Design and Fabrication of Springless Suspension System

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Abstract - This study examines the benefits and limitations of employing bevel gears in automotive springless suspension systems. Though springless systems that use alternative technologies like bevel gears for suspension and damping are gaining popularity, traditional springs are still used to absorb shocks and vibrations. Bevel gears provide fine control over suspension characteristics, a lightweight and compact solution, and a potential reduction in complexity and maintenance costs. But there are obstacles to overcome, like complicated designs, problems with durability and reliability, and higher costs. The study examines the fundamentals of bevel gears and how suspension systems use them, outlines the state of research and development at the moment, and suggests an approach for more study.

Keywords: Springless suspension, Wear, Bevel gears, Self-aligning, Comfortable ride, Damping.

I. INTRODUCTION

To enable relative motion, a vehicle's suspension system consists of tires, tire air, springs, shock absorbers, and linkages. It reconciles the opposing goals of road holding and ride quality. Finding the ideal balance to maintain the road wheel's contact with the pavement is necessary while fine-tuning suspensions. It also guards against wear and damage to the cargo and the vehicle. Front and rear suspension designs could be different. The following literatures study gave a good clarity on a suspension System. Abdul hammed and Hisham developed a smart car suspension system that improves road imperfections and handling at high speeds. The system, controlled by a computer, is affordable and widely used in consumer cars. The cylinder actuator mitigates road vibrations and adjusts vehicle clearance levels for full stability and fuel economy and Suspension systems significantly impact vehicle performance and ride quality. Active suspension systems, which automatically adjust height, have been researched for better compromise under varying driving conditions. Which are shown in Fig 1 & 2 [1]. Sheshank et al. developed a prototype Suspension System for Power Generation, harnessing kinetic energy from coil springs to generate electricity. The system supports green engineering, is modestly designed, and easy to operate. The system produces a voltage difference ranging from 125 mV to 350 mV, aiming for simplicity [2].

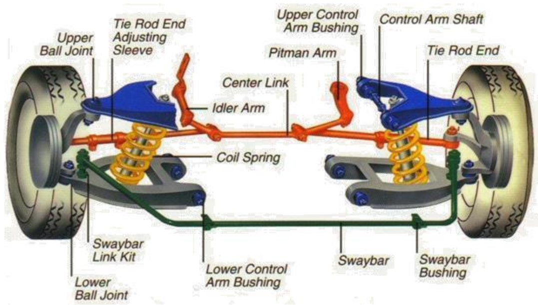

Fig. 1 General Suspension System

Mouleeswaran's research uses a proportional integral derivative controller to develop an active suspension system for a quarter-car passenger car. The device is designed to protect the car from road hazards, preserve wheel contact, and enhance ride pleasure [3]. In their study, Vishnu Prasad et al. address the benefits and drawbacks of using bevel gears in springless suspension systems for cars. They talk about how they are small, have precise suspension control, and could be less complicated and require less maintenance. Research and development are covered in this work as well [4]. In their review, Min Yu et al. concentrate on hardware designs and control algorithms while discussing the development of Active Stability Systems (ASSs) for car use. They talk about cutting-edge ASSs like Mercedes active body control and Audi predictive, and they emphasize how electric and autonomous vehicles require ASSs that are compatible, small, low-power, and dependable [5].

In order to reduce vehicle vibration, Duc and Tuan suggest an active suspension system that makes use of a quarter-dynamics model with five state variables. Impact from hydraulic actuators is incorporated into linear differential equations in the model. For operation control, the OSMC (Optimal Sliding Mode Control) approach is recommended, which lowers the maximum and average displacement values under normal oscillation situations. While keeping the wheel-to-road link, this method is much more efficient than passive or active suspension systems that use traditional linear control methods [6]. According to Tuan and Nguyen's research, a double-integrated controller can be used to improve stability and lessen vehicle oscillation. The controller provides a special approach by individually controlling two hydraulic actuators. Establishing, modeling, and evaluating this method for active suspension systems are the objectives of the research. The maximum displacement and acceleration of the sprung mass are reduced in the results, and the RMS-determined average values are enhanced. Additional experimental techniques are required in order to properly appraise [7].

