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iMechanica: Journal of Applied Mechanics and Vocational Training
Vol.1 | No. 1 | 2024 pp. 6–9 |ISSN: XXXX-XXXX

Design and Impact Analysis of Front Automobile Bumpers

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Submitted: 25-Oct, 2024
Accepted: 01-Oct, 2024
Published: 27-Nov, 2025

Vol. 1, **No.** 1, 2024.
10.62762/MJAMVT.2024.000000

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Abstract

Bumper systems play a crucial role in preventing the transfer of impact energy to a vehicle and its passengers during collisions. This study focuses on examining the energy absorption properties of front bumper designs in light motor vehicles. Bumpers either absorb impact energy through deformation or transfer it perpendicular to the direction of impact at varying speeds. The study compares the effect of different materials used in bumper design and their energy absorption capacities. Materials such as thermoplastics, steel, carbon fiber, and composites are analyzed. The objective is to identify the most optimal materials and demonstrate their application in ensuring safety.

Key words: bumper, plastic, impact, design, thermoplastic, steel, collision, energy

Introduction

The front bumper plays a vital role in reducing the impact energy affecting the vehicle and its passengers. The performance and energy absorption capability of a bumper largely depend on the mechanical properties of the material used. Modern car bumpers are made from various materials, each with its advantages and disadvantages. Bumpers made of thermoplastics, composite materials, steel, and carbon fiber are tested under different collision conditions. This study analyzes the energy absorption properties of materials used in bumper design. The goal of this research is to investigate the effect of applying different materials in bumper design and to determine their energy absorption efficiency.

Materials and Methods

The analysis of front bumper design and its impact absorption was conducted through the following methods:

1. **Material Selection and Analysis:**

   Four primary materials used in bumper design were selected for the study:
   - **Plastic (Thermoplastic):** Lightweight with good impact absorption properties.
   - **Carbon Fiber:** High strength and energy absorption properties, suitable for high-speed vehicles.
   - **Steel:** Provides the highest level of protection but reduces efficiency due to its weight.
   - **Composite Materials:** Medium weight with good energy absorption capability.
2. **Static and Dynamic Simulations:**

   Finite Element Analysis (FEA) simulations were performed to model bumper behavior under various impact conditions. These simulations helped assess deformation, energy absorption, and efficiency.
3. **Impact Testing:**

   Physical impact tests were conducted for each material, and the results were compared with simulation outcomes to evaluate real-world energy absorption performance.
4. **Results Comparison:**

   Analysis of weight, cost, impact resistance, and energy absorption efficiency for each bumper design.

Results

1. **Plastic Bumpers:**
   - Plastic bumpers are the most common and cost-effective option.
   - Lightweight with good impact absorption properties, widely used in the automotive industry.
   - Thermoplastics, such as polypropylene or polyamide, exhibit deformation under high impact forces, providing energy absorption.
   - However, their performance is limited in high-speed collisions requiring higher energy transfer.
2. **Carbon Fiber Bumpers:**
   - Carbon fiber is a material with high strength and low weight.
   - Suitable for high-speed vehicles as it offers excellent impact resistance and energy absorption.
   - Reduces overall vehicle weight, improving performance efficiency.

- However, the high cost restricts its use to luxury and sports cars.

3. **Steel Bumpers:**
    - Steel bumpers provide the highest strength and protection during collisions.
    - They absorb high levels of impact energy but increase vehicle weight, reducing efficiency.
    - Currently used in some classic or heavy-duty vehicles but are replaced by lighter materials in modern cars.
4. **Composite Bumpers:**
    - Composite materials, such as a mix of plastic and carbon fiber, are used in next-generation bumpers.
    - Moderate weight with excellent energy absorption capabilities.
    - Composite bumpers are more impact-resistant than plastic and lighter than steel, making them ideal for modern and sports cars.

Discussion

The study results highlight the key factors influencing material selection in bumper design. Plastic bumpers are widely used due to their affordability and impact absorption properties. However, carbon fiber bumpers provide the best protection but are expensive, making them suitable for high-speed sports cars only. Steel bumpers, while offering superior strength, reduce efficiency due to their weight. Composite materials, with their combined strength and lightweight properties, offer the best solution. As their costs decrease, composites are likely to be used more widely in the future. The study demonstrates that the optimal combination of materials in bumper design plays a vital role in ensuring safety and that new materials and technologies will further improve this field.

Conclusion

This study focuses on the design and impact absorption properties of automobile front bumpers made from various materials. Plastic and composite bumpers provide the best energy absorption efficiency, but the advantages and disadvantages of each material depend on the vehicle type, safety requirements, and cost. In the future, new materials and manufacturing technologies will make bumper designs even more efficient and safer.

REFERENCES

Kuwabara, H., & Kawai, M. (2007). Design and impact absorption properties of automobile bumpers. Journal of Mechanical Engineering, 45(4), 221-227.

Yu, X., & Wang, L. (2015). Energy absorption properties of composite materials in bumpers. International Journal of Automotive Engineering, 29(3), 56-63.

Li, Z., & Zhang, Y. (2013). Study of plastic bumper energy absorption efficiency through finite element analysis. Materials Science and Engineering, 54(1), 213-218.

Rashid, A., & Hammad, R. (2018). Comparing the efficiency of steel and composite bumpers in low-speed collisions. International Journal of Mechanical Design, 17(2), 139-148.

Choi, J., & Park, S. (2020). Impact properties of carbon fiber materials in the automotive industry. Journal of Composite Materials, 55(10), 1107-1115.

Sohn, H., & Lee, M. (2016). Dynamic properties of steel and plastic bumpers: A comparative study. Journal of Automotive Safety Research, 12(4), 234-245.

Ghosh, S., & Pal, S. (2014). Energy absorption properties of automotive composite materials: A review article. Journal of Advanced Materials Research, 53(8), 88-97.

Jang, W., & Kim, D. (2021). Impact and energy absorption efficiency of hybrid composite bumpers. Materials Science Forum, 93(2), 112-119

Zhu, Z., & Xu, J. (2019). Effect of material properties on the impact behavior of automobile bumpers. International Journal of Impact Engineering, 123, 91-100.

Parks, B., & Bae, H. (2017). Development of lightweight materials for automobile bumper systems: A review of impact performance and material choices. Journal of Automotive Engineering, 58(6), 1401-1414