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Review RTFM

Safety Braking System to Avoid the Failure in Air Brake Hoses

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Abstract

The braking system represents one of its most important components of any vehicle, as failure can result in devastating accidents. This study describes the design and development of an Air Brake Hose Failure Detection and Safety Braking System to address the problem of brake failure in big vehicles. The system monitors the condition of air brake hoses in real-time and provides audio-visual alerts to the driver in case of any abnormalities. A secondary braking system is integrated into the design to activate automatically upon detecting brake hose failure, ensuring continuous vehicle control and safety. The proposed system integrates pneumatic cylinders, solenoid valves, pressure switches, and a sensor-based monitoring mechanism to effectively prevent fluid leakage and ensure reliable braking performance. Designed for heavy vehicles such as buses and trucks, the system continuously monitors pressure levels and responds in real time to any abnormalities. This proactive approach helps maintain consistent braking functionality, reducing the risk of accidents caused by brake failure. Initial testing demonstrates the system's efficiency, showing it to be both cost-effective and space-saving. Its modular design allows for easy integration into existing vehicle systems without major modifications. Overall, the solution offers a robust and adaptable safety enhancement for commercial transportation, supporting both operational reliability and improved road safety.

Keywords: Brakes, fluid leakage, detection, secondary brakes line, safety

INTRODUCTION

A mechanical device, called a brake, slows, pauses, or stops the velocity of an object in motion. Although alternative forms of energy conversion may be employed, the majority of brakes use friction between two surfaces that are compressed together to transform the kinetic energy of the moving object into heat. For example, regenerative braking generates a large amount of energy, including heat energy, into electrical energy, which can be stored or returned to the source for later use. Other methods convert kinetic energy to potential energy in stored form, such as pressurized oil or compressed air. In brake discs, fins, and rails, eddy current brakes use magnetic fields to transform kinetic energy into electric current, which is subsequently transformed into thermal energy. Alternative braking methods are available for converting kinetic energy into different forms, such as transferring it to a rotating flywheel.

Brake systems are essential to the automotive industry because they provide critical safety and reliable performance for vehicles worldwide [1]. Automated control systems currently operate the majority of equipment. To satisfy the demands of a growing population, inexpensive, effective, and dependable machine control systems are required. The main objective of this project is to keep an eye on the braking system at all times when a car is moving. Currently, several factors contribute to

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accidents, including brake failure, which can be caused by inappropriate use, inadequate maintenance, or product defects. In cars, brake accident monitoring is crucial to prevent accidents that can endanger human lives. The circuit, known as the brake failure indicator circuit, continuously checks the condition of the brakes and displays an audiovisual signal. The brake system of the car is accurate and functions properly when the green LED blinks and piezo buzzer sound for approximately a second when the brake is used to slow or stop the vehicle. When brakes are engaged, the buzzer does not sound, and the red LED glows if the brake system malfunctions. In addition, this system avoids fluid leaks from the brake and continues the bypass in the event of primary brake line failure.

LITERATURE REVIEW

Mohan created a method to stop collisions caused by brake failure, and their solution detects hydraulic brake failure due to oil leakage using sensors, which warns the driver about the failure, activates a secondary braking system using hub motors on the rear wheels, and cuts off the engine ignition to help stop the vehicle [2]. Ahmed created a method to stop accidents caused by brake failures. Their project detected brake pressure loss using sensors. This system warns the driver of brake failure, activates a secondary braking system powered by rear-wheel motors, and ensures safety using both primary and backup braking systems. This device helps prevent accidents by offering an alternative method of stopping the car if the main brakes fail [3]. Venkatachalapathi developed a system to detect brake failure and overheating in cars. Their system used sensors on brake shoes and liners. As per the work done, it is useful to detect wear or damage in the braking system, send signals to a microcontroller for analysis, activate a warning indicator if an issue is found, and stop the vehicle if the failure is serious. This system enhances safety by alerting drivers to break issues before accidents occur [4]. Chaudhary developed an automatic brake failure indicator to monitor a vehicle's braking system in real-time. Their system uses audio-visual alerts to indicate brake condition, Green LED and beep brake working fine, and Red LED and no beep brake failure is detected. This system helps drivers quickly identify brake issues and reduce accidents caused by brake failure [5]. Anant Nemade studied road accidents and brake failures, emphasizing the importance of properly maintaining brakes in preventing accidents. Their study highlights brake failure as a major accident cause and a manufacturer's responsibility, regular brake maintenance to improve safety, and India's goal of reducing road accidents by 50% (2011-2020) [6]. They concluded that while technology enhances safety, basic brake system upkeep is crucial for preventing accidents [7].

The braking system and indicator to indicate brake failure automatically, developed by R. Kishan, help prevent accidents caused by brake failure. The system monitors the braking system and alerts the driver to a buzzer if failure occurs. It also activates a secondary braking system using a motor to apply backup brakes and to safely stop the vehicle. Compact, affordable, and easy to implement, this system enhances vehicle safety by providing an early warning and backup braking [8]. Plug stem failure was analyzed to investigate its cause [9].

METHODOLOGY

The control unit, frame, and pressure differential sensor circuit comprise an Automatic Brake Failure Indicator and Auxiliary Braking System. The brake valve unit receives control signals from the sensor that gauges the pressure in the brake fluid line. The auxiliary brake is coupled to the wheel frame, and when the primary port valve detects air loss, the secondary valve instantly activates, applying the backup brake, and stopping the car [10]. The pressure transducer sensor constantly monitored the brake line pressure. If the primary air disc brake fails and pressure is lost, the sensor warns the driver with a warning signal and activates the secondary braking system, which uses hub motors in the wheels.

