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DEVELOPMENT OF REGENERATIVE SUSPENSION FOR ELECTRIC VEHICLE

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ABSTRACT

Design of a suspension system that harvests energy from the suspension system. The design must not be too like the market's standard suspension, especially in terms of packaging. The goal of the research is to design an energy harvesting suspension on an electric vehicle that uses the rack and pinion type to convert kinetic energy to electrical energy and to analyse the performance of the regenerative suspension design in terms of generator speed produced using SolidWorks motion study analysis. The process begins with identifying the design aim in terms of dimension and suspension operating mechanism. The type of regenerative suspension is then chosen depending on the findings of the literature review. The CAD is created in SolidWorks based on the sort of regenerative suspension system used. Design enhancements are done to improve the design's quality. Rack and pinion were selected as the design. The design is capable of a 165mm compression stroke and 518 revolution per minute at 2.5 Hz. For its creation, the project made use of SolidWorks CAD software and Microsoft Excel. Its main goal was to create a regenerative suspension for electric cars (EVs) that could absorb kinetic energy and convert it to electrical energy. The project successfully found the most efficient mechanism for the regenerative suspension design by using motion analysis in SolidWorks.

KEYWORD

Regenerative suspension, Electric Vehicle, CAD, 3D printer

INTRODUCTION

Suspension systems for EVs share many similarities with those for traditional ICE vehicles but also come with some unique considerations due to the characteristics of electric propulsion systems. In the early days of the automobile, suspensions were rudimentary, often consisting of simple lead springs or coil springs. These suspensions were relatively stiff, offering limited comfort and handling characteristics. One of the major advancements in a suspension technology was the introduction of independent suspension systems. Instead of a solid axle connecting the two wheels, independent suspensions allowed each wheel to move independently, providing a smoother ride and better handling. This innovation improved both comfort and traction (Lv et al., 2020).

Modern day suspensions often include electronic components and sensors to adapt to changing road conditions and driving styles. Adaptive suspension systems can adjust damping rates, ride height, and other parameters in real-time to provide a balance between comfort and performance. Advancements in materials technology, such as the use of lightweight alloys and composite materials, have allowed for the reduction of unsprang weight in suspensions. This has improved the handling and the fuel efficiency.

When the car is driven on the road, linear vibration is sent to the suspension, causing it to move upward and downward. During the downward movement, both nuts travel downwards, and the left-hand screw rotates clockwise, and the left overrun clutch engages and turns the left gear clockwise, but when the movement is upwards, the right-hand screw rotates only in one direction and turns the shaft of the generator unidirectionally. Supercapacitors store the energy. The ball screw is a mechanism that converts vibrational translational motion into rotary motion. (Huang et al., 2015). With increasing concern for the environment, there is growing concern in sustainable materials and energy-efficient suspension designs, such as regenerative suspension system that can recover and restore energy during vehicle movement. As suspension development continues to evolve, driven by a combination of factors, including safety, comfort, performance, and environmental concern with helps of technology advances, we can expect suspensions to become even more capable in the future. The energy is stored in supercapacitors (Zhang et al., 2016).

The objective of this development is to fabricate the actual size of the regenerative suspension that had already been design by using CAD software by using 3D printer for complex part and to analyze the motion study of the suspension system under certain conditions. The CAD design of this suspension system will be based on the previous UTM researchers which it is still not ready for fabrication, because it focuses only on the function but did not consider of manufacturability and availability of the standard component.

MATERIAL AND METHODOLOGY

In this project, SolidWorks Computer-Assist Drawing (CAD) was used to design the desired model of the regenerative suspension by using 3D CAD. The suspension system will use the dimension from the sedan car suspension system in the market nowadays. 3D CAD was used to design the suspension with the diameter of 160 mm and maximum elongation of 570 mm, as shown in Table 1. Suspension system will be based on the mechanical design using the rack and pinion design to gain a better efficiency which was up to 70% to 80%. It also can provide suitable damping ratio which will produce a comfortable ride for the vehicle.

To fabricate this suspension system, 3D printer will be utilized to produce the desired complex design of the suspension system. Some of the standard component also will be used when fabricating the regenerative suspension system. The workability of this prototype will be focusing on generating the electrical power from the vibration that produced from the suspension itself, as shown in Figure 1.

Table 1: Product Design Specification of Regenerative Suspension

No.	Suspension requirement	Target
1.	Maximum elongation	570 mm
2.	Diameter	160 mm
3.	Weight	Less than 30 kg
4.	Compression stroke	15 mm
5.	Damping coefficient	In the range of 1139.2 – 1424.0 N.s/m which is for the comfortable car.
6.	Toughness	Can have endure the static and dynamic force from load. Static force of 3813.64 N.

