Review of Recent Trends In Manufacturing Processes and Property Analysis of Magnesium Matrix Composites


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ABSTRACT
Wide variety of novel materials has been developed for the last few decades, which are rapidly replacing by Magnesium because of its strength to weight ratio. In this paper, recent trends in manufacturing processes and property analysis of magnesium matrix composite technologies are reviewed. The conventional and new processing techniques for the fabrication of magnesium matrix composites are summarized. The mechanical properties are subsequently discussed.

KEYWORDS: Magnesium alloy, Processing techniques, Mechanical Properties.

INTRODUCTION
Composite materials (or composites) are engineering materials made from two or more constituent materials with significantly different and improved physical or mechanical properties than the constituents. These constituent materials remain distinct on a macroscopic level within the composite structure. There are two parts in a composite: matrix and reinforcement. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcement’s of composites material report their special mechanical and physical properties to enhance the matrix properties. The wide varieties of matrix and reinforcement materials allow the designer of the product or structure to select an optimum combination. The matrix material is to be introduced to the reinforcement base before or after the reinforcing material is placed into the mold cavity or onto the mold surface. The matrix material experiences a bonding event, after which the part shape is effectively set. A Metal Matrix Composite (MMC) is a type of composite material with at least two constituent, one being a metal. The other constituent may be a ceramic or organic compound in the form of fibers, whiskers or particulates. Generally, the reinforcement material is characterized by low densities, high strength, stiffness and hardness whereas the matrix material generally has high ductility and toughness.

Also, the extent to which a certain property is present in an MMC can be controlled by selecting the suitable amounts of matrix materials and reinforcement materials. Hence, the Metal Matrix Composites are providing a suitable flexibility in terms of properties required. When at more than three materials are present, it is called as hybrid composite material. Metal matrix composites are made by dispersing a reinforcing materials or particles into a metal matrix [24].
Magnesium Matrix Composites are the type of MMC in which one of the constituents is magnesium or its alloy that is reinforced with ceramics fiber, whiskers, etc. Magnesium alloys have been increasingly used in the automotive and aerospace industries in recent years due to their lightweight. Magnesium is the lightest structural metal with a potential to replace aluminum as its density is about 35% lower than aluminum. The density of magnesium is approximately one fifth of steel, two-thirds of that of aluminum and one-quarter of zinc. As a result, magnesium alloys and composites offer a very high specific strength among conventional engineering materials and alloys. In its pure form of magnesium is not adequately strong to be used in many other engineering and other applications. To improve its strength-to-weight ratio, magnesium is alloyed with various metals or materials. Advantages of magnesium alloy or composites are such as good machining ability, high strength-to-density ratio and weldability of magnesium alloys and make them excellent candidates for engineering applications where the weight is of primary importance. However, compared to other structural metals, magnesium alloys have a reasonably low absolute strength, especially at elevated temperatures. At present, the most widely used magnesium alloys are based on the Mg-Al system and their applications are generally limited up to temperatures of 120°C. Further improvement in the high-temperature mechanical properties of magnesium alloys will greatly develop their structural applications. The magnesium matrix composite unidirectionally reinforced with continuous carbon fiber can readily show a bending strength of 1000 Mpa with a density as low as 1.8 g/cm³. The superior mechanical property can be retained at elevated temperatures of up to 350–400°C. Moreover, composite materials are more flexible in constituent selection so that the mechanical properties of the materials can be tailored [19]. The major disadvantage of metal matrix composites usually lies in the comparatively high cost of fabrication and of the reinforcement materials. The availability of a widest variety of reinforcing materials and the development of new processing techniques are attracting interest in metal matrix composite materials. This is particularly true for the high-performance magnesium based matrix materials, not only it’s characteristics of composites material, but also the formation of a composite may also be the only effective approach to strengthening some magnesium alloys. The potential applications of magnesium matrix composites in the automotive industries such as piston ring grooves, disk rotors, gears, connecting rods, gearbox bearings, and shift forks, etc., Magnesium alloys are divided into two groups: cast magnesium alloys and wrought magnesium alloys. Among cast magnesium alloys, AZ63, AZ81, AZ91, AM50, K51, ZK61, ZE41, ZC63, Elektron 21 are classified, particularly AZ91 alloy systems were selected to be used in various structural components because of high specific strength and good castability. Wrought magnesium alloys are classified into AZ31, AZ61, AZ80, ZK60, ZC71, Elektron 675, having the advantage of better mechanical properties, can be used in some application areas such as window frames and seat frames. AZ31 is the most widely used wrought magnesium alloy because of its good combination of strength, ductility, and corrosion resistance.

