Design and Fabrication of Frictionless Braking System

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Abstract: The idea of electromagnetic braking comes with the advantages and disadvantages of stresses in calipers and dissipation of heat. The electromagnetic braking system entirely depends on magnetic power to move the parts of the braking system. The system indulges the principle of if a magnetic field is induced in the rotating disc, then the other side produces the eddy current of the movement or rotation of the disc brake. The major parts of an electromagnetic braking system are braking discs, solenoid, circuit board, step-down transformer and battery power.

Keywords: Electromagnetic Braking, Control of Current, Electromagnet, Rotating Disc.

Introduction:

The Frictionless Braking system:

A frictionless electromagnetic braking system utilizes linear alternators which are controlled by a power electronics converter interface to capture the car's kinetic energy and generate braking force on the wheel.

Electromagnetism: Electromagnetism is one of the four fundamental interactions in nature. The other three are the strong interaction, the weak interaction and gravitation. Electromagnetism is the force that causes the interaction between electrically charged particles; the areas in which this happens are called electromagnetic fields.

Magnetic Effect of Current: The term "Magnetic effect of current" means that "a current flowing in a wire produces a magnetic field around it". The magnetic effect of current was discovered by Ousted in 1820. Ousted found that a wire carrying a current was able to deflect a magnetic needle.

Electromagnet: An electric current can be used for making temporary magnets known as electromagnets. An electromagnet works on the Magnetic effect of current. It has been found that if a soft iron rod called core is placed inside a solenoid, then the strength of the magnetic field becomes very large because the iron ore is magnetized by induction.

Eddy Currents: When the moving conductor is introduced in the magnetic field then current is generated in the conductor, this phenomenon is called as the Eddy currents.

1.1 Background of the Project

Automobile industry is a constantly changing industry with the fast pace of technological developments and implementations. With introduction of new and powerful machine the need to stop these machines also arises.

Not on stopping but increasing the efficiency to maximum in order to keep the energy losses to minimum. Generally, friction braking or exhaust braking is used in the automobiles, friction or exhaust braking system comprises of means to use friction to convert Kinetic energy of body into Heat energy causing the motion to retard.

The stopping force generated by a braking system is more than the actual energy generated by engines. Nowadays the greater power of engines and greater need for safety has caused to develop a system to minimize the dangers. Vehicle safety improvement is one area in the automobile industry that is increasingly being emphasized with passing time. Stability of vehicles running on the road is very much dependent on the on-going improvements in brake technology. Currently, for the purpose of improving braking functionality and to have the least environmental impact, automotive manufacturers are investing in developing EMB (Electromechanical braking systems). Electromagnetic brakes are simply an mechanical brakes which bring about retardation by applying electromagnetic induction in the disc brake in direction opposite to the rotation of the actual disc i.e. If vehicle is moving forward then rotation of disc will be clockwise (Frame of reference is from left hand side of vehicle) then the magnetic field will be counter clockwise. By this way the motion of the brake is retarded by the brakes but there is no physical contact in any case.

This is a revolutionary concept. Hence electrical energy from the appropriate power source is used to the purpose. As any type of brake, the heat energy is generated in the brakes which have to be exhausted into environment but wear and tear is minimized. Brakes are imperative for any vehicle and a substantial vehicle by and large uses grating brakes alongside Electromagnetic brakes. This venture primarily concentrates on building slowing mechanism, which can be material in bike at fast and low upkeep cost. This framework utilizes an electromagnet connected directly to vehicle's battery. Electromagnetic brakes are likewise called electro-mechanical brakes or EM brakes and moderate or stop movement utilizing electromagnetic constrain to apply mechanical resistance.

1.2 Significance of the Project

Electromagnetic brakes are a new revolutionary concept. It is found that electromagnetic brakes generate negative energy which is twice as that of the Energy generated by engines, and three times more the exhaust system. Types of braking system is Exhaust braking system

Drum Brakes: In drum brakes the motion is retarded by using a brake pad mounted inside the drum of the wheel. Which brakes are applied then the pad lined with frictional material rubs against the drum and retardation is observed.

