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METHODOLOGY STUDY AND ANALYSIS OF MAGNESIUM ALLOY METAL MATRIX COMPOSITES

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

[a & c] Assistant Professor, Department of Mechanical Engineering, Jay Shriram Group of Institutions, Tirupur-638660, Tamilnadu, India.

b Professor, Department of Mechanical Engineering, Coimbatore Institute of Technology, Coimbatore, Tamilnadu-638660, India.

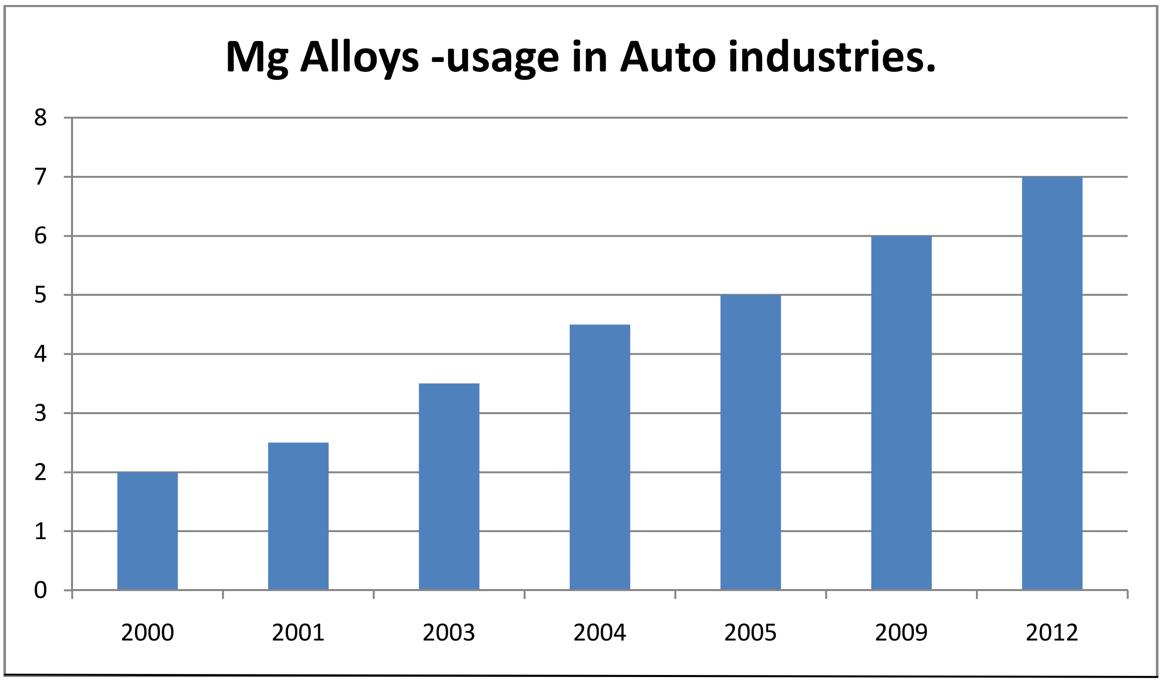
ABSTRACT

Magnesium alloys have been increasingly used in the automotive and aircraft industry in recent years due to their Light weight Magnesium alloys have excellent specific strength and stiffness, exceptional dimensional stability, high damping capacity, and high recycle ability. Magnesium and its alloys are becoming widely recognized as playing an increasingly important role in automotive, aircraft, and electronic consumer products. Magnesium alloy metal matrix composite (MMC) containing 14 vol. % Saffil fibres. The squeeze casting process was used to produce the composites and the process variables evaluated were applied pressure, from 0.1 MPa to 120 MPa, and preform temperature from 250 °C to 750 °C.

Keywords: Metal Matrix Composite (MMC), Magnesium alloy, Mechanical properties, Squeeze casting.

