ISSN 2348 – 7968

Analysis of a squeeze cast magnesium alloy with Aluminium metal matrix composites

Dr.R.Maguteeswaran[a*], Dr. R.Sivasubramanian [b], Mr.V.Senthilraja[c]

[A] Professor, Department of Mechanical Engineering, Jay Shriram Group of Institutions, Tirupur, Tamilnadu, India.

[B] Professor, Department of Mechanical Engineering, Coimbatore Institute of Technology, Coimbatore, Tamilnadu, India.

[C] Assistant professor , Department of Mechanical Engineering, Jay Shriram Group of Institutions, Tirupur, Tamilnadu, India.

Abstract

The main objective of this paper is to study of metal matrix composites (MMC). The metal matrix composite has the advantage of high strength and stiffness. The current literature Metal matrix composite was discussed and also adds this article. The Aluminum, Titanium and Manganese metal matrix are focused to these articles. The literature were discussed various different applications of MMC's are focused. The read these literatures finally find out the problem of MMC's. The problem finding of the metal matrix composite is manufacturing and machining. The MMC applied the light weight and high strength applications. The satisfied this type of application as very high expensive to finished the product or part. The manufacturing's of MMC's used by powder metallurgy, liquid metallurgy, stir casting and squeeze casting methods. The manufacturing methods are explained in this article shortly. The MMC's process flow analyses are divided into four parts. The first one discussed the CAD/CAM industrials environment. The CAD/CAM industrials environment designs the shape of the product or parts. The second one discussed testing of MMC's. The MMC's checked with tensile, compressive, hardness, bending, impact and fatigue etc. third part as manufacturing like that used any one of the process involved to produce the given product or parts. The final module was machining processes. The involvement of machining process already as turning, drilling and milling are discussed in this area. Finally these article learning of MMC's and their suitable machining manufacturing applications**.**

Keywords: Metal Matrix Composite (MMC), CAD/CAM, Powder metallurgy, Casting, machining process, mechanical testing.

1. Introduction

The history of development of metal, ceramic & carbon matrix composites is much more recent than that of the polymer matrix composites. Initial research on the metal and ceramic matrix composites are based on continuous carbon or boron fibers, but there were difficulties in producing good quality composites due to adverse chemical reaction between these fibers and the matrix. With the development of new fibers, such as silicon carbide or aluminium oxide, in the early 1980s, there has been renewed interest and an accelerated research activity in developing the technology in both metal and ceramic matrix composites. The initial impetus for this development has come from the military and aerospace industries, where there is a great need for materials with high strength- to – weight ratios or high modulus- to – weight ratios that can also withstand severe high temperature or corrosive environments. Presently, these materials are very expensive and their use is limited to applications that can use their special characters, such as high temperature resistance or high wear resistance. With development of lower cost fibers and more cost effective manufacturing techniques, it is conceivable that both metal and ceramic matrix composites will find commercial applications in automobiles, electronic packages, sporting goods and others [1].

The carbon matrix composites are more commonly known as carbon- carbon composites, since they use carbon fibers as the reinforced for the carbon matrix. The resulting composites have a lower density higher modulus and strength, lower coefficient of thermal expansion, and higher thermal shock resistance than conventional graphite. The carbon matrix composites have been used as thermal protection materials in the nose cap and the leading edges of the wing of space shuttles. They are also in rocket nozzles and exit cones, and aircraft brakes, and their potential applications include in pistons in internal combustion engines, gas turbine components, heat exchangers and bio-medical implants.

METAL MATRIX COMPOSITES

The Metal Matrix Composites (MMC) can be divided into four general categories:

1. Fiber – reinforced MMC containing either continuous or discontinuous fiber reinforcements; the latter are in the form of whiskers with

ISSN 2348 – 7968

approximately 0.1- 0.5 μm in diameter and have a length-to-diameter ratio upto 200.
2. Particulate reinforced MMC containing either particles or platelets that range in size from 0.5 to 100 μm. the particulates can be incorporated into the metal matrix to the higher volume fractions than the whiskers.
3. Dispersion-strengthened MMC containing particles that are < 0.1μm in diameter.
4. In situ MMC, such as directly solidified eutectic alloys.

In this article, we focus our attention on the first two categories, more specially on whiskers and particulate-reinforced MMCs. More detailed information on the MMC can be found in references [2-5].

Continuous carbon or boron fiber-reinforced MMCs have been under development for > 20 years; they have been found limited use due to problems in controlling the chemical reaction between the fibers and the molten metal at high processing temperatures used for such composites. The result of this chemical reaction is a brittle interphase that reduces the mechanical property of these composites. Fiber surface treatments developed to reduce this problem increase the cost of the fiber. Additionally, the manufacturing cost of continuous carbon or boron reinforced MMC is also high, which makes them less attractive for many applications. Much of the recent work on MMC is based on silicon carbide whiskers (SiC_w) or silicon carbide particulates (SiC_p). SiC is less prone to oxidative reactions at then processing temperature used. Furthermore, not only they are less expensive than carbon or boron fibers, but also they can be incorporated into metal matrices using common manufacturing techniques, such as powder metallurgy and casting.

2.0 literature review

Comprehensive literature review can be found in Zhi-hong GUO,Hua HOU,Yu-hong ZHAO,Shu-wei QU[6] , The squeeze cast process parameters of AZ80 magnesium alloy were optimized by morphological matrix. Experiments were conducted by varying squeeze pressure, die pre-heat temperature and pressure duration using $L_9(3^3)$ orthogonal array of Taguchi method. In Taguchi method, a 3-level orthogonal array was used to determine the signal/noise ratio. Analysis of variance was used to determine the most significant process parameters affecting the mechanical properties. Mechanical properties such as ultimate tensile strength, elongation and hardness of the components were ascertained using multi variable linear regression analysis. Optimal squeeze cast process parameters were obtained.

