Investigation and Analysis of Properties of Magnesium Alloy for Suitability to Electric Vehicle Components

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Abstract. Magnesium is very attractive material with the combination of good strength, low weight and low corrosiveness. The uses of its alloy materials through various manufacturing methods are found in aerospace and automotive components in common inspired by weight restriction and reduction. Magnesium alloys are very light, strong and also possesses high thermal radiation properties. The high performance magnesium alloys with high temperature characteristics, pressure tightness and their ability to produce complex shapes makes it suitable in producing different aircraft components. As, the whole world is moving into the future of electric mobility through e-bikes and cars, research is already into the choice of materials for its components. As weight to power ratio is the major design issue in e-vehicles, a project to optimize a perfect material for the chassis becomes essential in the development of e-mobility. This project is about determining the strength capability of magnesium alloys for suitability as a material in electric vehicle chassis that wants for high strength and low weight. Thus, magnesium alloys like AZ91D and AZ31B are chosen as per ASTM standards for a stress analysis into manufacturing of electric vehicle chassis. The chassis of electric vehicle is designed as per its requirements taking into consideration of present development and a static and dynamic analysis is being carried out using a suitable finite analysis package for determining an optimum material.

Keywords: Magnesium Alloys, ASTM, Chassis, e-mobility.

1. Introduction
Magnesium is the lightest common structural Alkaline earth metal and is abundantly available in the earth’s crust and seawater with a density value of 1.738 g/cm³ in its solid state. It is a material that can be trusted when reliability is essential. In that alloys are combining of magnesium with other metals (called an alloy), often aluminum, zinc, manganese, silicon, copper, rare earths and zirconium [1]. The physical and Mechanical properties of magnesium are important to engineers in the design of low weight components and structures. These are cost competitive to other lightweight materials. Magnesium is used in a ample variety of applications from related to medical and metallurgical to chemical and pyrotechnic which makes it an indispensable part of many industries [2]. Magnesium is a versatile creep resistant metal that can be shaped into almost any form using a variety of techniques. Magnesium takes 40% less energy to produce than aluminium and it can
be completely recycled apparently at the end of its life. The main target of this paper is on the utilization of magnesium alloy to determine its strength capability for suitability as a material in electric vehicle chassis [3]. The efficiency of an e-vehicle depends upon the weight of the vehicle body. Using light weight material like magnesium as a component in the electric vehicle chassis design may help to retain high strength and reduce the overall weight of the vehicle and thus improving the performance as well. Magnesium is strong, lending this excellent compressive strength to vehicle structural performance and providing safety without compromise and also eco-friendly in nature.

This Work discusses the material properties and mass-saving potentiality of magnesium alloys in resemblance with major automotive materials: mild steel, advanced high strength steel (AHSS), aluminum. In this work, the current advantages, Disadvantages, technological impediment and future prospects of Mg alloys in the electric vehicle industry are given. The alloy evolution and manufacturing processes of magnesium extrusion and sheet products are compiled [4]. The opportunities and objection of wrought magnesium alloys for automotive applications are discussed. There is a great need for developing wrought magnesium products to provide improved mechanical and physical properties, crash performance and corrosion resistance.

Magnesium alloys like AM60B, AZ91D and AZ31B are chosen as per ASTM standards for a stress analysis into manufacturing of electric vehicle chassis [5]. The chassis of electric vehicle is designed as per its requirements taking into consideration of present development and a static and dynamic analysis is being carried out using a suitable finite analysis package for determining an optimum material [6]. The usage of magnesium in electric automotive applications is also assessed for the brunt on environmental conservation thus reducing the overall weight which can improve its efficiency.

The main objective of the Paper is used to find out the Light Weight Alloy to improve Efficiency of the Vehicle and also reduced in Weight in Automobile Field.

2. Materials and methods

Magnesium is the lightest structural metal. Magnesium alloys have characteristics of low density, high specific strength and excellent machinability, attracting more and more attention [7]. However, their poor mechanical properties make them impossible for wide applications in electronics, automotive and aerospace industries. Here we try to determine properties of magnesium alloy for suitability to use in electric vehicle components. Magnesium alloys are Compound of magnesium with other metals (called an alloy) of aluminum, zinc, manganese, silicon, copper, native metal and zirconium[8]. In Mg alloys have a hexagonal lattice structure, which affects the fundamental properties of these alloys.