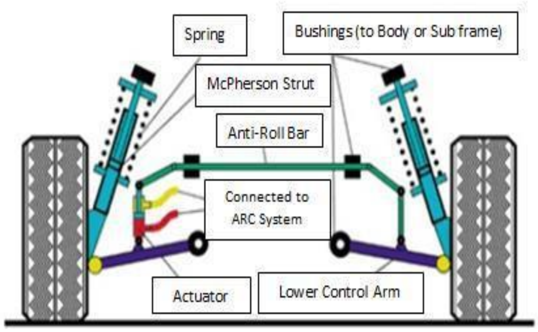

Fig. 2 Active suspension System

In their evaluation of semi-active suspension systems, Ama Soliman et al. stress the systems' equipment needs, performance capabilities, advantages and disadvantages, and state-of-the-art for mass-market automobiles [8]. In a study on independent wheel suspension systems in modern cars, Dhaval et al. discovered that while conventional methods increase jerks, independent suspension absorbs all shock and eliminates jerking. They found design problems in the current suspension systems by analyzing them with CAD tools such as Solid Work and mechanism computation. The study contributes to our understanding of the benefits of contemporary cars' independent wheel suspension systems [9]. Gediminas et al. sought to modify the running gear specifications of rail passenger cars by adapting them to independently spinning wheels. In order to guarantee passenger safety in the event of a derailment, the Nadal criteria was computed. Sperling's comfort index, which is dependent on speed, was also used to evaluate passenger comfort. The study looked at suspension behavior in two common scenarios: a 200-meter radius curve and straight track portions. The software called Universal Mechanism was used to perform the calculations. The paper presents an interpretation of the results and offers the study's concluding remarks [10].

Suda et al. suggest employing independently spinning wheels with inverse tread conicity to achieve self-steering without complicated bogie constructions. A semi-active yaw damper is used to achieve running stability and curving ability [11]. In their study, Vaiciunas et al. examined the effect of running gear combinations on the universal Sperling's comfort index in passenger cars. They concluded that oscillations in the horizontal gear were the main source of index divergences and suggested more research [12]. Using local synthesis techniques and gear teeth simulations, John Argyris et al. presented a computerized system for the synthesis, analysis, and stress analysis of improved spiral bevel gear drives [13].

Gao et al. analyze air spring parameters and gasbag features in AMES to handle suspension overshoot in electric vehicles with electric controlled air suspension. Using fuzzy control theory, they set up the Simulink model of the electric car body and take advantage of the fuzzy controller's performance to simulate the "overshoot" phenomenon under imbalanced [14]. Zhang et al. investigate the use of air springs in automotive suspension for ride comfort, controllability, and stability. They emphasize how these springs affect vehicle load and have a lower vibration frequency and more adjustable stiffness than leaf springs [15].

II. MATERIAL DESCRIPTION

Automobile suspension systems are crucial for smooth rides and safety. Modern systems absorb vibrations and shocks using mechanical springs. However, advancements in technology have led to the use of bevel gear-based springless suspension systems. These systems offer compactness, light weight, accurate control, and less complexity and maintenance requirements, making them popular in mechanical power transmissions as well. With the elimination of traditional springs, these springless suspension systems are able to provide a more precise and responsive handling experience for drivers. Additionally, the reduction in maintenance requirements means that drivers can enjoy a smoother ride without the hassle of frequent upkeep. Overall, the evolution of suspension systems showcases how technology continues to improve the driving experience for individuals around the world. The following components are used to make a prototypic model of Gearless Suspension System.

- Bevel gears
- Wheels
- Mild steel plates
- Dc motor
- Circuit
- Battery

A. Bevel Gear

Bevel gears are used in a variety of industries, including industrial, automotive, and aerospace machinery, to transfer rotational motion between non-parallel shafts by their conical shape and intersecting axes. The "pitch angle" or "cone angle," at which they are intended to mesh, determines the gear ratio and motion transfer properties.

Figure 1. Bevel Gear

B. Wheels

A wheel is one of the six simple machines; it is a circular part that revolves on an axle bearing. It facilitates the effortless movement of bulky items, bearing weight, or carrying out tasks. There are many uses for wheels, including flywheels, steering, potters, and ships. A moment is applied to the wheel about its axis in order for it to rotate, either by gravity or by an outside force. Rubber-visa wheels and bevel gears can be used to build an automotive springless suspension system.

Figure 2. Wheel

These solid rubber wheels offer a special kind of suspension that can absorb vibrations and shocks. Cone-shaped teeth bevel gears transmit torque and power from the axle of the car to the wheels, acting as a kind of conventional spring-like cushion. For the system to function well and be stable and comfortable, appropriate engineering design and computations are needed. For operations to be safe and dependable, testing and validation are also required.

