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Design and Fabrication of Automatic Brake Failure Indicator with Electromagnetic Coil Type Braking

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Abstract

An electromagnetic brake is a new and revolutionary concept which is totally friction less. Electromagnetic brakes are the brakes working on the electric power & magnetic power. An Electromagnetic Braking system uses Magnetic force to engage the brake, but the power required for braking is transmitted manually. Electromagnetic braking system is a modern technology braking system used in light motor & heavy motor vehicles. This system is a combination of electro-mechanical concepts. The frequency of accidents is now-a-days increasing due to inefficient braking system. It is apparent that the electromagnetic brake is an essential complement to the safe braking of heavy vehicles. It aims to minimize the brake failure to avoid the road accidents. It also reduces the maintenance of braking system. An advantage of this system is that it can be used on any vehicle with minor modifications to the transmission and electrical systems. An Electromagnetic Braking system uses Magnetic force to engage the brake, but the power required for braking is transmitted manually. The disc is connected to a shaft and the electromagnet is mounted on the frame .When electricity is applied to the coil a magnetic field is developed across the armature because of the current flowing across the coil and causes armature to get attracted towards the coil. As a result, it develops a torque and eventually the vehicle comes to rest. These brakes can be incorporated in heavy vehicles as an auxiliary brake. The electromagnetic brakes can be used in commercial vehicles by controlling the current supplied to produce the magnetic flux. Making some improvements in the brakes it can be used in automobiles in future.

Keywords : Braking System, Electromagnet coil , Brake Failure Indicator ,Gear

Introduction

A brake is a device, where it restricts motion. It is commonly known that the brakes use friction to convert kinetic energy into heat. But the Electromagnetic brakes have been used as supplementary retardation equipment in addition to the regular friction brakes on heavy vehicles. They work on the principle of electromagnetism. The working principle of this system is that when the magnetic flux passes through and perpendicular to the rotating wheel the eddy current flows opposite to the rotating wheel/rotor direction. By using the electromagnetic brake as supplementary retardation equipment, the frictions brakes can be used less frequently and therefore practically never reach high temperatures. In this research work, with a view to enhance to the braking system in automobile, a prototype model is created and analyzed.

It aims to minimize the brake failure to avoid the road accidents. It also reduces the maintenance of braking system. An advantage of this system is that it can be used on any vehicle with minor modifications to the transmission and electrical systems. Electromagnetic brakes operate electrically, but transmit torque mechanically. This is why they used to be referred to as electro-mechanical brakes. Over the years, EM brakes became known as electromagnetic, referring to their actuation method. Since the brakes started becoming popular over sixty years ago, the variety of applications and brake designs has increased dramatically, but the basic operation remains the same

2. Principle objectives

The main objective of this work is to continuously monitor the braking system at each and every time during the operation of the vehicle

i. The main theme of our project is to monitor the brake system at every moment Today accidents are occurring due to lot of reasons
ii. To make human life easier by using technology.
iii. To Make Vehicle Automation
iv. To Save life, to small Number of Accidents involving trains and ships Caused by Brake failure

3. Methodology

To fabricate the model it all begins with a systematic plan where the fabrication is of a seven steps of solving process. The steps are as follows a bill of materials (BOM) as shown in table:3.1, Is a formal and complete hierarchal documentation of the specific items that need to be included in a finished product.