Tamer Ozben, Erol Kilickap, Orhan Çakır [7] gives a primitive study for the results of experimental investigation on mechanical and machinability properties of silicon carbide particle (SiC-p) reinforced aluminium metal matrix composite. The influence of reinforced ratios of 5, 10 and 15 wt.% of SiC-p on mechanical properties was examined. The effect of machining parameters, e.g. cutting speed, feed rate and depth of cut on tool wear and surface roughness was studied. It was observed that increase of reinforcement element addition produced better mechanical properties such as impact toughness and hardness, but tensile strength showed different trend; increased upto 10 wt.% of SiC-p reinforced and then decreased when 15 wt.% of SiC-p reinforcement addition. Machinability properties of the selected material were studied and higher SiC-p reinforcement produced a higher tool wear; surface roughness was generally affected by feed rate and cutting speed.

M.T. Abou El-khair, A. Lotfy, A. Daoud, A.M. El-Sheikh[8] have mentioned the impotant of ZA27 alloy based composites were synthesized by stirring method, followed by squeeze casting. Stir casting was employed successfully to incorporate 5 vol. % of various reinforcement particulates, namely, SiC, ZrO_2 or C. The porosity in the composites was decreased by squeeze pressure. The presence of particles and/or application of squeeze pressure during solidification resulted in considerable refinement in the structure of the composites. The microstructures, X-ray diffraction (XRD) and energy dispersive X-ray analysis (EDXA) results indicated that no significant reactions occurred at the interface between the SiC or C particles and ZA27 alloy. However, in case of ZrO_2 reinforced ZA27, the ZrO_2 reacted with Cu present in the molten ZA27 alloy, forming Cu_5Zr. Thermal analysis showed that both α and β nucleation and growth temperatures of the composites were lower than those of the ZA27 alloy. The presence of particles in the as-cast or squeezed composites led to not only an accelerated age hardening response, but also an increase in the peak hardness of the composites. The values of coefficient of thermal expansion (CTE) of the composites were drastically lower as compared to those of the ZA27 alloy. The tensile properties of the composites decreased as a result of the addition of the particles. Scanning electron microscope (SEM) pictures of the composites indicated that cracks mainly initiated at particle–matrix interface, propagated through the matrix and linked up with other cracks leading to failure of the composites.

Examining from the perspective of investigation for composite manufacture, T.P.D. Rajan, R.M. Pillai, B.C. Pai,[9] The present investigation is on characterization of functionally graded composites based on 356 cast and 2124 wrought aluminum alloys reinforced with SiC particles of 23 μm average particle size processed by liquid metal stir casting followed by horizontal centrifugal casting. A maximum of 45 and 40% SiC particles are obtained at the outer periphery of the Al(356)-SiC and Al(2124)-SiC FGMMC casting respectively. The maximum hardness obtained at the outer periphery after heat treatment for Al(356)-SiC and Al(2124)-SiC FGMMC are 155 BHN and 145 BHN respectively. The freezing range of the matrix alloy has been found to dictate the nature of transition from particle enriched to depleted zone. These composites are suitable for making engineering components, which require very high surface hardness and wear resistances with high specific strength.

Mohsen Masoumi, Henry Hu [10] gives a brief summary about the paper reports the effect of applied pressure on the tensile properties and the microstructure of squeeze cast Mg–5 wt. %Al–1 wt. %Ca (AX51) alloy. In this study, applied pressures from 3 to 90 MPa were considered. It was observed that the fraction of second phases and porosity level reduces with an increase in applied pressure. The tensile tests results indicate that ultimate tensile strength (UTS), yield strength (YS) and elongation (E_f) of AX51 alloy increase with increasing applied pressures. The improvement in tensile properties was attributed to the casting densification and presence of higher amount of solute in the matrix. The scanning electron microscopy (SEM) fractographs reveal that the fracture modes of the squeeze cast alloy is more ductile at higher applied pressures. The crack initiation occurred mostly in the vicinity of Mg–Al–Ca particles.

S. Gopalakrishnan, N. Murugan[11] addressed Metal matrix composite (MMC) focuses primarily on improved specific strength, high temperature and wear resistance application. Aluminum matrix reinforced with titanium carbide (Al–TiC_p) has good potential. The main challenge is to produce this composite in a cost effective way to meet the above requirements. In this study Al–TiC_p casting with different volume fraction of TiC was produced in an argon atmosphere by an enhanced stir casting method. Specific strength of the composite has increased with higher % of TiC addition. Dry sliding wear behavior of AMC was analyzed with the help of a pin on disc wear and friction monitor. The present analyses reveal the improved specific strength as well as wear resistance.

S.H. Chen, P.P. Jin, G. Schumacher, N. Wanderka[12] developed the microstructure and interface of an $Mg_2B_2O_5$ whisker-reinforced magnesium composite were characterized using optical microscopy, transmission electron microscopy and X-ray diffraction. It was found that the $Mg_2B_2O_5$ whiskers have a twinned structure with the (2 0 2) as the twin plane and growth direction along [0 1 0]. The MgB_4O_7 particles and the globular Mg_2Si particles were observed within the $Mg_2B_2O_5$whisker, and at the interface between the $Mg_2B_2O_5$ whiskers and Mg matrix, respectively. The MgO and MgB_2 phase formed at the matrix–whisker interface during vacuum-gas pressure infiltration process due to the interfacial reaction. The crystallographic orientation relationships between the $Mg_2B_2O_5$ whisker and the interfacial reaction products were found to be $[0\,1\,0]_{Mg_2B_2O_5}$//$[1\ 1\ 0]_{MgO}$ and $[1\ 1\ 0]_{MgO}$//$[2\,\bar{1}\,\bar{1}\,0]_{MgB_2}$, and $(2\,0\,2)_{Mg_2B_2O_5}$//$(0\ 0\ 2)_{MgO}$ and $(0\ 0\ 2)_{MgO}$// $(0\,0\,0\,1)_{MgB_2}$, respectively. The factors that influence the microstructure of the $Mg_2B_2O_5$ whiskers and the formation of the interfacial reaction products of Mg_2Si, MgO and MgB_2 phases were discussed.

