight percent. Mechanical alloying of powders resulted in improvement in hardness and compressive strength of Al –SiCp composites with 5 to 30 weight % of SiCp. (verma, 2012).

Friction Stir Process: FSP is a solid state processing technique to obtain a fine-grained microstructure. This iscarried out using the same approach as friction stir welding (FSW), in which a non-consumable rotating tool with a specially designed pin and shoulder is plunged into the interface between two plates to be joined and traversed along the line of the joint. Localized heating is produced by the friction between the rotating tool and the work piece to raise the local temperature of the material to the range where it can be plastically deformed easily. It is well known that the stirred zone consists of fine and equiaxed grains produced due to dynamic recrystallization. Though FSP has been basically advanced as a grain refinement technique, it is a very attractive process for also fabricating surface Composites.

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C. Maxwell Regilet. al. carried out the FSP at a tool rotational speed of 1600 rpm, traverse speed of 60mm/min and axial force of 8 KN. Two passes were applied in opposite directions. The microstructure and sliding wear behavior of the fabricated SCLs were evaluated. TiC and B4C particles were distributed homogeneously in the SCLs. Both the particles behaved as one type of reinforcement particle during FSP.

Table.1 Comparison between liquid and solid state processes.

Liquid state Process

S.NO	MMC fabrication method	Inference	Applications	Expensive/Inexpensive
1	Squeeze Casting Process	Pertinent applicable to any type of reinforcement and suitable for mass production	Used in automotive and aeronautical industry for producing different components like pistons, connecting rods, rocket arms, cylinder heads, front steering knuckle, cylindrical components, etc.	Moderate
2	Stir casting method	Depends on material properties and process parameters. Suitable for particulate reinforcements in Aluminium metal composites.	Applicable to large quantity production commercial method of producing aluminium based composites.	Least Expensive
3	In-Situ Process	Good reinforcements homogeneous distribution of the reinforcing particles.	Automotive applications	Expensive
4	Ultrasonic Assisted casting	Nearly uniform distribution and good	Mass production and net shape fabrication of complex	Expensive

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		dispersion	structural composites.	

Solid State Process

S.NO	**MMC fabrication method**	**Inference**	**Applications**	**Expensive/Inexpensive**
1	Powder metallurgy	Both matrix and reinforcements used in powder form. Best for particulate reinforcements	Production of small objects like bolts, piston, valves, and huge applications in automotive industry, aircraft industry, defence, sports industry.	Moderate
2	Friction stir casting process	Used as surface modification process. Increase in micro hardness of the surface, significant improvement in wear resistance.	Automotive and aerospace applications	Moderate/Expense

CONCLUSION

Thecurrent review drawn, theoretical and experimental results obtained many investigators in the field of aluminium alloy – Metal matrix composites. A considerable amount of interest in Al-MMCs revealed by examiners from academics and industries has helped in conduction of various studies and has enriched our

knowledge about the processing of Aluminium Alloy composites, their physical properties, mechanical properties.

- Microstructure shows the absence of micro porosity, and grain refinement interfacial bond between matrix and reinforcement.
- It has been witnessed that among all the production techniques considered, stir casting method out as the greatestinexpensivetechnique.
- Experimental results show a nearly uniform distribution and good dispersion of the nano-particles within the Al matrix. Both hardness and tensile strength areenhanced by incorporation of nano materials into matrix. The enhancement in values of hardness and tensile strength observed in this experiment is due to small particle size and good distribution of the particles.
- Increase in weight percentage of fly ash composites caused to increase porosity even in squeeze casting but lesser than gravity cast matrix alloy.

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