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Evaluation Of Mechanical Properties Of Magnesium [AZ91] Reinforced With Carbon Nanotubes And Sic/Al_2O_3

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Abstract— This paper deals with the study of mechanical properties of magnesium alloy (AZ91) reinforced with carbon nanotubes and SiC/Al2O3. Magnesium being a light-weight andcorrosion free metal, has got wide range of applications. The mechanical properties such as tensile strength and hardness increases with SiC/Al2O3. Metal matrix is formed stir casting process. Aluminum and silicon carbide are used as binding materials to bind the carbon nanotubes the metal matrix is formed by bottom type stir casting machine. Various tests are made by which it is seen that hardness and tensile strength of the metal matrix got increased.

Keywords—metal matrix composite, carbon nanotubes,SiC/Al2O3

I. INTRODUCTION

During the two decades, automotive engineers have increasingly focused on magnesium alloys due to their low density and their high specific strengths. In earlier part of the last century, magnesium alloys suffered from low corrosion resistance, usually due to iron, copper and nickel impurities, but nowadays alloys with good corrosion properties and coatings are available. Stir casting is the process used for 60% of magnesium alloys, and most of it is produced for room temperature applications. Aluminum-magnesium alloys are mainly used for electronic and machine tool applications. These alloys are easily able to be cast and machined. Magnesium is one of the lightest metal in the world and free from corrosion. It has got more scope and a variety of applications. We have taken a step to improve its hardness, tensile strength and ductility by reinforcing multi walled carbon nanotubes and SiC/ Al2O3. These Additives increase its mechanical properties. The process is carried out by means of bottom pour stir casting machine. AZ91 is magnesium alloy with a small percentage of aluminium and zinc. A study is made on AZ91 magnesium alloy to enhance its mechanical properties. AZ91 has good castability and mechanical properties compared to magnesium. The enhancement provides a way for various application of magnesium. The uniform spread of carbon nano tubes and SiC/ Al2O3 helps in enhancing the properties

II. LITERATURE SURVEY

Most of the magnesium produced globally comes from natural minerals such as dolomite and magnesite in the form of magnesium carbonate. It can be found in seawater which contains 0.13 percent of the element in the form of magnesium chloride, and in salt lakes brines or underground mineral salt deposits. Magnesium can be produced through several different methods including the electrolytic process or thermal reduction as practiced in the most commonly used pidgeon process. The electrolytic process involves the electrolysis of molten magnesium chloride between 6550C and 7200C which produces molten magnesium and chloride. The magnesium chloride comes either from salty brines after solar evaporation and chemical treatments or solid carnallite (KCl.MgCl2.6H2O) dehydrated[1]. The metal is cast intoingots for further processing as needed and the chloride by product may be sold for use in the production of polymers. In the thermal reduction method calcined magnesium containing ores (magnesite and dolomite) are broken down into fine powder and mixed with reducing agents and catalyst agent. The mixture is heated upto 12000C in a vacuum chamber producing magnesium vapors which later condense into crystals. The crystals are then melted, refined and poured into ingots for further processing. The Pidgeon process isone of the methods of magnesium metal production, via a silicothermic reduction. Practical production requires roughly 35–40 MWh/ton of metalproduced, which is on par with the molten salt electrolytic methods of production, though above the 7 MWh/ton theoretical minimum.

A. Materials

III. EXPERIMENTAL STUDY

already being used in polymers to control or enhance conductivity and are added to anti-static packaging.

A carbon nanotube is a tube-shaped material, made of

The materials used are:

1. Magnesiumalloy[AZ91]
2. Carbonnanotubes
3. SiC/Al2O3

1. Magnesium

Magnesium is the lightest of all the metal elements and is primarily used in structural alloys due to its light weight, strength, and resistance to corrosion. There are over 60 different minerals known to have a magnesium content of 20% or more, making it the eighth most abundant element in the earth's crust. But when water bodies are accounted for, magnesium becomes the most abundant element on the surface of the earth. That is because of the significant magnesium content in salt water, which averages about 1290 parts per million (ppm). Yet, despite its abundance, global magnesium production is only about 757,000 tonsper year.

Alloy AZ91 is the most widely used magnesium die cast alloy and has an excellent combination of mechanical Properties, corrosion resistance, and castability. The AZ91 has much better properties when compared to the monolithic magnesium[2]. Corrosion resistance is achieved by enforcing very strict limits on three metallic impurities—iron, copper and nickel. These are limited to very low levels making it necessary to use primary magnesium in the production ofthisalloy.

