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Experimental and Investigation of Wheel Hub by using Aluminium and Magnesium Composite Material and Evaluate the Mechanical Properties

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Abstract

Metal Matrix Composites (MMC's) have been developed to meet the demand for lighter materials with high specific strength, and wear resistance. Among Metal matrix composites particulate reinforced aluminium and magnesium composites are attractive due to significant improvements in mechanical and physical properties. In this work, an effort has been designed to raise the reliability of using Al-Mg composites with other alternatively materials for wheel hub. This paper analysis the wheel hub material on mechanical properties of the Al-Mg composite material by using composite model plate evaluate the mechanical properties.

Keywords: Metal Matrix Composites, Wear Resistance.

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1. Introduction

A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The two constituents are reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fiber or a particulate. Particulate composites have dimensions that are approximately equal in all directions. They may be spherical, platelets, or any other regular or irregular geometry. Particulate composites tend to be much weaker and less stiff than continuous fiber composites, but they are usually much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percent) due to processing difficulties and brittleness. A fiber has a length that is much greater than its diameter. The length-to-diameter (l/d) ratio is known as the aspect ratio and can vary greatly. Continuous fibers have long aspect ratios, while discontinuous fibers have short aspect ratios.

Continuous fiber composites normally have a preferred orientation, while discontinuous fibers generally have a random orientation. Examples of continuous reinforcements include unidirectional, woven cloth, and helical winding. while examples of discontinuous reinforcements are chopped fibers and random mat. Continuous-fiber composites are often made into laminates by stacking single Sheets of continuous fibers in different orientations to obtain the desired strength and stiffness properties with fiber volumes as high as 60 to 70 percent. Fibers produce high-strength composites because of their small diameter; they contain far fewer defects (normally surface defects) compared to the material produced in bulk.

2. Construction

2.1. Rim

The rim is the "outer edge of a wheel, holding the tire." It makes up the outer circular design of the wheel on which the inside edge of the tire is mounted on vehicles such as automobiles. For example, on a bicycle wheel the rim is a large hoop attached to the outer ends of the spokes of the wheel that holds the tire and tube. In the 1st millennium BCE an iron rim was introduced around the wooden wheels of chariots.

2.2. Hub

The hub is the center of the wheel, and typically houses a bearing, and is where the spokes meet. A hubless wheel (also known as a rim-rider or centerless wheel) is a type of wheel with no center hub. More specifically, the hub is actually almost as big as the wheel itself. The axle is hollow, following the wheel at very close tolerances.

2.3. Spokes

A spoke is one of some number of rods radiating from the centre of a wheel (the hub where the axle connects), connecting the hub with the round traction surface. The term originally referred to portions of a log which had been split lengthwise into four or six sections.

Figure 1. Wheel

The radial members of a wagon wheel were made by carving a spoke (from a log) into their finished shape. A spoke have is a tool originally developed for this purpose. Eventually, the term spoke was more commonly applied to the finished product of the wheelwright's work, than to the materials used.

2.4. Wire

The rims of wire wheels (or “wire spoked wheels”) are connected to their hubs by wire spokes. Although these wires are generally stiffer than a typical wire rope, they function mechanically the same as tensioned flexible wires, keeping the rim true while supporting applied loads. Wire wheels are used on most bicycles and still used on many motorcycles. They were invented by aeronautical engineer George Cayley and first used in bicycles by James Starley. A process of assembling wire wheels is described as wheel building.

3. Selection Of Compenents

3.1. Wheel Hub

A hub is the central part of a wheel that connects the axle to the wheel itself. Many expressions use the term for a literal or figurative central structure connecting to a periphery. A wheel hub assembly, also referred to as hub assembly, wheel hub unit, wheel hub bearing, etc., is an automotive part used in most cars, passenger vehicles and light and heavy trucks. A hub assembly contains the wheel bearing and the hub to mount the wheel to vehicle. It is located between the brake rotors and axle. It is located between the brake drums or discs and the drive axle. On the axle side, it is mounted to the holding bracket from the chassis; on the disc side, the wheel is mounted to the bolts of the WHA. When replacing, a wheel hub assembly should be torqued to the vehicle’s specifications to prevent failure.

Figure 2. Wheel hub

In automotive suspension a steering knuckle is that part, which contains the wheel hub or spindle and attaches to the suspension components. It is variously called a steering knuckle, spindle, upright or hub as well. The wheel and tire assembly attach to the hub or spindle of the knuckle where the tire/wheel rotates while being held in a stable plane of motion by the knuckle/suspension assembly.

