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Review on Design and Structural Analysis of a Differential Gearbox and Casing for Electric Vehicles

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Abstract: The rapid growth of electric vehicles (EVs) necessitates innovative approaches to improve power transmission efficiency, reduce weight, and enhance overall vehicle performance. A critical component in EV drivetrains is the differential gearbox, which transfers torque from the electric motor to the drive wheels while allowing differential wheel speeds during cornering. Conventional gearboxes, typically constructed from heavy cast iron or steel, significantly increase vehicle weight, adversely affecting energy efficiency and battery range. This study focuses on the design, modeling, and structural analysis of a single-speed, two-stage reduction compound differential gearbox and its casing, specifically optimized for EV applications. Finite Element Analysis (FEA) is employed to evaluate stress distribution, deformation, and thermal behavior under varying torque loads. The study explores alternative lightweight materials to replace traditional metals without compromising mechanical strength or durability. The proposed design aims to optimize structural performance, reduce overall weight, and ensure reliability under operational conditions. Results from this research provide valuable insights for developing advanced, lightweight differential gearboxes that enhance EV efficiency, improve driving range, and meet modern performance and durability requirements.
Keywords: Electric Vehicles (EVs), Differential Gearbox, Casing , Finite Element Analysis (FEA), Modal Analysis etc.

I. INTRODUCTION

The global transition toward sustainable transportation has accelerated the development and adoption of electric vehicles (EVs), ushering in a new era of automotive engineering. Unlike conventional internal combustion engine (ICE) vehicles, EVs demand specialized components that optimize energy usage, reduce emissions, and improve overall performance. Among these critical components, the differential gearbox plays a pivotal role. It is responsible for distributing torque from the electric motor to the drive wheels, allowing them to rotate at different speeds during cornering—essential for smooth and safe driving. However, the traditional differential gearboxes used in ICE vehicles are often unsuitable for EV applications due to their bulk and weight [1].

In EVs, weight reduction is a fundamental design goal, as it directly influences battery efficiency, driving range, and dynamic performance. Traditional gearboxes made from cast iron or cast steel are robust but heavy, contributing significantly to the vehicle's curb weight. Excess weight increases energy consumption, limits acceleration, and reduces range—all of which are critical performance parameters for EVs. Therefore, the need arises for lightweight materials and optimized designs that do not compromise on strength, durability, or functionality [2][3].

This study aims to address these challenges by focusing on the modeling and analysis of an EV-specific differential gearbox and its casing. The objective is to design a single-speed, two-stage reduction gearbox that meets specific torque and performance requirements while significantly reducing weight. A two-stage reduction system allows for compactness and torque multiplication, making it ideal for electric drivetrains that operate over a wide range of speeds and loads [4].

The gearbox casing, which houses and supports internal components such as gears, shafts, and bearings, must be structurally sound to withstand operating loads and environmental stresses. It should also have good thermal conductivity to dissipate heat generated during operation and should be designed to minimize noise and vibration. Therefore, material selection and structural optimization are crucial aspects of this research [3][4].

To achieve the design goals, this project utilizes CAD software for creating a precise 3D model of the gearbox assembly. Subsequently, Finite Element Analysis (FEA) is performed using ANSYS 14.5 to assess the structural integrity of the gearbox casing. Static analysis determines the stress and deformation under varying torque conditions, ensuring that the gearbox can handle peak loads without failure. In addition, modal analysis is conducted to identify the natural frequencies of the gearbox casing. Understanding these frequencies is critical for avoiding resonance, which can lead to excessive vibrations and eventual mechanical failure. The modal analysis is performed under free-running conditions, without applying boundary constraints, to evaluate the inherent dynamic behavior of the structure [5].

The study also includes statistical and dynamic analysis to evaluate various design alternatives and material combinations. By identifying optimal design parameters and lightweight, high-strength materials such as aluminum alloys or composite structures, the project seeks to enhance the performance and efficiency of EV powertrains.

This research not only aims to design a reliable and efficient differential gearbox for EVs but also provides a deeper understanding of structural behavior under operational conditions. The outcomes are expected to contribute to the broader goal of improving EV performance, extending battery life, and supporting sustainable transportation.

