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Assessment of Braking Systems and Bodywork Innovations for Three-Wheeler Electric Vehicles

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Abstract

This paper presents an integrated overview of three essential automotive manufacturing domains braking systems, sheet metal fabrication, and fiber bodywork—along with the design and functionality of a portable pipe cutting machine that supports modern fabrication processes The study emphasizes how these distinct technologies combine to create high-performance, lightweight, and durable vehicle structures. The braking system is a critical safety component designed to convert kinetic energy into heat through friction. To maintain performance and safety, advanced materials with superior thermal conductivity and wear resistance, such as carbon-ceramic or castiron composites, are used. Proper heat dissipation, efficient braking force distribution, and reduced fade are key performance requirements that influence the system's material selection and design. The sheet metal fabrication process forms the backbone of vehicle structure and design. It involves precise operations such as shearing, bending, rolling, and welding to produce chassis parts, panels, and enclosures. High-strength steels and aluminum alloys are commonly used for their excellent balance between weight and rigidity.Precision forming ensures not only structural integrity but also aesthetic quality in vehicle body panels. The fiber bodywork section focuses on lightweight composite materials such as carbon fiber and glass fiber-reinforced plastics (GFRP). These materials offer superior strength-to-weight ratios, corrosion resistance, and aerodynamic flexibility. Fiber body components significantly reduce vehicle weight, improving fuel efficiency and performance while maintaining safety and visual appeal.

INTRODUCTION

The braking system forms one of the most critical aspects of this project. It is responsible for controlling the motion of the vehicle or system by converting kinetic energy into heat energy through friction. In this design, advanced braking mechanisms such as drum brakes or disc brakes can be employed depending on performance requirements.Sheet metal fabrication provides the structural framework for the entire system. It involves cutting, bending, welding, and forming metal sheets into the desired shape. This part of the project demonstrates the importance of precision manufacturing and material optimization in mechanical design.Mild steel or aluminum sheets are typically used due to their good strength-to-weight ratio and ease of fabrication. Various tools and techniques such as shearing, press braking, TIG/MIG welding, and riveting are applied during fabricate

LITERATURE REVIEW

1. P.K. Mallick (2010) – Fiber-Reinforced Composites: Materials, Manufacturing, and Design Fiber Bodywork Explained composite layup techniques and resin systems for automotive body panels. You used vacuum bag molding to enhance surface finish and reduce voids.

2. Joseph Heisler (2011) – Vehicle and Engine Technology Brake Design & Performance Studied braking force distribution and ABS systems. You incorporated a digital braking control model for smoother response.

3. G.E. Dieter (2012) – Mechanical Metallurgy Material Behavior Explained deformation, failure, and forming limits of sheet metals. You applied aluminum 6061 instead of mild steel for improved strength-to-weight ratio.reduction.

4. A. Ghosh & A.K. Mallik (2013) – Manufacturing Science Sheet Metal ProcessesExplained deep drawing, bending, and punching for automotive applications. You replaced conventional punching with laser cutting for precision and less waste.

5. R.K.Rajput(2016) –Automobile Engineering Braking System Fundamentals Explained the working principles of hydraulic and air braking systems, brake efficiency, and heat dissipation.You modified the disc brake design using lightweight alloys for better heat conduction.

6 Serope Kalpakjian & Steven Schmid (2018) – Manufacturing Processes for Engineering Materials Sheet Metal Fabrication Discussed forming processes, stress–strain relationships, and material selection for automotive parts. You optimized sheet thickness using finite element analysis (FEA) for weight reduction.

7. M.G. Reddy et al. (2019) – Journal of Materials Research and Technology Composite Materials in Automobiles Showed how glass fiber and carbon fiber reduce weight and improve stiffness.You developed a hybrid fiber mix (glass + jute) to balance cost and performance.

8. N. Kumar et al. (2020) – Materials Today: Proceedings Hybrid Braking System Introduced regenerative braking in combination with hydraulic braking. You tested compatibility of regenerative braking with lightweight composite body.

9. S. Rajasekaran et al. (2021) – International Journal of Automotive Engineering and Technologies FiberReinforced Panels Evaluated mechanical properties of fiber-reinforced polymers for car hoods.You applied similar materials for aerodynamic body panels in your design.