**II. Processing techniques of magnesium metal matrix composites:**

The processing of composites is very challenged to homogeneously distribute the reinforcement into matrix phases to achieve a defect-free microstructure such as blow holes, voids, and porosity. The composites reinforcing phase can be classified either particles or fibers based on the shape, the reinforcing phases in the composite materials. The particulate-reinforced composite is more preferable to the fiber-reinforced composite for automotive applications because of its relatively low cost and suitability for automatic processing techniques.

**A. Conventional processing techniques:**

The manufacturing processing of a magnesium matrix composite is almost similar to that of an aluminum matrix composite because of its similar melting temperatures of magnesium and aluminum alloys [19]. For example, Magnesium Matrix Composites are fabricated by different techniques like stir casting, squeeze casting and powder metallurgy, etc.,

**B. Stir Casting Process**

The stir casting process is most preferred manufacturing techniques because of it's a low cost, easy flexibility and also near-net shape formation of the metal matrix composites. In the stir casting process, the reinforcing phases (usually in particulate form) are uniformly distributed into molten magnesium alloy by means of mechanical stirring. The process is usually carried out in an inert gas atmosphere so as to prevent the reinforcement particles from mixing with the melt. A typical stir casting process of magnesium matrix composite is illustrated in Fig. 1. Mechanical stirring in the furnace is a key element of this process. The final product of molten alloy with ceramic particles, can be used for permanent mold casting or die casting or sand casting. Stir casting is most suitable for manufacturing of composites material with up to 30% volume fractions of reinforcement. The cast composites are sometimes further extruded to refine the microstructure, to reduce porosity and to homogenize the distribution of the reinforcement. Magnesium composites with various matrix
compositions, such as AZ31, AZ63, CP-Mg (chemically pure magnesium), ZC63, ZC71, and AZ91, have been produced using this method.

In the composite material, a homogeneous distribution of secondary particles is critical for achieving a high strengthening effect because of its uneven distribution can lead to premature failures in both reinforcement-free and reinforcement-rich areas. The reinforcement-free areas are tending to be weaker than the other areas. These areas are early failures take place due to the following conditions such as under an applied stress, slip of dislocations and initiation of microcracks. In the reinforcement-free areas of significant segregation or agglomeration of normally highly brittle hard particles due to weak bonds are formed in the material which can lead to the reduced mechanical properties.

![Fig. 1: Stir Casting Process](image)

An interesting recent development in stir casting is a two-step mixing process [25]. In this process, the matrix material is heated to the above its liquidus temperature of the metal so that the metal is totally melted. The molten metal is then cooled down to a temperature in between the liquidus and solidus points temperature and it was kept in a semi-solid state. At this stage, the preheated reinforcement particles are slowly added and mixed. The slurry is again heated into a liquid state and it was mixed thoroughly in a matrix metal. This two-step mixing process has been effectively used in the fabrication of aluminum A6061 and 356 matrix composites reinforced with SiC particles. The resulting microstructure has been found to be more uniform distribution in the matrix material than that of the conventional stirring process.

The usefulness of this two-step processing method is mainly attributed to its ability to break the gas layer around the reinforcement particle surface. The reinforcement particles are a generally thin layer of gas absorbed on their surface, which impedes wetting between the reinforcement particles and molten metals. The mixing of the particles in the semi-solid state can more effectively break the gas layer because of its high melt viscosity produces a more abrasive action on the reinforcement particle surface compared with conventional stirring. Hence, the breaking of the gas layer has improved the effectiveness of the subsequent mixing in a completely liquid state.

Another concern with the stir casting manufacturing process is the entrapment of gasses and unwanted inclusions formation. Magnesium alloy is more sensitive to oxidation. Once gasses and inclusions are entrapped during this process, the increased viscosity of the vigorously stirred melt prevents easy removal of these detrimental. In order to prevent the entrapment of gasses and inclusions, the stirring process needs to be more judiciously controlled for a magnesium alloy than for an aluminum alloy.

