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Different Advances of Metal matrix Composite- A Review

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Abstract —*Composite materials or simply composites are combinations of materials. They are made up of combining two or more materials in such a way that the resulting materials have certain design properties on improved properties. Conventional materials like Steel, Brass, Aluminium etc will fail without any indication. Cracks initiation, propagation will takes place within a short span. Now a day to overcome this problem, conventional materials are replaced by Composite materials. The potential has been recognized in the aluminium-based materials. Aluminium and its versions have been already widely used in automotive, aerospace industry; however, their utility spectrum still avoids the tribologically sensitive purposes. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. In this paper the potential of use of metal matrix composite (MMC) with particular reference to the advance engineering industry. Initially, the necessary properties are identified, then, the work explores the investigations done on different Metal Matrix composites.*

Keywords- Composite material, Metal Matrix composite(MMC),Nano particles.

1.INTRODUCTION

Two or more chemically different constituents combined macroscopically to yield a useful material which is called composite material. One constituent is called reinforcing phase and the one in which the reinforcing phase is embedded is called matrix.

Composite material offers to engineers many advantages that are especially appealing for engineering applications. They are made up of combining two or more materials in such a way that the resulting materials have improved properties . The Aluminium alloy composite materials consist of high specific strength, high specific stiffness, more thermal stability, more corrosion and wear resistance, high fatigue life. When designed properly, the new combined material exhibits better properties than would each individual material. The requirement of composite material has gaining momentum in these days due to these properties. Apart from defense and automotive industries, aircraft industries also using composites largely in the present days for reducing the weight of the aircraft and improved strength. The addition of high strength, high modulus refractory particles to a ductile metal matrix produce a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement.

Aluminium based composite materials are leading ones in this area, they are fabricated using many methods, including powder metallurgy processes, and then formed The metal matrix composite can be reinforced with particles, dispersoids or fibres. However, the biggest interest in composite materials is observed for those reinforced with hard ceramic particles due to the possibility of controlling their tribological, heat- or mechanical properties by selection of the volume fractions, size, and distribution of the reinforcing particles in the matrix. The ceramic pre forms, being a framework, are the base of the composite materials manufactured by infiltration method. These pre forms mainly determine the structure and the properties of the final product. The properly manufactured semi-finished product should be characterized by open porosity allowing the liquid metal to flow as easily as possible.

1.1 Matrix and Matrix materials

The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. Aluminium, magnesium, Iron and copper mostly investigated matrix materials due to its high strength to weight ratio. Aluminium and magnesium have earmarked their slot in the MMCs due to low density and machinability. Elements like silicon, zinc, magnesium, and copper are gifted with adequate solubility which makes them feasible to be used as key alloying elements. Particle size having significant role in the MMCs. Grain refinement can reduce the thermal expansion, hence strength of the matrix increased. Shape, size and volume fraction of the reinforcement also have an important role in strength of the composite.

Types of composite

(i)Organic Matrix Composites (OMCs)

(ii)Polymer Matrix Composites (PMCs)

- Thermoset
- Thermoplastic

(iii) Carbon Matrix Composites (CCCs)
(iv) Metal Matrix Composites (MMCs)
(v) Ceramic Matrix Composites (CMCs)

1.2 Reinforcement

Function is to reinforce the primary phase. Imbedded phase is most commonly one of the following shapes:

- Fibers
- Particles
- Flakes

In addition, the secondary phase can take the form of an infiltrated phase in a skeletal or porous matrix Example: a powder metallurgy part infiltrated with polymer.

The reinforcement of metals can have many different objectives;

- Increase in yield strength and tensile strength at room temperature and above while maintaining the minimum ductility or rather toughness,
- Increase in creep resistance at higher temperatures compared to that of conventional alloys,
- Increase in fatigue strength, especially at higher temperatures,
- Improvement of thermal shock resistance,
- Improvement of corrosion resistance,
- Increase in Young's modulus,
- Reduction of thermal elongation.

Literature Review

Dinesh M. Pargunde et al. has studied on AlSiC based MMC. He tried to develope Silicon Carbide (AlSiC) with an objective to develop a conventional low cost method of producing Metal Matrix Composites. The results were evaluated by Brinell Hardness Test, Charpy Impact Test , micro-structure study and Corrosion Test. The trend of hardness and impact strength with increase in weight percentage of SiC were observed and recommendation made for the potential applications accordingly. By this experimental analysis, it is observed that 25% SiC with Aluminum is the optimum mixture for the Metal Matrix Composites.