4. Literature Review

Alloys are being increasingly used in automotive and aerospace industries for critical structure applications because of their excellent castability and corrosion resistance and, in particular, good mechanical properties in the heat-treated condition. These are known as 4xxx series of wrought alloys and 3xx.0 and 4xx.0 series of casting alloys. In these alloys is intentionally added to induce age hardening through precipitation of Si metastable phases or Guinier Preston zones. Ramarao et al. examined that gun metal alloy-boron carbide composites were fabricated by liquid metallurgy techniques with different particulate weight fraction. Phase identification was carried out on boron carbide by x-ray diffraction studies microstructure analysis was done with SEM a composites were characterized by hardness and compression tests.

Dheerendra Kumar Dwivedi says that the influence of sliding interface temperature on friction and wear behavior of cast Al– (4–20%) Si–0.3% Mg has been reported. Wear and friction tests were performed under dry sliding conditions using pin on disc type of friction and wear monitor with the data acquisition system conforming to ASTM G99 standard. It was found that sliding interface temperature has close relation with wear and friction response of these alloys. Initial rise in interface temperature reduces the wear rate and as soon as a critical temperature (CT) is crossed, wear rate abruptly increases in case of all the compositions used in this investigation. Most of the earlier studies have focused on developing MMCs with commercially available aluminum alloys. Commercial aluminium alloys were selected for MMCs because they offer good mechanical properties, easily available and many of them are suitable for heat treatment. The common series of wrought aluminium alloys are 1000 (Pure aluminium), 2000 (Al-Cu), 3000(Al-Mn) 4000 (Al-Si), 5000 (Al-Mg) 6000 (Al-Si-Mg), 7000 (Al-ZnMg) and 8000 (Al-Li). Table 2.1 shows the some of the wrought aluminium alloy used as matrix material. Among the cast aluminium alloys, aluminum silicon, aluminum-copper, and aluminum-magnesium alloy systems are broadly used for MMC applications Abdel-Azim et al. (1995), observed in 2024 Al / alumina composites, matrix microstructure refinement is better than compare with matrix alloy produced in vortex method. An increase in amount of alumina particles in the matrix decreases the grain size.

Surappa's (1997) review concluded that the wetting of the reinforcement by the liquid metal, homogeneous mixing of the melt-particle slurry as well as particle-solidification front interactions determines the final particle distribution and matrix microstructure. Dendrite Arm Spacing (DAS) and matrix grain size were affected by the presence of reinforcing particles.

Hasim et al. (1999, 2001) discussed the difficulties associated in attaining a uniform distribution of reinforcement, good wettability between substances, and a low level porosity in stir casting process. Variables such as holding temperature, stirring speed, size of the impeller, and the position of the impeller in the melt have important influence in the production of cast metal matrix composites. The same author has observed that use of magnesium enhances wettability, though increasing the content above 1 wt.% magnesium increases the viscosity of the slurry to the detriment of particle distribution.

Increasing the volume percentage of SiC particles in the matrix alloy decreased the wettability Kok (2005) observed that in the case of 2024Al / alumina composite, density of the composites increased with increasing weight percentage. The wettability and the bonding force between aluminium alloy and alumina particles were improved by the applied pressure after pouring and porosity also decreased because of this pressure. The tensile strength and hardness of MMCs increased while the elongation of composites decreased with decreasing size and increasing weight percentage of the particles in stir casting method.

5. Development Of Aluminium Alloys

The chief alloying constituents added to aluminium are copper, magnesium, silicon, manganese, nickel and zinc. All of these are used to increase the strength of pure aluminium. Two classes of alloys may be considered. The first are the 'cast alloys' which are cast directly into their desired forms by one of three methods (i.e., sand-casting, gravity die casting or pressure die casting), while the second class, the 'wrought alloys', are cast in ingots or billets and hot and cold worked mechanically into extrusions, forgings, sheet, foil, tube and wire. The main classes of alloys are the 2000 series (Al-Cu alloys), which are high-strength materials used mainly in the aircraft industry, the 3000 series (Al-Mn alloys) used mainly in the canning industry, the 5000 series (Al-Mg alloys) which are used unprotected for structural and architectural applications, the 6000 series (Al-Mg-Si alloys) which are the most common extrusion alloys and are used particularly in the building industry, and the 7000 series (Al-Zn-Mg alloys) which are again high strength alloys for aircraft and military vehicle applications. The alloy used in any particular application will depend on factors such as the mechanical and physical properties required, the material cost and the service environment involved. If a finishing treatment is to be applied, then the suitability of the alloy for producing the particular finish desired will be an additional factor to be taken into account. The great benefit of aluminium is that such a wide variety of alloys with differing mechanical and protection properties is available, and these, together with the exceptional rang e of finishes which can be used, make aluminium a very versatile material.