Among these principle, stir casting process allows the use of conventional processing methods for the addition of appropriate stirring method systems such as mechanical or electromagnetic or ultrasonic or centrifugal force stirring is needed [3]. The major advantage of stir casting process is applicability to large quantity production. Among all the well-established metal matrix composite fabrication techniques methods, stir casting is the most economical. When compared to other methods, stir casting costs is very less as one-third to one tenth of mass production [4, 5]. For that reason, stir casting process is presently the most popular
commercial method of producing aluminum-based composites. However, no commercial use of stir casting process has been reported on magnesium matrix composites.

**C. Squeeze Casting Process:**

The manufacturing process of the squeeze casting of a magnesium matrix composite is illustrated in Fig 2. During squeeze casting, the reinforcement (either powders or fibers/whiskers) is generally made into a preform and placed into a casting mold. Then molten magnesium alloy is poured into the mold and solidified under high pressure. The advantages of Squeeze casting is allowing for the incorporation of higher volume fractions (up to 40–50%) of reinforcement into the magnesium alloys when compared to stir casting process [26], and the selective reinforcement of a portion of a mechanical component.

![C. Squeeze Casting Process](image)

**Fig. 2:** The process of squeeze casting

In the magnesium matrix composites, however, the pressure for squeeze casting is to be properly controlled by means of excessively high pressure may create a turbulent flow of molten magnesium, causing magnesium oxidation and gas entrapment [6].

The excessively high pressure can also damage the reinforcement in a composite material and reduce the mechanical properties of the developed composites [7]. The two-step squeeze casting process, consisting of infiltration at low pressure and solidification at high pressure of the matrix alloy. This process has been successfully performed to fabricate a SiC/<ZK51A magnesium matrix composite [6]. The shortcomings of the squeeze casting process lie mainly in the constraints on the processing imposed by the casting shape, dimensions and its low suitability for large quantity automatic production.

**D. Powder Metallurgy Process:**

In the powder metallurgical process, magnesium and reinforcement powders are properly mixed, pressed under some pressure, degassed and sintered at a particular temperature under a controlled atmosphere gas or in a vacuum. The merits of these processing techniques consist of the capability of incorporating a moderately high volume fraction of reinforcement material and fabrication of composites with matrix alloy and reinforcement particle that are immiscible by liquid casting. However, powder metallurgy method requires alloy powders that are generally more expensive than the bulk material and involves complicated processes during the material fabrication process. Thus, powder metallurgy may not be an ideal manufacturing processing technique for mass production. Powder metallurgy fabrication methods are described above or well established and embody the mainstream of the manufacturing routes for the magnesium matrix composites. A comparison evaluation of these three traditional MMCs processing techniques is provided in Table [4].

**III. Other Processing Techniques:**

**A. Pressure less infiltration Techniques:**

Magnesium Matrix Composites is fabricated through one of manufacturing techniques such as spontaneous or pressure less infiltration is comparatively new as compared with pressure infiltration (squeeze casting) techniques. During the infiltration techniques, Due to the capillary action, the molten alloys flow is through the channels of the reinforcement bed or performs. For the spontaneous infiltration is to occur certain criteria have to be met the SiC/Mg composite has been attained using this method [8]. The experimental set-up of the spontaneous infiltration is shown schematically in Fig. 3.
SiC particles and infiltration agent SiO$_2$ powders were mixed and placed in an alumina crucible, then placed in a steel crucible. Another alumina crucible, which contained pure magnesium, was set beside the infiltration alumina crucible to monitor the temperature during the infiltration process. When the system was heated, the pure magnesium ingot was set on top of the powder mixture. The magnesium alloy was melted and spontaneously infiltrated the powder mixture. On viewing, the microstructure of the infiltrated SiC/Mg composite showed a high volume fraction of SiC particles and it was distributed very evenly. The mechanism for spontaneous infiltration is considered to be the high temperature generated at the infiltration front resulting from the reactions between magnesium and SiO$_2$ [8]. The infiltration behavior depends mainly on the SiO$_2$ content and the powder size. Without the SiO$_2$ there was no infiltration, and the minimum SiO$_2$ content needed to start the infiltration process increased with a decrease in the SiC powder size. The proposed pressureless mechanism implies the existence of other infiltration agents and it can be reacted with Mg to generate a high temperature. This was confirmed by the fact that TiO$_2$ can also be used as an infiltration agent [9].