Table 3.1- Bill of materials

S.No	DESCRIPTION	QTY	MATERIAL
1	FRAME	1	MILD STEEL
2	METAL STRIP	1	MILD STEEL
3	WHEEL	1	RUBBER
4	BATTERY	1	ELECTRICAL
5	AC MOTOR	1	ELECTRICAL
6	BELT	1	NYLON
7	PULLEY	1	CAST IRON
8	BEARING	1	STAINLESSSTEEL
9	SWITCH AND BUZZER	1	ELECTRICAL
10	SHAFT	1	MILD STEEL

3.1. COMPONENTS

3.3.1 Frame

The metal frame is generally made of mild steel bars for machining, suitable for lightly stressed components including studs, bolts, gears and shafts as shown in figure 3.1 It can be case-hardened to improve wear resistance. They are available in bright rounds, squares and flats, and hot rolled rounds

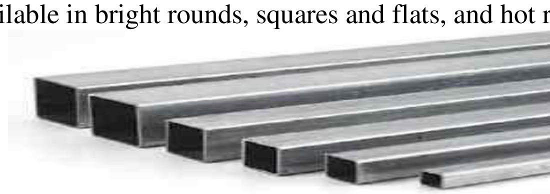

Figure 3.1 frame

Suitable machining allowances should therefore be added when ordering. It does not contain any additions for enhancing mechanical or machining properties. Bright drawn mild steel is an improved quality material, free of scale, and has been cold worked (drawn or rolled) to size. It is produced to close dimensional tolerances.

3.3.2 Metal Strip

Metal strips can be designed and manipulated through a large number of processes which are grouped into categories as shown in figure 3.2. They are joining and assembly processes, deformation processes, material removal processes, heat treating processes, and finishing processes.

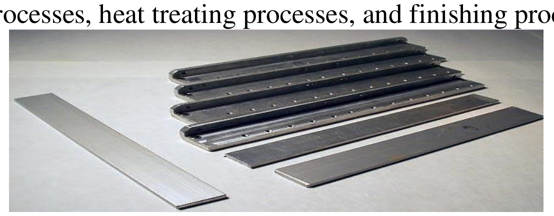

Figure 3.2 Metal Strip

3.3.3 Wheel

The materials of modern pneumatic tires are synthetic rubber, natural rubber, fabric and wire, along with carbon black and other chemical compounds as shown in figure 3.3 They consist of a tread and a body. The tread provides traction while the body provides containment for a quantity of compressed air.

Figure 3.3 Wheel

3.3.4 AC Motor

A.C induction motors as shown in figure3.4.are the most common motors used in industrial motion control systems, as well as in main powered home appliances. Simple and rugged design, low-cost, low maintenance and direct connection to an AC power source are the main advantages of AC induction motors. Various types of AC induction motors are available in the market with Voltage - 230 V, Frequency of 50HZ, power -1/4HP with 1440RPM.

Figure 3.4 AC Motor

3.3.5 Battery

Batteries are used for storage of excess solar energy converted into electrical energy as shown in figure 3.5. Batteries seem to be the only technically and economically available storage means. It is necessary that the overall system be optimized with respect to available energy and local demand patterns. To be economically attractive the storage of solar electricity requires a battery with a particular combination of properties

Figure 3.5 Battery

4.3.6 Pulley

A pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable or belt, or transfer of power between the shaft and cable or belt as shown in figure 3.6. In the case of a pulley supported by a frame or shell that does not transfer power to a shaft, but is used to guide the cable or exert a force, the supporting shell is called a block, and the pulley may be called a sheave .A pulley may have a groove or grooves between flanges around its circumference to locate the cable or belt. The drive element of a pulley system can be a rope, cable, belt, or chain .It is a simple machine that helps change the direction and point of application of a pulling force..

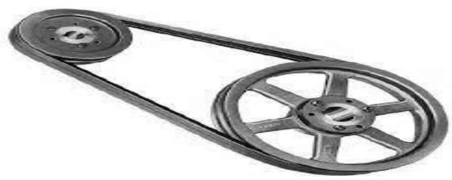

Figure 3.6 Pulley

3.3.7 Belt

A belt is a loop of flexible material used to link two or more rotating Shaft mechanically, most often parallel. Belts may be used as a source of motion, to transmit power efficiently or to track relative movement as shown in figure 3.7 Belts are looped over pulleys and may have a twist between the pulleys, and the shafts need not be parallel.