1.0 INTRODUCTION

Metal composite materials have found application in many areas of daily life . Often it is not realized that the application makes use of composite materials. These materials are produced in the conventional production and processing of metals. Here, the Dalmatian sword with its meander structure, which results from welding two types of steel by repeated forging, can be mentioned. Materials like cast iron with graphite or steel with high carbide content, as well as tungsten carbides, consisting of carbides and metallic binders, also belong to this group of composite materials. For many researchers the term metal matrix composites is often equated with the term light metal matrix composites (MMCs).Substantial progress in the development of light metal matrix composites has been achieved in recent decades, so that they could be introduced into the most important applications. In traffic engineering, especially in the automotive industry, MMCs have been used commercially in fiber reinforced pistons and aluminum crank cases with strengthened cylinder surfaces as well as particle-strengthened brake disks.



2.0 LITERATURE REVIEW

Lloyd, D. J. have mentioned [4]Particle reinforced metal matrix composites are now being produced commerically, and in this paper the current status of these materials is reviewed. The different types of reinforcement being used, together with the alternative processing methods, are discussed. Depending on the initial processing method, different factors have to be taken into consideration to produce a high quality billet. With powder metallurgy processing, the composition of the matrix and the type of reinforcement are independent of one another. However, in molten metal processing they are intimately linked in terms of the different reactivities which occur between reinforcement and matrix in the molten state. The factors controlling the distribution of reinforcement are also dependent on the initial processing method. Secondary fabrication methods, such as extrusion and rolling, are essential in processing composites produced by powder metallurgy, since they are required to consolidate the composite fully. Other methods, such as spray casting, molten metal infiltration, and molten metal mixing give an essentially fully consolidated product directly, but extrusion, etc., can improve the properties by modifying the reinforcement distribution. The mechanical properties obtained in metal matrix composites are dependent on a wide range of factors, and the present understanding, and areas requiring further study, are discussed. The successful commercial production of metal matrix composites will finally depend on their cost effectiveness for different applications. This requires optimum methods of processing, machining, and recycling, and the routes being developed to achieve this are considered.

M.S. Yong, states that paper reports the influence of process variables on a zirconium-free (RZ5DF) magnesium alloy metal matrix composite (MMC) containing 14 vol. % Saffil fibres. The squeeze casting process was used to produce the composites and the process variables evaluated were applied pressure, from 0.1 MPa to 120 MPa, and preform temperature from 250 °C to 750 °C. The principal findings from this research were that a minimum applied pressure of 60 MPa is necessary to eliminate porosity and that applied pressures greater than 100 MPa cause fibre clustering and breakage. The optimum applied pressure was established to be 80 MPa. It was also established that to ensure successful preform infiltration a preform temperature of 600 °C or above was necessary. For the optimum combination of a preform preheat temperature of 600 °C and an applied pressure of 80 MPa, UTS of 259 MPa was obtained for the composite. This represented an increase of 30% compared to the UTS for the squeeze cast base alloy. [17].

X.J. Wang, K. Wu, investigated the fracture behavior of SiCp/AZ91 magnesium matrix composite fabricated by stir casting is investigated using the in situ SEM technique. Experimental results show that (1) the dominant microcrack nucleation mode is interface decohesion in particle-dense regions because of the weak interface formed during the solidification process of the composite and large stress concentrations caused by particle segregation, (2) microcracks coalesce by the failure of matrix ligaments between microcracks while additional microcracks are initiated in the particle-dense region ahead of the coalesced microcracks, and (3) cracks propagate by coalescence of microcracks or along the particle/matrix interface. And so we come to the conclusion that the fracture mechanism of SiCp/AZ91 composite is interface-controlled. The in situ SEM observations are verified by complementary SEM studies of the fractured specimens of conventional tensile tests. And so, the in situ SEM observations can be qualitative representation on the fracture behavior of bulk SiCp/AZ91composite [18].

