CHAPTER-1

INTRODUCTION

INTRODUCTION

This chapter has three sections. The first section provides a brief background and need of lightweight materials for automobile and other essential applications. In the second section, the scopes of the current research work are stated, and the objectives of the work are mentioned in the last section of this chapter.

1.1. Background

The demand for low weight material is increasing day by day because of the rapid depletion of fossil fuels. On account of safety measure, the weight of a vehicle increases tremendously in the 21st century. To decrease fuel consumption in the automobile and aerospace industries, design engineer feels enormous pressure to search and develop new lightweight materials. Magnesium alloy is one of the lightest structural material, which may be used to replace steel and aluminum alloys, it can also be a substitute of some plastic plastic-based materials due to its property of good thermal conductivity. The use of magnesium alloy can reduce CO_2 emission which is the current demand for environmental legislation. The magnesium is one of the lightest engineering materials having density 1.74. It is one third lighter than aluminum, three forth lighter than zinc and four fifth lighter than steels. Initially, magnesium was not the materials of choice for a design engineer due to its high cost until about two and a half-decade back.

Now, scientists, researchers, and engineers are showing interest in the magnesium-based materials primarily because of its gradually decreasing cost and less energy consumption and greenhouse gas emissions. Magnesium in pure form has limited application in the structural area due to its extremely high corrosion. Magnesium is generally used with aluminum as an alloying element to improve the machinability and corrosion resistant. The development of composite materials especially metal matrix composite (MMC) has also been one of the most important innovations in the manufacturing industry over the past four decades. Traditionally lightweight materials are magnesium, aluminum, and titanium due to their capability of reducing the weight of the component and their devices which was earlier made from the steel based material.

The magnesium-aluminum based alloy and composites are introduced with improvement in their mechanical and wear properties. Magnesium alloy and composite offers the combined benefit of high strength and lightweight as well as excellent corrosion resistant due to the presence of aluminum [1]. Aluminum alloy based MMC has already been mostly manufactured in research and development as well as in various industrial applications. The magnesium alloy based MMC also demonstrates similar mechanical properties with lighter in weight. However, limited research works have been done on magnesium alloy based composite due to its high processing cost. The melting and protection of melt of magnesium required high-grade technology. Initially, the cost of production of magnesium alloy and composites was very high that limit their applications in the structural area. The price of crude oil increases exponentially for the last two decade, and the number of the vehicle also increases day by day. To prevent rapid depletion of fossil fuel and to decrease the emission of greenhouse gases, weight reduction of the transport vehicle is the only solution for the above problem. Thus the demand for the price reduction leads to the design and fabrication of high-performance magnesium alloy based composites using cost-effective and innovative routes.

Magnesium alloy is an excellent contender for lightweight structural application because of its low mass density that renders a high specific stiffness and strength. Apart from density magnesium possesses good dimensional stability, high damping capacity high stiffness, excellent machinability, excellent casting properties, and excellent high temperature creep properties [2]–[5]. The first commercial production of magnesium was recorded in Germany in 1916 [6]. By the end of 1945 production of magnesium had increased to 237K tons worldwide [7]. In the year 2000, 366K tons of magnesium was consumed for different applications. The worldwide magnesium production in 2004 was recorded as 584 K metric tons according to the US geological survey of minerals yearbook [8], production of magnesium was reported by 478,000 tons in the first half of 2013, 26% higher than that in the first half of 2012 by China's [9]

There are several magnesium alloy systems such as Mg-Al, Mg-Al-Zn, Mg-Zn, Mg-Mn, Mg-Zr, Mg-RE, and Mg-Th systems. Among these systems, Mg-Al-Zn (AZ) system are widely used in the industrial application convenient in their fabrication and availability [10]. AZ91 is one of the most commonly used magnesium alloys in which aluminum mainly improve strength, hardness, and castability. Zinc is added to increase corrosion resistance and strength without reducing ductility. AZ91 is extensively used in applications such as in automobile, aerospace transportation industries and other portable equipment. The lightweight magnesium can be used in sports equipment to alleviate tiredness of sports person. Use of magnesium in electronics devices can enhance heat transfer more efficiently than plastics-based polymer or composites.

