Modification and Implementation of Automatic Hand Brake System using Sensor

Rohit Khubalkar[1], Saurav Kumar[2], Kishen Jadhav[3], Vaibhav Regundawar[4], Aniket Phatangare[5]

[1,2,3,4]BE UG Student, Dept. of Mechanical Engineering, Dr. D. Y. Patil Institute of Technology, pimpri-411018, Maharashtra, India
[5]Assistant Professor, Dept. of Mechanical Engineering, Dr. D. Y. Patil Institute of Technology, pimpri-411018, Maharashtra, India

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Abstract - *One of the most important safety features in an automobile is brake. A typical automobile consists of two types of brakes, one for retarding the speed of vehicle while it is in motion and other is to hold the vehicle in its place when standing still or parked. The latter is mostly important when the vehicle is parked on slope. It is important to disengage the handbrake before starting the vehicle from rest position. Due to operator errors the conventional handbrake system remained engaged even when the vehicle was moving due to manual operation of the hand lever through which the handbrake is operated. This led the brakes to become ineffective and eventually they failed to serve their purpose. To overcome all the limitation of the conventional system we proposed the new automatic handbrake engagement and release system.*

Study takes into account several safety issues and permutations with the hand brake which are listed below as problem statements. The objective of the project is to develop a smart handbrake system that resolve all safety issue and also assist the driver while climbing steep slopes in dense traffic. Study work include the brake effort calculation for given condition of operation design of all components using theoretical method for strength, 3-D modeling of components and assembly. The fabrication of the unit is done using suitable process and test carried out on the unit to prove that the above said four features work in the model.

***Key Words*: Smart handbrake, Automobile, Conventional, Automatic.**

1. INTRODUCTION

Conventional hand brake feat involves the human interference. While not pull or pushing the lever, the hand brake won't work. Also, generally as a result of negligence or in emergency conditions, we humans have a tendency to usually forget to use parking brakes. This could result in rolling of auto just in case of slopes and collision with different vehicles in park. Constant enhancements in active safety and enhancements with relation to the dependableness and luxury of operation mean that mechanical handbrakes are progressively being replaced by automatic mechanical device systems. [3]

Thus, we develop such system in which hand brakes operation is controlled with ignition system and seatbelt system of the vehicle. Means a hand brake mechanism, ignition system and seatbelt system of vehicle is interconnected each other for applying the hand brake while parking.

2. PROBLEM STATEMENT

In automobile, Handbrake (Parking brake) is the system used for safety. Conventional system works by operating handbrake lever manually. In this system, it is observed due to manual errors the brakes remain engaged when vehicle is moving. This condition causes safety hazards which may cause damage the system components. During travel on the steep slope in upward direction, if the vehicle accidently goes into neutral or engine stops, the tendency of the vehicle is roll backwards, here we need the downhill locker. It is mandatory for the driver to wear seat belt or safety but it is often overlooked and may prove fatal if vehicle meets with an accident.

The statement of study is “modify the current handbrake system to introduce automation in system” to reduce human interaction and make seatbelt wearing compulsion.

3. OBJECTIVES

1. To develop automation unit to reduce human manual interaction.
2. To make use of seatbelt mandatory.
3. Prevent damage of the engine due human error.
4. Make the system available at low cost.
5. To maintain the correctness in hand brake operation in case of hand brake is not fully remove or lock in case of emergency braking system action.

4. COMPONENTS

The automatic handbrake system contains the following components
Solenoid actuator
Proximity sensor
Motor
Electronic relay

Limit switch
Brake assembly

4.1 Solenoid Actuator

The solenoid actuator is an electromechanical device that convert electrical energy into mechanical pushing or pulling force or motion. The solenoid actuator consists of an electrical coil wound around a cylindrical tube with a ferromagnetic actuator or plunger that is free to move IN and OUT of coil body.