This device functions as a supplementary braking system, assisting the driver in properly stopping the vehicle and ensuring the passenger's safety. Brake failure, frequently caused by poor maintenance or product flaws, is a serious safety issue. Monitoring brake performance in automobiles is critical for saving lives and preventing accidents [4]. Vehicle safety focuses on avoiding accidents and limiting their negative consequences, particularly for human health. Vehicles have a variety of safety measures, some meant to protect people and others to protect others on the road. We are happy to present our latest project, "Automatic Braking Fluid Leakage Detection with Safety Bypass Braking System," which enhances vehicle safety by utilizing sensors and auxiliary braking units.

DESIGN

Design involves the application of scientific principles, technical knowledge, and creativity to develop or improve machines and mechanisms that efficiently and economically perform specific functions. Therefore, a careful design approach is required. System design and mechanical design are the two primary components of the design process.

System design focuses on addressing physical constraints, selecting basic working principles, determining space requirements, and arranging various components. Key considerations in the system design include the selection of the system based on physical limitations. Compatibility with mechanical design is ensured by accommodating the dimensions and specifications defined during the mechanical design [3]. Efficient component arrangement to maximize space utilization and for ease of maintenance and servicing is achieved through simplified layouts that facilitate easy assembly and quick decision-making during component installation. In mechanical design, the components are categorized based on whether they are custom-designed or purchased. The custom parts are carefully detailed, and their dimensions are compared with the standard dimensions available on the market. This helps to streamline the assembly process and post-production work. The design process includes specifying tolerances and creating process charts handed over to the manufacturing team. For purchased parts, catalogs were consulted to ensure ease of procurement, and the necessary specifications were provided. The following are the design calculations for the system.

Motor Selection

- The motor was a single-phase DC motor with a power rating of 50 watts.
- Its speed ranges from 40 to 60 revolutions per minute (rpm).

Torque of Motor

$$P = \frac{2\,\Pi\,\mathrm{N}\,\mathrm{T}}{60}$$

$$T = \frac{60 \times 50}{2 \times \pi \times 60}$$

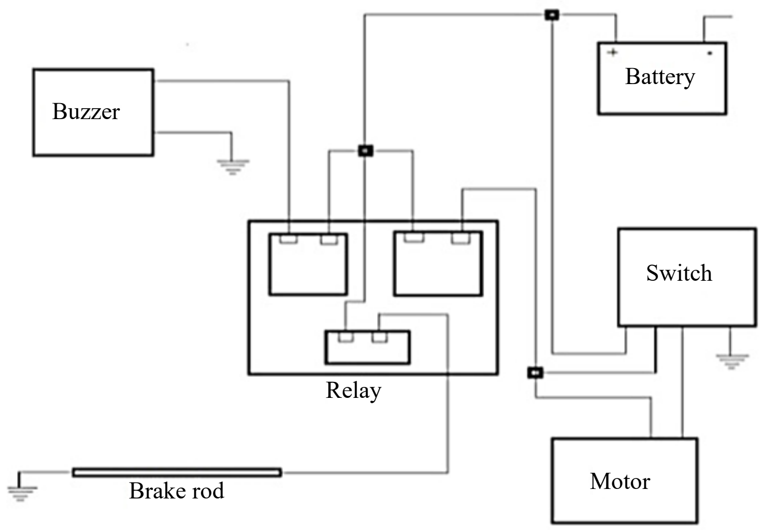

Figure 1. Circuit Diagram.
Note: T = 7.96 N-m.

An open belt drive transmits power from the motor shaft to the input shaft (Figure 1).

20 mm is the motor pulley diameter.

The diameter of the IP shaft pulley is 60 mm.

Reduction Ratio = 3 Speed of Motor = 60 rpm

Speed of motor pully = 60 rpm *Speed of shaft pully* = 20 rpm IP shaft speed = 60/3 = 20 rpm.

Torque at IP rear shaft = 3 x 7.96= *23.88 Nm*

Design of Belt Drive

Pulley diameter for motor d = 20 mm

Pulley diameter for shaft D = 60 mm

Coefficient of friction = 0.23

Let,

Thickness of belt = 5 mm

Width of belt = 6 mm

Mass of belt per unit length is given by;

ρ = density of belt material = 950 kg/m^3

M = 0.0285 kg/m

Shaft Design

By using ASME Code:

Select d =12 mm

Bearing Selection

- Equivalent dynamic load Pe = 110.3625 N
- Bearing life is, L^{10} = 28.35 millions of revolutions.

Design of Pneumatic Cylinder

- S_{ut} = Ultimate tensile strength = 200 N/mm^2
- μ = Poisson's ratio for the cylinder material = 0.29
- di = Inner diameter of cylinder = 25 mm
- t = 0.25 mm
- A = 490.87 mm^2 Piston
- A_{PR} = 412.334 mm^2 Piston rod side

Design of Disc Brake

The frictional radius Rf for uniform pressure theory:

- Rf = 63.33 mm.

The torque capacity of brake is Mt = 3264.26 N.mm.

Area of Pad A = 490.86 mm^2

Angular dimensions of the pad θ = 17.99^0

CONCLUSIONS

The proposed system enhances vehicle safety by detecting brake hose failures and automatically activating secondary braking mechanisms to prevent accidents. Integrated pressure sensors enable real-time monitoring, offer early warnings of potential brake system issues, and allow timely intervention. This proactive safety feature is particularly beneficial for air-brake vehicles, such as buses and trucks, where brake failure can lead to severe consequences. The compact and cost-effective design of the system ensures ease of installation with minimal modifications, making it suitable for both new and existing vehicles. Their scalability and adaptability support their widespread adoption in the transportation industry. By combining reliability, affordability, and efficiency, the solution significantly contributes to reducing brake-related accidents and improving the overall road safety for heavy-duty vehicles.

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