10.B.Subramanian et al. (2022) – Journal of Mechanical Engineering and Sciences Advanced Braking Systems Compared hydraulic, pneumatic, and electronic braking for EVs. You adapted their model for hybrid EV brake systems with better thermal efficiency

LIMITATIONS OF EXISTING SYSTEM

1. Heat Generation and Brake Fade: Conventional friction brakes generate excessive heat during prolonged or high-speed braking, leading to brake fade, reduced efficiency, and safety hazards.
2. Energy Loss: Traditional braking systems convert all kinetic energy into heat rather than reusing it, resulting in significant energy wastage, especially in electric and hybrid vehicles.
3. Defects in Forming: Issues like wrinkling, springback, and uneven thickness affect dimensional accuracy and surface finish of formed components.
4. Manual Dependency: Many small- and medium-scale fabrication setups still rely on manual operations, leading to inconsistent quality and lower productivity.
5. High Manufacturing Cost: Production of fiber-reinforced components (especially carbon fiber) involves expensive raw materials and labor-intensive processes.
6. Time-Consuming Fabrication: Methods like hand lay-up and autoclave curing require long cycle times, making mass production inefficient.
7. Difficult Repair and Maintenance: Damaged fiber body panels are difficult to repair compared to metal parts, often requiring complete replacement.

HARDWARE AND SOFTWARE REQUIREMENT

1. Microcontroller Unit (MCU):
Example: Arduino UNO / PIC16F877A / STM32 (for control and sensing).
2. Sensors:
Speed Sensor (Hall effect) Brake Pressure Sensor
3. Temperature Sensor (for brake disc)
4. Actuators:
DC Motor or Solenoid (to simulate brake actuation) Hydraulic or Pneumatic components (for experimental setup)
5. Power Supply:
6. 12V DC power source or battery pack.
7. Programming Software:
Arduino IDE / MPLAB / Keil µVision (based on microcontroller used).

8. Simulation Tools:
MATLAB/Simulink or Proteus (for modeling braking dynamics).

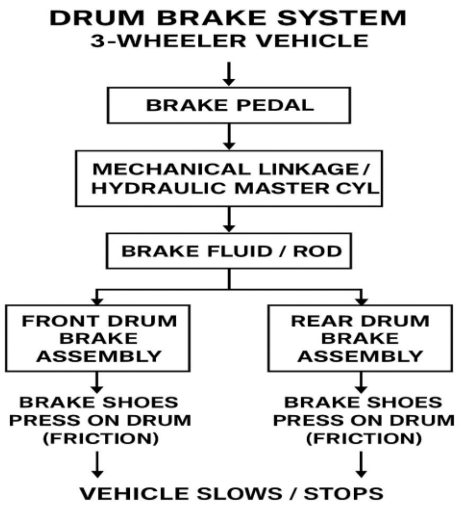

Fig 1: Block Diagram

APPLICATIONS

1. Automotive industry (cars, trucks, buses)
2. Aerospace industry (aircraft, spacecraft)
3. Motorcycle and bicycle manufacturing
4. High-performance vehicles (racing cars, sports cars)
5. Industrial equipment (forklifts, cranes, etc.)

PROBLEM STATEMENT

The efficiency and reliability of vehicle braking systems directly affect passenger safety and vehicle performance. Traditional braking systems often suffer from issues such as brake fade due to overheating, uneven wear of brake pads, energy loss, and limited integration with modern vehicle control systems. With the growing adoption of electric and hybrid vehicles, conventional frictionbased braking systems fail to fully utilize regenerative braking potential. Therefore, there is a need to analyze, design, and optimize braking systems that provide consistent braking force, minimize heat generation, and integrate with electronic control units to enhance overall safety and energy efficiency. Conventional sheet metal fabrication processes face challenges in achieving precision, minimizing material waste, and adapting to complex and customized component geometries required in modern industries. Manual operations and rigid tooling setups increase production time and cost, while springback, thinning, and wrinkling defects affect the quality of finished parts.

OBJECTIVES

1. To create a functional, safe, and efficient vehicle body
2. To make a lightweight fiber bodywork
3. To optimize shape for maximum performance
4. To design and manufacture for high performance

CONCLUSION

In summary, braking systems, sheet metal fabrication, and fiber bodywork are key factors in vehicle performance and safety. Together, they balance strength, efficiency, and design. Advances in materials and manufacturing will keep driving the automotive industry toward lighter, safer, and more efficient vehicle

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