Sri Priya R et al. have studied mechanical properties of Al 6061 reinforced with Al_2O_3 and SiC with stir casting technique. Four set of combinations with different Proportions of reinforcement is developed . Mechanical properties of composite such as tensile test, Hardness Test, Impact test are studied and the results are discussed. From the results, it is noted when the contribution of SiC and Al_2O_3 increases, yield strength and ultimate strength got increases but elongation found decreases.

Gurvishal Singh et al. studied on Aluminum metal matrix composite reinforced with Red Mud, SiC and Al_2O_3. It is studied that micro hardness and resistance to wear of MMCs is produced by reinforcement and also the wear properties are improved remarkably by introducing hard inter metallic compound into the aluminum matrix. It is studied that micro hardness and resistance to wear of MMCs is produced by reinforcement and also the wear properties are improved remarkably by introducing hard inter metallic compound into the aluminum matrix.

Gyanendra Singh et al. have taken an sample of aluminum composite material containing Cu-Zn-Mg. The purpose was to study the mechanical properties of Aluminum composite material & find the working capacity with compare to pure Aluminum metal. It is seen that mechanical properties like hardness, ductility, tensile strength, stiffness increased.

Katica Milos et al. have integrated Ceramic particles Al_2O_3 into soft aluminium, various particle sizes and share, by powder metallurgy techniques .Mechanical properties have been studied with respect to the share, size of particles, type of Al/ Al_2O_3, as well as the graphite addition. It is concluded that Good bonding of Al and Al_2O_3 has been achieved as well as the homogeneous distribution of the hard phase within the matrix of up to 30 mas.% Al_2O_3.

A. Wlodarczyk-Fligieret al. have compared modern method composite materials with aluminium alloy matrix reinforced by Al2O3 particles manufacturing. this composite was manufactured by two methods: powder metallurgy and pressure infiltration of porous performs by liquid alloy EN AC AlSi12. In the case of material manufactured by extrusion method banding of the reinforcing particles parallel to the extrusion direction was noted on the longitudinal micro sections. In the case of composites fabricated by pressure infiltration method of ceramic performs with liquid aluminium it has been proved that the infiltration process is taking place at full level what confirms lack of pores in the material.

Neelima Devi. C et al. They have replaced conventional materials like Steel, Brass, Aluminium with Aluminium alloys as they fail without any indication. They conducted experiments for tensile strength by varying mass fraction of SiC (5%, 10%, 15%, and 20%) with Aluminium. The maximum tensile strength has been obtained at 15% SiC ratio. Mechanical and Corrosion behavior of Aluminium Silicon Carbide alloys are also studied.

A. Arora et al. have studied fabrication of Metal Matrix Composite by using an Aluminium plate and Molybdenum powder by Friction Stir Process .Their aim was to produce a superficial MMC layer on the Al plate in order to increase the mechanical properties of the as received Al plate. The results shows good dispersion of the Mo powders on the top surface of the samples, conversely in the cross section no molybdenum powders were observed. So it seems that the this technique is useful to produce a superficial layer with improved performances due to the dispersion of powders to surface of metal matrix composite.

Anil Kumar Bodukuri have prepared Al—SiC—B4C metal matrix composite from sintering of mechanically alloyed powder in powder metallurgy processes. Three different combinations of compositions in volume fraction were chosen namely 90%Al 8%SiC 2%B4C, 90%Al 5%SiC 5%B4C and 90%Al 3%SiC 7%B4C and their mechanical properties were studied. It is observed that as increase in percentage of B4C the micro hardness of the metal matrix composite has increased significantly.

V. Vembu et al. have developed the mathematical model to optimize the heat treatment process for maximum tensile strength and ductility of aluminum (8011) silicon carbide particulate composites. The process parameters were aging temperature, solutionizing time, and aging time. The experiments were performed on an universal testing machine according to centre rotatable design matrix. The ANOVA technique was used to check adequacy of the model. The optimum parameters were received for maximum tensile strength. Fractographic examination showed the cracks and dimples on the fractured surfaces of heat-treated specimen. From the residual plots it is observed that the regression model is well fitted with observed values and high correlation exists between fitted values and observed values.