II. PROBLEM IDENTIFICATION

1) Electric vehicles (EVs) require highly efficient and lightweight power transmission systems to maximize energy efficiency and driving range.
2) Traditional differential gearboxes are generally constructed from heavy cast iron or steel, significantly increasing the vehicle's overall weight and energy consumption.
3) Excessive gearbox weight reduces battery performance and limits the potential distance an EV can travel on a single charge.
4) The differential gearbox casing must endure varying torque loads and thermal conditions during operation, which can lead to stress concentration, deformation, or failure if not properly designed.
5) Conventional gearbox designs are often not optimized for the specific torque and speed requirements of modern electric drivetrains.
6) Finding suitable lightweight materials that can maintain high mechanical strength, resist wear, and handle thermal effects remains a challenge.
7) Inadequate casing design may allow contamination or lubricant leakage, compromising gearbox durability and efficiency.
8) There is a lack of comprehensive studies that integrate advanced modeling, lightweight material selection, and stress analysis for EV-specific differential gearboxes.
9) Addressing these issues is vital to developing a high-performance, reliable, and efficient gearbox system for next-generation electric vehicles.

III. LITERATURE SURVEY

A. *Literature Review*

Ganesan and Kumar (2021) analyzed a lightweight gearbox design for EVs using aluminum alloys to replace conventional cast iron. Their study focused on stress analysis and weight reduction using ANSYS Workbench. They observed a 40% weight reduction with comparable strength and performance. The gearbox design was optimized for electric drivetrain requirements, which have different load characteristics than internal combustion engines. Their findings highlight the potential of material substitution in improving EV efficiency. Modal and harmonic analyses were also conducted to avoid resonance issues. This paper provided essential insights into how lightweight materials and FEA-based design can enhance EV transmission systems while ensuring durability under variable torque loads.

Zhang et al. (2020) conducted a finite element-based analysis of an EV gearbox housing using aluminum alloy instead of traditional cast steel. The study demonstrated that significant weight savings could be achieved without compromising structural integrity. Stress and deformation under maximum torque loads were within safe limits. Modal analysis was performed to ensure the natural frequencies of the housing did not align with operational excitation frequencies. The authors emphasized the importance of considering both static and dynamic loading conditions during the design process. Their work supports the use of advanced simulation tools and alternative materials for optimizing EV gearbox housings to enhance overall energy efficiency and reduce vehicular weight.

Singh and Mehta (2019) investigated the stress distribution and vibrational characteristics of gearbox housings under varying operational loads. The study employed FEM analysis to evaluate the modal frequencies and potential resonance conditions. It was found that increasing structural stiffness and optimizing support geometry could significantly reduce vibration amplitudes. While their research was conducted on a conventional gearbox, the insights are applicable to EV systems, where noise and vibration reduction is critical for passenger comfort and mechanical safety. The paper emphasized the role of modal analysis in predicting system behavior under operational conditions and provided design recommendations to minimize vibrational failures in gearbox assemblies.

Huang and Zhou (2018) presented a comprehensive thermal and structural analysis of an EV gearbox housing using finite element methods. Their research showed that aluminum-based alloys not only reduce weight but also enhance thermal dissipation, which is critical in electric drivetrains. Static structural analysis confirmed the casing could withstand peak torque loads, while thermal simulations demonstrated that the selected material reduced temperature rise during prolonged operation. The study concluded that thermal and structural optimization must go hand-in-hand for effective EV gearbox design. Their integrated approach provides a model for balancing heat management, weight, and durability in high-performance EV components.

Borkar and Deshmukh (2022) focused on optimizing a differential gearbox casing using FEA with the goal of weight minimization and performance enhancement. They explored different materials, including magnesium and aluminum alloys, and analyzed their impact on stress, deformation, and vibration characteristics. The simulation results showed that optimized aluminum casings achieved up to 30% weight reduction with minimal compromise in strength. The authors also conducted modal analysis to identify critical natural frequencies and avoid resonance. The study underscores the potential of FEA in evaluating design alternatives and material suitability in automotive transmission systems, particularly for lightweight, high-efficiency applications like electric vehicles.