1. Carbonnanotubes

Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of materials science and technology.Though composite materials have good improvement in various properties when reinforced with CNT, there are still some difficulties faced inuniform dispersion of CNT in matrix phase. Reinforcement of CNT causes a change of scale of reinforcement and this poses challenges such as development of new processing techniques for these composites, in mechanics research ofthe composites. Some new techniques must be developed for cost-effective production of CNTs with higher efficiency and purity so that macroscopic amount of CNT reinforced composites can be developed[3]. There are many other composites yet to be tested which may yield good properties for practical applications. Formation of carbide on the surface of CNTs and its effects on the mechanical properties of composites needs to be assessed as the load transferability and strength of CNTs can be improved. Further studies are required in assessing the various health and environmental hazards imposed by the CNT reinforced composites.

The discovery of carbon nanotubes (CNT) in 1991 opened up a new era in materials science. These incredible structures have an array of fascinating electronic, magnetic and mechanical properties. CNT are at least 100 times stronger than steel, but only one-sixth as heavy, so nanotube fibers could strengthen almost any material. Nanotubes can conduct heat and electricity far better than copper. CNT are carbon, having a diameter measuring on the nanometer scale. A nanometer is one-billionth of a meter, or about 10,000 times smaller than a human hair. CNT are unique because thebonding between the atoms is very strong and the tubes can have extreme aspect ratios. A carbon nanotube can be as thin as a few nanometers yet be as long as hundreds of microns[4]. To put this into perspective, if your hair had the same aspect ratio, a single strand would be over 40 meters long. Also, Carbon Nanotubes reinforced metal matrix composites were reviewed and it was observed that the composites reinforced with CNT showed improved mechanical properties which can be utilised for various practical applications. Some challengesfaced in areas like uniform dispersion of CNTs in matrix phase, reduction of carbide formation etc., limits the utilization of these composites on macro scale. Compromising these challenges by some future studies in this field can make these composites as materials of the future for engineeringapplications Carbon nanotubes have many structures, differing in length, thickness, and number of layers. The characteristics of nanotubes can be different depending on how the graphene sheet has rolled up to form the tube causing it to act either metallic or as a semiconductor. Thegraphite layer that makes up the nanotube looks like rolled- up chicken wire with a continuous unbroken hexagonal mesh and carbon molecules at the apexes of the hexagons.

2. Aluminium

In this experiment aluminum and the silicon carbide is used as the binding material. Here aluminum is added in equal proportion of silicon carbide for binding effect.

Aluminium is a silvery-white metal, the 13th element in the periodic table. One surprising fact about aluminium is that it's the most widespread metal on Earth, making up more than 8% of the Earth's core mass. It's also the third most common chemical element on our planet after oxygen and silicon[5]. At the same time, because it easily binds with other elements, pure aluminium does not occur in nature. The most common form of aluminium found in nature is aluminiumsulphates. These are minerals that combine two sulphuric acids: one based on an alkaline metal (lithium, sodium, potassium rubidium or cesium) and one based on a metal from the third group of the periodic table, primarilyaluminium.

3. Siliconcarbide

Silicon carbide, exceedingly hard, synthetically produced crystalline compound of silicon and carbon. Its chemical formula is SiC. Since the late 19th century silicon carbide has been an important material for sandpapers, grinding wheels, and cutting tools. More recently, it has found application in refractory linings and heating elements for industrial furnaces, in wear-resistant parts for pumps and rocket engines, and in semiconducting substrates for light- emitting diodes. Silicon carbide is the only chemicalompound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractories, ceramics, and numerous high- performance applications. The material can also be made an electrical conductor and has applications in resistance heating, flame igniters and electronic components. Structural and wear applications are constantly developing.

IV. PREPARATION OFSPECIMENS

Usually magnesium alloy done by powder metallurgy since AZ91 having good castability we have done by using stir casting process.

A. Powdered metal process

The powdered metal process of shaping metals into desired shapes does share more than a few similarities with die casting process. In this metal part manufacturing process, manufacturers compress the premixed metal powder into a mold through a high-pressure press, which leads to the formation of a substance called compact. Manufacturers then use a sintering oven to heat the compact product to a temperature that is slightly lesser than the melting point of the metal. The compressed metal powder fuse with one another during the process and it gives rise to the finished metal part.

