Advance Drive Interface, Brake Health Monitor

Venkateshwaran Ramesh[1], Ezhilarasan A[2]

[1,2]*UG students, Dept. of automobile Engineering, Sri Venkateswara college of Engineering, Chennai, India*

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Abstract - *Today's world is highly fast-paced, and we all know how vital brakes are in this environment. The effectiveness of the braking system is critical in avoiding accidents and saving lives. In addition, the majority of car accidents are caused by brake failure. Here, I'm interested in learning about the reasons of hydraulic braking system failure. The brakes are a car's most significant active safety feature and one of its most critical components. Many drivers, on the other hand, do not appear to comprehend it. According to data, the brakes account for around 30% of the problems found by the ITV. When anything goes wrong with the automobile, bringing it to the shop isn't enough. Brake fluid leaks are a common occurrence. If brake fluid escapes in any situation, it may result in an accident. As a result, leakage and performance are critical. The pressure decrease in the brake fluid line suggests a problem with the braking system in this case. The front display shows that the pressure has dropped.*

***Keyword's*: Braking, Leakage, Failure, Safety, Pressure, Display**

1. INTRODUCTION

Intelligent systems that remain within the car and aid the driver in a number of ways are known as advanced driver interface systems. This system displays virtual information on the state of an automobile component, as well as analyses the component and displays the results of the analysis (working condition and life span of the component). The benefit of employing this technique is that it eliminates accidents caused by component failure. According to the National Highway Traffic Safety Administration (NHTSA) National Motor Vehicle Crash Causation Survey, vehicle malfunctions such as braking failure cause around 2% of all motor vehicle crashes. Brake failure is responsible for around 22% of all automobile accidents. By analyzing an automobile subsystem (brake) and displaying virtual data.

1.1 LITERATURE REVIEW

Marcus Bomer, Harald Straky, Thomas Weispfenning, and Rolf Iserman are among the cast members. As electronic equipment become more integrated with mechanical components, mechatronic systems' problem detection and diagnostics become more vital. The work of defect detection may be separated into two parts in general. The present process state must first be derived from the process's observable input and output signals in the first stage. Model-based fault detection approaches such as parameter estimates, state estimation, and parity equations, as well as signal-based methods such as signal spectrum estimation, can be used to do this. Following that, the derived characteristics are compared to the fault-free condition. This causes a variety of symptoms that indicate the presence of problems. The goal of fault diagnosis in the second stage is to determine the kind, magnitude, and location of the problem.

a) Brake Fault Diagnosis: V.Indira, R.Vasanthakumari Machine fault diagnostics is a branch of mechanical engineering that focuses on locating machine flaws. The most likely defects leading to failure were identified using a variety of approaches such as vibration analysis, acoustic emissions, thermal imaging, and so on. Methods such as spectrum analysis, wavelet analysis, and waveform analysis are used to analyse the vibration signals. This type of study will provide you the information you need to decide when maintenance intervention is necessary. The findings of these studies are utilised in failure analysis to figure out what caused the defect in the first place. A machine learning technique can be used to do this failure analysis.

b) Fault Diagnosis of Hydraulic Brake: R.Jegadeeshwaran, R.Jegadeesh Vibration signals from a car will be non-stationary due to wear and tear. To overcome such issues, data modelling employing a machine learning technique might be applied. Feature extraction, feature selection, and feature categorisation are the three fundamental phases in machine learning. Statistical features, autoregressive moving average (ARMA) features, histogram features, and wavelet features are all examples of features. Statistical characteristics were employed in this investigation.

1.2 Brake Fluid Leaks in Hydraulic Brake System:

The hydraulic braking system is designed to operate in a closed environment. A brake pedal, numerous switches, a reservoir, brake lines, various cylinders, linkages, pistons, and braking fluid make up the brake system. The reservoir, master cylinder, and brake lines are all immobile, whereas switches and pistons are constantly moving. Damage to any of these components can lead to brake fluid leaks, which can damage the vehicle's braking performance and reaction.

1.3 Causes of Brake Fluid Leaks:

There are various scenarios in which a vehicle's brake fluid leaks. A leak might be coming from one of the rubber hoses, braking calipers, wheel cylinders, or master cylinders.

