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BRAKE SHOE OVERHEAT INDICATION SYSTEM FOR HEAVY VEHICLES IN HILL STATIONS USING THERMOCOUPLE AND ARDUINO

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Original research

A B S T R A C T

This paper introduces a novel Brake Shoe Overheat Indication System designed to enhance the safety of heavy vehicles operating in hill stations. The system utilizes a combination of thermocouples and Arduino microcontroller to monitor and indicate brake shoe temperatures. A threshold temperature of 300 degrees Celsius is set, and the system provides visual indications through green and red lights along with an audible alarm, thereby preventing accidents due to brake overheating. This system aims to enhance safety by providing real-time alerts to drivers, minimizing the risk of accidents due to brake failure.

1. INTRODUCTION

This paper addresses this issue by presenting a Brake Shoe Overheat Indication System, leveraging thermocouple technology and Arduino microcontrollers.This system aims to enhance safety by providing real-time alerts to drivers, minimizing the risk of accidents due to brake failure (Jiménez et al., 2016). Number of the systems could be find using Arduino platform (Aswani et al., 2008). Safety critical situations are for example loss of control (such as rollover and lateral stability) and a majority of these occur during speed when cornering. Other critical situations are avoidance manoeuvre and road edge recovery (Trigell et al., 2017).

2. SYSTEM ARCHITECTURE

Arduino boards can be used and programmed in various ways, and can be arranged in various combinations forming some typical implementation architectures (Matijevic & Cvjetkovic, 2016). The core components include a thermocouple embedded in the brake system and an Arduino microcontroller responsible for processing temperature data (Zheng et al., 2018; Igorevich, 2020). When the temperature surpasses the predefined threshold of 300 degrees Celsius, the system activates a red light indicator and a buzzer alarm, signaling the need for immediate attention. Conversely, a green light indicates normal operating temperatures

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3. HARDWARE IMPLEMENTATION

Integrate the thermos couple into the brake system, ensuring proper placement for accurate temperature measurements (Belhocine & Afzal, 2020). Connect the thermocouple to the Arduino microcontroller following the designed architecture (Tayab & Yuen, 2017). Connect and test the visual indicators (red and green lights) and the buzzer to ensure they respond correctly to the programmed conditions.

4. SYSTEM BLOCK DIAGRAM

The design of hardware components are done and processed by Arduino UNO. The software implementation is by Arduino IDE tool. Figure 1 depicts block diagram of the system.

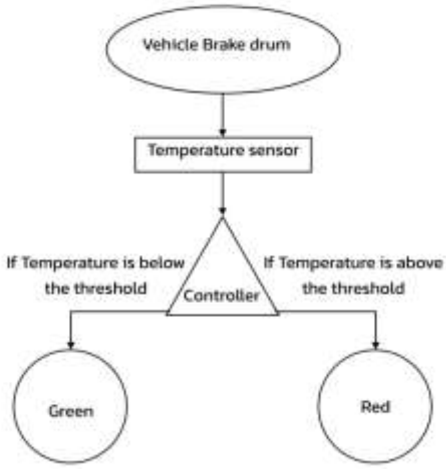

Figure 1. Block diagram of the system

If temperature is below the threshold the indicator is green, if temperature is above the threshold the indicator is red.

5. OPERATION OF THE SYSTEM

The Brake Shoe Overheat Indication System operates by continuously monitoring the temperature of the brake shoes in heavy vehicles navigating hill stations. Embedded within the brake system, a thermocouple detects temperature variations and transmits analog signals to an Arduino microcontroller (Carminati & Scandurra, 2021).

Through a calibration process, these signals are converted into accurate temperature readings (Bramley & Pickering, 2006). The system compares these readings with a predefined threshold of 300 degrees Celsius. If the temperature surpasses the threshold, the microcontroller triggers a red light indicator and activates a buzzer alarm, providing immediate visual and auditory warnings to the driver.

Conversely, if the temperature remains below the threshold, a green light indicates normal operating conditions. This proactive approach enables drivers to take timely actions, such as reducing speed or finding a safe stopping point, thereby preventing potential accidents caused by brake overheating in challenging terrains. The continuous monitoring capability ensures ongoing safety assurance throughout the vehicle's journey.

6. ARDUINO PROGRAM

In the following section the Arduino program is presented.

```
// Define pins for components
const int thermocouplePin = A0;   // Analog pin for thermocouple
const int greenLightPin = 2;// Digital pin for green light
const int redLightPin = 3;   // Digital pin for red light
const int buzzerPin = 4;     // Digital pin for buzzer
 // Define threshold temperature in degrees Celsius
const int thresholdTemperature = 300;
 void setup() {
  // Initialize digital pins
  pinMode(greenLightPin, OUTPUT);
  pinMode(redLightPin, OUTPUT);
  pinMode(buzzerPin, OUTPUT);
   // Serial communication for debugging (optional)
  Serial.begin(9600);
}
 void loop() {
  // Read analog value from thermocouple
  int thermocoupleValue =
analogRead(thermocouplePin);
   // Convert analog value to temperature in degrees Celsius
  float temperature =
analogToCelsius(thermocoupleValue);
   // Print temperature for debugging (optional)
  Serial.print("Temperature: ");
  Serial.print(temperature);
  Serial.println(" °C");
   // Check if temperature exceeds the threshold
  if (temperature > thresholdTemperature) {
        // Activate red light and buzzer
        digitalWrite(redLightPin, HIGH);
        digitalWrite(buzzerPin, HIGH);
        // Optionally, you may want to add a delay or other actions here for driver awareness
  } else {
        // Deactivate red light and buzzer, activate green light
        digitalWrite(redLightPin, LOW);
        digitalWrite(buzzerPin, LOW);
        digitalWrite(greenLightPin, HIGH);
  }
   // Add a delay to prevent rapid readings (adjust as needed)
  delay(1000);
}
```

```
// Function to convert analog value to temperature in degrees Celsius
float analogToCelsius(int analogValue) {
  // Your conversion logic based on thermocouple characteristics
  // This is a simplified example, actual conversion may vary
  // Consult the thermocouple datasheet for accurate conversion formulas
  float resistance = 10000.0 / ((1023.0 / analogValue) - 1.0);
  float temperature = 1.0 / ((1.0 / 298.15) + (1.0 / 10000.0) * log(resistance / 10000.0));
  temperature -= 273.15;  // Convert from Kelvin to Celsius
  return temperature;
}
```

7. ADVANTAGES

7.1 Enhanced Safety

Provides real-time monitoring of brake shoe temperature, offering immediate alerts in case of overheating. Reduces the risk of accidents due to brake failures, especially in challenging terrains like hill stations.

7.2 Adaptability to Different Vehicles

Applicable to a wide range of heavy vehicles operating in diverse environments, making it a versatile safety solution.

7.3 Proactive Warning System

Alerts drivers before critical failure occurs, allowing for timely intervention and preventive actions. Enables drivers to take precautionary measures, such as reducing speed or finding a safe stopping point.

8. MODEL PROJECT IMAGE

Figure 2. Model of the system

Figure 2 depicts model of brake shoe overheat indication system for heavy vehicles in hill stations using thermocouple and Arduino.

9. CONCLUSION

This system consists of various sensors to monitor the safety while operating. The Brake Shoe Overheat Indication System presented in this paper demonstrates a proactive approach to enhance heavy vehicle safety in hill stations. By leveraging thermocouple technology and Arduino microcontrollers, the system effectively monitors brake temperatures, issuing timely warnings through visual and auditory signals. Implementation of this system has the potential to significantly reduce the incidence of accidents resulting from brake failure in challenging terrains.

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