Figure 3.7 Belt

V-belts have mainly replaced flat belts for short-distance power transmission; and longer-distance power transmission is typically no longer done with belts at all. V belts solved the slippage and alignment problem. It is now the basic belt for power transmission. They provide the best combination of traction, speed of movement, load of the bearings, and long service life. They are generally endless, and their general cross-section shape is roughly trapezoidal (hence the name "V"). The belt also tends to wedge into the groove as the load increases— the greater the load, the greater the wedging action—improving torque transmission and making the V-belt an effective solution, needing less width and tension than flat belts.

V-belts trump flat belts with their small centre distances and high reduction ratios. The preferred centre distance is larger than the largest pulley diameter, but less than three times the sum of both pulleys. Optimal speed range is 1,000– 7,000 ft/min (300–2,130 m/min). V-belts need larger pulleys for their thicker crosssection than flat belts. For high-power requirements, two or more V-belts can be joined side-by-side in an arrangement called a multi-V, running on matching multi-groove sheaves.

3.3.8 Switch and Buzzer

In electrical engineering, a switch and buzzer as shown in figure 3.8 is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another. A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, train and confirmation of user input such as a mouse click or keystroke.

Figure 3.8 Switch and Buzzer

3.3.9 Ball Bearing

A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races as shown in figure 3.8 .The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least three races to contain the balls and transmit the loads through the balls. .Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races**.** An angular contact ball bearing uses axially asymmetric races.

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Figure 3.9 Ball Bearing

3.3.10 Electromagnetic Brake

Selection of the electromagnetic braking system is to minimize the problems which normally occur in the conventional type of braking system where to overcome some problems like efficiency, maintaining parameters, safety. Hence to overcome these problems the electromagnetic braking system is been selected for the further process as shown in figure 3.10

"Electromagnetic braking system" and the main component required is the electromagnet, whereas the emf rule states that the metal is completely winded and it has been enclosed so that it can be ready to use anytime. When the current is passed the coils inside are excited and the magnetic field is produced from the electromagnet

Figure 3.10 Electromagnetic brake

3.4. Complete Assembly

The modeling is an entirely new approach to the sales, project estimation, and initiation phase of a project as shown in figure 3.11

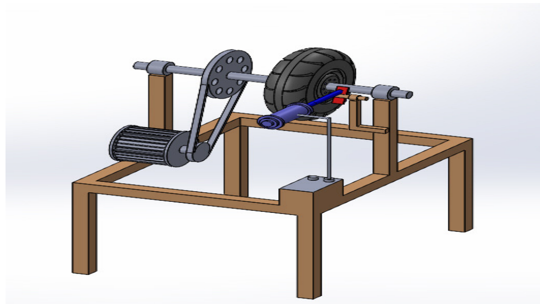


Figure 3.11 Complete Assembly

3.4.1. Load Characteristic

In real applications, various kinds of loads exist with different torque-speed curves. For example, Constant Torque, Variable Speed Load (screw compressors, conveyors, feeders), Variable Torque, Variable Speed Load (fan, pump), Constant Power Load (traction drives), Constant Power, Constant Torque Load (coiler drive) and High Starting/Breakaway Torque followed by Constant Torque Load (extruders, screw pumps).

The motor load system is said to be stable when the developed motor torque is equal to the load torque requirement. The motor will operate in a steady state at a fixed speed. The response of the motor to any disturbance gives us an idea about the stability of the motor load system. This concept helps us in quickly evaluating the selection of a motor for driving a particular load.

3.4.2 Power Transmission

Belts are the cheapest utility for power transmission between shafts that may not be axially aligned. Power transmission is achieved by specially designed belts and pulleys. The demands on a belt-drive transmission system are huge, and this has led to many variations on the theme. They run smoothly and with little noise, and cushion motor and bearings against load changes, albeit with less strength than gears or chains. When an endless belt does not fit the need, jointed and link V-belts may be employed. Most models offer the same power and speed ratings as equivalently sized endless belts and do not require special pulleys to operate.