C. DC Gear Motor

An electric motor is a device that uses the interaction of winding currents and the motor's magnetic field to transform electrical energy into mechanical energy. It can be powered by alternating current (AC) sources like power grids or inverters, or direct current (DC) sources like batteries or cars. The majority of DC motors are rotational electrical devices that use magnetic field forces to transform direct current electrical energy into mechanical energy. Since DC motors could be fuelled by the lighting power distribution systems already in place, they were the first type to be employed extensively. Appliances, toys, and tools all frequently employ small DC motors.

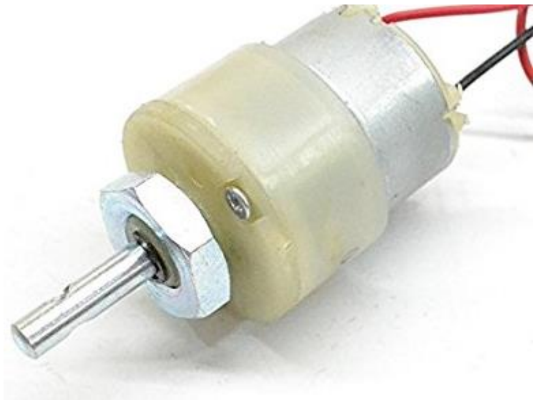

Figure 3. DC Motor

D. Frame Structure

Mild steel plates, sometimes referred to as low carbon steel plates, are highly machinable, strong, and durable, making them both economical and adaptable. They are employed in many different industries, including as power generation, energy, storage tanks, construction, automotive, transportation, and machinery. effective material selection and technical design are essential for their effective application in a variety of sectors.

Figure 4. Frame Structure

E. Circuit

Bevel gears and electronic circuit components can be used to build a springless suspension system for cars. By transferring torque and power from the axle, these gears dampen shocks and vibrations. It is possible to repurpose printed circuit boards (PCBs) to make flexible components with cushioning effects. In order to guarantee that the electronic circuit components and bevel gears are integrated correctly and provide the required performance, stability, and durability, proper engineering design and calculations are essential. In order to guarantee dependable and safe functioning, testing and validation are also required.

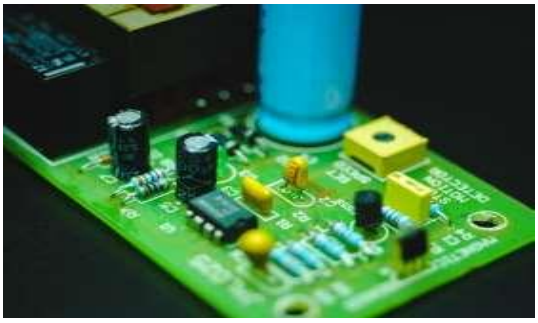

Figure 5. Circuit Board

III. CONSTRUCTION

Bevel gears can be used in the design of an automotive springless suspension The stem. Cone-shaped teethed bevel gears can be used to transmit torque and power from the axle of the car to the suspension system, offering a mechanical way to absorb shocks and vibrations. The bevel gears can be stacked in many ways, like worm or helical gears, to build a suspension system that is capable of efficiently reducing impacts and vibrations caused by uneven surfaces. To attain the intended performance and stability, the right gear ratios, tooth profiles, and bevel gear location in the suspension system should be determined using proper technical design and computations. When compared to conventional spring-based suspensions, the springless suspension system built with bevel gears may offer benefits including lighter weight, a more straightforward design, and possibly even lower costs. Considering elements like load capacity, durability, and safety requirements, testing and validation should be done to guarantee the bevel gears-based springless suspension system in the car operates safely and dependably.

IV. WORKING PRINCIPLE

An oscillating system and a differential mechanism are combined in the springless suspension system. A differential is a gear train consisting of three drive shafts, where the rotational speed of one shaft equals the average speed of the others or a fixed multiple of it. The repeated element is called oscillation. The majority of the system's frame is composed of mild steel. There is free oscillation of the tire-supporting frame. The differential is attached to the same frame. One gear in the differential system is the driving gear since it is coupled to a motor. On both sides, a bevel gear connects the driving gear. Every gear is linked to a pair of wheels on either side. Every wheel has its own motor driving it. Even on uneven terrain, the oscillating feature ensures that the vehicle continues to move forward while the motor ensures that the wheels and gears keep turning.