Anthony Xavior M et al. have studied that aerospace and automotive industries want to introduce hybrid metal matrix composites in their components due to their excellent mechanical and physical properties, leading to reduction in the weight of structural components. They focused on the effects of reinforcement particle types, shape, size and volume fractions on machinability parameters like the cutting force, tool wear, chip formation and surface roughness. Then, the role of various cutting parameters like cutting speed, feed, depth of cut and tool material, tool geometry and cutting conditions during turning of hybrid metal matrix composites are critically reviewed. It was concluded that Optimization of machining parameters like nose radius and operation conditions are very important for minimize the tool wear, maximize the metal removal rate and better machinability.

Biswajit Das et al. have fabricated an in-situ multi-component reinforced aluminium copper alloy based metal matrix composite by the flux assisted synthesis. It was seen by the optical microscopy analysis that TiC particles are formed in the composite. Then the feasibility and dry machining characteristics of Al–4.5%Cu/5TiCmetal matrix composite in CNC milling machine using uncoated solid carbide end mill cutter was investigated. The effect of machining parameters like feed, cutting speed, depth of cut on the response parameters like cutting force and COM is determined by using ANOVA .It was investigated that cutting speed and depth of cut played a major role in affecting cutting force .For studying the response parameters, regression equations were developed and checked with a number of test and it is observed that the percentage error for both the responses is less than ±3%, which indicates there a close agreement between the predicted and the measured results.

Jeong-HaYou has studied three most promising Cu-matrix composite materials in terms of thermal, mechanical and HHF performance as structural heat sink materials. He has shown that All of the three composites exhibited far superior ultimate tensile strength at elevated temperatures than CuCrZr alloy. In particular, thermal conductivity was only moderately degraded by the reinforcements up to 50%. For future application to DEMO diverter target, the industrial scale production technology needs to be developed. In addition, the- oretical methodology for the modeling of deformation, damage and fracture needs to be established.

Pardeep Sharma et al. has worked on effect of graphite particles addition on microstructure of Al6082 metal matrix composites manufactured by stir casting process. The reinforcement content varied from 0% to 12% in a step of 3%. The microstructures were analyzed by scanning electron micrographic test. Different elements present were verified by X-ray diffraction technique to justify the elemental map analysis. It is seen that there is a reasonably non-uniform distribution of graphite particles in the matrix. The hardness of composites decreased by 11.1% with respect to addition of percentage of Graphite (0–12%).

M.J. Shen et al. have studied AZ31B magnesium matrix composites reinforced with two volume fractions (3 and 5 vol.%) of micron SiC particles which were fabricated by semisolid stirring assisted ultrasonic vibration process. The as-cast material was extruded at 350C with extrusion ratio of 15:1 at a ram speed of 15 mm/s. The microstructure of the composites was investigated by the transmission electron microscope ,optical microscopy, and the scanning electron microscope. It is seen that The presence of 1 mm-SiC particles helps in improving elastic properties and tensile strength. The ultimate tensile strength and yield strength of the 5 vol.% SiCp/AZ31B composites were simultaneously improved. It is observed that Most of the 1 mm SiCp are distributed along grain boundaries in 3 vol.% and 5 vol.% SiCp/AZ31B composites while some dispersed 1 mm SiCp are inside the grains of matrix in the SiCp/AZ31B composites and also large scale dynamic recrystallization is seen in extruded 5 vol.% 1 mm-SiCp/AZ31B composite with an average grain size of 3 mm.

Maguteeswaran R has worked on reinforcing Iron oxide (Fe3O4) in aluminium matrix composites to increase their conductivity and to improve mechanical properties such as hardness and tensile strength LM25 aluminium alloy metal matrix composites (MMCs) reinforced with iron oxide (Fe3O4) particles up to 3, 6 and 9 % was produced by stir casting. It is observed that from the microstructure analysis, the particles were distributed uniformly in the optical micro-graphs. It shows good distribution of particles and very low agglomeration of reinforced material produced by stir casting method. The hardness, tensile and wear rate of this composite were found 12% optimal using mechanical testing instruments.

