Design and Development of Intelligent Braking System (IBS)

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Abstract— The aim of the project is to design and construction of Intelligent Braking System (IBS) a module used for vehicles in the hill stations. Auto breaking system is used when vehicle is moving upward direction. The project was divided into two phases. The First phase is to demonstrate the application of MEMS. The second phase of the project attempts controlling motors. MEMS sensor is interfaced to micro controller using I2c protocol, microcontroller receives the data from the MEM sensor and process it according to the data from the sensor appliances are operated. Application are like refrigerators, microwave ovens, Theaters hospitals etc. I2C protocol is used for interfacing MEMS sensors with micro controller, Micro controller main functionality is to receive signals for sensors and process information by taking desired decision. Applications which use this technology are refrigerators, operation theaters and microwaves. MEMS-based sensors are a class of devices that builds very small electrical and mechanical components on a single chip.

Key words: Intelligent Braking System, IBS

I. INTRODUCTION

In this work the mechanism has been developed to stop the vehicle from rolling backwards when the vehicle is moving in the hill roads. Ratchet and Pawl mechanism has been identified to arrest the motion to the front axle. Anti-Roll Back mechanism has been fabricated and tested on the front axle assembly. The mechanism works well. Ratchet and pawl mechanism is used in many applications effectively where the one side power transmission is required for example in (i) Giant wheel- It is the large wheel used in the amusement parks to rotate along the horizontal axis to rotate in one direction while carrying the number of passengers. (ii)Clocks- where the hands rotate in clockwise directions only.(iii) Baffle gates- in the entrances of many buildings which rotates about vertical axis in one direction.(iv) Shaping Machines – in the crank and slotted arm. In the hill station, the most common problem to the drivers is to park their cars in the slope and to start up the car. While waiting in the traffic, the cars have to move on step by step very slowly, this situation is a difficult one for the drivers to make their car not to roll back in the slope. So the mechanism has to be developed to stop the vehicle from rolling back and it should not stop the vehicle in accelerating forwards. This function can be achieved by using the ratchet and pawl mechanism. The ratchet and pawl has to be designed and has to be fit in the front drive shaft in case of the front drive vehicles. The Maruti Swift Dzire car is considered and the ratchet and pawl has to be designed for it. In order to design for the worst case the road maximum slope is considered- Zoji pass Road Kashmir which has 21.80 o with gradient 2/5.

A. *Problem Statement*

Design and develop a prototype model of showing the concept of automatic hill station braking system which will show the working of application of brakes in emergency conditions while driving on slopes in hill stations road conditions.

B. *Objective*

1) To Design and develop a prototype model of showing the concept of automatic hill station braking system while driving on slopes in hill stations road conditions.
2) To fabricate the model of the same which will show the working desired by emergency braking on slopes in hill station roads.
3) To provide safety options while driving in hill stations.
4) To test the model under different conditions of speed and slopes.

C. *Scope*

A ratchet is a device which is used in vehicles over a few decades and when a vehicle is negotiating a turn, the outside wheel travels a greater distance and turns faster than the inside wheel. The ratchet gear is the device transmitting the power to each wheel, allows one wheel to turn faster than the other. Degrees of automation are of two types, viz.full automation and semi automation. In semi automation a combination of manual effort and mechanical power is required whereas in full automation human participation is very negligible.

D. *Methodology*

In this work, Ratchet and Pawl mechanism is identified to arrest the backward motion to the car. The ratchet is placed in the front drive shaft and the Pawl is fitted with the frame. When the vehicle is moved in the hill road, the lever has to make the pawl to touch the ratchet. If the vehicle tends to move backward direction, the pawl would stop the ratchet to move Counter Clock-wise direction with respect to front wheel. As the vehicle is in neutral position, the pawl engaged the ratchet and the vehicle did not move in .The IR transmitter circuit is to transmit the Infra-Red rays. If any obstacle is there in a path, the Infra-Red rays reflected. This reflected Infra-Red rays are received by the receiver circuit is called "IR Receiver". The IR receiver circuit receives the reflected IR rays and giving the control signal to the control circuit. The control circuit is used to activate the solenoid valve. If the solenoid valve is activated, the compressed air passes to the Single Acting Pneumatic Cylinder. The compressed air activates the pneumatic cylinder and moves the piston rod. If the piston moves forward, then the breaking arrangement activated. The breaking arrangement is used to break the wheel gradually or suddenly due to the piston movement. The breaking speed is varied by adjusting the valve is called "Flow Control Valve". The technology of pneumatic has

gained tremendous importance in the field of workplace rationalization and automation from old-fashioned timber works and coal mines to modern machine shops and space robots. It is therefore important that technicians and engineers should have a good knowledge of pneumatic system, air operated valves and accessories. The air is compressed in an air compressor and from the compressor plant the flow medium is transmitted to the pneumatic cylinder through a well laid pipe line system. To maintain optimum efficiency of pneumatic system, it is of vital importance that pressure drop between generation and consumption of compressed air is kept very low.