Sharma and Thakur (2020) presented a detailed study on the design and efficiency analysis of a single-speed gearbox for electric vehicles. Using CATIA and ANSYS, they modeled the gearbox system and performed structural simulations to evaluate stress and deformation. The study revealed that gearbox efficiency can be improved by up to 15% through the use of optimized gear profiles and lightweight aluminum casing. Their analysis also included load distribution and material fatigue life, demonstrating that material and structural optimization are essential for enhancing the performance and durability of EV transmission systems. The study provides a solid foundation for further research in lightweight and efficient EV gearbox development.

Kim and Lee (2019) applied topology optimization techniques to reduce the weight of an automotive gearbox housing without compromising structural strength. The study utilized FEA tools to identify and remove low-stress regions in the gearbox casing. The optimized design showed a 25% weight reduction and improved vibration resistance. Although the case study focused on conventional vehicles, the approach is directly applicable to EVs, where minimizing weight is crucial. The paper emphasized the importance of incorporating modal and harmonic analysis early in the design process. The authors concluded that topology optimization is an effective strategy for developing high-performance, lightweight gear housings in modern vehicle systems.

Patel and Desai (2021) investigated the structural performance and vibrational behavior of gearbox casings specifically designed for electric scooters. Using ANSYS Workbench, they performed static stress and modal analyses under real-time torque values. Their findings demonstrated that magnesium alloy casings offered the best trade-off between weight and structural performance. The modal analysis identified critical frequency ranges, allowing designers to avoid resonance with motor vibrations. The study also proposed minor geometrical enhancements to stiffen the structure and reduce deflection. This work supports the trend of designing EV-specific transmission components using advanced materials and simulations for lightweight and vibration-resistant systems.

Reddy and Rajan (2017) conducted a vibration and material optimization study for EV differential gearboxes. Their objective was to identify materials that minimize noise, vibration, and harshness (NVH) characteristics while also reducing weight. Through modal and harmonic analyses using ANSYS, they compared steel, aluminum, and hybrid composites. The aluminum alloy performed optimally in terms of weight and frequency behavior. The study concluded that using aluminum with internal ribs significantly increased natural frequency, thus reducing vibration. The research emphasized the importance of NVH consideration in differential gearbox design for EVs, as consumer comfort and mechanical longevity depend on it.

Thomas and Gupta (2022) carried out a comparative analysis of various materials for EV gearbox casings, including traditional metals, polymer composites, and hybrid materials. The study used simulation and experimental methods to analyze tensile strength, thermal conductivity, and vibration response. It was observed that carbon-fiber-reinforced polymers (CFRP) offered substantial weight reduction—up to 50%—while maintaining acceptable stiffness and thermal stability. However, issues with cost and manufacturability were noted.

The study recommended a hybrid metal-polymer structure for mass-market EVs. Their comprehensive analysis underscored the need for sustainable material choices in gearbox design, balancing weight, strength, and production feasibility for large-scale adoption.

B. *Literature Summary*

The reviewed literature highlights the growing emphasis on optimizing differential gearbox designs specifically for electric vehicles (EVs), focusing on improving energy efficiency, structural integrity, and weight reduction. Traditional materials like cast iron and steel, although durable, significantly increase the overall weight of the vehicle, thereby reducing battery efficiency and range. Several researchers, including Ganesan & Kumar (2021) and Zhang et al. (2020), explored the use of lightweight materials such as aluminum and magnesium alloys, demonstrating notable reductions in weight without compromising structural strength. Studies by Kim & Lee (2019) and Patel & Desai (2021) introduced topology optimization and modal analysis techniques to eliminate low-stress areas and avoid resonance frequencies, improving vibration resistance and operational safety. Reddy & Rajan (2017) emphasized noise and vibration control (NVH), while Thomas & Gupta (2022) highlighted the potential of hybrid materials and composites. However, most works lack a holistic approach combining thermal, structural, and vibrational analyses. The literature establishes a clear need for an integrated design methodology using advanced materials and finite element methods to develop lightweight, high-performance gearbox systems tailored specifically for modern EV applications.