Disc Brakes: Disc brakes are hydraulic type of braking system. In this braking system which brakes are applied fluid from master cylinder is generates pressure and this pressure is passed through fluid lines. This fluid applies pressure on slave cylinders, causing them to rub against the disc. Heads of slave cylinders are also coated with frictional material to increase the effectiveness.

When braking action is brought by the use of electromagnetic induction rotation Electromagnetic brakes brings about the same action as above stated brakes only with greater efficiency and effectiveness. In this report we observe the studies done on the said topic and various developments the field of braking and careful use of energy.

1.3 Project Rationale:

Electromagnetic braking systems are a process design activity which is of paramount importance. For this reason, computerized automation is essential to integrate braking systems. A literature review of the state-of-the-art trends and approaches for braking system is presented. Some shortcomings of the current approaches are also discussed new research focus areas are explored. A part that must be machined is held by an assembly or a component. This assembly or component is further defined. It must be designed properly so that it would fit the shape of the part and also be compatible to the machining process.

This review would discuss the basics and techniques etc. and would also dwell on planning, dedicated design, and verification of design and of course how all these can be integrated with the main process.

1.4 Scope of the Project

Electromagnetic braking system is found to be more reliable as compared to other braking systems. In oil braking system or air braking system even a small leakage may lead to complete failure of brakes.

While in electromagnetic braking system as four disc plates, coils and firing circuits are attached individually on each wheel, even any coil fails the brake does not completely fails remaining three coil works properly. And this system needs very little of maintenance.

In addition, it is found that electromagnetic brakes make up approximately 80% of all of the power applied brake applications. Electromagnetic brakes have been used as supplementary retardation equipment in addition to the regular friction brakes on heavy vehicles. The frictions brakes can be used less frequently and therefore practically never reach high temperatures.

The brake linings would last considerably longer before requiring maintenance and the potentially "brake fade" problem could be avoided. This enhanced braking system not only helps in effective braking but also helps in avoiding the accidents and reducing the frequency of accidents to a minimum. Furthermore, the electromagnetic brakes prevent the danger that can arise from the prolonged use of brake beyond their capability to dissipate heat.

Production costs, time required for product development, time required for process development are all significantly reduced by the proper utilization of tools. Not only the above-mentioned benefits but also the simulation techniques that are involved in braking systems give a boost to quality assurance of the final part.

Moreover, it becomes easier to make cost estimates for making business related quotations to customers, specifying parameters as specifications for technical purposes as all these are required in the mechanisms prevalent in the business world.

1.5 Objectives

1. To assess the tools and techniques for designing, implementing, and evaluating ubiquitous computing Systems used by developers
2. To formulate practical solutions that addresses the functionality of these systems.
3. This review considers the various steps that are required for the design. It also presents the various important researches that have been conducted the world over, and describes the requirements for braking Systems that have developed over time.
4. Moreover, the paper also dwells on the most important and related Research that has been carried out in the field which has utilized intelligent techniques and principles that relate to this type of work. The review also presents the CBR approach (case-based reasoning).
5. It has been considered as the most successful he most successful approach. The presentation of this approach uses information on various applications, the different stages of systems based on design. It also describes the work principles as well as the relevant approaches that have been proposed.

2 LITERATURE SURVEY

2.1 Sumit Patel,(2015) [1] : Engineering complications in actual sense incorporate linguistic information process that proves complex to enumerate through conventional calculations since it is a representation of subjective knowledge. Failure to quantify linguistic information results, therefore, to assumptions in developing mathematical models. Moreover, in transportation engineering, several values are described through improbability, subjectivity; imprecision's as well as ambiguity. The electromagnetic braking system uses magnetic strength to decrease or stop the speed in wheel rotation. The idea of electromagnetic braking comes with the advantages and disadvantages of stresses in calipers and dissipation of heat. The electromagnetic braking system entirely depends on magnetic power to move the parts of the braking system. The system indulges the principle of if a magnetic field is induced in the rotating disc, then the other

side produces the eddy current of the movement or rotation of the disc brake.