Fig -1: Solenoid Actuator

4.2 Proximity Sensor

The proximity sensor as the name suggests senses the proximity of the indexer buttons which acts as stops, such that when they come in front of the proximity sensor the table the relay is operated to stop the table motion. The proximity sensor is connected to the electronic relay and the power source. The sensor we used is of inductive type. An inductive proximity sensor belongs to the category of non-contact electronic proximity sensor. It is used for positioning and detection of metal objects. The sensing range of an inductive switch is dependent on the type of metal being detected.

Fig -2: Proximity Sensor

4.3 Motor

Motor used is a Single-phase 220V 50Hz AC motor, , Speed is continuously variable from 0 to 8000 rpm. The speed of motor is variated by means of an electronic speed variator. Motor is a commutator motor i.e., the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed variator, thereby the speed is also is changes.

Fig -3: Motor

4.4 Electronic Relay

The electronic relay is mounted on the sheet metal panel on the base frame. The electronic relay is connected to the proximity sensor and the motor input circuit. The function of the electronic relay is to cut off power supply when the proximity sensor is operated. The electronic relay is a type of an electronic switch that opens or close the circuit contacts by using electronic component without any mechanical operation. In this relay, the current carrier pilot relaying scheme is used for the protection of the transmission line.

Fig -4: Electronic Relay

4.5 Limit Switch

The inching switch is connected between the electronic relay and the proximity sensor, this switch when operated by-passes the proximity sensor, thereby operating the motor momentarily as long it is kept pressed.

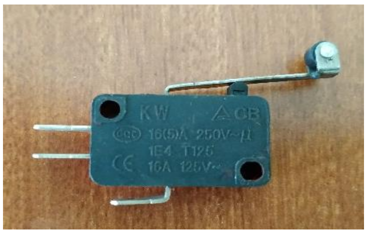

Fig -5: Limit Switch

4.6 Brake Assembly

Brake Calliper

The brake caliper consists of caliper bracket, outer brake pad, caliper frame, piston, Inner brake pad, slider pins, dust boots and rubber below. The caliper frame is having a banjo fitting through which the fluid will reach till the piston. The pressurized fluid from the petal side is capable of pushing the piston with great force. Also, the caliper frame is free to slide along the slider pins within the fixed end.

When you apply the brake, the caliper will receive the high-pressure hydraulic fluid from the brake master cylinder. The fluid will push the piston which makes the inner brake pad to squeeze against the disc rotor circuits. As a result, the fluids backward force will push the caliper frame along the slide pin which makes the outer brake pad squeeze against the other side of disc rotor.

Brake Disc

The brake disc is an important component of the brake system. If the brake system is to be able to decelerate the vehicle in safety and comfort at all times – bringing it to a complete stop if necessary – the brake disc must combine with the brake pads to generate a brake torque (a brake force). This torque is transmitted to the wheel hub and from there to the wheel rim. During braking, the vehicle's kinetic energy is converted into thermal energy due to friction between the brake pads and the brake disc, thereby enabling a reduction in speed to be achieved.

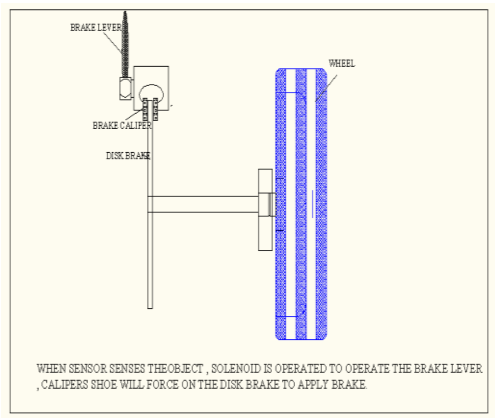

Fig -6: Brake Assembly

All the components are assembled together to the main frame.