M.S. Song, M.X. Zhang, S.G. Zhang, B. Huang, J.G. Li [13] developed TiC ceramic particulates locally reinforced aluminum matrix composites were successfully fabricated via self-propagating high-temperature synthesis (SHS) reaction of Al–Ti–C system during aluminum melt casting. The SHS reaction could be initiated when Al contents in the green compacts ranged from 20 wt. % to 40 wt. %. With increasing Al contents, the ignition delay time was prolonged and the adiabatic combustion temperature was lowered. Using XRD and DSC analysis, the SHS reaction characteristic was discussed. The result showed that Al serves not only as diluents but also as an intermediate reactant participating in the SHS reaction, determining the reaction process and its final products. The SEM images revealed a relatively uniform distribution and nearly spherical morphology of TiC particulates in the locally reinforced region, and excellent adhesion and gradient distribution between the TiC particulates reinforced region and Al-matrix. The size of the TiC particulates decreased obviously with increasing Al contents in the blends.

Comprehensive literature review can be found in P.K. Rohatgi, A. Daoud, B.F. Schultz, T. Puri [14] the feasibility of incorporating fly ash cenospheres in die cast magnesium alloy has been demonstrated. The effects of fly ash cenosphere additions on the microstructure and some of the salient physical and mechanical properties of magnesium alloy (AZ91D) metal matrix composites were investigated. The control AZ91D alloy and associated composites, containing 5, 10, and 15 wt. % of fly ash cenospheres (added), were synthesized using a die casting technique. A micro structural comparison showed that micro structural refinement – occurred due to

ISSN 2348 – 7968

the fly ash additions and became more pronounced with an increase in the percentage of the fly ash added. The metal matrix areas nearer to the fly ash particles exhibited a greater degree of refinement than was observed in the areas further away from these particles. Both filled and unfilled fly ash cenospheres, and porosity were observed in the microstructures. The composite specimen densities decreased and the coefficient of thermal expansion did not change significantly as the volume percent of fly ash was increased within the range investigated. The hardness values of the composite specimens exhibited an increase in proportion to the increase in percentage of added fly ash. The tensile strength of the composites also increased as the concentration of fly ash cenospheres was increased. In contrast, the Young's modulus of these composite samples, as measured by non-destructive pulse-echo method, decreased as the percentage of fly ash in the composite was increased. SEM micrographs of the tensile fracture surfaces showed broken cenospheres on the fracture surface and evidence of 'pull outs', where fly ash particles were previously embedded in the matrix. Compression testing results showed that the presence of 5 wt. % cenospheres decreased the compressive strength and compressive yield strength of the composite relative to that of the AZ91D matrix alloy. Surprisingly, a significant change in compression strength was not observed for the composites with 10 and 15 wt.% cenospheres in comparison to the AZ91D matrix alloy. In contrast to the tensile tests, no cenosphere remnants were observed on the compressive test fracture surface of the composites. This observation suggests that the fracture of the composite was initiated within the AZ91D matrix by normal void nucleation and growth, followed by crack propagation through the matrix, avoiding any of the cenospheres, leading to composite fracture of the matrix.

Barbara Previtali , Dante Pocci, Cataldo Taccardo [15] have mentioned the important of this paper is aimed at studying the application of traditional investment casting process to obtain components in discontinuously particle reinforced aluminum matrix composites Using the double stir method, a mixed liquid slurry of aluminum alloy and 20% SiC or 7.5% B_4C carbides was obtained. As a case study a component from the textile sector was produced in unreinforced alloy and in both composites. The wear resistance of the components in the three different materials was ranked. Moreover, analysis of particle distribution and optical and scanning electron microscope observations of reaction products were also performed. Results show that components in aluminum alloy with SiC as reinforcement have uniform distribution of ceramic particles, sound interface without fragile compounds and wear resistance higher than that of components reinforced with B_4C particles.

3.0 Problem findings and discussion

Metal matrix composites (MMCs) have emerged as an important class of materials, which are increasingly being utilized in recent years. Application of these materials in certain areas is limited due to difficulties in machining. The principal machining parameters that control machinability characteristics are extrinsic parameters (cutting speed, feed rate, depth of cut, and type of cutting tools) and intrinsic parameters (particulate size, volume fraction, and type of reinforcement). Different cutting tools used in machining these materials are given in the order of decreasing hardness as PCD, CBN, TiC, Si_3N_4, Al_2O_3, Mg and WC. The present review is focused on the influence of cutting parameters, morphology, distribution, and volume fraction of reinforcement on the surface finish, tool life, cutting forces, and chip formation. This review will provide an insight into selecting the optimum machining parameters for machining metal matrix composites.

