Mechatronic approach in hydraulic braking system

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Abstract: In present automotive sector there are magnificent transformations from mechanical to electrical with intensive changes. Each and every one is showing enthusiasm towards vehicles. In addition, humans are very much fascinated towards vehicles where they are driving faster than before. Many types of braking system have been introduced but this paper explains whether the brakes can be applied with less human effort by removing the solid linkage present in between pedal and master cylinder. In order to make the braking system economical and affordable, we are introducing a mechatronic technique which helps us in eliminating the solid linkage present in between the pedal which is linked to master cylinder, linking the pedal to linear potentiometer for the resistance. As the resistance starts varying, difference in braking will be observed. This technique helps in reducing manual effort. Working will be effective and efficient if the components are given more than recommended power supply.

Keywords: Linear Potentiometer, Arduino Uno, Nema Motor, Hydraulic brake parts.

1. INTRODUCTION

Action made to stop the vehicle. In the beginning, Cable brakes are introduced to stop the vehicle. As the generations are passing on, there are tremendous transformations in braking systems. After the cable brakes, Hydraulic brakes have came in to existence which helped in reducing the stopping distance with less time. In order to eliminate the major drawback of hydraulic brakes where the vehicle may lead to skidding if the brakes are applied suddenly in panic condition with more effort. Antilock braking system has created the sensation in this contemporary era by eliminating that drawback with better traction control and enhanced safety.

Components include in hydraulic brakes[3] are Master cylinder, Fixed caliper, Hosepipe and a Rotor. Master cylinder is a device used to convert the force in to pressure.

![Figure 1. Master cylinder](image-url)
Hose pipe is a passage of fluid and acts as mediator in between the master cylinder ‘figure 1’ and caliper. Caliper is a housing of brake pads with a rotor[1][2] present in between that brake pads. Brake fluid is completely filled inside the system. When the force is applied on the master cylinder, pressure is created inside the fluid. That pressurized fluid passes through hosepipe to the caliper.

![Figure 2. Caliper](image)

Caliper ‘figure 2’ stops the disc by forcing the brake pads[4] against it. Friction is created and heat is generated between them. That heat is dissipated by the channels present on the disc.

Braking System and Types:
- Hydraulic braking system[6]
- Electromagnetic braking system
- Servo braking system
- Mechanical braking system [5]

1.1. Mechatronic Approach:
Linear Potentiometer [10]: It is the device used in varying the resistance according to the slider present inside it. It is connected to the pedal. It is linked in a way that, as the pedal is pressed forward direction then parallelly resistance also increased. If the pedal gets retracted , slider of the potentiometer will return to its initial position, then resistance will also gets neutral.

![Figure 3. Linear Potentiometer](image)

Arduino Controller: Arduino[12] is a device used in creating interactive electronic objects. Maximum number of inputs can be given through programming where it stores that program and functions effectively if the required recommended power supply is given.

Linear potentiometer ‘figure 3’ is linked with this controller. As the resistance is varied in the potentiometer if the pedal is moved, then this controller takes that resistance as input and it uses an external electromagnetic switch in order to transform that information as output.
Using Relay as electromagnetic switch, connected with arduino ‘figure 4’ which controls Nema motor for pressing the master cylinder. Creating the mechanism which converts the rotatory motion of motor into linear motion. Linear motion of that motor functions accordingly to press the master cylinder.

2. PROBLEM STATEMENTS:

- Solid linkage is present which acts as a connection for pedal and master cylinder.
- More manual effort is required to apply sudden brakes.

3. SOLUTION METHODOLOGY:

**Step 1 STUDY:** Firstly, identifying the parts used in hydraulic brakes and understand their working. Filling the brake fluid inside the system by bleeding process. No air bubble should be present inside the system in order to stop the rotor.

**Step 2 PROBLEM IDENTIFICATION:** Solid linkage is present in between the pedal and master cylinder which increases manual effort

**Step 3 OBTAINED SOLUTION:** Eliminating that linkage and combining nema motor with master cylinder helps in reducing manual effort

**Step 4. APPLICATION:** Can be applicable for mini four wheelers like Go-kart, E-kart and student formula car.

Here, Simulation of this approach can also be done using finite element methods[8] which helps in solving complex engineering problems. Indeed, those methods can be used in order to know the results in advance.

4. OPERATION:

Pedal is connected with linear potentiometer(Figure 5). Resistance of potentiometer varies as the pedal travels forward. Potentiometer is connected to arduino[11][12]. Here, arduino takes the resistance as input and gives the output to nema motor which is connected with master cylinder and parallely connected to battery for power supply. Nema motor functions according to resistance variations of potentiometer. Nema motor is controlled with Arduino where maximum of inputs can be given to arduino for enhancing safety like Roll rate, Yaw rate, front wheel speed, rear wheel speed, lean angle, engine torque and many more. According to the resistance, motor works and presses master cylinder[7].

![Arduino Uno](image-url)
Master cylinder[9] is filled with brake fluid (DOT 3 or DOT 4 or DOT 5 or DOT 5,1). Because of the force, pressure is created inside the system. That pressurized fluid presses the brake pads and those pads are forced against the rotor. Finally, Brakes are applied.

![Flow chart of Mechatronic approach in Hydraulic Brakes](image)

**Figure 5.** Flow chart of Mechatronic approach in Hydraulic Brakes

5. RESULTS AND DISCUSSIONS:

- All the results which are considered in braking system will be achieved are appropriate.
- The components used will be effective and efficient and have life more than expectancy. Motor converting its rotatory motion into linear motion and functions according to the resistance given by potentiometer.
- Manual effort is reduced as there is no manual force applied on the master cylinder.
- If the tyre tread is more without any wear then stopping distance and time also decreased.

6. CONCLUSION:

Firstly, Manual effort is reduced as the solid linkage is eliminated which was present in between the pedal and master cylinder. Parameters which are considered in braking system have resulted as appropriate. Brakes are working effectively and efficiently without any signal errors as the inputs are given exactly as assumed.

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