S. Ravi Kumar briefly explained the Characterizing residual stresses in the reinforcement of cast composites have been studied in the present work. Micro Raman Spectroscopy is a unique tool for determining the strain on the reinforced fibres in ceramic/polymer/MMC. Stress induced Raman shifts can be used to determine the stress/strain in films, fibres and particulates in composites. In this paper, the application of Micro Raman Spectroscopy as a non-destructive technique in providing information on the compressional/tensile strain in reinforcements in metal matrix is investigated. Examples are taken from hybrid Mg based composites reinforced with carbon fibres, Mg_2Si in situ reinforcement, formed by the addition of Si in to the matrix and SiC particles. The studies on the strain measurements in as-cast condition and its comparison after thermal cycling of the composites using the bandwidth measured are discussed. Analysis of the bandwidth offers a tool to understand that the wavenumber shift is strain induced. With this, the compressional state of the fibres embedded in the matrix can be analysed. [19].
M. Svoboda, stated the comparison is made between the creep characteristics of the unreinforced squzee -cast AZ91 and QE22 magnesium alloy and their hybrid composites reinforced with 7 vol.% short carbon fibres and 15 vol.% SiC particulates. Although the creep resistance of the reinforced AZ91 alloy is considerably improved by comparison with the unreinforced matrix alloy, no beneficial effect of hybrid reinforcement on the creep resistance of QE22 was found. A detailed micro structural evaluation of the materials was performed. It was possible to relate the creep results to the micro structural features.[20]

3.0. THE PROCESSING OF MAGNESIUM MATRIX COMPOSITES

A key challenge in the processing of composites is to homogeneously distribute the reinforcement phases to achieve a defect-free microstructure. Based on the shape, the reinforcing phases in the composite can be either particles or fibers. The relatively low material cost and suitability for automatic processing has made the particulate-reinforced composite preferable to the fiber-reinforced composite for automotive applications.

The Magnesium Matrix Composites (MMC) can be processed by different methods as follows:

1. Conventional processing
2. Stir casting

3. Squeeze casting
4. Powder metallurgy

CONVENTIONAL PROCESSING

Due to the similar melting temperatures of magnesium and aluminum alloys, the processing of a magnesium matrix composite is very similar to that of an aluminum matrix composite. For example, the reinforcing phases (powders/fibers/whiskers) in magnesium matrix composites are incorporated into a magnesium alloy mostly by conventional methods such as stir casting, squeeze casting, and powder metallurgy.

STIR CASTING

In a stir casting process, the reinforcing phases (usually in powder form) are distributed into molten magnesium by mechanical stirring. Stir casting of metal matrix composites was initiated in 1968, when S. Ray introduced alumina particles into aluminum melt by stirring molten aluminum alloys containing the ceramic powders [8].

SQUEEZE CASTING

Although the concept of squeeze casting dates back to the 1800s [6, 7], the first actual squeeze casting experiment was not conducted until 1931 [14]. Fig. 2 illustrates the process of the squeeze casting of a magnesium matrix composite [9]. During squeeze casting, the reinforcement (either powders or fibers/whiskers) is usually made into a preform and placed into a casting mold. The molten magnesium alloy is then poured into the mold and solidified under high pressure. Compared with stir casting, squeeze casting has the advantages of allowing for the incorporation of higher volume fractions (up to 40–50%) of reinforcement into the magnesium alloys [9], and the selective reinforcement of a portion of a mechanical component.

POWDER METALLURGY

A variety of magnesium matrix composites have been fabricated through powder metallurgy such as SiC/AZ91 [42–44], TiO2/AZ91 [10], ZrO2/AZ91 [11], SiC/QE22 [12], and B4C/AZ80 [13]. In the powder metallurgical process, magnesium and reinforcement powders are mixed, pressed, degased and sintered at a certain temperature under a controlled atmosphere or in a vacuum. The advantages of this processing method include the capability of incorporating a relatively high volume fraction of reinforcement and fabrication of composites with matrix alloy and reinforcement systems that are otherwise immiscible by liquid casting.