C. *Research Gap*

Despite significant advancements in the modeling and analysis of gearbox systems for electric vehicles (EVs), notable research gaps remain. Most existing studies focus on conventional material substitution (e.g., steel to aluminum) but lack exploration of advanced composites or hybrid materials that offer superior weight-to-strength ratios. Additionally, limited integration of multi-objective optimization—considering thermal, vibrational, and structural performance simultaneously—has been observed. Current research often isolates static or modal analysis without a holistic design-validation approach, especially under real-world dynamic torque conditions. Moreover, there is inadequate emphasis on EV-specific gearbox designs tailored for high-efficiency, low-noise operation. This project addresses these gaps by optimizing an EV-specific differential gearbox through advanced materials, integrated FEA, and dynamic performance evaluation for enhanced efficiency and reliability.

IV. RESEARCH METHODOLOGY

A. *Criteria for selecting this study:*

1) Focused on electric vehicle (EV) applications, making it directly relevant to modern drivetrain requirements.
2) Investigates lightweight materials (aluminum, magnesium, composites), addressing vehicle weight and energy efficiency concerns.
3) Incorporates Finite Element Analysis (FEA) for stress, deformation, and modal behavior, ensuring structural reliability.
4) Studies differential gearbox design, a critical EV component affecting torque distribution and wheel dynamics.
5) Considers multi-stage reduction gearboxes, relevant for EV motor speed-to-torque optimization.
6) Evaluates vibrational and thermal performance, essential for passenger comfort and mechanical longevity.
7) Applies topology and material optimization, providing insights into efficient structural design and NVH reduction.
8) Offers experimental validation or comparative simulations, strengthening confidence in proposed designs.
9) Highlights the trade-off between weight reduction and mechanical strength, crucial for EV efficiency.
10) Combines design, structural, and operational perspectives, offering a comprehensive approach missing in many prior studies.

B. *Method of analysis*

1) CAD Modeling: Create detailed 3D models of differential gearbox and casing using SolidWorks or CATIA.
2) Material Selection: Evaluate conventional metals, lightweight alloys, and hybrid composites for strength, weight, and thermal behavior.
3) Static Structural Analysis: Apply torque loads and boundary conditions using FEA (ANSYS Workbench) to identify stress concentrations and deformation zones.
4) Modal Analysis: Determine natural frequencies and mode shapes to avoid resonance during EV operation.
5) Thermal Analysis: Simulate temperature rise and thermal expansion under prolonged operational conditions to assess material suitability.

6) Dynamic Load Simulation: Model real-world torque variations to predict performance under acceleration, braking, and cornering scenarios.
7) Topology Optimization: Remove low-stress regions to reduce weight while maintaining structural integrity.
8) Comparative Evaluation: Assess different materials and geometries for weight, strength, thermal performance, and vibration characteristics.
9) Validation: Ensure design meets mechanical and thermal safety factors and supports manufacturability.

C. Comparison and Analysis

Sr. No	Author(s) & Year	Material/Method	Key Findings	Relevance to Study
1	Ganesan & Kumar (2021)	Aluminum alloys, FEA	40% weight reduction, comparable strength, modal analysis avoided resonance	Demonstrates material substitution for EV gearboxes
2	Zhang et al. (2020)	Aluminum, FEA	Stress and deformation within safe limits, modal analysis for frequency alignment	Supports lightweight material use and vibration control
3	Singh & Mehta (2019)	FEM, structural & vibration	Optimized stiffness reduces vibration amplitudes	Provides design insight for NVH improvement
4	Huang & Zhou (2018)	Aluminum, thermal & structural FEA	Reduced weight, improved heat dissipation, structural reliability	Integrates thermal management with structural design
5	Borkar & Deshmukh (2022)	Aluminum & magnesium alloys, FEA	Up to 30% weight reduction, resonance avoided	Highlights multi-material optimization potential
6	Sharma & Thakur (2020)	CATIA & ANSYS, structural analysis	15% efficiency improvement, stress and fatigue life analyzed	Demonstrates design optimization impact on performance
7	Kim & Lee (2019)	Topology optimization	25% weight reduction, vibration resistance improved	Shows effectiveness of topology optimization for EVs
8	Patel & Desai (2021)	Magnesium alloy, FEA	Optimized geometry, vibration-resistant design	Supports EV-specific lightweight casing design
9	Reddy & Rajan (2017)	Aluminum & hybrid composites, NVH	Aluminum with ribs reduces vibration, optimal weight	Highlights NVH considerations for EV comfort
10	Thomas & Gupta (2022)	CFRP & hybrid materials, simulation & experiment	Up to 50% weight reduction, acceptable stiffness, hybrid structures recommended	Explores advanced materials for mass-market EV gearbox