The major parts of an electromagnetic braking system are braking discs, solenoid, circuit board, step-down transformer and battery power. In other words, human operators, dispatchers, drivers, as well as passengers, gauge the context of a situation through idiosyncratic knowledge or linguistic evidence in regular decisions. Electromagnetic braking system is classical example of increased effectiveness of braking system while minimizing losses. In this paper the focus is provided on comparison between Electromagnetic braking system and conventional exhaust braking system. The focus of Electromagnetic system is to increase the safety of the device meanwhile keeping the losses to minimum. The sole aim of the research study lies on providing advantages of both the systems as well as clearly mentioning their ambiguities.

2.2 Sevvel P, Nirmal Kannan V,(2014) [2] : 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. In this project the advantage of using the electromagnetic braking system in automobile is studied. 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

The electromagnetic diffusion and the electromechanical phenomena arising in a solid cylinder rotating inside a magnetic field are here analyzed. The study is developed through a time stepping Finite Element voltage-driven formulation, employing the sliding mesh technique for handling the cylinder motion. The influence on the dynamic behavior and energy dissipation of the material electric and magnetic properties, the geometrical parameters and the supply conditions is investigated considering a model problem. 2006 Elsevier Inc. All rights reserved

2.3 McConnell, H.M,(1954), [3] : Most of the braking systems utilize friction forces to transform the kinetic energy of a moving body into heat that is dissipated by the braking pads. The overuse of friction-type braking systems causes the temperature of the braking pads to rise, reducing the effectiveness of the system. 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. The eddy-current is created by the relative motion between a magnet and a metal (or alloy) conductor. The current induces the reverse magnetic field and results in the deceleration of motion.

The proposed mechanism implements this phenomenon in developing a braking system. The potential applications of the braking system can be a decelerating system to increase the safety of an elevator or any guided rail transportation system As a result it develops a torque and eventually the vehicle comes to rest. In this project the advantage of using the electromagnetic braking system in automobile is studied. 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. . 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.

2.4 Tatsuya YAMASAKI, (2007). [4] : An automatic brake system for a vehicle consists of an electric motor, related to the motor for transmission motion from the motor to a brake lever that pushes the restraint. This project provides a brand new idea style of the EMPB (electro mechanical parking brakes) system that has straightforward and cheap characteristics. This project deals with coming up with and fabrication of EMPB system. Mechanical device hand brake system conjointly remarked as brake by-wire, replace typical parking braking systems with a totally electrical part system. This happens by replacement typical linkages with electrical motor-driven units. The braking force is generated directly at every wheel by high performance electrical motors and automobile management, that area unit controlled by an ECU. The electronic hand brake replaces the traditional handbrake. It's operated by a switch within the centre console. The mechanical device hand brake provides the subsequent edges over the traditional handbrake: easy use-the hand brake is applied totally no matter the strength of the driving force. Safety-the electrical hand brake applies mechanically once the key is off from the ignition.

3 WORKING DESIGN

3.1 Block Diagram

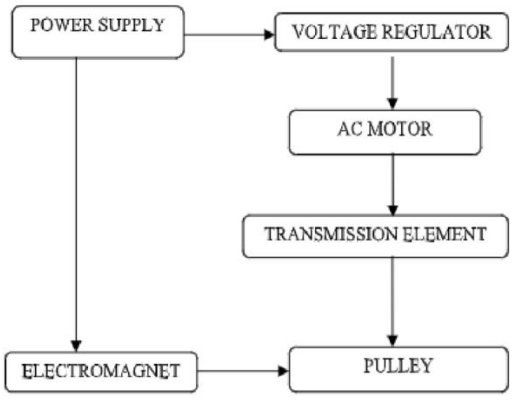

Fig 3.1 Block Diagram

ELECTROMAGNETIC BRAKE

Electromagnetic brake slows down an object through force created by an electromagnetic induction, which acts as a

resistance to motion of the vehicle. This type of brake applied pressure on two distinct objects to gradually slow the vehicle in a uniform manner.