3.1 process flow analysis

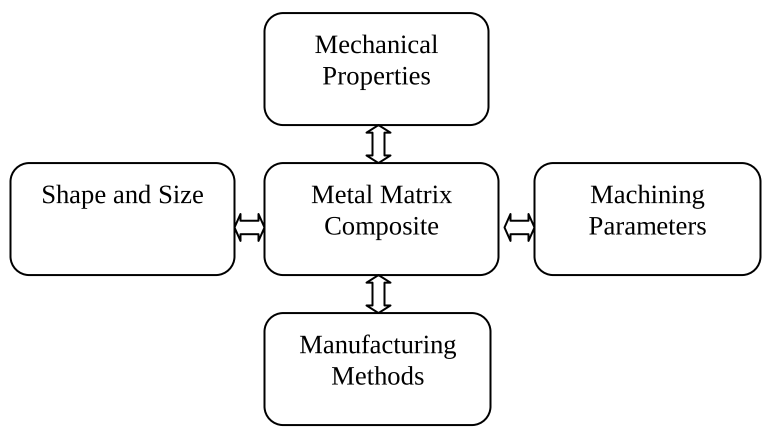


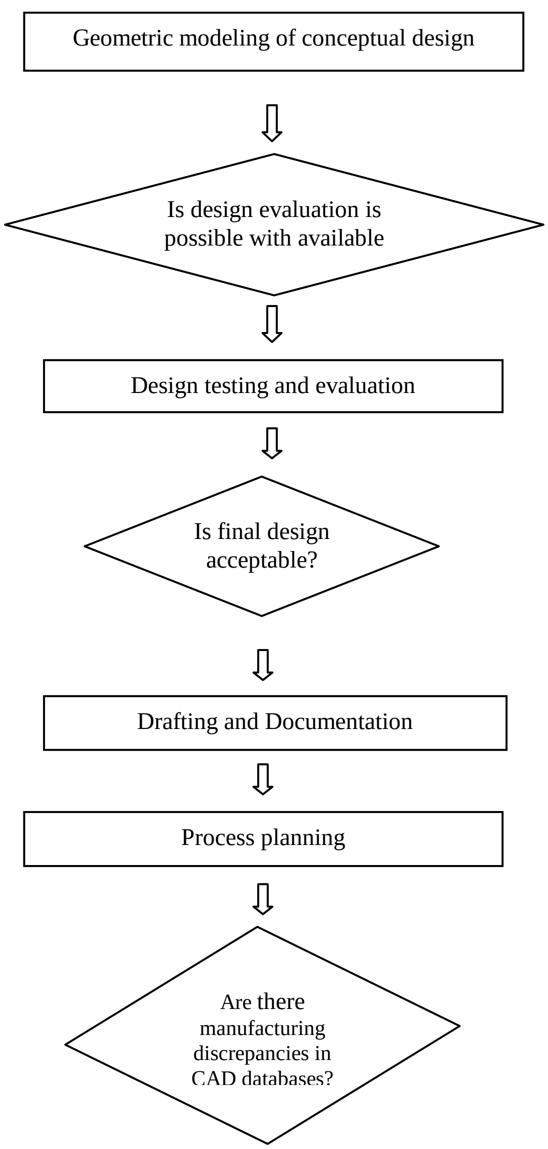
Fig 1. Process flow analysis of Metal Matrix Composite

The fig 1. Shows process of metal matrix composite. It is divided into four major areas like that design and analysis, mechanical testing properties, manufacturing and machining.

3.2 Design and Analysis

Design area is to design the shape and size of the component. Now a day's design a component using cad /cam interface. it is a easily tool design a component.

CAD/CAM is technology both hardware and software and applications driven field. Aerospace, automotive and shipbuilding industries have influenced, to great extent, the development of lofted and sculptured surfaces. Therefore understanding the utilization and implementation of the CAD /CAM technology in an industrial environment helps to close the gap between creating the technology, managing it, using it and more importantly learning it. Fig 3.1 Shows, in a general sense, how a typical CAD/CAM system is utilized in a typical industrial environment. The fig 3.1 shows the major components or packages that exist. The detailed capabilities and functions of each package as well as the various types of existing user interface are what makes these systems look entirely different. As a matter of fact, practical experience has proven that learning one system is sufficient to learn another one at a much faster pace. This faster pace is attributed to dealing with same functions. All the user has to do is to adjust to the user interface and the management hierarchy of the new system. One might conclude that learning the generic basic concepts behind these systems does not only speed up the training curve of perspective users but it also helps them utilize the technology productively [16].



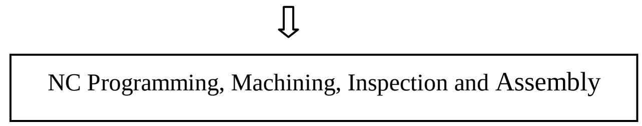


Fig.2 Utilization of Typical CAD/CAM Systems in an industrial environment

3.3 Mechanical testing Properties

The following test considers checking the mechanical properties:

Tensile, compression and bending tests

The Tensile, compression and bending tests are carried out on a universal testing machine with a capacity of 200 tons or more. Tensile testing is more common than compression testing, which is done for a limited number of materials such as concrete, brick, ceramics, etc. a pulling load is applied for tensile specimen and compressive load for compressive test piece. Machine gives continuous record of loads, deformation, etc. to help subsequent analysis and calculation of important quantities relating to tensile and compressive strength. Test procedures and specifications for test piece are kept as per relevant standards [17].

Hardness testing

In selecting materials to withstand wear, properties often considered are hardness and toughness. Hardness enables the material to resist penetration and scratching. Hardness of a metal can be tested by several methods as brinell, Rockwell, Vickers, shore seleroscope.

Hardness gives a general indication of the strength of material and its resistance to scratching and wear. A relationship has been established between ultimate tensile strength (UTS) and Brinell hardness (HB) for steels as follows:

UTS (Mpa) = 3.5 (HB)

Where HB is in kg/mm^2 as measured for a load of 3000kg.

Hot Hardness is the Hardness of the material at elevated temperature and is an important factor considered for metal cutting tools, dies used for hot working operations and casting operations.

Hardenability is the measure to response of a metal to the process of hardening. It refers to the depth within a specimen up to which appreciable Hardness can be attained. Harden ability is determined largely by the presence of alloying elements in the hardened metal. It is tested by Jominy and Quench harden ability test.

BRINELL HARDNESS

It is based on the area of indentation a steel or carbide ball makes in the surface of testing specimen for a given load when loaded for 15sec. on ferrous metals and up to 30sec. on non- ferrous metals specimen. After the load is released, the diameter of the spherical immersion made in the surface of the test piece is found using brinell microscope and the Brinell hardness number.