- Whether the lines have a hole, a split, or a damaged portion, braking fluid will begin to leak. When braking, the lines that transport the liquid back and forth through the brake system will cause a quick shift in sensation. The brake pressure will not be present due to the hole or breaking in the line, therefore it will feel and maybe not deliver enough stopping force.

- The fluid from the brake is sometimes removed by the bleeder valve's bolts or valves and sent to other sections of the braking system. It is typical to have braking issues when it fails. This usually occurs after the brakes have been replaced or the fluid has been cleaned, and the bolts have been tightened

- The master cylinder is the component of the braking system through which the majority of the brake fluid goes. It is one of the most prevalent causes of brake fluid leaks since it tends to wear down with time and mileage.

- When a wheel cylinder or caliper is damaged, it begins to leak fluid. When this happens, the most revealing sign is braking fluid on the wheel's edges, as the liquid tends to seep towards the wheel when it leaks.

2. SCOPE OF THE PROJECT:

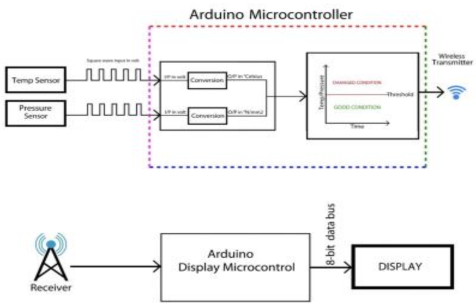

Fig -1: Scope Design of the Health Monitor

A driver Interface system will be created using an Arduino microcontroller. The Arduino microcontroller controls the interface screen. The interface screen receives touch input from the end-user. Then the interface screens provide engineering vehicle information to the end-user. Provide technical feedback for drivers who are interested in gaining knowledge about their vehicle information. The Brake Health Monitor to modify driving cycle. The location of the interface screen is in the

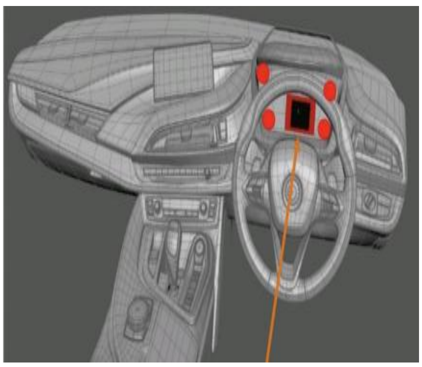

Fig -2: Interface Screen Mounting Tabs

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vehicle dashboard. And the mounting place should not be in a blind spot. And the end-user can access the interface screen without any disturbance and the interface screen also should not disturb any other parts of the dashboard. The brightness of the screen should be in low or medium. Because the brightness will distract the driver. The cordless transceiver module is a compact design and circuit. The Auto-Cad 3D modeling (fig. 2) shows the mounting tabs in a model car dashboard. Those red dots are suitable places for the interface screen mount.

2.1 Target Features:

Display the following features in the driver interface screen.

- The pressure of brake fluid
- Pressure leak in the hydraulic brake system
- Condition of the hydraulic brake system
- The temperature of a brake disc (Rotor)

3. SIMULATION:

In addition to the advancement of new technologies, the design process in the industry has changed dramatically in recent years. For sophisticated embedded systems, Model-Based Design is now widely employed in the automobile, aerospace, and other sectors. A traditional design workflow contains the following steps:

- Requirement
- Design
- Implementation
- Test and Validation

Simulink is a graphical programming environment that uses MATLAB to model, simulate, and analyze multi-domain dynamical systems. It has a graphical block diagram tool and a configurable collection of block libraries as its primary interface.

3.1 Hydraulic Brake System Model:

The brake pressure leak simulation modal has a physical vehicle brake system model and simulation vehicle brake system model. The pressure leak only occurs in the physical vehicle model. Brake input block and pedal displacement to pedal force block are giving brake pedal force (in kg) to the physical and simulation system model. The blocks are shown below in (Figure. 3) Hydraulic brake system model block

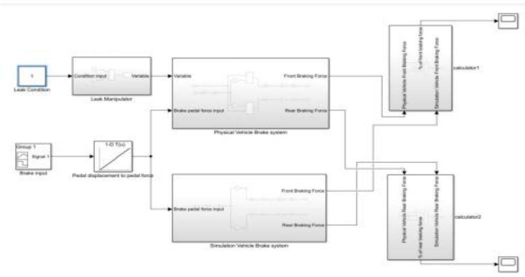

Fig -3: Hydraulic brake system model block.

