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SYNTHESIS AND WEAR BEHAVIOR OF MAGNESIUM MATRIX HYBRID COMPOSITE

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ABSTRACT:
Magnesium hybrid composite are used for many applications like defence organizations, automobile industry and aerospace. The composite has low density, good mechanical properties, light weight and good physical properties. The density of magnesium is two third of that of aluminium. The magnesium alloy compared to other alloy has low mechanical strength. To improve the strength, wear resistance, reinforcement elements are added.
In this experimental study, magnesium based boron carbide (B4C) and graphite (Gr) particle reinforced hybrid composite materials were manufactured by powder metallurgy. The tribological property and hardness of these composite materials were investigated. The results of the tests revealed that the graphite reinforced hybrid composites exhibited a lower wear loss with comparable hardness compared to the unreinforced Mg alloy and Mg–B4C composites.

INTRODUCTION:
Most of the parts in the industries are replaced by light weight, low cost and abundant materials so that parts if need to be replaced then the parts can be replaced easily. Materials that are easily available and light weight are mostly composites. These composites are now replacing the steel, aluminium and other alloys because these have limited application when compared with composites.

Materials are being developed a lot in the recent times. The department that develops and tests materials are nano technology, metallurgy, metrology, material testing, and much more. The material development has always been the method of improving the equipment and also has promoted the life of human being to a next stage.
Material had already started its advancing when alloys of metals were developed. Material expansion was mainly focused on metals because all the parts and equipment were all made with the help of metals.

Materials were first identified in Stone Age. Stone-Age cultures were limited by which rocks they could find locally and by which they could acquire by trading. The use of flint axe around 300,000 BCE is sometimes considered the beginning of the use of ceramics. The use of polished stone axes marks a significant advance because a much wider variety of rocks could serve as tools.

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The innovation of smelting and casting metals in the Bronze Age started to change the way that cultures developed and interacted with each other. Starting around 5500 BCE, early smiths began to re-shape native metals of copper and gold - without the use of fire - for tools and weapons. The heating of copper and its shaping with hammers began around 5000 BCE. Melting and casting started around 4000 BCE. Metallurgy had its dawn with the reduction of copper from its ore around 3500 BCE. The first alloy, bronze came into use around 3000 BCE. Iron-working came into prominence from about 1200 BCE.

In the 10th century BCE glass production began in ancient Near East. In the 3rd century BCE people in ancient India developed wootz steel, the first crucible steel. In the 1st century BCE glassblowing techniques flourished in Phoenicia. In the 2nd century CE steel-making became widespread in Han Dynasty China. The 4th century CE saw the production of the Iron pillar of Delhi, the oldest surviving example of corrosion-resistant steel.

An alloy is a mixture of metals or a mixture of a metal and another element. Alloys are used in a wide variety of applications. In some cases, a combination of metals may reduce the overall cost of the material while preserving important properties. In other cases, the combination of metals imparts synergistic properties to the constituent metal elements such as corrosion resistance or mechanical strength. The primary metal is called the base, the matrix, or the solvent. The secondary constituents are often called solutes.

When two or more different materials are combined, the result is a composite. The first uses of composites date back to the 1500 B.C. When early Egyptians and Mesopotamian settlers used a mixture of mud and straw to create strong and durable buildings. Straw continued to provide reinforcement to ancient composite products including pottery and boats.

Later, in 1200 AD, the Mongols invented the first composite bow. Using a combination of wood, bone, and "animal glue," bows were pressed and wrapped with birch bark. These bows were powerful and accurate. Composite Mongolian bows helped to ensure Genghis Khan's military dominance.

The recent researches of the composite is taking a huge step forward by making material more reliable and are more special selected for each application accordingly. The material advancement now is industry is by reducing the size of material molecules so that all the properties can be more accurately measured. The specific properties of material differ as the application changes, the specific property are those property that are present in the material which are needed to be increased or decreased respectively.
So to increase or decrease the specific property different techniques are used. Not only increase of property but also many new materials are developed which are replacing all the alloys in the recent scenario.

EXPERIMENTAL PROCEDURE

1. POWDER MORPHOLOGY

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In this experimental work magnesium (Mg) powder with mean particle size of 60 mesh (99.8%purity) is used as the matrix material. Boron carbide(B_4C) with mean particle size of 220 mesh(98%purity) and graphite with mean particle size of 60 mesh (99%purity) which are used as reinforcements. The particle size and phase purity of magnesium (Mg), boron carbide (B_4C) and graphite powders are used in preparation of composites.