6. Stir Casting

The composites were prepared by stir casting process. Shows schematic diagram the original setup of the stir casting process. Resistance furnace with a temperature range of 3000 C was used to melt the matrix material. The furnace has a temperature controller with k type thermocouple to control and measure the temperature. An electric motor is fixed at the top of the furnace to provide stirring motion to the stirrer. The speed of the stirrer can be varied as the setup has a speed controller attached to it.

6.1. Preheating of alloy

Heat treatment of the particles before dispersion into the melt aids their transfer by causing desorption of adsorbed gases from the particle surface. Heating alloy particles to 1000 C. Preheating of alloy particles removing surface Impurities and in the desorption of gases, and alters the surface composition by forming an oxide layer on the surface. The addition of pre-heated particles in Al and magnesium melt has been found to improve the wettability property. A clean surface of provides a better opportunity for melt particles interaction, and thus, enhances wetting.

6.2. Addition of Coverall Powder

The flux used is Coverall. It is the composition of Potassium chloride (KCl) + Nitric acid (HNO3), its function is to avoid oxidation. Coverall powder is added twice during the casting process. Initially, when the ingots are placed in the crucible, later while stirring of preheated alloy particles. The recommended amount that is to be added is 250gm for a melt of 50kg.

6.3. Addition of Degasser Powder

Degasser powder is added to the molten metal when it reaches a temperature of 800 C. The recommended amount to be added is 250gm for a melt of 50Kg. Degasser powder reduces blow holes formed during the casting process. The reasons for adding degasser powder are as below

- When alloy is in the molten state, it tries to absorb hydrogen from the atmosphere.
- When the absorbed hydrogen is unable to escape from the molten metal, it results in the formation of blow holes.
- When coverall 65 is added, it forms a thin film over the molten metal and prevents contact of molten metal with the atmosphere.
- When degasser tablets are added to molten metal, the chlorine present in these tablets react with hydrogen in the molten metal and form hydrochloric acid which dissolves in the molten metal, thereby reducing blow holes.

6.4. Pouring of Molten Metal

The material is stirred with 300 rpm for thirty minutes. The stirred metal is then slowly poured into the die which is preheated to a temperature of 973 C. The die is allowed to cool in air for two hours and then the specimen is removed.

6.5. Solution Treatment

During casting low cooling rate of the alloy allows for the strengthening of alloy phase to precipitate out of solution and grow into large incoherent phases within the matrix. In the as cast structure, the large, incoherent nature of the phase does little to increase the strength of the alloy. To obtain finely dispersed Al-Mg a solution heat treatment should be conducted.

7. Result

7.1. Test Specimen

Figure 3. Test Specimen

Table 1. Materials

Materials	**Ratio 1**	**Ratio 2**	**Ratio 3**
Aluminium	90%	88%	89%
Magnesium	9%	10%	8%
Tungsten	1%	2%	3%

Table 2. Hardness Test

Material	Hardness number BHN	Hardness value MPa
Sample 1	5.83	15.6
Sample 2	15.05	48
Sample 3	9.2	28.5

Table 3. Tensile Test

Material	Tensile Stress at break (N/mm2)
Sample 1	145.23
Sample 2	256.25
Sample 3	175.56

Table 4. Compressive Test

Material	Compressive stress (N/mm2)
Sample 1	138.56
Sample 2	255.87
Sample 3	175.78

Table 5. Wear Test

Material	W0 (g)	W1 (g)	Time (min)	Wear Rate (g/m)
Sample 1	**7.12**	**7.02**	**25**	**0.010**
Sample 2	**6.192**	**6.150**	**25**	**0.0022**
Sample 3	**6.377**	**6.308**	**25**	**0.00350**

8. Conclusion

Wheel hub material using a melt of aluminium and magnesium used fabricate matrix composite. Two casting temperatures and stirring time were applied to focus on composite materials especially aluminium and magnesium composites having good mechanical properties compared with the wheel hub materials. It is used in various automobile application these materials having light weight along with high hardness. It with stand high load compare with the existing materials are most applicable in the engineering products instead of existing materials. Finally, it was concluded that the percentage of al-mg increases automatically the hardness strength increased.

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