ADVANTAGES

- Reduced Weight
- Improved Performance
- Increased Durability
- Simplified Design

APPLICATION

- Electric Vehicles
- High-Performance Vehicles
- Off-Road Vehicles
- Military Vehicles

V. CONCLUSION

In conclusion, the idea of employing bevel gears to create springless suspension for cars has potential to revolutionize the automotive suspension system. Benefits of using bevel gears instead of typical springs or dampers for mechanical suspension include lighter weight, easier design, and maybe better performance under specific circumstances.

But there are obstacles and constraints to overcome, like the requirement for accurate gear manufacturing and design, possible problems with noise and vibration, and the requirement for extensive testing and validation. To fully explore the potential of springless suspension employing bevel gears, more research and development work is needed. This includes looking into various gear configurations, materials, lubrication techniques, and practical performance. Bevel gears-based springless suspension has the potential to be a practical alternative for automotive suspension systems in the future, providing enhanced handling, ride comfort, and overall vehicle performance with further technological and engineering breakthroughs.

REFFERENCE

[1] Abdulhammed and Hisham “Development of A New Automotive Active Suspension System”, Materials Science and Engineering (2017), 280.

[2] Shashank R, Shashank Kashikar S, Vishnu Sriram, Vivian Douza D, R. Srinivas, Manjunath M. Ullegaddi and Arun R “Design and development of suspension system for power generation”, Materials Today: Proceedings 42 (2021) 758–763.

[3] Mouleeswaran Senthil kumar “Development of Active Suspension System for Automobiles using PID Controller”, Proceedings of the World Congress on Engineering (2008), Vol 02.

[4] Vishnu prasad B, Nagaraja K, Murugendra arali, Thippeswamy PS and Thippeswamy R “Springless suspension system for an automobile”, JETIR (2014), Vol 10, pp: 881-886.

[5] Min Yu, Simos Evangelou A and Daniele Dini “Advances in Active Suspension Systems for Road Vehicles”, Engineering 33 (2024) 160–177.

[6] Duc Ngoc Nguyen and Tuan Anh Nguyen “Enhancing the performance of the vehicle active suspension system by an Optimal Sliding Mode Control algorithm”, Plos One (2022).

[7] Tuan Anh and Nguyen “Improving the Comfort of the Vehicle Based on Using the Active Suspension System Controlled by the Double-Integrated Controller”, Shock and Vibration (2021).

[8] AMA Soliman1 and MMS Kaldas “Semi-active suspension systems from research to mass-market – A review”, Journal of Low Frequency Noise, Vibration and Active Control (2019), pp: 1-9.

[9] Dhaval Patel P, Hardik Gohel R, Dhaval Panchal H and Sanjay Chourasia K “Design and Analysis of Suspension System”, Journal of Engineering and Technology (2022), 14.

[10] Gediminas Vaiciunas, Stasys Steisunas and Gintautas Bureika “Adaptation of Rail Passenger Car Suspension Parameters to Independently Rotating Wheels”, Transport Problems (2022), Vol 17, pp: 215-226.

[11] Yoshihiro Suda, Wenjun Wang, Minoru Nishina, Shihpin Lin & Yohei Michitsuji “Vehicle System Dynamics: International Journal of Vehicle Mechanics and Mobility”, Vehicle System Dynamics (2012), Vol 50, pp: 291-302.

[12] Gediminas Vaiciunas, Stasys Steisunas and Gintautas Bureika “Specification of estimation of a passenger car ride smoothness under various exploitation conditions”, Maintenance and Reliability (2021), Vol 23, pp:719-725.

[13] Lajqi Shpetim, Pehan Stanislav, Lajqi Naser, Baxhaku Bashkim, Ymeri Besim. Influences of the Suspension Parameters on the Vehicle Suspension Performance for a Terrain Vehicle. Journal of Mechanics Engineering and Automation (2012), New York, vol. 2, no. 9, pp. 550-554

[14] Gao Zepeng, Nan Jinrui, Liu Lian and Xu Xiaolin “Research on air suspension control system based on fuzzy control”, Energy Procedia 105 (2017) 2653 – 2659.

[15] Jianwen Zhang, Yang Xinglong, Lin Yi and Wang Wangyu, Meng Lingzhang, Yu Fei and Wang Lin “Performance Simulation Research on Bus with Air Suspension”, International Truck and Bus Meeting and Exhibition (2002).