3.2 Physical Vehicle Brake System Model:

The physical vehicle brake system is getting the brake pedal force and leak manipulation variable from leak manipulator sub-blocks. The brake pedal input force is driver applied force. And used gain blocks to calculate the force on the master cylinder. Then using product block to calculate variable efficiency in the physical vehicle. Finally, the front wheel braking force and rear wheel braking force are calculated. The block is shown below (Figure.4) Physical

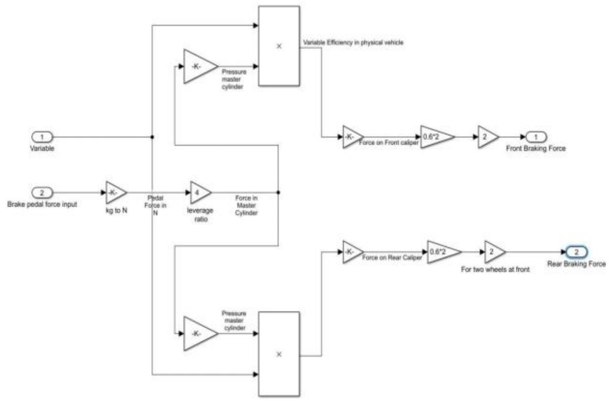

Fig -4: Physical brake system model block.

3.3 Leak Manipulator Model:

Leak manipulator is creating a pressure leak in the physical vehicle brake system. This leak manipulator is getting input from a constant block. There is a pressure leak if the value of the constant block is one, otherwise, there is no pressure leak. And the random number generator is used in this model. Here, the low pass filter is used to reduce the noise in the signal. The block is shown below in (Figure. 5)Leak manipulator model block.

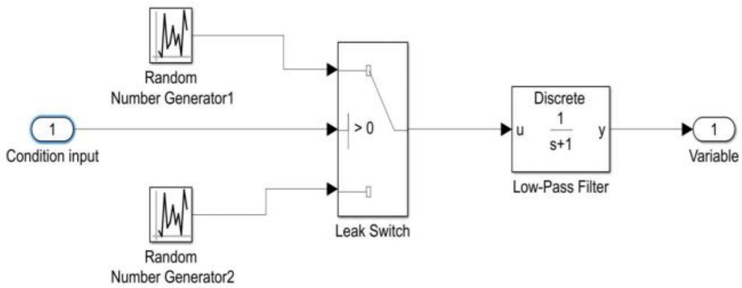

Fig -5: Leak manipulator model block

3.3 Simulation Vehicle Brake System Model:

The simulation vehicle brake system is getting the brake pedal force from the bake input block and pedal displacement. The brake pedal input force is driver applied force. And used gain blocks to calculate the force on the master cylinder. Then the front wheel braking force and rear wheel braking force are calculated. There is no pressure leak in the simulation vehicle brake system. The block is shown below in (Figure. 6) Simulation vehicle brake system model block.

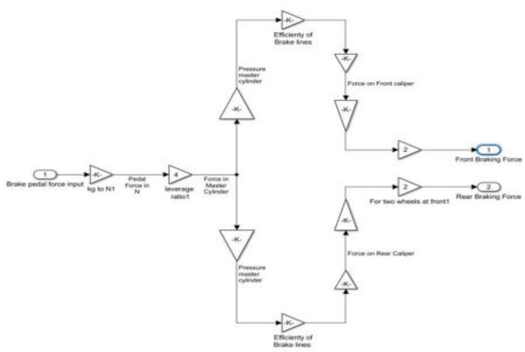

Fig -6: Simulation Vehicle brake system model block.

3.4 Percentage of Rear Wheel Braking Force Model:

The rear braking forces of the physical vehicle and simulation vehicle brake system are compared. Finally, the percentage of rear wheel braking force is calculated. The Percentage of Rear Wheel Braking Force Model.

Eventually, this simulation model will be created four graphs. The graphs show the change in brake force comparing with the ideal model. Without pressure leak, the actual model has a small change in force 20 percentage of braking force. And it is reduced from the ideal model. But in with leak model, the braking force changes 58 percentage with respect to the ideal model. By analyzing the graphs, set 53 to 59 percent braking force as a threshold point. When the braking force goes around 53 to 59 percent, there is a pressure leak.