D. Evaluation of methodologies used in the reviewed studies

1) Finite Element Analysis (FEA): Most studies employed FEA for stress, deformation, thermal, and vibration analyses, providing accurate simulation-based evaluation of gearbox performance.
2) Modal & Harmonic Analysis: Frequently used to identify natural frequencies, avoid resonance, and reduce NVH, ensuring operational reliability.
3) Topology Optimization: Applied in several studies to remove low-stress regions, achieving weight reduction without compromising structural strength.
4) Material Substitution Studies: Focused on lightweight alloys (aluminum, magnesium) or composites, often compared with conventional steel for weight and durability.
5) CAD-Based Modeling: SolidWorks, CATIA, or similar platforms were used to create detailed gearbox and casing geometries for FEA and optimization.
6) Integrated Thermal-Structural Analysis: Some studies combined thermal simulations with structural evaluation for high-efficiency EV designs.
7) Experimental Validation: Limited in most studies; simulations often lacked real-world testing for verification.
8) Multi-Objective Evaluation: Rarely integrated stress, thermal, and vibration performance simultaneously.

E. Highlighting trends, advancements, and challenges

1) Trends

- Shift toward lightweight materials like aluminum, magnesium, and composites for EV gearboxes.
- Increased use of FEA and modal analysis for structural and vibration optimization.
- Adoption of topology and geometry optimization to minimize weight and improve NVH.
- Integration of multi-stage reduction gearboxes for efficient torque management in EV drivetrains.
- Growing focus on EV-specific gearbox designs tailored for high efficiency and low energy loss.

2) Advancements

- Up to 50% weight reduction achieved using advanced alloys or hybrid materials.
- Improved thermal management through material selection and casing design.
- Enhanced vibration resistance and NVH control via modal and harmonic analysis.
- Optimization of gear profiles and load distribution for higher efficiency and durability.
- Topology optimization techniques enabling lightweight, high-strength gearbox structures.

3) Challenges

- Limited real-world experimental validation of simulation results.
- High cost and manufacturability issues for composite or hybrid materials.
- Insufficient integration of structural, thermal, and vibrational analysis in a single design workflow.
- Lack of dynamic load simulations under real driving conditions.
- Balancing weight reduction with mechanical strength and durability remains a critical challenge.

V. DISCUSSION

A. Synthesis of findings from literature

1) Lightweight Materials: Aluminum, magnesium, and hybrid composites consistently reduce gearbox weight by 25–50% without compromising strength.
2) Structural Optimization: FEA-driven analysis identifies stress concentrations and enables geometry and topology optimization for enhanced durability.
3) Vibration & NVH Control: Modal and harmonic analyses are crucial for avoiding resonance, improving passenger comfort, and extending component life.
4) Thermal Management: Integration of thermal simulations with structural analysis ensures material stability and performance under prolonged EV operation.
5) Multi-Stage Gearbox Design: Two-stage reduction gearboxes efficiently convert high-speed motor output to optimal wheel torque while maintaining structural integrity.

6) Design Integration: Combining material selection, structural, thermal, and vibration analyses leads to higher efficiency and reliability, though rarely applied holistically in prior studies.
7) Efficiency & Performance: Optimized casings and gear profiles improve energy efficiency, reduce NVH, and enhance overall EV drivetrain performance.
8) Research Gap: Few studies integrate all performance aspects with advanced lightweight materials for EV-specific differential gearboxes.