3.2 Components

The following are the components used in the work as follows, DC Motor, Resistance type current regulator, V Belt Wheel, Metal Disc, Electromagnet, Vertical holding column Control Switch, Fasteners / Bearings etc..

3.3 DC Motor

Fig 3.2 DC Motor

The rotary motion of the wheel is given by the DC motor. The electric motor converts electric energy into mechanical energy by electromagnetic induction. The motor been used here is the typical grinder motor of 12 volt, speed of 600 rpm and Power of 30 watts

3.4 Regulator

The regulator been used in order to control the speed of the electric motor. The speed is controlled by changing the current of the electric supply to the motor. The current can be adjusted to match the need of the process. The higher current of the output voltage is, the higher the speed of the motor, and thus, the output of the process. Here the capacity of the regulator is 220V±10% in voltage, 50HZ in frequency and 400watt is used.

3.5 Belt

A belt is made up of a polymer material used to transmit power between two or more rotary shafts, mostly parallel in arrangement. Belts may be used to transmit power effectively. Belts are fitted over grooves in pulleys and also may have twists between pulleys, and the shafts need not to be parallel in all conditions. Flat belt, V-belt, Round belt is some important types of belts. Here the V-belt has been looped over the driving motor and the driven wheel.

3.6 Pulley

The pulley has been used to mound the metal disc along with it. It provides the rotary motion from motor to the disc by the use of V-belt. Here we used a typical pulley with six arms. The material of the pulley is used as hardened plastic

3.7 Metal Disc

The metal disc is one of the important components been used here. It is made up of cast iron. The reason for using cast iron plate is that the plate is to be magnetic material. it has a hole in order to reduce the weight. There are four holes drilled for screw. At last the disc is fitted with the pulley by the use screws. Dimensions: - Ext. dia. - 97-98mm Thickness - 5.6mm

3.8 Electromagnet

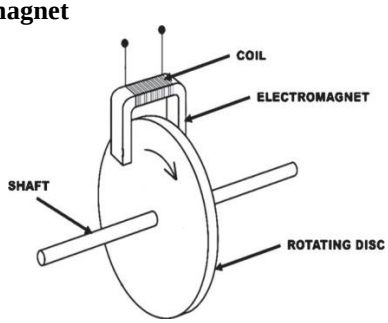

Fig 3.7 Electromagnet

Electromagnet is the device which gets magnetized when the current is feed into it. Here the electromagnet is designed by modified a typical transformer. The transformers has double side outer core around the inner core. This outside core of the transformer is removed and then arranged as single side. Now it is act as an electromagnet.

Working on	DC 220 volt
Nos of magnet	2 Nos

3.9 Switch and Wires

ON/OFF switch used to control the power supply to the electromagnet. It is connected with the electromagnet. A typical common electric switch is used here. When the rotation of the pulley is to be stop, the braking is applied by turned the switch on. When the free rotation of the pulley is required the switch is turned off. To provide the electric supply to the motor and the electromagnet the electric wire is used here. The copper wire has been used here since it has the better electrical conductivity and wire is 7nos x 15 swg and 6 mtr.

3.10 Bolts and Nuts

To join the motor, electromagnet, vertical column with the wooden base and to join the metal disc with the pulley the bolts and nuts are used. The 7mm bolts and the 13mm nuts are used for the joints with the wooden base. The 4mm bolts and the 8mm nuts are used for the joint of disc with pulley.

3.11 Wheel

Fig 3.10 Wheel

Dimension- Internal dia. - 22mm External dia. - 300mm Width - 47mm Iron Bush -5.5mm Material - Vulcanized rubber. Justification: - It was cheap and easily available.