4. DESIGN AND PROTOTYPE:

The brake health monitor is divided into two units which are brake unit and dashboard unit. These units are fixed in different places of the vehicle. So, the NRF23L01 transceiver module helps to communicate with each other. Both units can transmit the data as well as receive the data. When the brake unit is transmitting the data, the dashboard unit is receiving the data from the brake unit. There are no data losses because it is cordless. And this NRF23L01 transceiver module's frequency range is 2.3Ghz ISM band.

4.1 Measuring Brake Pressure and Fluid Leak:

The pressure transducer is mounted on the brake line by T-joint. The brake pedal has a stopper at some constant point. This stopper will not allow the brake pedal to go further. Now conduct the test on the good condition of the brake line, the transducer will send a voltage signal to the Arduino Uno microcontroller. The voltage signals are already calibrated to the appropriate pressure units(N/mm2). The microcontroller is continuously monitoring brake pressure at the constant brake force. And the tests will conduct in the different brake forces. Set this constant brake pressure as a threshold at constant brake pressure and when the pressure goes below the threshold at the constant condition, there is brake fluid pressure leak. These data are stored in the local Arduino Uno microcontroller.

4.2 Measuring Disc Brake Rotor Temperature:

The infrared temperature sensor is mounted near the disc brake rotor. This brake rotor is a dynamic object which means it is spinning. So, the sensor takes 120 milliseconds to measure the temperature of the rotor. And this sensor sends direct temperature output Arduino Uno (This sensor has a built-in library so no need to calibrate it). These data are also stored in the local Arduino Uno microcontroller.

4.3 Wireless Data Transmission:

The brake unit Arduino Uno microcontroller stores data from the pressure transducer and the infrared temperature sensor. And the stored data are compared to the reference data (it is an open-loop system) and processed by Arduino Uno microcontroller. Those processed data are transmitting via radio signals by using the NRF23L01 transceiver module.

The dashboard unit's NRF23L01 transceiver module receives those signals from the brake unit's transceiver module. Dashboard Arduino Mega 2560 microcontroller receives data from this transceiver module. And the microcontroller is stored this data in its flash memory.

4.4 Driver Screen Interfacing:

The 2.3" TFT touch shield is controlled by Arduino Mega 2560 and it programmed in Arduino IDE (Arduino Integrated development environment ARM 63bits) software. The sensors are transmitting real-time data to Arduino Mega microcontroller and this microcontroller is processing the data and displays it in the interface screen. The driver interface screen receives input from the end-user by touch the screen (Figure.7) shows how the brake health monitor Internal interface looks like.

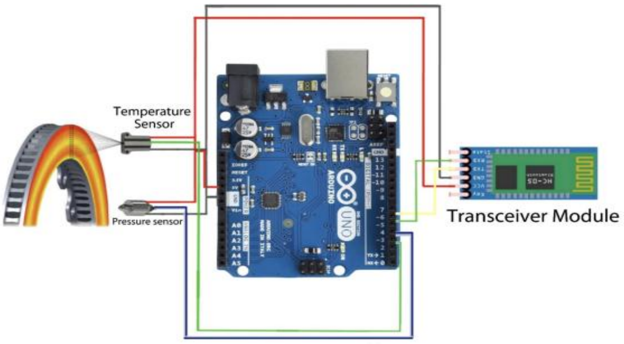

Fig -7: Brake health monitor Internal interface

The interface screen displays real-time data. And the dashboard unit has a buzzer. The buzzer will alert the driver if the brake system has a failure. (Figure.8)shows virtual information to the end-user.

Fig -8: virtual information to the end-user.

Displayed Virtual Information (Figure.9):

- Brake fluid pressure
- Brake disc temperature
- Brake fluid leak
- Condition of brake system

Fig -9: Brake health monitor user interface

5. CONCLUSION

Through the course of this report, a detailed simulation of a model for a vehicle braking system has been described. Developed the driver interface tool by using the Arduino microcontrollers and TFT touch screen shield, which provides virtual information and precautionary alert about the brake system of the vehicle. Wireless communication of data from sensors to the interface is incorporated through Telemetry. Modelling of the advance driver interface to simulate the working principle of a hydraulic brake system has been presented in detail, satisfying all its parameters.

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