During infiltration, SiC particles may react with the Al to give Al$_4$C$_3$. The extent of this reaction increases with increasing infiltration time and Mg content. The Si released by this reaction can then react with Mg to form Mg$_2$Si. The composites produced by pressureless infiltration are non-uniform with Al decreasing and the reinforcing phase increasing towards the base of the composites. It is suggested that the microstructural heterogeneities arise in part from differences in density between the molten Al and the reinforcing phase.[10]

**B. In-situ synthesis Process:**

Unlike other fabrication methods of the composite material, in-situ synthesis is a process wherein the reinforcements are formed in the matrix by means of controlled metallurgical reactions. During this fabrication process, one of the reacting elements is generally a constituent of the molten matrix alloy. The other reacting elements may be either gaseous phases or externally-added fine powders. One of the final reacting products is the reinforcement homogeneously distributed in the matrix alloy. This kind of internally-produced reinforcement has many desirable attributes. For example, it is more lucid with the matrix and has both a finer particle size and a more homogeneous distribution of particle. However, in-situ synthesis process requires that the reaction system is very carefully screened. The favorable thermodynamics of the anticipated reaction is the pre-requisite for the process to be applicable. Reasonably fast reaction kinetics are also required to make the fabrication process practical.

**Fig. 3:** The setup of Mg Pressureless infiltration

**Table 1:** Comparison table:

<table>
<thead>
<tr>
<th>Method</th>
<th>Working range</th>
<th>Metal yield</th>
<th>Reinforcement fraction (vol%)</th>
<th>Damage to reinforcement</th>
<th>Fabrication cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stir casting</td>
<td>Wide range of shape, larger size (up to 500 kg)</td>
<td>Very high, &gt;90%</td>
<td>~30</td>
<td>No damage</td>
<td>Least expensive</td>
</tr>
<tr>
<td>Squeeze casting</td>
<td>Limited by preform shape, (up to 2 cm height)</td>
<td>Low</td>
<td>~45</td>
<td>Severe damage</td>
<td>Moderately expensive</td>
</tr>
<tr>
<td>Powder metallurgy</td>
<td>Wide range, restricted size</td>
<td>High</td>
<td>-</td>
<td>Fracture</td>
<td>Expensive</td>
</tr>
</tbody>
</table>

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Remelting and dilution technique can be used to in situ synthesize TiC particulates reinforced Mg-MMCs successfully. Damping capacity of Mg-MMCs was higher than that of AZ91 magnesium alloy, because of it’s the high dislocation density in Mg-MMCs caused by the nominal addition of TiC particulates. Damping capacity of Mg-MMCs is dependent on temperature intensively, and they increase significantly as the temperature ascending. Under various vibration frequencies, there is relevant temperature peak at damping–temperature curve around 130ºC and 240ºC. The former temperature peak is due to dislocation motion, and the later is due to interface sliding.

In recent years, the in-situ synthesis method was comprehensively studied for aluminum matrix composites. However, for magnesium matrix composites, a lot of research process is going in this technique still now.

C. Mechanical Alloying Process:

Mechanical alloying, which was developed in the late 1960’s is a process in which raw metal powders are mixed with high energy milling balls, with or without additives material and in an inert atmosphere. (Strictly speaking, the mechanical alloying is also a powder metallurgy process). During the mixing process, the powders go through frequently cold welding and fracturing till the final composition of the very fine powders corresponds to that of the initial charge [11]. Along with the refining of metal powders, some solid-state chemical reactions may also occur, driven by the high mixing energy method. Thus, materials of exclusive microstructures and properties can be produced during the mechanical alloying process. This technique has been extensively applied to generate oxide dispersion strengthened alloys (nanocomposites).

D. Spray Forming Process:

Spray forming (spray deposition) is a process in which an atomized stream of molten metal droplets is directed into a substrate to build up bulk metallic materials. For a metal matrix composite, reinforcing particles are injected into the stream of the atomized matrix materials. The droplet velocities typically average about 20–40 m/s, and inhomogeneous distributions of ceramic particles are often present in the spray formed metal matrix composite [12].