Fig. 1: Three dimensional model of ratchet and pawl mechanism

II. WORKING PRINCIPLE

The aim is to design and develop a control system based an intelligent electronically controlled automotive braking system is called "AUTOMATIC BRAKE FOR HILLS STATION". This Braking system is consists of IR transmitter and Receiver circuit, Control Unit, Pneumatic breaking system. The IR sensor is used to detect the hills obstacle. There is any obstacle in the path, the IR sensor senses the hills obstacle and giving the control signal to the breaking system. The pneumatic breaking system is used to break the system. Air brakes use compressed air to make the brakes work. Air brakes stop large and heavy vehicles. Safely; but the brakes must be maintained and used correctly. Air brakes are three different braking systems: service brake, parking brake and emergency brake systems. The emergency brake system uses parts of the service and parking brake systems to stop the vehicle if the service brake system fails. B. Air brake system parts The air brake system consists of the following parts. 1). Air compressor pumps Air compressor pumps air into the air storage tanks (reservoirs). It is connected to the engine through gears or a vbelt. The compressor may be air cooled or cooled by the engine cooling system. It may have its own oil supply or it may be lubricated by engine oil. If the compressor has its own oil supply, check the oil level during the pre-trip inspection. 2). Air compressor governor Air compressor governor controls when the air compressor pumps air into the air storage tanks. When air tank pressure rises to the cut-out level (around 125 pounds per square inch-psi), the governor stops the compressor from pumping air. When the tank pressure falls to the cut-in pressure (around 100 psi), the governor allows the compressor to start pumping again. 3). Air storage tanks Air storage tanks hold compressed air. The number and size of the tanks vary between vehicles. The tanks will hold enough air to allow the brakes to be used several times even if the compressor stops working. Air tank drains allow you to drain water and compressor oil that may accumulate in the tanks. Water and oil tend to collect in the bottom of the air tank and are bad for the air brake system. The tank must be drained completely to remove all moisture. Otherwise, water can freeze in cold weather and cause brake failure. Each air tank is equipped with a drain valve in the bottom. Fig 8 shows the air storage tank arrested. The same can be achieved if this model is fitted in the car. This will be the case while fitting this mechanism in the drive shaft of the car. When it has been done the car cannot move in reverse direction in the slope as the pawl locks the ratchet. The fabricated mechanism is fitted in drive shaft for testing experimentally to check whether the functionality has been achieved (Figure 5). The hand driven lever is turned in forward direction, similar to forward motion of the car, the pawl does not stop the ratchet to rotate. The hand lever is turned in opposite direction similar to the reverse motion of the car in the hill road, and the pawl stops the rotation of the ratchet. So, the drive shaft and the wheels did not rotate. . The air is compressed in an air compressor and from the compressor plant the flow medium is transmitted to the pneumatic cylinder through a well laid pipe line system. To maintain optimum efficiency of pneumatic system, it is of vital importance that pressure drop between generation and consumption of compressed air is kept very low Design and develop a prototype model of showing the concept of automatic hill station braking system which will show the working of application of brakes in emergency conditions while driving on slopes in hill stations road conditions.

III. DESIGN DETAILS

A. Brake Force Calculation

Suppose a vehicle of mass 100 kg is traveling on a slope of 40 % height as shown in above figure 2 the various forces acting on vehicle are,

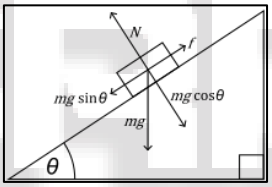

Fig. 2: Various forces acting on vehicle traveling on slopes

mg =downwards weight of vehicle.

N= normal reaction

Θ= slope angle = 40 degree.

So as shown in fig. the force on a vehicle while sliding down the slope is mgsinΘ,

So the braking force required to stop the vehicle by the brakes is - mgsinΘ (-ve sign indicates opposite direction of forces)

So the braking force is

F_b= mgsinΘ =mg*sin40 = 100*9.81*sin40= 630.57 N. =0.7KN.

Power required to drive brakes,

Power= work/time

1 watt = 1 Newton meter / sec.

Watt = 0.7 Newton meter / sec.

For a time period of 10 seconds and for displacement of 50 mm,

Watt = 0.7*0.05/10 = 0.035 watt.

So the power required to drive the brakes is 0.035 watt.