1.2. Scope of the work

The ultra-lightweight of magnesium alloy and significant improvement of mechanical properties on the addition of reinforcement in magnesium alloy motivated have current work. The application of magnesium alloy in the automobile and aerospace industry can save fuel and decrease the emission of greenhouse gases to protect the environment. The weight of the vehicle produces the highest impact on CO_2 emission/fuel saving and low weight can improve running efficiency of it as shown in Figure 1.1 [11].

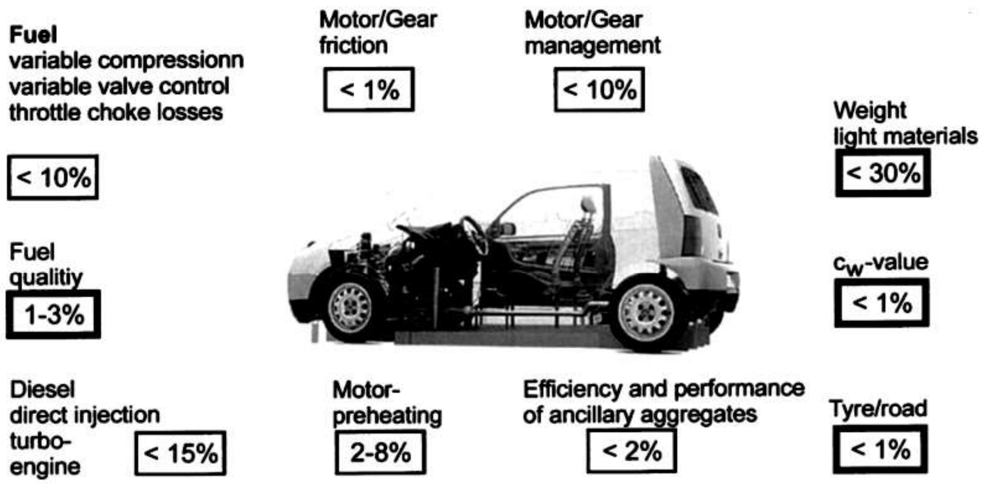

Figure 1. 1: Different technical measures on the CO_2 emission [11]

The casting is one of the most economical processes of producing magnesium alloy and composites. The processing of magnesium alloys and its composites has a broad scope because of the very high affinity of magnesium toward atmospheric oxygen. The experimental set-up required for casting magnesium alloy may be controlled or uncontrolled atmosphere using proper flux. The particulates reinforced metal matrix composite exhibit many excellent properties over another type of reinforcements, due to lower production cost and nearly isotropic properties. Many features of particulates reinforced composite have been improved beyond the limit of alloying [12], [13]. The ceramic oxide and carbide are better reinforcement for magnesium alloys because they can enhance mechanical as well as wear properties of the composites. The variation of the amount of the reinforcement by weight or by volume is highly dependent on its size. Therefore, heat and trial methods may be used to decide the optimum quantities of the reinforcement. In general nano-size particles are reinforced between the ranges of 0-3%, while the micron size reinforcement may be added up 30%. The scope of the current investigation encompasses the casting and characterizations of new magnesium alloy (AZ91) based metal matrix composites and evaluation of mechanical and wear properties.

1.3. Objectives of the work

This study aimed to develop the concept of processing of magnesium alloy, and its composite by developing the stir casting facilities. The various other objectives are summarised as given below:

1. To study the different methods of incorporating reinforcement in molten magnesium alloys.
2. Fabrication of magnesium alloy (AZ91) based metal matrix composites (MMCs) by reinforcing with a small variation (3, 6, 9, and 12 %) of SiC particulates having an average size of 40 microns.
3. Fabrication of magnesium alloy (AZ91) based metal matrix composites (MMCs) by reinforcing with a small variation (3, 6, 9, and 12%) of TiC particulates having an average size of 20 microns.
4. Evaluation of tensile, compressive, microhardness and wear behaviors of the above-fabricated composites.