A number of studies [13,14] on the fabrication of magnesium matrix composites using the spray forming method have examined the relationships between the spray processing parameters, the microstructure, and the mechanical properties of the composites. The process parameters were found to exert a considerable influence on the microstructure and properties of the a-SiC particle (8–12 μm) reinforced QE22 alloy [13]. But, due to the high cooling rate, the sprayed composite usually shows microstructural features typical of rapid solidification processes such as fine grains, porosity, and absence of brittle phases at the SiC/matrix interface.

IV Mechanical properties of magnesium matrix composites:

Improving mechanical properties such as tensile strength, creep resistance, Young’s modulus and fatigue resistance is generally the major attraction of composite materials. Nevertheless, the improvement in strength and rigidity resulting from the addition of the reinforcing phases to the matrix is normally at the cost of other some properties. Thus, the total benefit of the improvements in certain mechanical properties of the composite materials has to be weighed against the reduction in other properties and the additional cost.

Magnetism alloys possess higher specific strength than aluminum alloys and steels. Table: II For equivalent crush-loading capability, Mg extrusions exhibit higher potential than Al extrusions for weight reduction [22].

A. Creep behavior:

A magnesium alloy has a relatively low creep resistance, especially at high temperatures. The high creep rate of magnesium alloys usually results from grain boundary slide and dislocation slip at both basal and non-basal planes of the magnesium [15]. The damage to the fibers caused during material sample preparation has been found to be significantly deleterious to the creep resistance of AZ91 magnesium matrix composites reinforced with alumina short fibers [17].

<table>
<thead>
<tr>
<th>Property</th>
<th>Magnesium</th>
<th>Aluminium</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density at 20°C (g/cm³)</td>
<td>1.74</td>
<td>2.70</td>
<td>7.36</td>
</tr>
<tr>
<td>Elastic modulus (Gpa)</td>
<td>45</td>
<td>69</td>
<td>207</td>
</tr>
<tr>
<td>Melting point °C</td>
<td>650</td>
<td>660</td>
<td>1536</td>
</tr>
<tr>
<td>Boiling point °C</td>
<td>1105</td>
<td>2520</td>
<td>2862</td>
</tr>
<tr>
<td>Poisson’s ratio</td>
<td>0.35</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>Specific strength (kN/m²)</td>
<td>35-260</td>
<td>7-200</td>
<td>30-50</td>
</tr>
<tr>
<td>Specific stiffness (MNm/kg)</td>
<td>21-29</td>
<td>25-38</td>
<td>28-30</td>
</tr>
</tbody>
</table>
The creep behavior of a creep resistant AE42 magnesium alloy reinforced with Saffil short fibers and SiC particulates in various combinations in the longitudinal direction, in the temperature range of 175–300ºC and stress levels ranging from 60 to 140 Mpa using impression creep test technique.

At 175ºC, normal creep behavior is observed at all the stresses employed. At 240ºC, normal creep behavior is observed up to 80 Mpa and reverse creep behavior is observed above that stress. At 300ºC, reverse creep behavior is observed at all the stresses employed. This creep pattern remained the same for all the composites. The reverse creep behavior is observed due to extensive composite fiber breakage. The creep behavior resistance of the hybrid composites is found to be comparable to that of the all developed composite the fiber reinforced only with 20 vol.% Saffil fibers at all the temperatures and stresses tested level. So, the commercial point of view, the use of the hybrid composites, part of the expensive Saffil short fibers was replacing a SiC reinforced particulates, is beneficial[1].

B. Tensile Strength and Elastic Modulus:

With the addition of a reinforcement phase, both tensile strength and Young’s modulus of the magnesium alloys are, in general, increased. Within a certain range, both the yield strength and the elastic modulus of the magnesium matrix composite increase linearly with the increase in the volume fraction of the composite reinforcement [27]. Hybrid reinforcements, which involve more than one kind of particles or whiskers, have an even greater strengthening effect than a single reinforcement [18]. The reinforcement phases key strengthening mechanisms in magnesium composites are Particle strengthening, load transfer, work hardening and grain refinement of the matrix alloy. The dispersion of hard and fine particles in the matrix significantly blocks the motion of dislocations and thus strengthens the matrix material. Work hardening takes place due to the composite material is strained. The strain mismatch between the reinforcement and the matrix generally produces a higher density of dislocation in the matrix around the reinforcement, thus strengthening the material. Load transfer is a very important strengthening mechanism, especially for the fiber-reinforced composites. If the bonding between the matrix and the reinforcement is strong enough, the applied stress can be transferred from the soft matrix to the hard fiber/particle phases. Due to the much higher strength of the secondary hard phases, the relatively soft matrix is protected.