B. Methodology for Future Research Directions

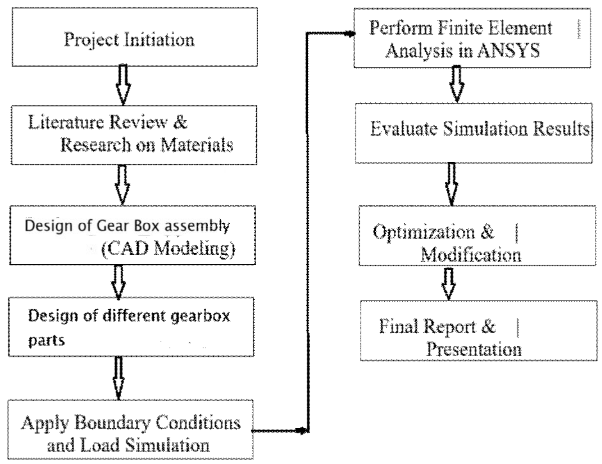


Fig.1. Flow Diagram of this study

1) The differential gearbox transmits torque from the electric motor to the drive wheels, enabling smooth power delivery while allowing the wheels to rotate at different speeds during cornering.
2) This study uses a single-speed, two-stage reduction compound gearbox to reduce the high-speed, low-torque output of the EV motor to a lower speed and higher torque suitable for the wheels.
3) The first reduction stage decreases the rotational speed while increasing torque, and the second stage further refines this output for optimal wheel performance.
4) The differential mechanism inside the gearbox splits the torque between the left and right wheels, compensating for differences in wheel rotation during turns.
5) The gearbox casing encloses and protects the gears, maintains alignment, and contains the lubricant that reduces friction and wear.
6) Finite Element Analysis (FEA) is applied to simulate stress, deformation, and thermal behavior under various torque loads to ensure structural reliability.
7) Lightweight materials are analyzed and selected to replace traditional heavy metals, minimizing weight without compromising strength.
8) The final design aims to balance durability, weight efficiency, and performance, contributing to greater energy efficiency and range in electric vehicles.