Mohan Raj A P has carried out experimental investigation on the workability and deformation behavior of sintered ferrous powder metallurgy cylindrical pre forms of different manganese content namely 0.20, 0.50, 0.70 & 1.00% with various carbon content of 0.05, 0.10, 0.15, 0.20 and 0.25% by weight basis with two different aspect ratios 0.45 & 0.60 during cold upset forming with molybdenum di sulphide as die wall lubricant under triaxial stress state condition. Study of the cold deformation behavior of the above said pre forms showed that the true effective stress is higher than the true axial, the true hoop and the true mean or true hydrostatic stress under triaxial stress state condition. The experiment results also show that adding further % of carbon decreases the stress values. It is also established that the preform which contains 0.10% carbon develops more stress value than other pre forms. One of the main reasons for its consideration was the it's low density and good wear and corrosion resistance.

Suryanarayanan K. et al. studied the potential of use Al-SiC metal matrix composite (MMC) with particular reference to the aerospace industry. Factors such as volume fraction of the reinforcing material, reactivity at interface, type of reinforcing material and distribution of the reinforcing material are reviewed. They studied Al-SiC MMC and its application in the aerospace industry by exploring their properties.

S A Mohan Krishna et al. prepared Aluminium based composites reinforced with Silicon Carbide and Graphite particles by stir casting technique. In this study, the effect of Silicon Carbide and Graphite on stir cast Aluminium Metal Matrix Composites has been viewed .In experiment 3 kg of Al 6061 alloy pieces in the sintering furnace is heated and allowed same to melt at 7800C and care has been taken to achieve complete melting. Approximately 5% weight of solid dry hexachloro-ethane tablets or degassing tablets has been used to degas the molten metal at temperature 7800C.

They have concluded that Stir casting is the most celebrated commercial method of producing aluminium based composites. The main advantages are simplicity, litheness and applicability to large quantity production. It is also striking because, in the principle of operation, it allows a conventional metal processing route to be used,
and hence minimizes total cost of the product.

I.M. El-Galy et al. have integrated the concept of functionally graded materials (FGM) to produce engineering materials with tailored contradictory properties that suit multi functioning components to enhance the design of metal matrix composites. They focused on characterization of functionally graded metal matrix composites (FGMMCs) based on pure aluminium matrix reinforced with different percentages and sizes of SiC particles. The horizontal centrifugal casting process under different conditions was used. Microstructure , tensile strength, hardness and wear rate measurements have been correlated with size and percentage of SiC particles and their distribution across the thickness of the cast tubes resulting from used casting parameters. Different weight fractions (0%, 2.5%, 5%, 7.5%,10% and 15%) of SiCp with three different particle sizes of 16, 23 and 500 lm have been investigated. 800, 900 or 1000 rpm rotational speeds were used. The hardness obtained in case of the smallest particle sizes is the highest among all tested particle sizes. It was also found that the increase in SiCp weight fraction resulted in a proportional increase in hardness of outer zone. The rate of increase- decreases slightly beyond 10 wt.% SiCp.

S.H. Tomadi has presented the effects of cutting parameters and corresponding prediction model on the surface roughness in the machining of AlSi/AlN metal matrix composite. This composite was fabricated with reinforcing smaller sizes of AlN particles at volume fractions of 10%, 15% and 20% with AlSi alloy. Taguchi's L18 orthogonal arrays approach was performed to determine the optimum cutting parameters using a signal-to-noise (S/N) ratio according to the stipulation of the smaller the better. A mathematical model of surface roughness has been developed using regression analysis as a function of all parameters with an average error of 10% can be observed between the predicted and experimental values. It was concluded that type of the cutting tool is the most significant factor, responsible to a lower surface roughness with the highest percentage of contribution of 45.5%.The volume fraction of AlN is second factor supporting the surface finish of the machined part, which contributed 20.2% to surface roughness value

CONCLUSION

Due to the challenges of development of material with better properties in advance engineering fields, Metal matrix composites have shown cost and energy advantages over traditional materials. The combination of different particles as rainforcement found to give better mechanical and physical properties.

Several limitations must be overcome in order to exploit the full potential of Metal matrix composites . At first proper manufacturing process should be developed and implemented. Secondly properties of composites are greatly depended on the volume percentages of rainforcement particles . The current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry.

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