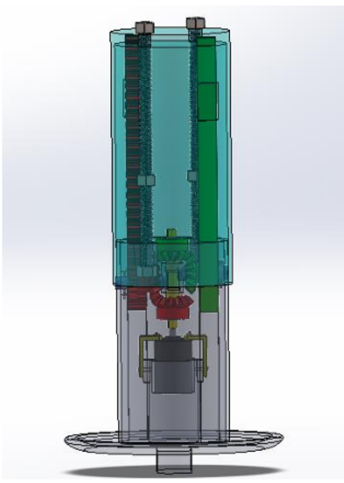

Figure 1: Design of Regenerative Suspension

RESULT AND DISCUSSION

The working mechanism of the rack and pinion design is changing the linear force to rotational force. Once the suspension exerted force from the car and from the road, there will be a vertical motion acting on the rack gear. When the car is moving, the road condition will create a force that will push the car body downward and upward. When the upper casing is pushed downward, the rack will move along with the upper casing, and it will rotate the pinion as it is attached with each other. As the pinion gear is rotating, the vertical bevel gear will rotate in the same direction with the pinion as the two gears are fixed together. Then, the vertical bevel gear will rotate the horizontal bevel gear. This is the point that the linear force will change to rotational force. The vertical bevel gear is not directly attached to the generator shaft instead this gear is insert with the one way bearing, this bearing will lock to the generator shaft. The clockwise direction will making the vertical bevel gear and one way bearing engaged. Thus, the one-way bearing will rotate the generator shaft. However, when the rack moves upward the vertical bevel gear will rotate anti-clockwise. For the second rack and pinion gear, the concept of the movement is similar with the first on but instead, the direction of the one-way bearing rotation is opposite with the other one. Therefore, the rotation of the shaft will always in one direction no matter the movement of the rack is down or up.

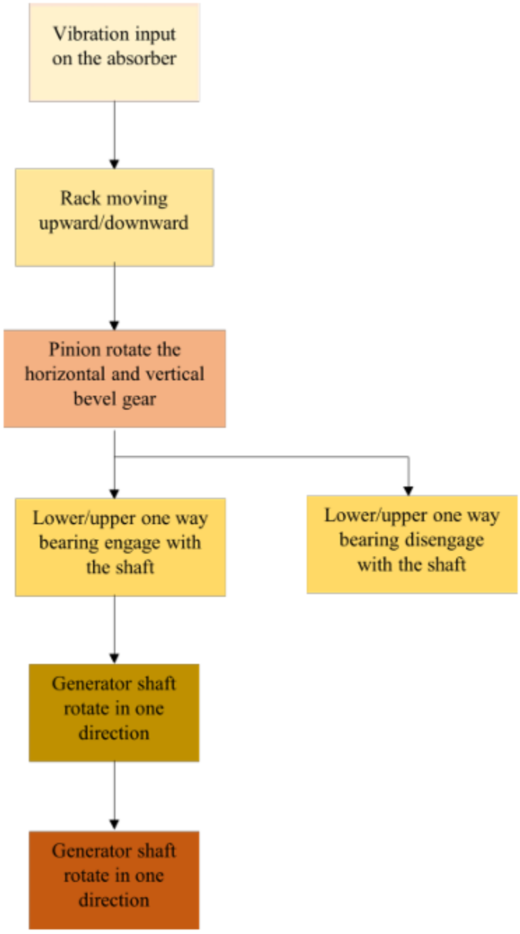

Figure 2: Flow Chart for the working mechanism of rack and pinion

The flow chart (Figure 2) indicates the working mechanism of rack and pinion type to generate electric energy through the suspension compression. The flow chart makes it easier to understand the working mechanism of rack and pinion. We can easily understand where the changes between linear for change to rotational force when there is vibration occur on the absorber as the flow chart show the step by step of the working mechanism of the rack and pinion type regenerative suspension system.

CONCLUSION

In conclusion, the project requires a fundamental knowledge of SolidWorks CAD software and Microsoft Excel to achieve the objective. A lot of research has been done to finish this project. This project uses the SolidWorks motion analysis to get the data from the CAD model design. With the rack and pinion gear mechanism, it allows the linear vibration input from the road converted to one way rotation motion that allow the generator run and produced electrical energy to the vehicle.

Since the previous researchers did not achieve the target to make the rack and pinion mechanism rotate in one direction, the protype can be completed by installing the one-way bearing between the horizontal bevel gear with the generator shaft. Other than that, the design only covers the mechanical part but not the electrical part. So, additional work is required to calculate the power output of the motor, ensuring it meets the targeted specifications outlined in the Product Design Specification (PDS).

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