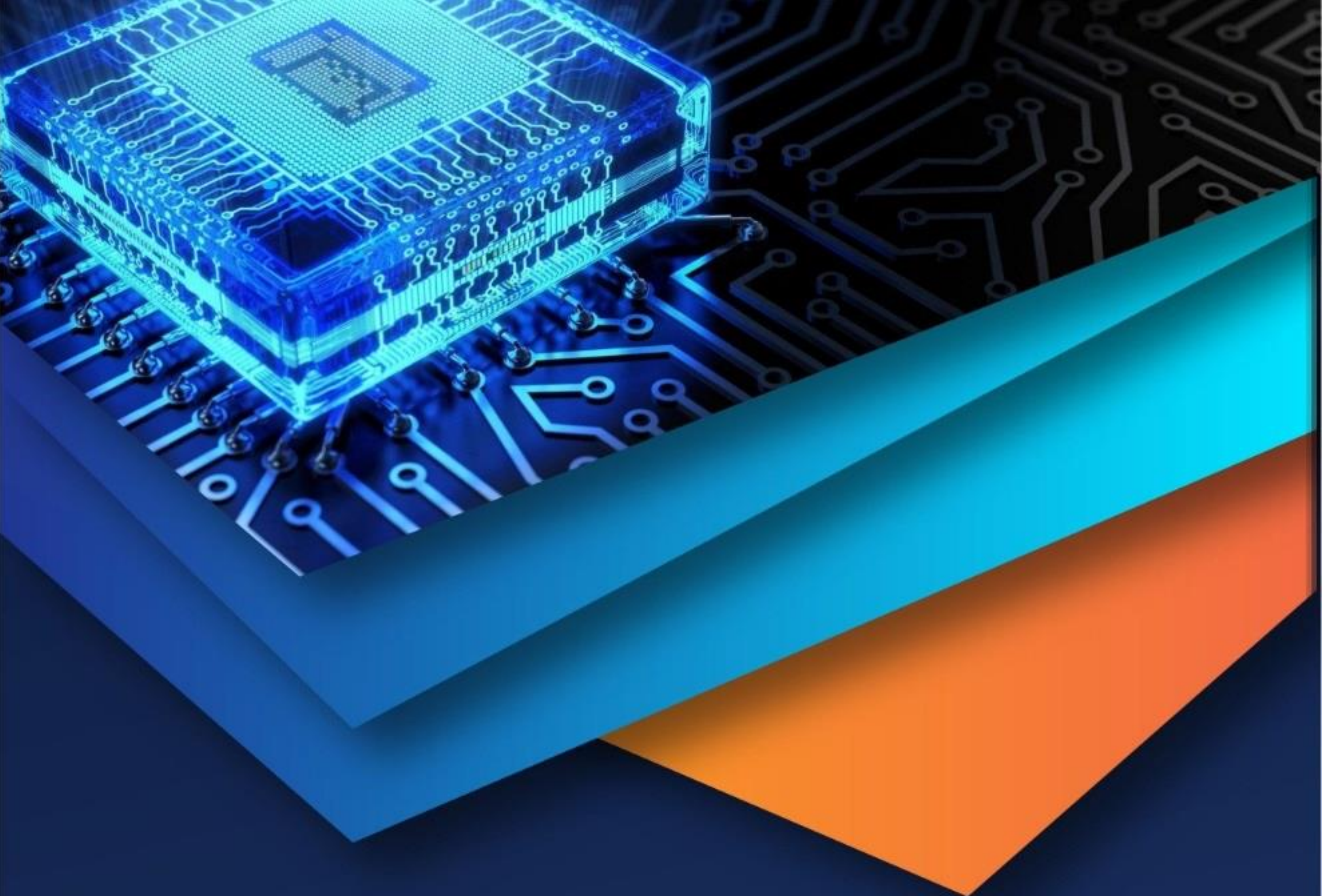
VI. CONCLUSION

The reviewed literature underscores the growing emphasis on designing lightweight, efficient, and reliable differential gearboxes for electric vehicles (EVs). Studies consistently demonstrate that substituting conventional materials like cast iron and steel with aluminum, magnesium, or hybrid composites significantly reduces weight while maintaining structural integrity. Finite Element Analysis (FEA), combined with modal, harmonic, and thermal analyses, has emerged as a critical tool for optimizing gearbox design, ensuring durability, minimizing vibration, and enhancing NVH performance. Topology optimization and geometry refinement further improve weight-to-strength ratios and operational efficiency. However, most studies focus on individual aspects—material selection, structural analysis, thermal management, or vibration control—rather than adopting an integrated, multi-objective approach.

Additionally, real-world dynamic loading and manufacturability considerations are often underexplored. This review highlights the need for comprehensive methodologies that simultaneously address structural, thermal, and vibrational performance using advanced materials tailored specifically for EV differential gearboxes. Implementing such holistic approaches can significantly enhance EV efficiency, reliability, and driving range, guiding future research and design strategies in this domain.

REFERENCES

[1] Ganesan, M., & Kumar, R. (2021). Design and Analysis of Lightweight Gearbox for Electric Vehicles. International Journal of Mechanical Engineering and Technology.
[2] Zhang, Y., Li, H., & Wang, J. (2020). Finite Element Analysis and Lightweight Design of Electric Vehicle Transmission Housing. Materials Today: Proceedings.
[3] Singh, A., & Mehta, S. (2019). Vibration and Stress Analysis of Gearbox Housing for Automotive Applications. Journal of Vibration Engineering & Technologies.
[4] Huang, X., & Zhou, D. (2018). Thermal and Structural Analysis of EV Gearbox Housing Using FEM. SAE International Journal of Materials and Manufacturing.
[5] Borkar, V. S., & Deshmukh, P. D. (2022). Optimization of Differential Gearbox Casing Using Finite Element Analysis. International Research Journal of Engineering and Technology (IRJET).
[6] Sharma, R., & Thakur, A. (2020). Design and Analysis of Electric Vehicle Gearbox for Efficiency Improvement. International Journal of Automotive and Mechanical Engineering (IJAME).
[7] Kim, H., & Lee, J. (2019). Lightweight Design of Automotive Gearbox Housing through Topology Optimization. Journal of Mechanical Science and Technology.
[8] Patel, J., & Desai, M. (2021). Structural and Modal Analysis of Gearbox Casing for Electric Scooters. International Journal of Engineering Trends and Technology (IJETT).
[9] Reddy, S. K., & Rajan, R. (2017). Vibration Analysis and Material Optimization of Differential Gearbox in Electric Vehicles. Engineering Science and Technology: An International Journal.
[10] Thomas, B., & Gupta, R. (2022). A Comparative Study on Gearbox Housing Materials for Sustainable EV Applications. Materials Research Express.



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