Study on the Mechanical Properties of Magnesium with glass particles

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Abstract - *Composite materials is the one which is made up of two or more materials, when blended together it shares its properties. These materials have become into existence for various application as many properties an individual material cannot possess . While producing a metal matrix composite production cost is an important factor. So, while developing a new material with low cost has great importance in this competitive world. In this study, metal–matrix composite is fabricated from magnesium powder and glass particles .Glass is the Reinforcement, is added in different percentages of 2%, 4% and 6% with magnesium. The method of production of the compact is obtained by powder metallurgy technique. The composite material is formed by various stages of compaction and sintering. The various test like corrosion test, compression test were examined to analyze the properties of the MMC. The addition of the glass particles in base magnesium indicates an improved behavior in the properties of MMC which are obtained from test results.*

Key Words: Magnesium powder, Glass particles, Powder metallurgy technique, Compaction, Sintering, MMC.

1.INTRODUCTION

In 1500 B.C was the first use of composites. Early Egyptians and Mesopotamians used a mixture of mud and straw to build strong buildings. Straw continued to provide reinforcement to ancient composite products including pottery and boats. In 1200 AD, the Mongols founded the first composite bow by using a combination of wood, bone, and animal glue. Bows were pressed and wrapped along with birch bark. These bows were very powerful. Composite Mongolian bows helped to ensure Genghis Khan's military dominance. During 1970s the composite industries began to develop. Better plastic resins and improved reinforcing fibers were produced. DuPont invented an aramid fiber, which has become the product of choice in body armor because of its very high tensile strength, density, and lightweight. Carbon fiber was also developed around 1970s, increasingly, it replaced parts formerly made of steel. Now a days designers are looking for the MMCs to provide the extra strength, stiffness, and higher temperature capabilities required for their advanced applications [1,2]. Since last 20years metal matrix composite has become a significant topic for the research and its commercial application [3]. The composite materials are replacing the traditional materials, because of its superior properties such as high strength, low thermal expansion, high strength to weight ratio. Metal matrix composites are used in the fields of automotive, aeronautical, marine and several applications due to their attractive properties compared to monolithic materials[4]. Now nano composites are gaining popularity in the material industry replacing the monolithic metals. The comparison of micro structural and mechanical attributes of nano composites and micro composites is a hot area of research. There has been an increase in wide use of MMCs in aircraft and automotive industry for structural applications due to the cost effective processing route[5]. While producing a metal matrix composite cost is the key factor in their wider application in various fields. It mainly depends on two factors that are the type of reinforcement using and the technique which is being used to produce the MMC. Only simpler fabrication methods, higher production volumes, and use of cheaper reinforcements can reduce the cost of MMCs[6]. Applications of magnesium in various fields have been increased due to its light weight material and good corrosion resistance properties. It is found that most of the Magnesium metal matrix composite uses reinforcements such as Silicon Carbide, Titanium Carbide, Aluminium oxide which are costlier and have a higher density[7]. In general, Hybrid MMCs are made by dispersing two or more reinforcing materials into a metal matrix[2].The powder metallurgy method improves the homogeneous dispersion of the powder particulates and it will provide a good surface finish. In this work, magnesium is chosen as primary material because Magnesium is best suit for lightweight applications as it is 35% lighter strength levels[9]. Glass is the reinforcement as it has good mechanical properties which will contribute a great factor for MMC.

2. MATERIALS

2.1 Magnesium

The eighth most present element in the earth's crust, is also a light, moderately hard, silver-white metal. While ingots of metal tarnish in the air and react slowly with water, finely divided powder is reactive. Magnesium does not occur un combined, also but is found commonly in the magnesite, dolomite, and several other minerals. It is the lightest of all the structural metals, making it essential as an alloy in aircraft and missile building. It has a purity of 99.2%. It has very good ductility, malleability and melting point is 96 K.

2.2Glass

The glass contains Silicon dioxide- 20.6%, Boron trioxide- 13%, Sodium oxide-4.%, Aluminium oxide- 2.3%. Glass is a low-cost material which is easily available and will also reduce the cost of MMCs, which makes this study a significant one. Glass has good chemical and corrosion resistance is mainly used for making modern laboratory glassware.

3 COMPOSITE PREPERATION

3.1 Mixing of raw materials

The raw materials magnesium and glass particles in various proportions are well mixed/ blended inside a self seal bag. During mixing it is made sure that, there is no air present inside the bag. The bag is continuously shuddered by hand continuously and rested for 10 hours before the compaction. There are three different formulations. Formulation-1 consist of 2% glass particles and 98% magnesium. Formulation-2 consist of 4% glass particles and 96% magnesium. Formulation-3 consist of 6% glass particles and 94% magnesium.