3-D Model of the Design:

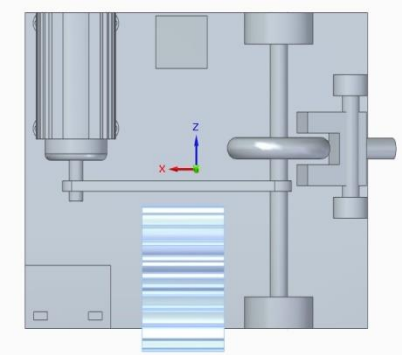

Fig 3.11 Top View of the Design

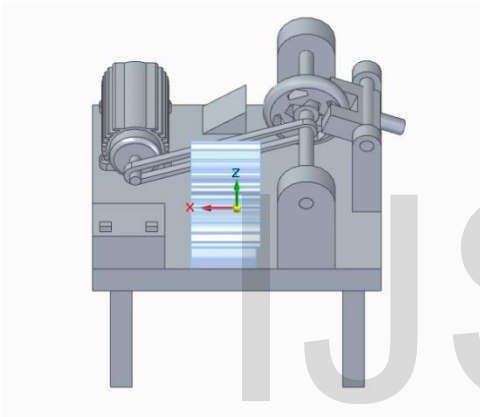

Fig 3.12 3D View of the Design

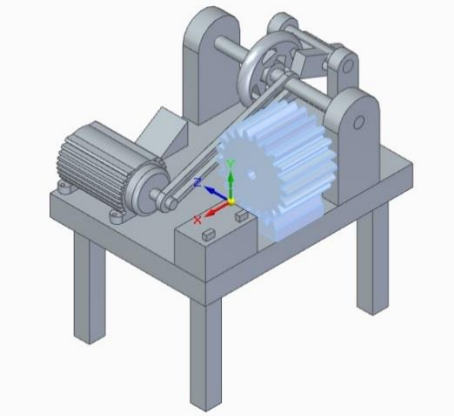

Fig 3.13 Orthogonal View of the Design

3.12 Construction Details

The construction of the system is done by the following manner. The system consists of a column. The pulley is mounted at the top of the vertical column. This setup is fitted on a wooden board which is act as a base. On the other end of the base, the motor is fitted with the help of bolts. The driving wheel pulley (motor) and the driven wheel pulley are looped by a typical v-belt. A metallic disc is mounted with the front of the driven pulley. An electromagnet is fitted in the front of the metallic disc which is fitted with driven pulley. The important thing is that the electromagnet is to be fitted with the smallest clearance with the metallic disc. The ON/OFF switch and the regulator are connected with the electromagnet and the motor respectively with the help of the electric wires to control the current supply to them.

3.13 Working Principle

The basic work of an electromagnetic brake is to reduce speed of the vehicle using electromagnetic force to induce a mechanical frictional resistance within the wheels. These kinds of brakes operate through an electric actuation, but transmit torque mechanically.

3.14 Working Methodology

When the power supply is given the motor, the pulley is driven by the belt. Now the pulley is continuously rotated. As the steel plate is connected along with pulley it is rotated in front of the electromagnet. When the braking is required the control, switch is turned on. So, the current or voltage is applied on the electromagnet. A magnetic field is created by an energizing coil by the application of voltage or current. This coil develops magnetic lines of flux between the metal discs thus attracting the armature to the face of the metal disc. When the current or voltage is removed from the brake (electromagnet) the metal disc is free to rotate. Here springs are used as medium to hold the armature winding of the electromagnet away from the disc. Rotating motion in wheels is achieved by switching controls of the supply to the coil. Slippage occurs only during deceleration only when the brake is engaged; there should not be slippage once the brake comes to a full halt.