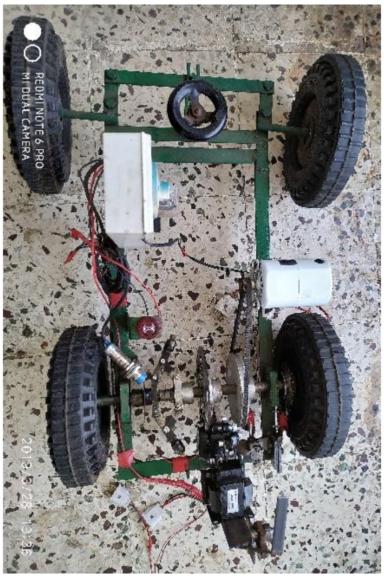

Fig -7: Assembly Model

5. DESIGN CALCULATION

5.1 Design of Belt Drive

Selection an open belt drive using V-belt;
Reduction ratio = 5
Planning a 1 stage reduction;
Motor pulley (ϕ D1) =20mm
Main shaft pulley (ϕ D2) =100mm
Input Data
Input power = 0.05kw
Input speed =1000 rpm
Center distance = 210 mm
Max belt speed = 1600 m/min = 26.67 m/sec
Groove angle (2 β) = 40^0
Coefficient of friction = 0.25
between belt and pulley
Allowable tensile stress = 8 N/mm^2
Selection Of Belt Section
Ref Manufacturers Catalogue

Table -1: Selection of belt section

C/S SYMBOL	USUAL LOAD OF DRIVE (KW)	NOMINAL TOP WIDTH (mm)	NOMINAL THICKNESS T (mm)	WEIGHT DER METER Kgf
FZ	0.03 - 0.15	6	4	0.05

$$\sin \propto = \frac{O_2M}{O_1O_2} = \frac{R_2-R_1}{x} = \frac{D_2-D_1}{2x}$$

$\Rightarrow \propto = 10.98^0$
Angle of lap on smaller pulley; i.e. motor puller;

$\theta = 180 - 2\propto$
$= 180 - 2(10.98)$
$\theta = 158.04$ radian
$\theta = 2.75^o$
Now;
Mass of belt /meter length =0.05 kgf
$\Rightarrow$Centrifugal Tension (Tc)= Mv^2
$\therefore$ Tc = $0.05\ (26.67)^2$
Tc = 35.56 N
Max Tension In Belt (T) = F_{All} X Area
= 8 x 20
=160N/mm²
Tension in Tight side of belt = T_1 = T-Tc
= 160 - 35.56
T_1 = 124.4 N

Tension in slack side of belt = T_2

$$2.3 \log\left[\frac{T_1}{T_2}\right] = \theta \times \mu \times \operatorname{cosec}\beta$$
$$= 0.25 \times 2.8 \times \operatorname{cosec} 20$$

$$\log \frac{T_1}{T_2} = 0.86$$

$$\Rightarrow \frac{T_1}{T_2} = 7.75$$

T_2 = 16 N
Power Transmitting Capacity Of Belt;
P = $(T_1 - T_2)$ v
= (124.24 - 16) 26.67
P= 3.13 kw
$\Rightarrow$ Belt can safely transmit 0.05 kw power
Selection Of Belt.
Selection of belt 'FZ 6 x 600' from std manufacturers catalogue

Table -2: Result

1.	BELT SELECTED	FZ 6 x 600
2.	Tight side Tension	T_1 =124.24 N
3.	Slack side Tension	T_2 = 16 N
4.	Motor pulley dia.(ϕ D_1)	D_1 =20 MM
5.	Main shaft pulley dia. (ϕD_2)	D_2 =100MM

5.2 Design of Input Shaft

Motor Torque

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

$$T = \frac{60 \times 60}{2\,\Pi \times 6000}$$

T = 0.095 N-m
Power is transmitted from the motor shaft to the input shaft of drive by means of an open belt drive,
Motor pulley diameter = 20 mm
IP _ shaft pulley diameter = 100 mm
Reduction ratio = 5
IP_shaft speed = 6000/5 = 1200 rpm
Torque at IP_shaft = 5 x 0.095 = 0.475 Nm
T_{Design} = 2 x T =0.95 Nm. ...FOS =2
= 0.95×10^3 N.mm
Ref :- PSG Design Data.
Pg No :- 1.10 & 1.12.0 1.17

Table -3: Selection Of Input Shaft Material

Designation	Ultimate Tensile Strength N/mm²	Yield strength N/mm²
EN 24 (40 N; 2 cr 1 Mo 28)	720	600