In particular, when the matrix and reinforcement interface is a relatively weak region of the material, the composite may fail prematurely at the interfaces. In this case, the addition of any secondary hard phase actually can reduce the material’s strength. Research focusing on an AZ91 magnesium alloy reinforced with 15 vol% SiC, TiB2, TiC, TiN, AlN, and Al2O3 has detected such an occurrence with AlN reinforcement, as shown in Fig.4, where a comparison is made between the ultimate tensile strengths and hardness of these composites [28]. This research also shows that the decrease in the tensile strength of AZ91, which has been attributed to excessive chemical reactions, different powder size distribution and wetting conditions, was caused by the addition of AlN.

C. Ductility:

The hard secondary phases in magnesium matrix composites have a two-fold effect. First, when these phases are present in magnesium matrix composites they can reduce their ductility by preventing plastic deformation. On the other hand, the particles can produce a grain refining effect that improves ductility. The net effect of the hard particles is, in general, to reduce ductility. This happens in both particle-reinforced [29] and fiber-reinforced composites. In contrast with the ceramic reinforced magnesium matrix composites, the elemental metallic powder-reinforced magnesium matrix composites show a much better ductility because of the reduced possibility of the breaking of the particles and interface.

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![Fig. 4: Strength and hardness of AZ91 reinforced with different Particles](image-url)
The reduced ductility in composites with a hard secondary phase is also evident in the interactions between the reinforcement and the dislocations. It is obvious that the resistance to the dislocation motion of the hard particles reduces the ductility of the composite materials. A research study examining the superplastic behavior of a fine-grained (≈2 μm) WE43 magnesium alloy containing spherical precipitates (≈200 nm) within grains revealed a superplasticity with an elongation to failure of over 1000 percent at 400°C. Dislocations were observed to interact with the particles within the grains. Data analysis based on the constitutive equation for superplastic flow demonstrated that the normalized strain rate for a particle-strengthened WE43 alloy was about 50 times lower than that of the same WE43 magnesium alloy without the hard precipitates. It would seem that the existence of intergranular particles diminishes the superplastic flow [20]. However, when compared to the breaking of large brittle particles and weak interface, the influence of very fine precipitates on the ductility may be less of a factor in a magnesium matrix composite.

V. Nanocomposites:

Nanocomposites are composites, which are produced when the reinforcing phase of the composite consists of nano-sized particles. Hence Magnesium nanocomposites are composites in which the matrix is formed of Mg and the reinforcing material is nano-sized particles. Carbon nanotubes are the nano-sized reinforcement material generally used, which tend to improve the electrical and thermal conductivity of the composites. Magnesium nanocomposites have the greater strength (both yield strength and ultimate tensile strength) and stiffness as compared to Mg-MMC. Also, the optical properties, thermal stability, chemical resistance, hardness, elastic modulus, and appearance are enhanced to a great deal with the addition of nano-sized reinforcement particles. When the processing of a Mg-MMC takes place the nanoparticles are added, the mass fraction of these being at the most 5 percent since they have a high surface area to volume ratio. The field of nanocomposites is still in its nascent stage and the applications to which Mg nanocomposites can be put are being gradually discovered [24].

Since the mechanical properties are improved due to the addition of nanoparticles, Magnesium nanocomposites can be used in those aerospace and automotive components where strength and stiffness hold importance like aircraft wings, brake rotor of a car etc. Hence Mg-nanocomposites have good future prospects in the automotive and aerospace industries, which will result in enhanced performance. A unique application of Mg-nanocomposites is in the storage of hydrogen gas. The H2 absorption capacities of the nanocomposite material exhibit 5.0-6.5 wt.% at high Hydrogen pressure (9MPa) and 296K temperature [6].

Conclusions:

A little bit amounts of time and continuous effort has devoted to the research and development of magnesium matrix composites in recent years. Various techniques have been developed and applied to the processing of magnesium matrix composites will make it possible for the automotive and aerospace industries to manufacture lighter, more environmentally friendly, safer and cheaper. The acceptance of the magnesium matrix composites as engineering materials depends not only on the performance advantages of the materials but also on the development of cost-effective processing technologies for these materials.

REFERENCES