ROCKWELL HARDNESS

Rockwell hardness is a much faster test and is the test also Rockwell hardness number is determined through an indentation made under a load. The indenter is, however, much smaller in size, and it could be a steel ball used for soft metals or a diamond cone used for hard metals.

IMPACT TEST

Many parts of a machine needed to be designed to stand impact loading and absorb the energy of impact within it through elastic action, thus providing damping effect. Impact test is done to determine the resistance to fracture against impact loads. Two tests are 1. Izod impact toughness test, 2. Charpy impact-toughness test. Energy required to fracture a notched specimen is measured in tests where measured energy is indicative of relative toughness of the material.

FATIGUE TEST

It is the phenomenon that begins with a minute crack in a metal, which, under the effect of repeated, gets developed into a crack leading to sudden unexpected failures. Fatigue failure normally starts at the surface of the work piece. Where stress is higher. Components subjected to fatigue loads are designed on the basis of fatigue strength of the metal, which is always lower than the yield strength of the metal.

3.4 Manufacturing Methods

A number of composite fabrication have been developed that can be placed under the following categories. They are (1) powder metallurgical techniques (2) liquid metallurgy (3) stir casting (4) squeeze casting.

THE POWDER METALLURGY PROCESS

The concept of making parts from metal powder is simple and straightforward; however, the techniques employed can be very sophisticated, requiring a high level of technical competence and a substantial investment in capital equipment. The process consists of three steps: blending, compacting, and sintering[18].

Blending

Blending is the process of powder agitation for the purpose of homogenizing the particle sizes. Mixing also takes place and serves to interdisperse powders of different chemical compositions. Alloyed powders are produced by combining a homogeneous mixture of carefully weighed and blended powders.

Lubricants are added to the powder to reduce friction between the particles as they are being compacted, as well as to reduce die wear. Stearic acid, lithium stearate, or powdered graphite are the principal lubricants used. Blending is almost universally done dry; however, in some finely divided aluminium powders, to reduce dust and the danger of explosion or fire, the process is done wet.

Compacting

After the metal powders have been blended to achieve various desired properties, they are pressed or compacted to the required shape, size, and density. Metal powders present problems of internal friction when pressed in the die. Both density and strength decrease in the powder mass as the distance from the punch increases. To minimize this condition, punches are used at both ends of the die as shown in fig. the use of lubricants improves the density, minimizes the load required, and increases life, particularly by easing part ejection. However, lubricants can create problems in reduced green strength, in feeding the powder into the die, and in lubricant reaction. Lubricants must be driven off by a low temperature stage heating before sintering,

For high volume production, tungsten carbide is used as the die material. Although the cost is higher, it will outwear the normally used tool steels by a ratio of about 10:1. Some carbide dies can be used to produce a million parts before tolerances are exceeded. High pressures, sometimes in excess of 50 tons /in^2.(689.5Mpa) are used to cause mechanical interlocking between the irregularities of the particles.

The compaction operation consolidates and dandifies the powders into what is commonly termed a green compact. The compact will be very close to the size, shape, density of the finished part. After ejection from the die the part can be handled, but is relatively fragile in the green state and if dropped will probably crack.

There are two main methods of compacting metal powders: (1) with a punch and die, and (2) isostatically. Part geometry is the major factor in determining which method is to be used. If the part shape is simple, mechanical pressing is likely to be used. Parts with intricate configurations can be made by isostatic compaction discussed later.

Die Compaction: Die compaction is limited to vertical motions only, so parts with back angles are undercuts cannot be made. For a mechanical press operating on powder fill/ compaction/ejection cycle of 3 to 4 seconds, approximately 1000 components can be produced per hour. For simpler parts, these outputs can be increased with multistation rotary presses, where multiple sets of tools are mounted on a rotary table. Punch motions are actuated by fixed, horizontal cam tracks or rollers, and the presses are capable of very high output rates in the order of 35,000 parts per hour.

Mechanical and Hydraulic Presses. Both mechanical and hydraulic types of presses are used for compacting. The advantages and limitation of each are briefly as follows.

Mechanical presses are of lower tonnage (usually 200 tons or less) and have faster cycles. Normally no dwell time is possible, although newer presses have clutches. Compacting is done to given height, not to a given pressure or density.

Hydraulic presses are of higher tonnage (usually 500 tons or more), have slower cycle time, even with accumulators, and have infinitely variable dwell time. Parts may be pressed to a given load to provide good density control. Limit switches may be used for height control.

SINTERING

Sintering is the third step in producing powdered metal parts. The green compacts are heated in muffle type or wire mesh conveyer belt furnace. Special atmosphere, such hydrogen or dissociated ammonia, are required for sintering of ferrous metal to control both carburization and de carburization of iron and iron rich compacts.

Furnace temperature vary with the sintering requirements; for brass, a temperature of 1600^o to 1615^0F (870^o to 880^oC)is satisfactory, and for stainless steel,2000^o to 2350^oF(1100^o to 1300^oC)is used. The temperature must remain between 60% to 80% of the melting point of the principle constituent. The sintering time may range from 20 minutes to an hour or more. The lubricants that were originally blended with the powders are permitted to burn off in a special chamber before the parts reach the high heat zone of the furnace.

LIQUID METALLURGY ROUTE:

Liquid state processes include stir casting or compo casting, infiltration, spray casting and in situ (reactive) processing. The selection of the processing route depends on many factors including type and level of reinforcement loading and the degree of micro structural integrity desired.[conference reference3]

STIR CASTING:

This involves incorporation of ceramic particulate into liquid aluminium melt and allowing the mixture to solidify. Here, the crucial thing is to create good wetting between the particulate reinforcement and the liquid aluminium alloy melt. The simplest most commercially used technique is known as vortex technique or stir casting technique. The vortex technique involves the introduction of pretreated ceramic particles into the vortex of molten alloy created by the rotating impeller. Lloyd (1999) has reports that vortex-mixing technique for the preparation of the ceramic particle dispersed aluminium matrix composites are originally developed by Surappa and Rohatgi (1981) at the Indian institute of Science, Bangalore. Subsequently, several aluminium companies further refined and modified the processes which are currently employed to manufacture a variety of aluminium metal matrix composites on commercial scale.

