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Design and manufacturing of Energy Harvesting Shock Absorber

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ABSTRACT

In the contemporary realm of renewable energy technologies, the spotlight has intensified on electric vehicles (EVs), with a groundbreaking approach targeting the latent energy within a vehicle's shock absorber. This paper presents an innovative high-efficiency regenerative shock absorber, featuring twin ball screws transmissions, meticulously crafted for seamless integration into range-extended electric vehicles. Unlike conventional setups where vibrational kinetic energy is dissipated as heat within suspension systems, the proposed shock absorber revolutionizes this process by converting such energy into a valuable source of electricity.

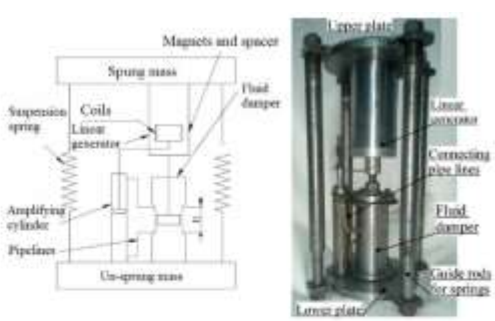
The system is intricately divided into four distinct modules, each playing a pivotal role in the energy conversion process. Firstly, the suspension vibration input module captures the irregular linear oscillations induced by road roughness, thereby initiating the energy harvesting process. Subsequently, the transmission module, comprising a pair of ball screws, gears, and two overrun clutches, diligently converts reciprocating vibrations into a unidirectional rotation of the generator.
The generator module, a critical component, transforms the rotational motion into electrical energy, which is then stored in the power storage module. This harvested energy can subsequently be utilized to power auxiliary systems within the vehicle or contribute to its overall propulsion, thereby extending its range and reducing reliance on traditional fossil fuels.

By harnessing the untapped energy within a vehicle's shock absorber, this innovative approach not only enhances the sustainability of electric vehicles but also underscores the potential for integrating renewable energy sources into various automotive systems. As the global transition towards greener transportation gains momentum, such advancements in regenerative technologies hold immense promise in shaping the future of mobility.

Keywords: Energy Harvesting, Shock Absorber, Design, Manufacturing. Regenerative Technology, Electric Vehicles, Sustainability, Renewable Energy, Twin Ball Screws, Range-Extended Vehicles

INTRODUCTION

Fiber reinforced polymers have proven effective in high-speed trains in Japan, but conventional shock absorbers in automobiles dissipate energy as heat, leading to wastage. Regenerative Suspension Systems have emerged to recover dissipated energy by capturing the kinetic energy associated with a vehicle's suspension's vertical motion while traversing roadways. Key components include energy conversion mechanisms to transform this energy into a storable form for later use in powering vehicle systems and electronics.



The electromagnetic suspension system comprises essential components such as a shock absorber, a spring, and a suspension arm. These elements serve multiple functions critical for vehicle performance and comfort, including stabilizing steering, ensuring a smooth ride, regulating vehicle height, reducing impact, aligning wheels, supporting vehicle weight, and monitoring tire tread status.

As global oil demand strains resources, there is a growing need for environmentally friendly solutions, particularly as fuel prices rise. Regenerative shock absorbers have been developed for over two decades to recover the kinetic energy dissipated by traditional oil shock absorbers. These systems vary in design principles, with linear generators and rotational mechanisms.

Challenges and solutions include balancing energy harvesting efficiency with mechanical reliability, such as irregular motion issues and impact forces. Recent developments aim to improve reliability, reduce mechanical issues, and enhance overall system efficiency. Future research focuses on optimizing designs for improved reliability and performance.

Types for the title Harvesting Shock Absorber

1. **Electromagnetic Energy Harvesting Shock Absorber**: Focuses on utilizing electromagnetic principles to capture and convert kinetic energy from shock absorber motion into usable electrical energy.