Table 1. Details of Reinforcement

S. No.	Magnesium (Wt. %)	Boron carbide (Wt. %)	Graphite (Wt. %)
	100	0	0
	95	5	0
	95	0	5
	90	5	5

2. MILLING

In this present investigation, Magnesium AZ91D was used as the matrix material. table 1 provides the details of the B_4C and graphite particulates, which were used as reinforcements. After weighing matrix and reinforcement powders as per the weight percentage, the mixing was done by a ball mill along with toluene which was used as process control agent. The details of the milling parameters was listed in the table 2.

Table 2. Details of milling parameters

Parameters	Units
Rotation speed	200 rpm
Milling time	120 minutes
Process control agent	Toluene
Ball to powder weight ratio	10:1
Inert gas used	Argon atmosphere

3. COMPACTION

In compaction, elevated pressure is applied to the powders to structure them into the required shape. The knowable compaction method is pressing, in which opposing punches compress the powders contained in a die. The work part after pressing is called a green compact, the word green meaning not yet fully processed. As a result of pressing, the density of the part, called the green density, is much better than the starting bulk density.

After blending the powders were heated upto 120 degree celsius for 2 hours in a oven for evaporating the volatile matters present in the mixture. The dried and blender mixtures were then pressed uni-axially in a hydraulic press at 55 KN, and green compacts having 15mm diameter and 20 mm height is obtained. Die wall lubrication was made using zinc stearate manually before each run.

As pressure increases, the particles are plastically deformed, causing inter particle make contact with area to boost and additional particles to make contact. This is done by a further reduction in pore volume as shown in the figure1.

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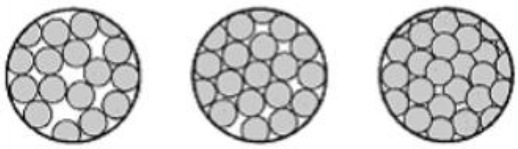

Figure1. Effect of applied pressure during compaction

4. SINTERING

Sintering is the process of compacting and forming a solid mass of material by heat or pressure without melting it to the point of liquefaction. Sintering happens naturally in mineral deposits or as a manufacturing process used with metals, ceramics, plastics, and other materials.

The atoms in the materials diffuse across the boundaries of the particles, fusing the particles together and creating one solid piece. Because the sintering temperature does not have to reach the melting point of the material, sintering is often chosen as the shaping process for materials with extremely high melting points such as tungsten and molybdenum. Sintering is effective when the process reduces the porosity and enhances properties such as strength, electrical conductivity, translucency and thermal conductivity.

Each green compacts were sintered in a muffle furnace at 550°C for 1 h and cooled to the room temperature in the furnace itself. To ensure safety and prevent oxidation the compacts were wrapped with aluminium foil.

5. HARDNESS TEST

Vickers hardness measurements were made on the polished all compositions of magnesium composites by hardness tester using 10kgf indicating load with a holding time of 15 seconds. Three measurements were made on all the samples and the average value is recorded.

6. WEAR TEST

Dry sliding wear test were performed in pin on disc equipment according to ASTM standards. The tribological performance of the hybrid composites was studied as a function of reinforcements content(wt%), sliding speed (m/s), sliding load (N) and sliding distance (m). Before and after each test, the specimen and counter face disc were cleaned with acetone to remove traces. The pin was weighted before and after testing to an accuracy of 0.0001 g to determine the amount of wear loss. The test was repeated three times, and the average results were taken.

RESULTS AND DISCUSSION

1. Variation in Vickers Hardness

The micro hardness tests were obtained in the polished samples using a Vickers method. This was done under a load of 10 kg and a holding time of 15 Seconds in concurrence with the ASTM standards.

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Table 3. Vickers Hardness of the Composites

S. No.	Composition (Wt. %)	Average Hardness (VHN)
	Mg	32
	Mg - 5%B_4C	54
	Mg - 5%Gr	36
	Mg -5% B_4C - 5%Gr	51

It was found that the hardness increases enormously when B_4C reinforcement content increases and if further increases lightly when Gr content increases. The hybrid composite displays higher hardness compared to the base material, which is attributed to the presence of hard B_4C. Furthermore, there is a slight decrease in hardness of the hybrid composite when compared to Mg-B_4C composite which may be due to the presence of Gr particles.

The addition of Gr particles led to decrease in hardness of hybrid composite when compared to Mg/ B_4C composite, due to the layer structure and of self-lubricating property. The figure 2 shows the variation of hardness of the composites as mentioned the table 3.