3.5. WORKING

In order to fabricate this work, only simple and readily available components were used. A braking system, an switch and buzzer, and a control unit make up this system. Electromagnetic coil braking is also employed. Normally, the brake is cut off it detects the vehicle's braking system. If the brake system functions normally, the buzzer will function normally as well. The buzzer detects when the braking system fails and provides signals to the control unit. The electromagnetic brakes are activated and the vehicle is stopped by the control unit connected to the electromagnetic brakes. As a result, when the brakes fail, the buzzers alerts it automatically and the auxiliary brakes are triggered.

4. Design Calculation

In this step it is more concentrated on to the design part where looking on to several alternatives of designs according to the installation specifications as planned in the previous steps.

Selection of V Belt

4. 1. V Belt Selection

Atype of Belt is selected

Usual load of drive (W) = 0.75 TO 5 kW

Nominal thickness (T) = 8 mm

Weight per meter = 0.106 kgf

- **Pulley Diameter Selection**

  Diameter of larger pulley = 450 mm [D]

  Diameter of smaller pulley = 75mm [d]

  Speed of motor smaller pulley = 1440rpm [N1]

  Speed of larger pulley =? [N2]

  N1/N2 = D/d

  1440/N2 = 450 /75

  N2 = 240 rpm

- **Centre Distance calculation**

Speed ratio (i) = D/d

i=450/75 = 6

Recommended C/D ratio = 0.85

C/450 = 0.85

Centerdistance = 382.5 mm

C_{min} =0.55(D+d)+T

= 0.55(450 +75) +8

C_{min}= 296.75mm

C_{max}= 2(D+d) =2(450+75)

C_{max}= 1050 mm

- **Nominal path Length(L) Selection**

L = 2C +p/2 x (D+d) +$(D-d)^2$/4xC

= 2x 382.5 +3.14/2 x 525 + $(375)^2$/4 x 382.5

= 765 + 824.25 + 140625/1530

L= 1681.16 mm

- **Modification factor selection**

Length of correction factor F_c= Nil

Arc of contact factor [F_d]

Arc of contact = 180-60 ° (D-d/C)

= 120 (450-75 /382.5)

= 117.64°

Correction Factor [F_d] =0.81

Service Factor [F_a]

Fa =1 [up to 10 hrs]

- **Maximum Power Capacity**

kW = $(0.45xS^{-0.09}$ -(19.62/de) -0.765x 10^{-4} x S^2)S

S = 5.6 m/sec

de= F_b x d_p

de= 1.14 x 75 = 85.5

= (0.45 x $5.6^{-0.09}$ – (19.62/85.5) – 0.765 x 10^{-4} x $(5.6)^2$) x5.6)

= (0.385 – 0.22 -0.00239) x5.6

A = 0.910 kW

- **Actual Distance Calculation**

Cactual = A + √A^2-B

A = L/4 - p[D+d\8]

= 1681.16/4 - 3.14 [525 /8]

= 420.29 – 206.06

A = 214.23 cm

B = $(D-d)^2$ /8 = $(375)^2$ /8

B = 17578.12

Cactual= 214.23 +√$(214.23)^2$ – 17578.12

= 214.23 + 168.27

C_{actual}= 382.50 mm

4.2. Brake Force Calculation

The total braking force required can easily be calculated by using Newton's Second law of Motion:

$V = \pi \times d \times N \div 60$ = (π x 0.276 x 150)/60 =2.1666m/s

A= (v-u)/t = (2.1666-0)/2.5 =0.86664m/sec^2

F= m x A=12 x 0.867=10.40N

T = (F x 0.5d)/R = (10.40 x 0.5 x 0.276)/1.725

Torque= 0.832Nm

4.3 Shaft Design Calculation

Length of the shaft (L) = 60 cm

Radius of the shaft (r) = 1.25 cm

Moment of Inertia of the shaft (I) = 1.916 cm^4

Maximum bending moment (M) = torque x radius

= 0.832 x0.0125

M = 0.0104 N/m^2

Maximum Bending Stress (T_b) = (Mx r)/I.