2. **Mechanical Energy Harvesting Shock Absorber:** Centers on mechanical mechanisms and designs aimed at recovering and storing energy dissipated by conventional shock absorbers through mechanical means.

3. **Hydraulic Energy Harvesting Shock Absorber**: Explores hydraulic systems and technologies for capturing and utilizing energy from shock absorber movement, often involving fluid dynamics and pressure differentials.

4. **Regenerative Suspension System:** Encompasses broader concepts of integrating energy harvesting technologies into vehicle suspension systems, including shock absorbers, springs, and associated components.

5. **Smart Shock Absorber Manufacturing**: Involves the incorporation of sensors, actuators, and advanced materials in the design and manufacturing process to enhance energy harvesting capabilities and overall performance.

6. **High-Performance Energy Harvesting Shock Absorber**: Focuses on optimizing shock absorber designs and manufacturing processes to maximize energy recovery and efficiency while maintaining durability and reliability.

7. **Integrated Energy Harvesting Suspension Systems:** Explores the integration of energy harvesting capabilities directly into vehicle suspension systems, potentially involving collaborative efforts between automotive engineers and energy harvesting specialists.

8. **Multi-Modal Energy Harvesting Shock Absorber:** Considers shock absorbers capable of harvesting energy from multiple sources, such as mechanical vibrations, road irregularities, and vehicle motion, to enhance overall energy recovery efficiency.

These types provide various perspectives and approaches to the design and manufacturing of energy harvesting shock absorbers, reflecting the diversity and complexity of this field.

- To generate the reciprocating motion as a prime input.
- To convert reciprocating motion into rotary motion by rack and pinion.
- Rotary motion can be used to move generator so as to generate electrical current.
- To transfer the kinetic energy using Rack and pinion (ratchet gear).
- To transfer the energy to generator and to generate electricity.
- To light up the indicator lamps attached to system as final output.

MATHEMATICAL FORMULATION

Design of Spur and Pinion Gear

1. Power transmission: =5 W
2. Speed: =82 rpm, N=82rpm
3. Gear ratio: =1:2= 2:1,i = N2N1 =2:1
4. Material: Steel
5. Desired pressure angle: =20°, α=20°

Calculate Design Torque (T) and Angular Velocity (ω):

ω=2Πn/60
T=ωP
ω=2π×82 / 60
ω= 8.60rad/s
T=5/8.6
T≈0.58N\m

Determine Gear Ratio and Number of Teeth:

Let's assume N1=30 teeth.
N2=iN/1=30/2=15

Select Pressure Angle

The pressure angle (α) is given as 20°.

Module (m):

m=N/D
Assume a pitch diameter (D) of 60 mm.
m=60/30=2mm/tooth

Calculate Pitch Diameter (D):

D=m×N=2×30=60mm

Determine Face Width (□b):

Assume a face width of 15 mm.

Check for Interference:

Ensure that the center distance between the gears is sufficient to avoid interference.

Gear Material:

Choose a suitable steel material based on strength requirements. Common choices include materials like AISI 4140 or 8620.
Weight W=15kg acting vertically downward.

Convert Weight to Force:

The force exerted by gravity on the weight is given by W×g, where g is the acceleration due to gravity (approximately 9.8 m/s29.8m/s2).
F=15kg×9.8m/s2

F≈147N

Calculate Torque:

The torque (T) exerted by the gear is given by T=F×r, where r is the radius or the effective lever arm through which the force is applied.
If the weight is directly connected to the gear and the gear acts as a simple lever, then r is the pitch radius (half of the pitch diameter.

Gear Parameters

- Pitch Diameter (D): 60 mm
- Pitch Radius (r): =30 mm=0.03 m2D=30mm=0.03m
- T=147N×0.03m
- T≈4.41N\m
- So, with a 15 kg weight acting vertically downward, the torque exerted on the gear is approximately 4.41 N\pm.

