Design and Development of Passive Magnetic Suspension System

Rajeev Dhavale[1], Somnath Gosavi[2], Balaji Ughade[3], Nitesh Rathod[4]
Department of Mechanical, PVPIT College of Engineering Pune, India

***Abstract*—This project explores a passive magnetic suspension system utilizing neodymium disc magnets arranged in a repulsive configuration to perform shock absorption in two-wheeler vehicles. The prototype employs like poles facing each other within steel hollow rods to create a stable air gap, producing suspension through magnetic repulsion. Mounted on a mild steel frame with welded joints, the system minimizes vibrations, noise, and body roll while offering customizable stiffness by adjusting magnet spacing. Designed as a low-maintenance and frictionless alternative to conventional suspensions, the system demonstrates potential for improved ride comfort and future automotive applications.**

Keywords: Magnetic Suspension, Neodymium Magnets, Shock Absorber, Two-Wheeler Suspension, Contactless Suspension

KEY FEATURES AND FUNCTIONS

A. Magnetic Suspension Setup
- Arranges permanent magnets in a repulsive configuration for shock absorption.
- Builds a rigid frame using mild steel and square bars for structural stability.

B. Shock Absorption
- Uses magnetic repulsion to cushion impacts from uneven surfaces.
- Reduces vibrations, noise, and body roll for improved ride comfort.

C. Adjustable Stiffness
- Allows tuning of repulsive force by adjusting magnet spacing.
- Customizes suspension response to suit different load and terrain conditions.

D. Maintenance and Efficiency.
- Operates without friction or lubrication, reducing wear and tear.
- Offers a low-maintenance alternative to traditional mechanical suspensions.

E. Maintenance and Durability
- Requires minimal maintenance due to contactless magnetic components.
- Offers increased lifespan by reducing mechanical wear and tear.

I. INTRODUCTION

Magnetic suspension systems offer an innovative, contactless approach to shock absorption by utilizing the repulsive forces between permanent magnets to stabilize and cushion vehicles and machinery. Unlike conventional suspensions that rely on springs or hydraulic fluids and suffer from wear, maintenance issues, and slower response times, magnetic suspension provides frictionless movement and faster adaptation to varying road conditions. This project focuses on a system using disc magnets arranged with like poles facing each other to create a repulsive force that absorbs shocks effectively while being supported by a durable mild steel frame.

The system's key advantage lies in its ability to modulate suspension stiffness by adjusting the magnet spacing, allowing for customizable ride comfort and improved stability. With fewer moving parts, reduced mechanical wear, and lower maintenance needs, magnetic suspension presents a promising alternative for automotive, bicycle, and industrial applications. This research explores the design, fabrication, and testing of a magnetic suspension prototype to demonstrate its potential as a next-generation shock absorption and stability solution.

Furthermore, magnetic suspension systems offer quieter operation due to the absence of physical contact between moving parts, reducing noise and vibrations transmitted to passengers. Their rapid response to dynamic road conditions enhances vehicle handling and safety. The technology also supports sustainability by eliminating the need for lubricants and fluids, reducing environmental impact. As automotive industries move towards smarter, more efficient systems, magnetic suspension could integrate with electronic controls to optimize performance in real time. Challenges such as cost and large-scale implementation remain, but ongoing research is steadily addressing these issues. This project contributes valuable insights into practical applications and future enhancements for magnetic suspension technologies.

II. METHODOLOGIES

The methodology for the fabrication of a magnetic suspension system involves a structured process encompassing design, simulation, fabrication, testing, and evaluation. Initially, the system is conceptualized using insights from existing literature, and designed in CAD software (e.g., SolidWorks) with calculations to optimize magnet spacing. Simulation tools like Ansys are then employed to predict performance under varying loads, allowing design refinements. Fabrication follows, using neodymium magnets and mild steel components, assembled through precise machining and welding. The system is then tested for shock absorption, stability, and load-bearing capacity using sensors and load cells. Finally, the results are evaluated and compared with conventional systems to assess performance, guiding future improvements.