T_b = (0.0104 x 0.0125)/ 1.916

T_b = 6784.96 N /m^2

4.4. Ball Bearing calculation

Outer diameter of the bearing = 40 mm

Inner diameter of the bearing = 25 mm

Thickness of the bearing =. 15 mm

Maximum speed of the bearing= 1400 rpm

Mean diameter = (D+d) /2 = (40+25)/2 = 32.5 mm

Mean diameter = 32.5 mm

4.5. Electromagnet

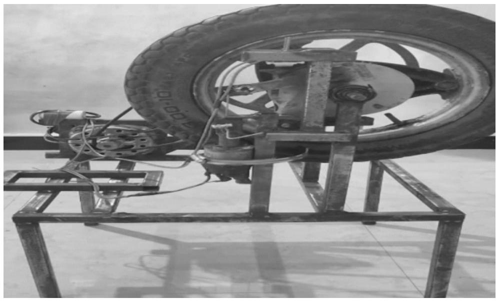
The list of electromagnets are used in braking system according to size and power as shown in Table 4.2

Table 4.2 Electromagnets

NUMBER	SIZE (mm)	RATED POWER(W)	ADHESIVE FORCE(N)
4340105	25-100	7	650
4340110	35-100	9	850
4340120	35-150	11	1650
4340125	35-200	13	2300
4340135	40-300	19	4000
4340145	50-400	28	8400
4340155	40-500	40	6000
4340165	40-600	46	6600

6. Fabrication model

Fabrication model of Automatic Brake Failure Indicator with Electromagnetic Coil Type Braking as represented in figure 7.1 & 7.2 Fabrication was the most important part of the project as effort was made to construct the brake failure indicator with locally available raw material procured at an economical rate and fabrication work was carried out with a semi-skilled approach, all of which was carried out in the college workshop with all necessary tools used being tools that are available at any workshop



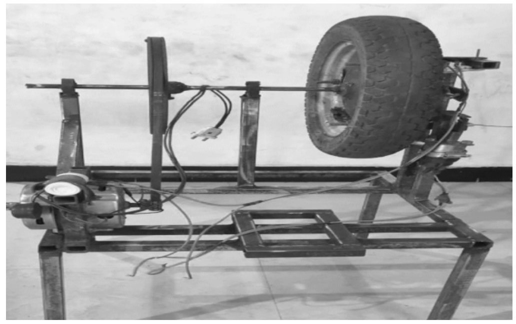


Figure 6.1 Side View & Front View of Fabrication Model

The electromagnetic coil braking and brake fail indicator designs have been tested, and the results are as follows.

(i) The feasibility of design calculations for various parts is examined.
(ii) Using design software, the various components of the brake system have been modeled.
(iii) The designed dimensions are used to develop assembly drawings.

7. Preliminary test

It is made for the working model as follows these steps:

- Every step of fabrication will be followed by testing the mechanisms or component.
- After all mechanisms are fitted properly, the machine will be given power and the machine will be tested.
- If everything goes as specified the machine will be ready for demonstrate ion and final presentation.

Conclusion

In comparison to alternative braking systems, electromechanical braking has been demonstrated to be more reliable. Even a little leak in an oil or air braking system might cause brake failure. While electromagnetic braking coils and firing circuits are individually attached to each wheel, even if one coil fails, the brake does not fail totally because the remaining three coils function normally. This method also requires less upkeep. Electromagnetic brakes also account for about 80% of all power applied braking applications. Electromagnetic brakes have higher performance than conventional brakes at high speeds but they cannot be used at low speeds. Hence it must be used as an auxiliary brake during high speeds. This system minimizes the number of accidents and saves lives. The project gives us more confidence that we will be able to put our theoretical knowledge into practice

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