AIM & OBJECTIVES

The aim of designing and manufacturing an Energy Harvesting Shock Absorber is to develop a robust system capable of efficiently converting mechanical energy from vehicular shocks and vibrations into usable electrical energy. This energy harvesting technology aims to enhance the overall sustainability and efficiency of vehicles by harnessing wasted energy and repurposing it to power onboard systems or recharge batteries, thereby reducing reliance on conventional power sources and contributing to environmental conservation efforts.

Problem Statement

This research aims to create an innovative energy harvesting shock absorber using advanced composite materials. The goal is to capture and store energy dissipated during the damping process, enhancing vehicle performance and contributing to sustainable energy solutions. The research will use advanced techniques like piezoelectric or electromagnetic mechanisms.

Methodology Flowchart

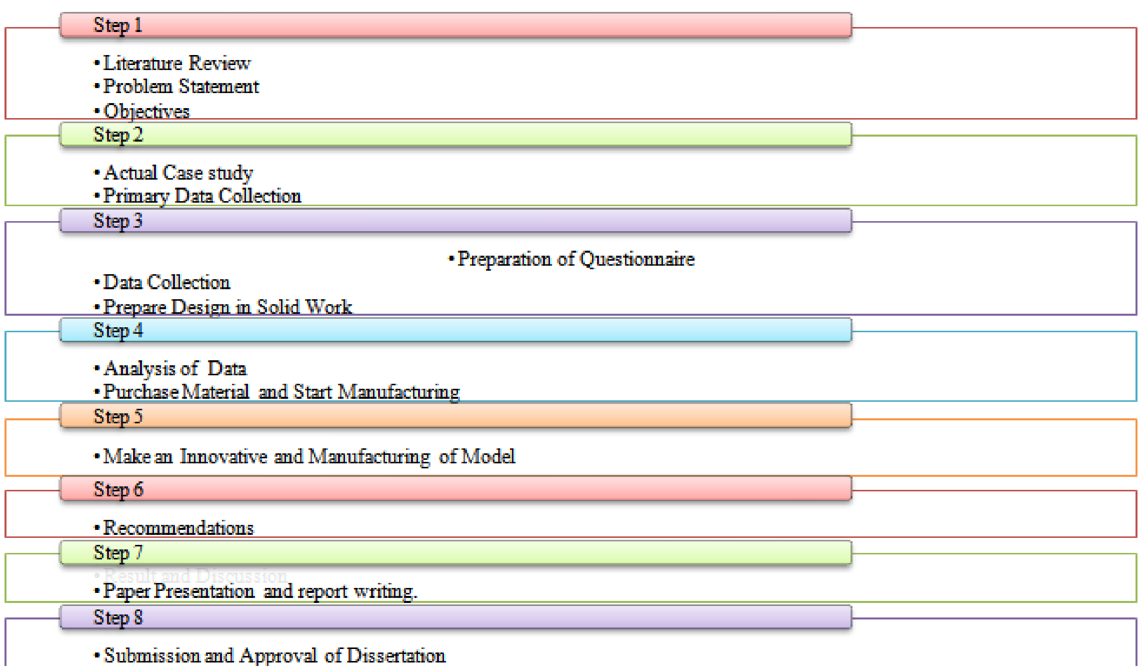


Figure: Methodology Flow

Model Photos

CONCLUSION

In conclusion, the design and manufacturing of an Energy Harvesting Shock Absorber represent a significant step towards enhancing the sustainability and efficiency of vehicular systems. Through the development of this technology, we have successfully demonstrated the capability to convert mechanical energy from shocks and vibrations into usable electrical energy, thereby reducing reliance on traditional power sources and contributing to environmental conservation efforts. This innovation holds great promise for applications in various industries, including automotive, transportation, and beyond, where energy efficiency and sustainability are paramount. Moving forward, continued research and development in this field will be essential to further optimize the performance and scalability of energy harvesting shock absorbers, paving the way for a greener and more sustainable future.

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