The vortex method is one of the better known approaches used to create and maintain a good distribution of reinforcement material in the matrix alloy. In this method, after the matrix material is melted, it is stirred vigorously to form a vortex at the surface of the melt, and the reinforcement material is then introduced at the side of the vortex. The stirring is continued for a few minutes before the slurry is cast.

SQUEEZE CASTING:

The squeeze casting process is actually a combination of casting and forging. A precise amount of molten metal is poured into the bottom half of a preheated die set and allowed to partially solidify. An upper die then descends applying pressure throughout the duration of solidification. Intricate shapes can be produced at that are far less than would normally can required for hot or cold forging. Both retractable and disposable cores can used to create holes and internal passages. Gas and shrinkage porosity are substance reduced and mechanical properties are enhanced. The process can be applied to both ferrous and nonferrous alloys and both wrought and cast alloy be processed.

An adaptation of the process can be used to produce metal matrix composites by forcing the pressurized liquid around formed or fiber reinforced that have been positioned in the mold. Another modification involves the use of thixotropic semi solid material. Here the need to introduce a precise amount of molten metal into the die is eliminated by starting with chucks of metal that have been heated into the semisolid range. Thixotropic material can be handled mechanically, like a solid, but shaped at low pressure because it flowed like a liquid when agitated or squeezed. The absence of the turbulent flow minimizes the gas pickup and entrapment. Since the material is already partially solid, solidification shrinkage and related porosity is reduced. Cooling while under pressure completes the solidification, while simultaneously producing high quality intricate parts with good finish and precision [20].

RULE OF THE MIXTURE

Rule of mixtures is a method of approach to approximate estimation of composite material properties, based on an assumption that a composite property is the volume weighted average of the phases (matrix and dispersed phase) properties. According to the Rule of Mixtures properties of the composite material are as follows

a) Density:- $d_c = (d_m * V_m) + (d_r * V_r)$ where,

Dc, dm, dr – densities of the composite, matrix and dispersed phase respectively;
V_m, V_r – volume fraction of the matrix and dispersed phase respectively.

b) Coefficient of Thermal Expansion:-

- Coefficient of Thermal Expansion (CTE) in longitudinal direction (along the fibers)
  $\alpha_{cl} = (\alpha_m * E_m * V_m + \alpha_f*E_f*V_f)/(E_m*V_m + E_f*V_f)$

α_{cl}, α_m, α_f – CTE of composite in longitudinal direction, matrix and dispersed phase (fiber) respectively;
E_m , E_f – modulus of elasticity of matrix and dispersed phase (fiber) respectively.

- Coefficient of Thermal Expansion (CTE) in transverse direction (perpendicular to the fibers).

$\alpha_{ct} =- (1+P_m)\alpha_m * V_m + \alpha_f * V_f$
P_m – Poisson ratio of matrix.
Poisson's ratio = Lateral strain/ Longitudinal strain

c) Modulus of elasticity:-

- Modulus of elasticity in longitudinal direction (E_{cl})

$E_{cl} = E_m*V_m +E_f*V_f$

- Modulus of elasticity in transverse direction (E_{ct})

$1/E_{ct} = V_m /E_m + V_f/E_f$

d) Tensile strength :-

- Tensile strength of long-fiber reinforced composite in longitudinal direction.

$\sigma_c = \sigma_m*V_m + \sigma_f*V_f$
Where σ_c , σ_m, ,σ_{fn} tensile strength of the composite, matrix and dispersed phase fiber respectively.

- Tensile strength of short fibered composite in longitudinal direction (Fiber length is less than critical value Lx)

$L_c = \sigma_f*d/\tau_c$
Where
d- Diameter of the fiber;
τ_c- shear strength of the bond between the matrix and dispersed phase (fiber).
$\sigma_c = \sigma_m*V_m + \sigma_f*V_f*(1 – L_c/2L)$
Where L – Length of the fiber.

3.5 Machining process

For complete the Manufacturing of composite metal matrix materials to involve the different machining process like that turning, milling, drilling etc., Particle reinforced aluminium matrix composites (AMCs) are high-strength lightweight materials consisting of a comparatively soft aluminium alloy and hard embedded ceramic particles. The high hardness of the particles results in excellent abrasion resistance. However, this property lends poor machinability involving high tool wear and surface imperfections on the work pieces. For this reason, CVD diamond tipped index able inserts were used for turning AA2124 with 25% volume proportion of SiC particles. The surface integrity is influenced by the tool geometry, which affects the stress condition in the shear zone. In the research described the influence of modified corner geometries and the width of flank wear land were investigated. The results showed that surface roughness values can be decreased by using tools with wiper geometry. An increasing flank wear land width of the inserts led to a reduction of the surface imperfections [21].

The influence of cutting conditions (cutting velocity and feed) and cutting time on turning metal matrix composites (MMCs). A plan of experiments, based on the techniques of Taguchi, was performed machining with cutting conditions prefixed in work pieces. An orthogonal array and the analysis of variance (ANOVA) are employed to investigate the cutting characteristics of MMC (A356/20/SiCp-T6) using PCD cutting tools. The objective was to establish a correlation between cutting velocity, feed and the cutting time with the tool wear, the power required to perform the machining operation and the surface roughness in work piece. These correlations were obtained by multiple linear regression. Finally, confirmation tests were performed to make a comparison between the experimental results foreseen from the mentioned correlations [22].