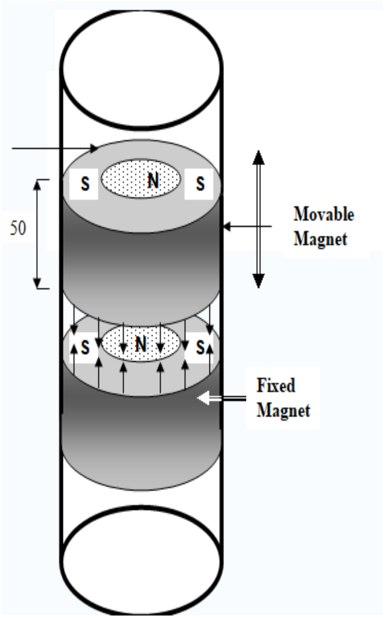

Figure 1 Systematic Diagram

III. LITERATURE REVIEW

Several studies highlight the growing relevance of magnetic suspension systems in enhancing ride comfort and reducing maintenance compared to traditional methods. daspute et al. (2017) demonstrated that magnetic repulsion effectively minimizes vehicle displacement and vibration, offering a low-maintenance alternative to hydraulic dampers.

Nalawade et al. (2024) explored the use of neodymium magnets in vehicles, showing improved responsiveness to road conditions and better durability. their findings support the system's potential to optimize control and comfort in real-time driving scenarios.

Bhagat et al. (2021) emphasized the manufacturing of permanent magnet-based suspension systems, noting reduced friction, adaptability, and minimal wear. these characteristics position magnetic systems as a promising replacement for conventional shock absorbers.

Nandish et al. (2019) and yadav (2018) both confirmed the effectiveness of magnetic repulsion for two-wheelers, with benefits like leak-free operation, weight reduction, and customizable stiffness. their research points to the long-term advantages of magnetic suspension in advancing sustainable, reliable vehicle design.

IV. CONCLUSION

- In conclusion, this research successfully demonstrates the feasibility and effectiveness of a passive magnetic suspension system using permanent magnets for two-wheeler applications. The system provides a smoother, more adaptive ride experience compared to conventional spring or hydraulic suspension by leveraging the repulsive force between neodymium magnets. The absence of fluid-based components and moving mechanical parts reduces wear and eliminates leakage issues, resulting in a low-maintenance and durable solution.
- Simulation tools such as finite element analysis played a crucial role in optimizing the design before fabrication, reducing the trial-and-error typically associated with prototyping. the fabricated model exhibited effective shock absorption during testing, validating both the design approach and material selection. additionally, the ability to fine-tune stiffness by adjusting magnet positioning offers a customizable suspension setup based on load and terrain conditions.

Beyond two-wheelers, this magnetic suspension concept holds promise for broader applications including lightweight electric vehicles, bicycles, and even public transport systems such as trams or light rail. Its contribution to sustainability—through energy efficiency, reduced environmental impact, and extended component lifespan—aligns with the global push toward greener transportation technologies.

Overall, the study highlights the potential of passive magnetic suspension systems as a next-generation alternative that balances performance, reliability, and environmental responsibility. Further research into material optimization, scalability, and dynamic response under real-time road conditions could unlock new possibilities for integrating magnetic suspension into mainstream automotive design.

REFERENCES

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Key Finding: Proposed a conceptual model of a magnetic suspension system for vehicles and discussed its benefits in reducing fluid leakage and mechanical degradation.

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Title: "Magnetic Suspension Systems: An Overview" – Journal of Applied Physics, Vol. 95, No. 2
Key Finding: Provided a comprehensive overview of magnetic suspension technologies, outlining fundamental principles, types of systems, and their advantages over traditional suspension methods.

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Key Finding: Detailed the design process and successful prototype implementation of a magnetic suspension system, highlighting improvements in response time and damping efficiency.