Torque required

Power P= 2πNT/60

Where p=0.035watt,

N= maximum rotations can be 500 rpm,

0.035=2*3.142*500*T/60

So we get torque T = $6.68*10^{-4}$ N.m.

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B. Base Frame

We design base frame by using aluminium square cross sectional tubes. This square tube is the alternative to the round tube. Square tubes are typically used for framework, gym equipment and awnings. Available in various sizes and materials. Square tube can be cut to fit individual needs using any metal saw.

Square tube dimensions =

Width = 1 inch = 25.4 mm

Height = 1 inch = 25.4 mm

Material = aluminium

Fig. 3: Aluminium square tubes

C. Shaft Design

We require 1 shaft in this model for that .The wheel we used is of diameter 200 mm.

1) Shaft Strength under Torsional Load

The shafts are always subjected to fatigue load hence they must be calculated for fatigue strength under combined bending and torsion loading. However, the initial estimate of diameter is obtained from the torque that is transmitted by the shaft. The bending moment variation along the length of the shaft is established after fixing some structural features like distance between supporting bearings and distance between points of application of forces and bearings.

Following notations will be used for shaft.

d = diameter of shaft,

Mt = torque transmitted by the shaft,

W = power transmitted by the shaft (W)= 25 watt

N = rpm of the motor shaft = 500 rpm

τ_s = permissible shearing stress,

σ_b= permissible bending stress, and

Mb = bending moment.

Considering only transmission of torque by a solid shaft.

The power transmitted by shaft and the torque in the shaft are related as

The shearing stress and the torque are related as

$$Mt = 10^{-3}\pi \tau * d^3 / 16$$

If Mt is in Nm and d in mm, τin N/mm^2, and d in mm

Service Condition	τ_s (MPa)
Heavily loaded short shafts carrying no axial load	48-106
Multiple bearing long shafts carrying no axial load	13-22
Axially loaded shafts (bevel gear drive or helical gear drive couplings etc.)	8-10
Shafts working under heavy overloads (stone crushers, etc.)	4.5-5.3

Table 1: Allowable Shear Stress for Shafts

For calculating shaft diameter, d, we substitute the permissible value of shearing stress in place of τ.

Shaft material - EN8 Steel

EN8 also known as 080M40. An unalloyed medium carbon steel. EN8 is a medium strength steel, good tensile strength. Suitable for shafts, stressed pins, studs, keys etc. AISI 1040.Available as normalized or rolled. EN8 is supplied as round drawn/turned, round hot rolled, hexagon, square, flats and plate. EN8 is a medium carbon steel usually supplied untreated. EN8 has good tensile strength and is often used in applications such as: shafts, gears, stressed pins, studs, bolts, keys etc.EN8 is a very popular grade and is readily machinable in any condition. It can be further surface-hardened to produce components with enhanced wear resistance, typically in the range 50-55 HRC through induction processes. It is also available in a free-machining versions, EN8DM and EN8M (212A42)

D. Bearing Selection

Bearing are required to mount the shaft to the frame stand. The use of bearings is to provide the end supports to the shafts as well as to provide a relative movable support. So that the pulley can rotate about its axis. We use here roller contact bearing of ball type. The shaft diameter is 15 mm so requires bearing has to be 15 mm inside diameter. According to bearing designation, 6002 will be appropriate for this assembly. As it have 15 mm inside diameter to mount the pulley shaft. Here we have two pulleys giving us two shafts which has four ends, so quantity of bearings required is 4.

- Radial Ball Bearing: 6202
- Dimensions of Bearing: Inside Diameter= 15mm, Outside Diameter =35 Mm, Wide= 12 Mm.

1) Radial Ball Bearing information

Radial ball bearings consist of an inner and outer ring with a cage containing a complement of precision balls. The standard Conrad-type bearing has a deep-groove construction capable of handling radial and axial loads from either direction in versatile designs that permit relatively high-speed operation.

2) Design Attributes

- Designed for better life in contaminated environment
- Special coatings provide for additional corrosion resistance.
- Special seal designs help keep lubrication in and contamination out.
- Snap ring grooves are available to simplify mounting.

Various seal and shield configurations, which help protect internal bearing components and retain lubricants, are available to suit a wide array of applications. EN8 is a very popular grade and is readily machinable in any condition. It can be further surface-hardened to produce components with enhanced wear resistance, typically in the range 50-55 HRC through induction processes.