Some of the Magnesium alloy composition are,

- Mg–Zn series alloys
- Mg–Al series alloys
- Mg–Mn series alloys
- Mg–RE series alloys
- Mg-Y-Gd-Zr alloy
- Mg-Zn-Ca alloy

E-bikes are infusing the automobile market slowly replacing the conventional petrol bikes in the near future. E-bikes are expected to perform just as equivalent to a petrol bike and the weight of the components is one of the prominent factors towards achieving high efficiency. In this project, chassis is chosen as the component and design is done for a bike with reference to its technical requirements. The design of a chassis of an e-vehicle is carried out in the project using a CAD software. With severe time and budget constraints, it was crucial to pick a design that could be constructed and tested on time. After a thorough survey of various magnesium alloys, AM60B is chosen for investigating the strength and other properties for e-bike chassis comparing to alloys of aluminum and steel. A feature of a great design is one that allows future work and improvements to be performed on it [9]. The materials and parts that are implemented in the system definitely will lead to future improvements and further work.
Magnesium alloys are cast-able metals and are thus casted into components by die casting. Magnesium high pressure die castings is one of the suitable methods by which magnesium are cast into useful parts [10]. It has a wide usage application in the typical vehicle architecture. A latest study showed that magnesium alloys can swallow significantly more energy than either aluminum or steel on an identical mass basis.

Some of the advantages of using Magnesium Alloys are,

- Low density,
- High fatigue limit;
- Can withstand greater impact loads than aluminium alloys;
- Good thermal conductivity;
- Good castability; good dimensional stability;
- Easy to recycle;
- Good machinability;
- Have better damping performance

To obtain experimental investigation, analysis of the 3D chassis design was carried out (Figure 1).

![Figure 1 3D Layout of Electric Bike Chassis](image)

A 3D cast model of the chassis is developed using a typical design package and finite element analysis of the chassis is carried out for evaluating the stress values and response when the chassis is subjected to various types of loads. The study is carried out as Static structural analysis.

3. Results and Discussion

The ultimate success of magnesium as a large-scale automotive material will depend on how these technological challenges are addressed. In that challenges are massive and global, and would require significant concert among industries, governments and academia from many countries.
The inflation in the potentiality application of magnesium profiles is solidly dependent on the question of whether established forming processes for aluminum and steel can be adapted to magnesium.

Momentous research is still desired on magnesium processing, Mg alloy development, joining, surface treatment Process, corrosion resistance and mechanical properties improvement to achieve future goals to reduce the vehicle mass.

Production and relevance technologies must be value effective for magnesium alloys to make magnesium alloys an economically viable alternative for the electric vehicle industry.

The advancements of eco-friendly environments and Mg as a substitute for steel and aluminum in automobile industries for upcoming years

The Alloy composition of the Magnesium-aluminum-manganese (AM) AM60B alloy, is presented in Table 1

Table 1. Alloy Composition

| SL.No | Alloy & Standard | Composition | Properties | Applications |
|-------|-----------------|-------------|------------|--------------|
| 1     | Magnesium-aluminum-manganese (AM) AM60B | Al-5.5-6.5, Mn -.24-0.6, Zn 0.22, Si 0.1, Cu- 0.01, Fe-.005, Ni-.002 | Better elongation and toughness, accomplished saltwater corrosion resistance, good yield, low thermal conductivity and a moderately low tensile strength. | Brackets, Seat Frames, Instrument panels, Steering wheels |

A 2D Design of the chassis for an Electric Vehicle is drawn on a plane using CAD software. It is then converted into 3D model. Analysis is done using SOLIDWORKS Software.

Figure 2 Stress analysis
In Figure 2, the stress analysis of the chassis design is done and the outcome is denoted.

![Stress Analysis](image)

**Figure 3** Displacement

In Figure 3, the Displacement of the chassis design is done and the outcome is denoted.

![Displacement](image)

**Figure 4** Factor of Safety

In Figure 4, the Factor of Safety for the chassis design is done and the outcome is denoted.

| Material | Weight (kg) | Factor of safety |
|----------|-------------|------------------|
| AM60B    | 3.17        | 6.16             |

**Table 2 Performance Analysis**

It is understood from the above table 2 that the Magnesium Alloy AM60B is much lightweight as compared to alloys of Aluminum and Steel.
4. Conclusion

Today's interest in magnesium alloys for automotive applications is based on the combination of high strength properties and low density. For this reason magnesium alloys are very attractive as structural materials in all applications where weight savings are of great concern. In automotive applications weight reduction will improve the performance of a vehicle by reducing the rolling resistance and energy of acceleration, thus increasing the overall efficiency.

The following are the conclusions based on the investigation done for different materials for an e-bike chassis.

- The overall weight reduction was observed.
- The increase in efficiency of the electric vehicle can be seen.
- The strength and stability of the body is observed to be more than other materials.
- Increase in Torsion stiffness and bending stiffness

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