B. Advantage of stir casting over powdermetallurgy

Both powdered metal and die casting processes of shaping metals are alloy friendly and they are an accurate choice for large product runs. Both processes offer high consistency and precision to the manufacturing process. In addition to that, both these processes are simple and they canbe used for producing complex metal parts. However, the products of powdered metal process are usually a lot heavier and thicker when compared to the products manufactured with die casting. Another significant thing to note is that powdered metal molds are a lot costlier, whereas die casting process is cheap, yet reliable.

1. Stir casting specimen exhibited high hardness compared to powder metallurgy
2. The finer grain structure and uniform distribution ofparticle than powder metallurgy
3. The materials have reduced porosity and increase in theductility and hardness

C. Experimentel Procedure

The following two samples were taken:

TABLE I. WEIGHT PERCENTAGE OF SPECIMENS

Samples (In chronolog icalorder)	**sample 1**	**sample 2**
Magnesium(AZ91 alloy)	95%(956 gm)	90%(900 gm)
Carbon nano tube	1.5%(12 gm)	2%(16 gm)
silicon carbide	1.75%(15.75 gm)	2.5%(19.75 gm)
alumini	1.75%(15.75	2.55%(19.75

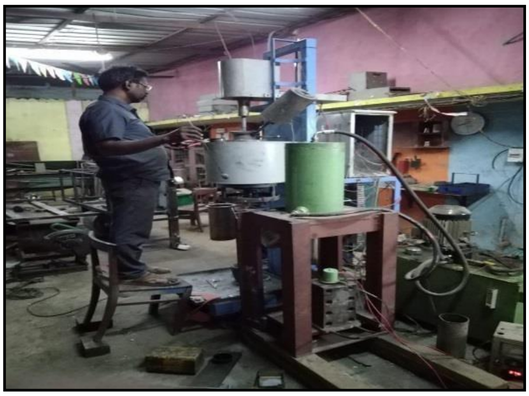
um powder	gm)	gm)

Initially the magnesium ingots were placed inside the crucible and was heated to 7300c. Once the ingots completely became molten, the above mentioned amount of carbon nanotubes, silicon carbide, aluminum were added in the same order. Stirring was continuously done after theaddition of eachconstituent.

The stirrer speed was maintained at 530 rpm.Before the molten was poured, the was preheated.Then the molten metal was poured into the die. Immediately a very high pressureof 12.258MPa was exerted on the molten metal in the die and squeeze casting was performed. The die was opened immediately and then the casting was taken out of it.

Fig. 2. Casting samples

V.
VI.
VII.



TESTIN
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A. Tensile test

Tensile test is also known as universal engineering test to achieve material properties such as ultimate strength, elongation. Yield Strength. These important properties obtained from this testing are useful for the selection of stable materials for anyapplications.

The test is carried out by applying axial load or longitudinal load at a specific extension rate to standard tensile specimen with known dimensions like gauge length, cross sectional area and thickness. The applied load and extension are recorded during the test for stress and strain calculation. A range of Universal standards such as American Society of Testing and Materials (ASTM), JIS Standards, DIN standard and British Standard. Each Standard may contain variety of test standards suitable for different materials. The universal standards we used for this experiment is ASTM. The materialspecimen is prepared as per the ASTM D638Standard.

B. Hardness test

Hardness is defined as the resistance of the metal to plasticdeformation usually by indentation.

Fig. 3 Brinell hardness tester

Fig. 4. Specimen after hardness test

*C.*Results

TABLE II. HARDNESS TEST

VIII. CONCLUSION

- The magnesium alloy AZ91 has got goodcastability.
- The cast formed by stir casting followed by squeeze casting are lessporous.
- The additives are evenly spread.
- It can be inferred from our project that the mechanical properties like tensile strength and hardnesscan be enhanced by the addition of SiC/Al2O3 and by reducing the weight percentage of the magnesiumalloy.
- The specimen with 85% magnesium and 10% SiC/Al2O3 has got more tensile strength when comparedto the other specimen with90% magnesium and 5% SiC/Al2O3.
- Thus the magnesium metal matrix compositecanbe used for variousapplications.

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S.NO	PARAMETER	SAMPLE 1	SAMPLE 2
1	Brinell Hardness	83,89,89	80,82,91
2	%Elongation	5	3
3	Tensile Strenth (Mpa)	171	125