3.15 Software Arduino IDE

Microcontroller	ATmega328P
Architecture	AVR
Operating Voltage	5 Volts
Flash Memory	32 KB of which 2 KB used by Boot loader
SRAM	2KB
Clock speed	16 MHz
Analog I/O Pins	8
EEPROM	1 KB
DC Current per I/O Pins	40 milliamps
Input Voltage	(7-12) Volt

3.16 What is Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

3.17 Why Arduino

Thanks to its simple and accessible user experience, Arduino has been used in thousands of different projects and applications. The Arduino software is easy-to-use for beginners, yet flexible enough for advanced users. It runs on Mac, Windows, and Linux.

Teachers and students use it to build low cost scientific instruments, to prove chemistry and physics principles, or to get started with programming and robotics. Designers and architects build interactive prototypes, musicians and artists use it for installations and to experiment with new musical instruments. Makers, of course, use it to build many of the projects exhibited at the Maker Faire, for example. Arduino is a key tool to learn new things. Anyone - children, hobbyists, artists, programmers - can start tinkering just following the step by step instructions of a kit, or sharing ideas online with other members of the Arduino community.

There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Netmedia's BX-24, Phidgets, MIT's Handyboard, and many others offer similar functionality.

All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50

Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.

Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs

Open source and extensible hardware - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

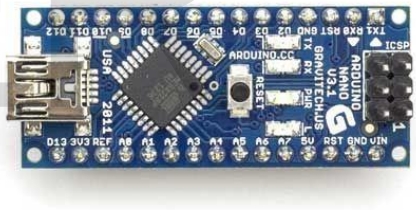

Fig 3.14 Arduino IDE

3.18 Shaft

Dimension - Length - 2.5 ft. Diameter - 16.5 mm Material? Iron Justification: - Available only of iron and diameter is adjusted keeping in view of wheel inner diameter. The length is adjusted according to the fabrication.

4. DESIGN PARAMETERS

12V DC Motor. (2.3mm shaft diameter, 2pin connection)
Speed of Motor: 600 RPM
Pulley Reduction Ratio: 1:1

4.1 Force Produced

The force between electromagnet and another piece of ferromagnetic material separated by a gap of distance G is,

$$F=\frac{(IN)2}{(2G)2} x\ \mu\ A$$

Where:

- $\mu = 4\pi*10^{-7}$
- F is the force in Newtons

- N is the number of turns
- I is the current in Amps
- A is the area in mm2
- G is the length of the gap between the solenoid and a piece of metal

Note, any units can be used for A and g so long as they are consistent

NOTE: These Calculations is done when ECU is switched off. When ECU is switched on these values will be divided proportionally to each brake.

1. Total Force produced,

$F= \frac{(N*I)2\ \mu\ A}{(2\ g2)}$

F= 161.7 N

2. Resistance of wire, $R= \frac{\rho L}{A}$

$= \frac{1.7*10^{-8}*13.8}{0.503}$

=0.466 Ω

3. Heat produced, H=I^2*R*T

= 4^2*0.466*60

= 447.36 J

4. Power transmitted by the motor,

P = 20 W

5. The twisting moment (T'),

$T' = \frac{P*60}{2\pi N}$

= 1.90 N.m

Shafts Subjected to Twisting Moment

$\frac{T}{J} = \frac{\tau}{r}$

for round solid shaft, polar moment of inertia,

$J = \frac{\pi d^4}{32}$,

So above equation becomes,

$T' = \frac{\pi \tau d3}{16}$,

d =3 mm.

Solid shaft of mild steel was used. Considering factor of safety, shaft of 7mm is used.

6. Kinetic energy of vehicle during braking is given by,

$KE=\frac{1}{2*m*(U2-V2)}$

=0.5*1*(102-02)

=50 J

Maximum weight transferred from rear to front wheels on applying brakes,

Condition: Wheel base equal to 3 times the height of its CG above the ground and adhesion factor of road is 0.6.

$W= \frac{\mu'*h*f*w}{(b*g)}$,

$= \frac{(0.6*0.6)*w}{3}$

=12w

Therefore, weight transfer= 12%.