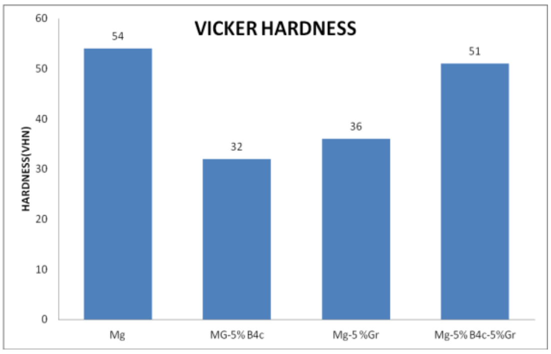

Figure2. Variation in Vickers Hardness

2. Variation in Wear Loss

The wear test was conducted on pin-on-disc apparatus as per the ASTM standard by varying the Sliding distance and the wear loss of the composites is given in the table 4. Figure 3 shows the effect of sliding distance wear loss for different values of weight percentage of B_4C and Gr hybrid composites. It has been observed that increases in B_4C content and Gr content results in decrease of wear loss.

Similar effects can be noticed for different sliding speed. Increase of the sliding distance make more contact between the pin to disc contact surface resulting in the increase in wear loss. The wear loss of the composites depends on the weight fraction of B_4C and Gr simultaneously. It shows that the optimum reinforcement content for the wear loss of the hybrid composite occurs at 5wt.% of B_4C and 5 wt.% of Gr for moderate sliding distances.

Table 4. Wear loss of Magnesium Composites

S. No.	Composition (Wt. %)	Sliding Load (N)	Sliding speed (m/s)	Sliding distance (m)	Wear Loss (gm)
	Mg	10	1	1000	0.0086
		10	1	2000	0.0091
		10	1	3000	0.0094
	Mg - 5%B_4C	10	1	1000	0.0081
		10	1	2000	0.0084
		10	1	3000	0.0087
	Mg - 5%Gr	10	1	1000	0.0077
		10	1	2000	0.0079
		10	1	3000	0.0082
	Mg -5% B_4C - 5%Gr	10	1	1000	0.0080
		10	1	2000	0.0082
		10	1	3000	0.0085

The self-lubricating effect is achieved by the addition of the Gr reinforcement in Mg- B_4C composites. When the amount of Graphite is increased from 0 to 5 wt. %, the wear loss of the composites is decreased over the distance range. The soft lubrication of Graphite particles, which get liberated throughout the sliding surfaces form a tribolayer between the contact surfaces thereby the wear loss is decreased. It is evident from the plot that the wear of hybrid composites decreases with increase in Graphite particles.

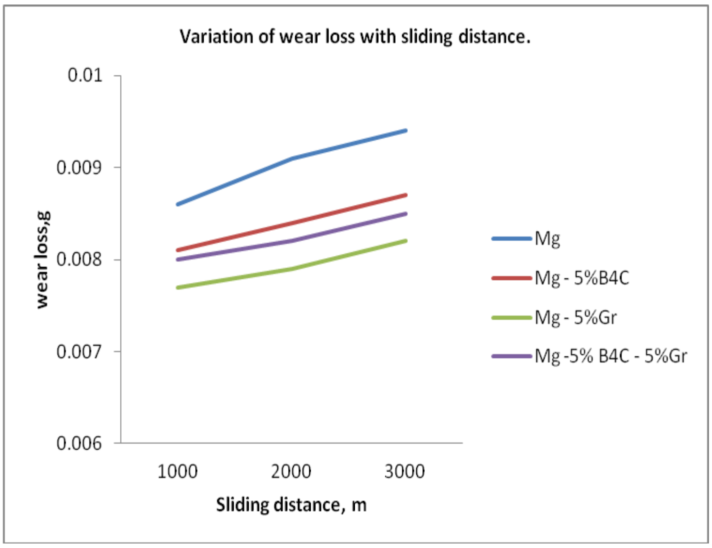

Figure3. Variation in Wear loss

CONCLUSION

Power saving and environmental issues leads to increased applications of lightweight materials especially in automobiles and aerospace industries. Recent research is going on in the Magnesium composites because of its low density and high specific strength.
In this work Hybrid Mg–B4C–Gr composite has been successfully developed by powder metallurgy technique as per the ASTM standards. Since Magnesium is a Hazardous material, during blending process, Toluene was used as the medium for process control agent to avoid oxidation.

The hardness and abrasive wear were evaluated. As compared with pure magnesium alloy, Hardness value of Mg–B4C composite is high compared to Mg alloy and Mg–B4C–Gr hybrid composite. This is due to the presence of graphite in hybrid composites.
The incorporation of B4C reinforcement to Mg alloy increases the wear resistance of the composite. The developed composite has exhibited higher wear resistance when compared with matrix and hybrid composite. The addition of Gr reinforcement in Mg–B4C composite as a hybrid reinforcement further decreased the wear resistance of the composite. The addition of graphite particles provides solid lubrication to the composites and decreases the metal to metal contact resulting in the reduction of the worn surface temperature. Therefore, the probability of adhesive wear is minimized by the addition of graphite to the base alloy and composites.

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