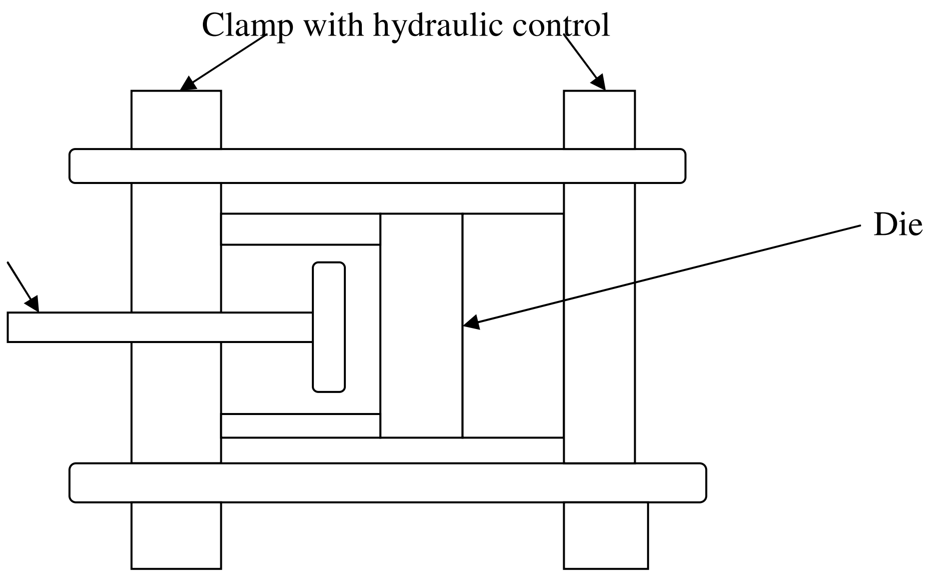
4.0. TABLE I Mechanical properties of various Mg based materials [15–16]

Materials	0.2%YS (MPa)	UTS (MPa)	Ductility (%)	Specific YS	Specific UTS
Mg	100	258	7.7	58	148
Mg/2%Cu	281	335	2.5	148	177
Mg/4%Cu	355	386	1.5	170	184
Mg/7%Cu	-	433	1.0	–	195
Mg/2%Ni	337	370	4.8	177	194
Mg/3%Ni	420	463	1.4	203	224
Mg/6%Ni	-	313	0.7	–	131
Mg/2%Ti	163	248	11.1	90	137
Mg/4%Ti	154	239	9.5	81	126
AZ91	263	358	7.2	145	197
AZ91/4%Cu	299	382	6.2	142	181
Mg/30%SiCp	229	258	2	105	118
AZ91D/10%SiCp	135	152	0.8	69	77
AZ91D/15%SiCp	257	289	0.7	126	142

5.0 FABRICATION METHODOLOGY FOR MAGNESIUM ALLOY COMPONENTS

Magnesium alloy can be cast into various types of methods including high pressure die casting, low pressure permanent mould, sand casting and squeeze methods. In this pressure die casting the alloys are injected through the nozzle to the extreme pressure to fill the mould now it is compressed through hydraulic press to lift the mould rise the compressive load with a short time (5-100ms).after the execution of high pressure bar up to (200 bars).then the cooling is done to high solidification rate of (75-1500K/S).for the high performance of the Mg-casting parts ,solidification of parts without blow holes and proper handling of liquid alloy to secure satisfactory metal quality.

Schematic Diagram for Cold Chamber Pressure Die Casting



6.0. CONCLUSION

The development of Magnesium MMC's survived. The current literature of Magnesium MMC's their performance were studied. The processing of MMC's divided into four major process, Conventional processing, Stir casting, Squeeze casting, and Powder metallurgy. Manufacturing and machining was studied. In this studied learn about the various manufacturing and machining processes. The future work is the combination of any one of the Aluminum, Titanium and hybrid MMC's and using suitable manufacturing processes and machining process.

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