Using ASME code of design ;
Allowable shear stress;
Fs_{all} is given stress ;
Fs_{all} = 0.30 syt = 0.30 x 600
=180 N/mm²
Fs_{all} = 0.18 x Sult = 0.18 x 720
= 130 N/mm²
Considering minimum of the above values ;
fs_{all} = 130 N/mm²
As we are providing dimples for locking on shaft ;
Reducing above value by 25%.
$\Rightarrow fs_{all}$ = 0.75 x 130
= 97.5 N/mm²
Considering pure torsional load;

$$T_{design} = \frac{\Pi fs_{all} d^3}{16}$$

$$\Rightarrow d^3 = \frac{16 \times 0.95 \times 10^3}{\Pi \times 97.5}$$

d = 7.0 mm
selecting minimum diameter of spindle = 16 mm from ease of construction because the standard pulley has a pilot bore of 12.5 mm in as cast condition, and a bore of minimum 16 mm for keyway slotting operation.

6. WORKING

In this model prime mover is used as drive train. Electronic speed regulator is used to vary input power to the motor by changing current, thus the speed also changes A V belt and pulley arrangement is used to transmit motion from pulley to the main rear input shaft. Electronic relay is mounted on the sheet metal panel on the base frame. The electronic relay is connected to the proximity sensor and the motor input circuit. The function of the electronic relay is to cut off power supply when the proximity sensor is operated. Brake assembly consisting of brake caliper and disc is mounted on the rear shaft (for model purpose) to perform braking action when lever is pulled. A solenoid actuator is connected to brake assembly. It is used to control hand lever of the brake. It is controlled using electronic relay circuit.

When the seatbelt and engine both are ON, and the driver forgets to disengage the handbrake lever and keeps on riding the vehicle, after reaching a particular speed the centrifugal governor- proximity sensor arrangement, which is used as speed sensor sends an electric signal to the electronic relay circuit. On receiving he electric signal from proximity sensor the electronic relay will cut the power supply to the solenoid actuator.

In solenoid actuator when electric signal passes through the solenoid, magnetic field is developed which pulls the ram of the solenoid behind and thus ram which is connected to the brake lever is pulled back to apply the brake. Due to cut in power supply from relay circuit, the magnetic field is lost and the ram of actuator is pushed forward due to spring force. As a result, hand lever is pushed forward, thus disengaging the brake.

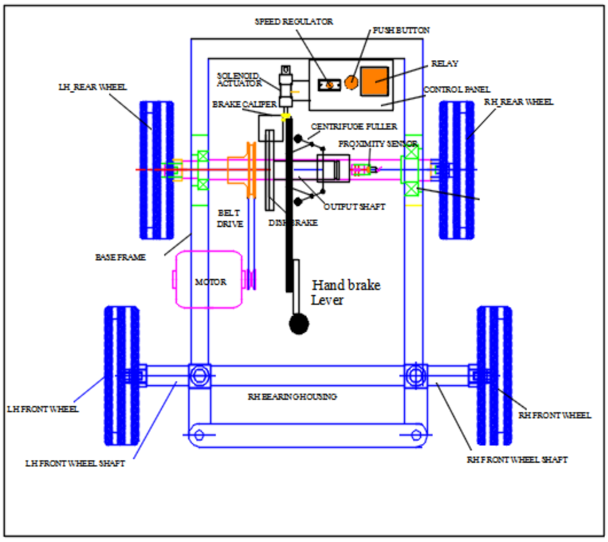

Fig -8: 2D Model

7. CONCLUSIONS

Modifying the current system to automatic hand brake system would provide effective solution for reducing human effort which is required for applying manual hand brake. This system can provide highly parking safety and braking effect. It provide quick braking and also simple in operation. Thus the use of conventional hand brake system can be eliminated using this system and the error occurring due to operator can be eliminated completely.

From our concept we ensure that driver compulsorily wears seat belt while driving. If he tries to run without wearing the seat belt the handbrakes could not be disengaged. By this driver's safety is ensured.

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