ISSN 2348 – 7968

An experimental and numerical study of the evolution of cutting forces, tool wear and surface finish, measured when drilling the particulate metal matrix composite A356/20/SiCp-T6 is presented. The experimental work was developed through the continuous measurement of the cutting forces with an appropriate piezoelectric dynamometer. The wear type was identified and its evolution with cutting time was measured. Drills with polycrystalline diamond were tested. The surface finish of the holes was evaluated with a profilometer.
Using the experimental results, a numerical search of optimal drilling conditions was performed. Since there are contradictory objectives, such as maximization of tool life and minimization of tool wear, the concept of the *Pareto optimum solution* is considered in the optimization procedure. An evolution strategy is adopted to obtain the optimal solution for cutting speed, feed rate and tool life prediction with industrial interest [23].

The wide scale introduction of metal matrix composite (MMCs) will increase simultaneously with development in technologies. Aluminium matrix composites are widely used for their favorable specific strength/stiffness and corrosion resistance properties. As a consequence of the widening range of applications of MMCs, the machining of these materials has become a very important subject for research. MMCs are extremely difficult to machine (turning, milling, drilling, threading) due to their extreme abrasive properties. With the projected widespread application of MMCs, it is necessary to develop an appropriate technology for their efficient and cost-effective machining. This paper deals with the surface integrity of drilled Al/17%SiC particulate MMCs. Dry drilling, tests, at different spindle-speed, feed rates, drills, point angles of drill and heat treatment, were conducted in order to investigate the effect of the various cutting parameters on the surface quality and the extent of the deformation of drilled surface due to drilling,. For this reason, the surface roughness of the work piece material was investigated after drilling, operations. The work piece material was drilled in four heat treatment conditions: as-received, solution treated, and solution treated and aged for 4 and 24 h. The drills used were 5 mm diameter, and 90°, 118° and 130° point angles. The experiments were performed under conditions the different speeds of 260 and 1330 rpm and the feed rates of 0.08 and 0.16 mm/rev. drilling, tests were carried out using high-speed steel (HSS), TiN coated HSS and solid carbide drills. In the experimental results, it is determined that increasing drill hardness and feed rate decrease the surface roughness of drilled surface for all heat treated conditions. In addition, the optimum surface roughness was determined when the solid carbide drill tools were used on the specimens with packaged condition [24].

In this study, wear behavior of various tools in milling process of Al-4Cu/B_4C_p composites was investigated. For this purpose, composite samples were produced by liquid phase sintering to be used in milling operation. Five different cutting speeds at a constant feed rate of 0.20 mm/z were used in order to determine the effect of cutting speed on tool wear and tool wear mechanism in milling of these composites. Milling operations were continued until flank wear limit (V_B)=0.3 mm was attained for each tool. Flank wear was determined by using optical microscopy whereas wear mechanisms were examined by using scanning electron microscopy (SEM). Experimental results brought out that triple coated tool showed the highest wear resistance at all cutting speeds. In addition lower cutting speeds yielded lower tool wear for all tools[25].

The quality of the components produced during end milling of Al/SiC particulate metal matrix composites (PMMCs) is important as it influences the performance of the finished part to great extent. Hence, the estimation of surface integrity can cater to the requirements of performance evaluation. Therefore, an understanding of surface integrity provides many opportunities to avoid failures enhance component integrity and reduce overall costs. This paper presents the results of an experimental research on end milling of Al/SiC PMMC. The aim of the investigation is to enhance the knowledge about the machinability of Al alloy reinforced with siC using TiAlN coated carbide end mill cutters. Investigations on surface quality and the extent of sub-surface damage of machined Al/SiC PMMC and Al alloy were carried out at different levels of cutting conditions. The comparison of Al/SiC PMMC and Al alloy on the basis of surface integrity (surface roughness, residual stress, microstructure and micro hardness) was tried out in order to know the machinability of two materials. The results show that the presence of the reinforcement enhances the machinability in terms of both surface roughness and lower tendency to clog the cutting tool, when compared to a non-reinforced Al alloy. The results would serve to understand the end milling machining process better; provide inputs that can ensure better machining of Al/SiC PMMC and thus expected to lead technological and economical gains with the use of Al/SiC PMMC in various industrial applications by replacing Al alloys[26].

4.0 Conclusions and Future work

In the present work, the manufacturing and machining of MMCs were investigated. The following results were obtained:

1. The history and development of MMC's were discussed.
2. The current literature of MMC's and the Aluminum, Titanium and Manganese MMC's and their performance were studied.
3. The process flow analysis of MMC's divided into four parts like that CAD/CAM, Testing, Manufacturing and machining was studied. In this studied learn about the various manufacturing and machining processes.
4. The future work is the combination of any one of the Aluminum, Titanium and Manganese MMC's and using suitable manufacturing processes and machining process.