3.2 Compaction process

Powder compaction is the method used in compacting metal powder in a die by applying high pressure. In general the tools are held in the vertical position with the punch tool comprising bottom of the cavity. The powder is compacted into a cylindrical shape and ejected from the die cavity. A pressure of 6500 Kg is applied through punches from both ends of the toolset in order to reduce the level of density gradient within the compact and it is held for 2 minutes. The powder is then compacted into a cylindrical shape and then ejected from the die cavity. The whole setup of the compaction machine is shown in the figure 1.

Figure 1: Manual compaction machine

3.3 Sintering

It is the method of compacting and forming solid mass of material either by high temperature or pressure without melting it to the level of liquefaction.The compacts are placed inside the furnace. The temperature of the furnace is made to increase gradually and reach 673 K. After reaching 673 K the furnace is switched off, the hydrogen gas is made to flow inside the furnace through a tube. The hot compacts are left inside the furnace for more hours to cool. Then the furnace is opened and the compacts are removed from the furnace. After the sintering process the compacts are subjected to finishing process. The setup of sintering is given in figure 2.

Figure 2: Sintering machine

4 COMPOSITE TESTING

4.1 Corrosion test

This test is used to measure the corrosion value and evaluate composite performance in salt/fog environment. The samples are subjected to salt spray chamber, fog test as shown in figure 3.

Figure 3: Salt spray chamber

The experimental apparatus contains following parameters - 92% humidity, 33 to 35 degrees centigrade temperature, 2 to 3 bar air pressure. The composition of the salt solution for 1 litre contains 5% NaCl, 1% Mg, De-ionized water 94%, pH of solution is maintained at 7.5 by addition of buffer solution and pH is measured once in 2 hours. The specimens are weighed initially and hung in the hangers with identification numbers. The specimens after 42 hours is taken out and are cleaned by immersing in hydrochloric acid and weighed finally. The results are tabulated in table 1.

4.2 Compression test

The compression test is used to find the behavior of the composite while experiencing a compressive load. The specimen is loaded in the machine as shown in figure 4 [10] and is being subjected to compressive load, the initial parameters and final parameters of the specimen were recorded. The load is applied, computer input series of recordings is noted down along with the time. The specimen is subjected to compressive load and the values are recorded from the beginning till the time when the composite starts to crack and results are obtained as in table 2. Result graph is plotted as shown in Graph-1, Graph-2, Graph-3.

Figure 4 : Compression testing machine

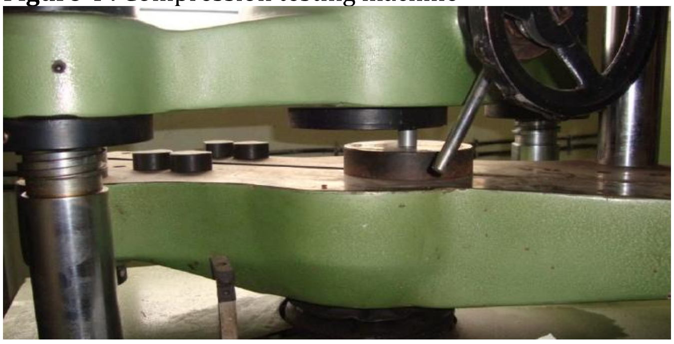


Figure 5: Compression of Specimen

5 RESULTS AND DISCUSSION

5.1 Corrosion Test

It can be seen from Table-1 the corrosion results of three formulations. The corrosion value is measured with respect to the %decrease in weight of composite. The Formulation-1 has a %decrease in weight of 9, Formulation-2 has a %decrease in weight of 5.2, and Formulation-3 has a %decrease in weight of 4. Since glass has resistance to corrosion, it improves the corrosion resistance of the MMC. It can also be seen the initial weights of the three formulations. Formulation-1 has a weight of 10.1g, Formulation-2 has a weight of 9.6g, Formulation-3 has a weight of 7.27g. The overall weight of composite varies with proportion of magnesium-glass concentration.

Table -1: Corrosion results of the three formulations.