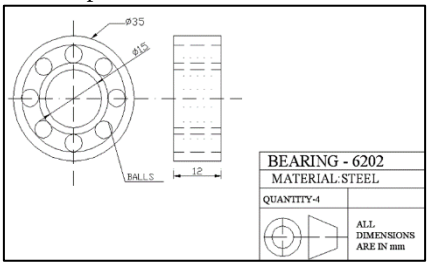

Fig. 4: Radial ball bearing, designation-6002

E. Ratchet Design

1) Standard dimension

Main dimensions of thesis expressed with a pitch diameter is an imaginary circle that rolls without slipping as a point of meeting two tooth profile pairs. The tooth size is expressed by the pitch circle is the distance along the circle of the distance between two profiles of adjacent teeth. Pitch circle is a circle which has the radius of half the pitch diameter with its center at the axis of the gear. The relationship between pitch diameter and pitch circle can be seen by the following equation: Pitch circle formula for spur gear

2) Design for Mechanical Strength - Lewis Equation

Now the major parameter remaining in gear design is width of the gear teeth, b. This is determined by checking whether maximum bending stress induced by tangential component of transmitted load, Ft at the root of gear is greater than allowable stress. As we know power transmitted, P and pitch line velocity V of the gear Ft can be determined using following relation.

One can easily find out maximum value of bending stress induced if all geometrical parameters shown in above figure are known. But the quantities t and l are not easy to determine, so we use an alternate approach to find out maximum bending stress value using Lewis approach. Maximum bending stress induced is given by Lewis bending equation as follows.

As,

σ = bending stress in gear tooth

Ft- maximum allowable tangential force acting on tooth due to braking force as calculated above = 7 N

D = diameter of pinion

b= face width of pinion = 15 mm

Y = Lewis form factor = 0.344 for 27 no. of teeth

Lewis form factor which is a function of pressure angle, number of teeth and addendum and dedendum. Value of Y is available as in form of table or graph. Using above relation one can determine value of b, by substituting maximum allowable stress value of material in LHS of equation. But a gear design obtained so will be so unrealistic, because in this design we are considering gear tooth like a cantilever which is under static equilibrium. But that's not the actual case. In next session we will incorporate many other parameters which will affect mechanical strength of the gear in order to get more realistic design. So dimensions are

Module (m) = 4mm

Width of ratchet (b) = 10 mm

Minimum number of teeth on ratchet = 32

PCD of ratchet = 123 mm.

3.5 Pawl Design

Diameter of pawl (Dp) = 10mm

Length of pawl (L) = 70 mm

Width of pawl= 10 mm

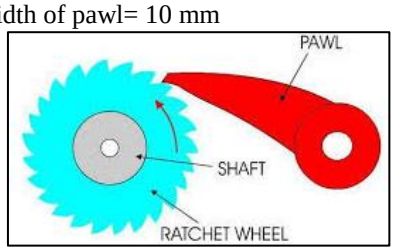

Fig. 5: Schematic of Ratchet pawl

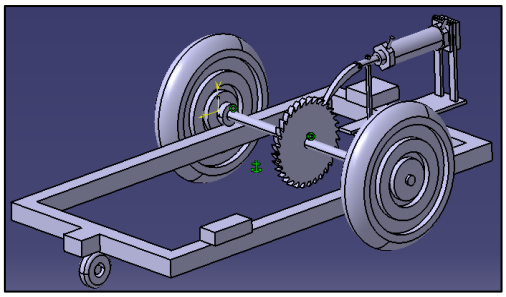

Fig. 6: Proposed model of braking system using CATIA V5

IV. COMPARISON WITH CONVENTIONAL HAND BRAKE

Conventional Hand Brake System	Intelligent Braking System
Activation is manual	Activation is automatic
No use of sensor and electronic control Hence results may vary	Use of sensor and electronic control makes it more precise and accurate
Cannot move after applying brakes until brakes are disengaged hence only useful for parking and stopping.	Can move the vehicle in forward direction but not in reverse makes it useful while driving on slopes etc.
Requires more time for activation	Activation is through pneumatic actuator and sensor hence quick.

Table 2: Showing comparison between conventional hand brake and intelligent braking system

V. CONCLUSION

Thus the mechanism can stop the vehicle from rolling back in hill roads. This would be more helpful for the drivers to drive their cars comfortably in hilly roads and he can take off the car in the uphill without rolling back the car. The project Intelligent Braking System (IBS) for hill station vehicle using sensors has been successfully designed and tested. It has been developed by integrating features of all the hardware components used. Presence of every component has been reasoned out and placed carefully thus contributing to the best working of the unit. Secondly, using highly advanced IC's and with the help of growing technology the project has been successfully implemented.

ACKNOWLEDGMENT

The authors wish to thanks Prof. V.S.Jadhav for their valuable support and also wish to thanks all contributors for their valuable contributions.

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