5.0 References

1. P.K. Mallick, Fiber reinforced composites - Materials, Manufacturing and design, CRC Press Taylor and Francis group. (2007) 31.
2. R.k. Everett and R.J. Arsenault (eds), "Metal Matrix Composites: Mechanisms and Properties", Academic press, San Diego (1991).
3. R.k. Everett and R.J. Arsenault (eds), "Metal Matrix Composites: Mechanisms and Properties", Academic press, San Diego (1991).
4. T.W.Clyne, P.J.Withers, "An Introduction to Metal Matrix Composites", Cambridge University Press, Cambridge, UK (1993).
5. N.Chawla, K.K.Chawla, "Metal Matrix Composites", Springer, New York (2006).
6. Zhi-hong GUO,Hua HOU,Yu-hong ZHAO,Shu-wei QU, "Optimization of AZ80 magnesium alloysqueeze cast process parameters using morphological matrix", Transactions of Nonferrous Metals Society of China(2012) 411-418.
7. Tamer Ozben, Erol Kilickap, Orhan Çakır, "Investigation of mechanical and machinability properties of SiC particle reinforced Al-MMC", Journal of materials processing technology(2007) 220-225.
8. M.T. Abou El-khair, A. Lotfy, A. Daoud, A.M. El-Sheikh, "Microstructure, thermal behavior and mechanical properties of squeeze cast SiC, ZrO_2 or C reinforced ZA27 composites", Materials Science and Engineering: A(2011) 2353–2362.
9. T.P.D. Rajan, R.M. Pillai, B.C. Pai, "Characterization of centrifugal cast functionally graded aluminum-silicon carbide metal matrix composites", Materials characterization (2010) 923-928.
10. Mohsen Masoumi, Henry Hu, "Influence of applied pressure on microstructure and tensile properties of squeeze cast magnesium Mg–Al–Ca alloy", Materials Science and Engineering: A(2011) 3589–3593.
11. S. Gopalakrishnan, N. Murugan," Production and wear characterization of AA 6061matrix titanium carbide particulate reinforced composite by enhanced stir casting method", (2012) 302-308.
12. S.H. Chen, P.P. Jin, G. Schumacher, N. Wanderka, "Microstructure and interface characterization of a cast $Mg_2B_2O_5$whisker reinforced AZ91D magnesium alloy composite", Composites Science and Technology(2010) 123-129.
13. M.S. Song, M.X. Zhang, S.G. Zhang, B. Huang, J.G. Li, "In situ fabrication of TiC particulates locally reinforced aluminum matrix composites by self-propagating reaction during casting", Materials Science and Engineering: A(2008) 166–171.
14. K. Rohatgi, A. Daoud, B.F. Schultz, T. Puri, "Microstructure and mechanical behavior of die casting AZ91D-Fly ash cenosphere composites", Composites Part A: Applied Science and Manufacturing(2009) 883-896.
15. Barbara Previtali , Dante Pocci, Cataldo Taccardo, "Application of traditional investment casting process to aluminum matrix composites", Composite part A: Applied science and manufacturing(2008) 1606-1617.
16. Ibrahim Zeid, R.Sivasubramanian, "CAD/CAM Theory and Practice", Tata McGraw hill Education Pvt.Ltd(2011) 17-19.
17. J.P.Kaushish. "Manufacturing processes", Prentice Hall of India Pvt.Ltd(2008) 79-82.
18. Roy A.Lindberg. "Processes and Materials of Manufacture", Prentice Hall of India Pvt.Ltd(2008) 521-523.
19. M.Raj kumar, Dr.T.Sasi kumar, "Experimental analysis of Aluminium composite using stir casting technique", National conference on Emerging Trends in Mechanical Engineering ETME (2012) 9-14.
20. E.Paul DeGarmo, J.T.Black, Ronald A.Kohser, "Materials and Processes in Manufacturing", Prentice Hall of India Pvt.Ltd(2008) 408.
21. A. Schubert, A. Nestler, "Enhancement of Surface Integrity in Turning of Particle74 Reinforced Aluminium Matrix Composites by

ISSN 2348 – 7968

Tool Design", Procedia Engineering (2011) Volume 19, 300–305.

22. J.Paulo Davim, "Design of optimization of cutting parameters for turning metal matrix composites based on the orthogonal arrays", Journal of Materials Processing Technology (2003) Volume 132, Issues 1–3, 340–344.
23. J.Paulo Davim, C.A Conceição António, "Optimal drilling of particulate metal matrix composites based on experimental and numerical procedures", International Journal of Machine Tools and Manufacture(2001) Volume 41, Issue 1,21-31.
24. Gül Tosun, Mehtap Muratoglu, "The drilling of Al/SiC$_p$metal–matrixcomposites. Part II: workpiece surface integrity", Composites Science and Technology(2004) Volume 64, Issues 10–11,1413-1418.
25. M. Serdar Karakas Adem Acır,Mustafa Übeyli, Bilgehan Ögel, "Effect of cutting speed on tool performance in milling of B$_4$C$_p$reinforced aluminum metal matrix composites", Journal of Materials Processing Technology(2006) Volume 178, Issues 1–3, 241–246.
26. N. Suresh Kumar Reddy, Shin Kwang-Sup,Minyang Yang, "Experimental study of surface integrity during end milling of Al/SiC particulate metal–matrixcomposites", Journal of Materials Processing Technology(2008), Volume 201, Issues 1–3, 574–579.

First Author

Prof.Dr.R.Maguteeswaran working as a Professor in Mechanical Engineering at Jay Shriram Group of Institutions, Tamilnadu, India. Completed Doctoral Degree in Mechanical Engineering at Anna University, Chennai, Tamilnadu, India., M.E. Degree in CIM from Sona College of Technology, Salem, Tamilnadu (India) and the B.E. Degree in Mahendra Engineering College, Salem, Tamilnadu (India) and his research interest in Composite Materials, Finite element analysis and Production and Operation Management., published papers in five International Journals and 15 papers in various National and International Conferences.

Second Author

Prof. Dr.R.Sivasubramanian working as a Professor in Mechanical Engineering at Coimbatore Institute of Technology, Coimbatore, Tamilnadu, India. He completed Doctoral Degree and Master of Engineering in Mechanical Engineering at Bharathiar University, Tamilnadu, India. He was completed bachelor degree in mechanical engineering at University of Madras, Tamilnadu, India. He specialized in Production Machine Tools, CAD/CAM, Concurrent Engineering, FMS, TQM, CIM, Manufacturing Systems, and Team Engineering. He presented and published Number of papers in various journals/conferences/books at national and international levels. He also guided Doctoral Degree, Master of Science, and Master of Engineering at various Universities.

Third Author

Mr.V.Senthilraja working as an Assistant Professor in Mechanical Engineering at Jay Shriram Group of Institutions, Tamilnadu, India. Completed in Master Of Engineering in Engineering Design at Maharaja Engineering College ,Avinashi, Tamilnadu, India. And Bachelor of Engineering in M.P.Nachimuthu M.Jaganathan Engineering College Chennimalai, Tamilnadu, India. And interested in material science with analysis of a composite materials and its nature. He published 5 National and 3 International Journals and 10 papers in various national and International Conferences.