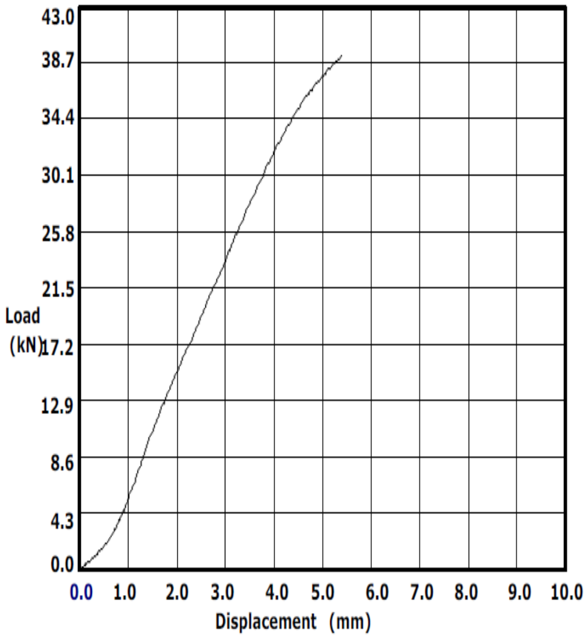
Formulation	Initial weight (g)	Final Weight (g)	Difference in weight (g)	% Decrease in weight (x 100)
1	10.1	9.2	0.9	0.09
2	9.6	9.1	0.5	0.052
3	7.27	6.92	0.35	0.04

5.2 Compression test

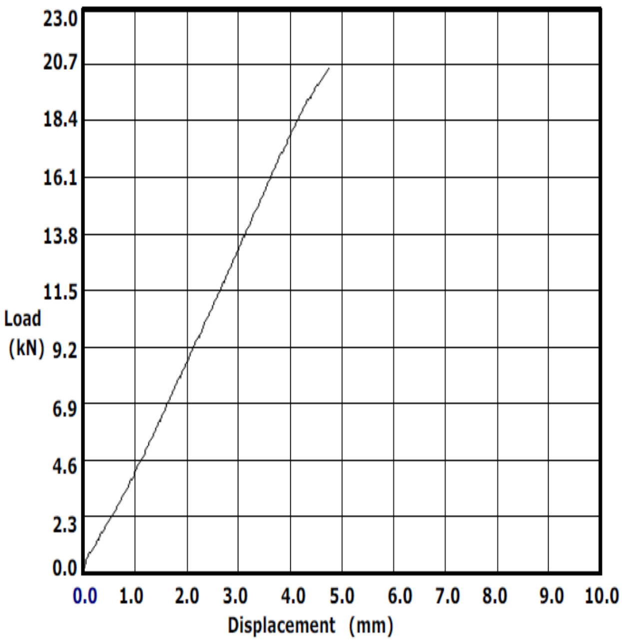
It can be seen from table 2 and from graph-1,2,3 (Load vs Displacement) about the compression results of three formulations. Formulation-1 has a %elongation of 21, Formulation-2 has a %elongation of 25 which is higher compared with Formulation-1, Formulation-3 has a %elongation of 14.5 which is lesser than Formulation-1 and Formulation-2. The Formulation-1 graph, Formulation-2 graph, and Formulation-3 graph, shows how the composite displaces with respect to the compressive load applied on it.

Table -2: Compression results of three formulations.

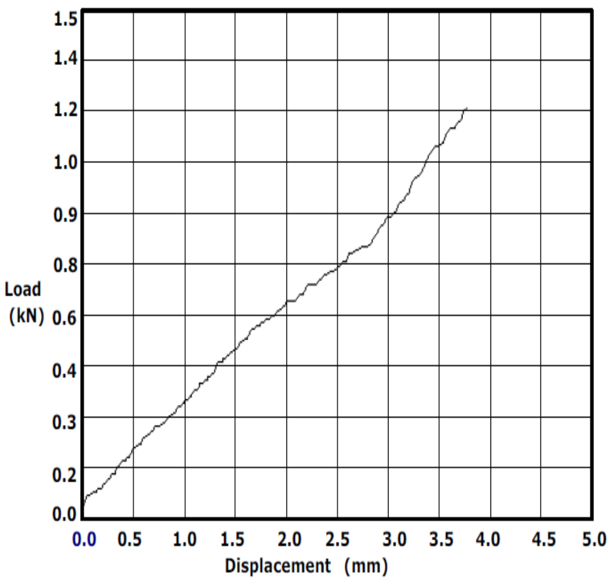
Formulation	Load (KN)	Maximum displacement (mm)	Elongation percentage
1	39.2	5.4	21
2	20.1	4.7	25
3	1.12	3.7	14.5



Graph -1: Formulation-1



Graph-2-Formulation-2



Graph - 3 Formulation - 3

6. CONCLUSION

In this paper, MMC is developed using magnesium and glass particle. The composite developed is of less weight and has good corrosion resistance. Fabrication process is simple and easy. This MMC can be used for marine application. The overall fabrication work was very easy and this can be further improved by adding another filler material which may further improve the mechanical properties of Magnesium. This composite material developing cost is very high and the overall process involved is minimum. Thus the processing side can also be improved in mere future by using any hybrid approach.

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