7. Minimum Stoppage Distance

When vehicle deaccelerate with g=9.8 m/s2,

$S= \frac{U2}{2g}$

$= \frac{102}{(2\ x\ 9.8)}$

S=5.20m

8. Average Braking Force to stop vehicle,

Work done to stop vehicle = Change in it's KE

FS =0.5MU2

$F= \frac{0.5*20*102}{5.1}$

F'=200 N

Since theoretically calculated force produced by electromagnets (F) is less than force required to stop the vehicle in 5.1 m so vehicle will stop at 6.2m.

4.2 Braking Efficiency

$\eta= \frac{0.4U2}{S}$

$= \frac{0.4*102}{5.1}$

η=80.1 %

NOTE: The value of efficiency changes for each velocity and respective stoppage distance.

DESIGN AND CALCULATIONS

4.3 Main Pulley speed

N1= 800 R.P.M

N2=? D1= 75 mm

D2= 50 mm

$\frac{N2}{N1} = \frac{D1}{D2}$

N2=640 R.P.M

4.4 Secondary Pulley Torque

Power = 200 watts

$P = \frac{2*\pi*N1*T1}{60*103\ T1}$ =3.66*103 N-mm

$T1 = \frac{\pi}{16*fs*d1\ 3\ Fs\ (Ind)}$ =0.044 N/mm2< fs (perm) = 34 N/mm2

Therefore, Design is Safe

4.5 Main Pulley Torque

Power = 200watts

$P = \frac{2*\pi*N2*T2}{60*103}$

T2= 5.49*103N/mm2

$T2= \frac{\pi}{16*fs*d2\ 3\ Fs}$

(Ind) =0.22 N/mm2 < fs (perm) = 34 N/mm2

Therefore, Design is Safe

4.6 For Load Calculation

Ft = $\frac{4P}{\pi d2}$

P = 704 KN

4.7 Belt calculation

Centre distance of pulley = 2 (D1 + D2)

C= 112.5

S = V = $\frac{(\pi * D1 * N1)}{60000}$ = 3.76 m/s

Arc of contact (α) = $\frac{1800 - (D1 - D2)}{C * 600}$ = 1630 330 = 2.85 Radian

L= $\frac{2*C + \pi (D1+D2)}{\frac{2 + (D1-D2)}{4*c}}$

L=422 mm

4.8 Design of Frame

Size of the Frame is 25*25*3 (b*d*t) square angle mild steel channel

Consider the maximum load on the frame to be 20 kg.

Max. Bending moment = force*perpendicular distance = 20*9.81*400

M = 78480 Nmm

We know, M / I = σb / y

M = Bending moment

I = Moment of Inertia about axis of bending that is; Ixx

y = Distance of the layer at which the bending stress is consider (We take always the maximum value of y, that is, distance of extreme fiber from N.A.)

E = Modulus of elasticity of beam material

I = BD^3/12-bd3 /12

= 25*25^3 / 12 -19*19^3/12

I = 21692 mm4 σb = My

I = $\frac{78480 * 12.5}{21692}$

σb = 45.22 N /mm²

The allowable shear stress for material is σall = Syt / fos.

Where Syt = yield stress = 210 MPa = 210 N/mm²

And FOS is factor of safety = 2

So σall= $\frac{210}{2}$ = 105 MPa = 105 N/mm²

Comparing above we get, σb < σall i.e 45.22 < 105 N/mm²

So design is safe.

Conclusion

We completed literature survey and fabrication work in progress. With one major challenge to check the compatibility of electromagnetic braking with Electronic brake distribution EBD as per our design and calculation which in testing phase of our project successfully gave proper brake force distribution among two pair of Electromagnetic Brakes and helps us to know about a new way to use EBD except with ABS. By doing this project we now know that EBD can successfully work with EM brakes. Electronic control unit also helped EM brake to last longer by only providing necessary amount of current required for safe braking which results in long lasting braking system.
In addition, it is found that electromagnetic brakes make up approximately 80% of all of the power applied brake applications. And by using EBD, surely this amount of percentage will increase which led to more efficient braking

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