Frictionless Electromagnetic Braking System

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Abstract - *An electromagnetic brake may be a new and revolutionary concept. Electromagnetic braking system may be a modern technology braking system utilized in light motor heavy automobiles. This system is a combination of electro-mechanical concepts. The frequency of accidents is now-a-days increasing thanks to inefficient braking system. It is apparent that the electromagnetic brake is an important complement to the safe braking of heavy vehicles. It aims to attenuate the breakdown to avoid the road accidents. It also reduces the maintenance of braking system. An advantage of this technique is that it is often used on any vehicle with minor modifications to the transmission and electrical systems. An Electromagnetic Braking system uses magnetism to interact the brake, but the facility 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 due to the present flowing across the coil and causes armature to urge attracted towards the coil. As a result, it develops a torque and eventually the vehicle involves rest. These brakes are often incorporated in heavy vehicles as an auxiliary brake. The electromagnetic brakes are often utilized in commercial vehicles by controlling the present supplied to supply the magnetic flux. The working rule of this technique 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. This eddy current trying to prevent the rotating wheel or rotor. This results in the rotating wheel or rotor comes to rest/ neutral these are totally friction less. Due to this, they are more durable have longer life spangles maintenance is there. These brakes are a superb replacement on the convectional brakes thanks to their many advantages. The reason for implementing this brake in automobiles is to scale back wear in brakes because it friction less. Therefore, there will also be no heat loss. The electromagnetic brakes are much effective than conventional brakes the time taken for application of brakes is also smaller.*

Key Words: Automobiles, Brakes, Electromagnetic System, Magnetic Flux, Economic

1. INTRODUCTION

Brakes are the device which are wont to retard the motion of moving vehicle for purpose of decreasing the speed and to avoid the accidents. In brakes the K.E. converted into heat with the assistance of friction between the restraint and disk. During this tremendous amount of warmth is generated and lost to the environment. Which in turns decreases the lifetime of restraint. The method of adjusting the restraint of auto isn't a cheap one. To avoid such energy losses and to form process more economical standard braking system is replaced by the more advance frictionless electromagnetic braking system. Which works on the principal of electromagnets. During this project we are making a braking system. Which may be applicable in two-wheeler at high speed and low maintenance cost. Here we are going to use an electromagnetic coil and a plunger. There's an electromagnetic effect which moves the plunger within the braking direction. When electricity is applied to the sector, it creates an indoor magnetic flux. That flux is then transferred into a hysteresis disk passing through the sector. The hysteresis disk is attached to the brake shaft. A magnetic drag on the hysteresis disk allows for a continuing drag, or eventual stoppage of the output shaft. There are many merits of using pure electronically controlled brake systems. The properties and behaviour of the brake are going to be easy to adapt by simply changing software parameters and electrical outputs rather than adjusting mechanical components. This also allows easier integration of existing and new control features like anti-lock braking system (ABS), vehicle stability control (VSC), electronic hand brake (EPB), etc., also as vehicle chassis control (VCC) and adaptive control (ACC). Diagnostic features and therefore the elimination of the water polluting brake fluids are additional benefits, also as alittle number of components, simplified wiring and generalized optimized layout.

2. LITERATURE REVIEW

Several literatures are identified within the field of Electromagnetic Braking system. Various authors are doing research add this particular area which are discuss below.

Umang S. Modi, Swapnil C. Bhavasar(June-2015) had done research add Current trends in Electro-magnetic Braking System. During this research work they stated that the potential of the braking system is often increased using electromagnetic brakes, and sliding mode controller are often used for satisfactory results for electromagnetic brake control. In this paper the authors have attempted to form practical electro-magnetic brakes and it's proposed to use the electro-magnetic braking system alongside the traditional braking to avoid overheating and breakdown. These electromagnetic brakes are often utilized in wet conditions which eliminate the anti-skidding equipment, and price of those brake are cheaper than the opposite types. Third paper represents a FEM model of magnetic braking. The model analyses and computes the magnetic flux at an early level of braking system design. This project demonstrated that the air gap features a significant effect on the magnetic flux from FEM model.[1]

Sagar Wagh, Aditya Mahakode, Abhishek Mehta and Vaneela Pyla (June2017) has done research work Electromagnetic Braking System in Automobile. During this research work they stated that 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 little leakage may cause complete failure of brakes. While in electromagnetic braking coils and firing circuits are attached individually on each wheel, even any coil fails the brake doesn't completely fails remaining three coil works properly. And this technique needs little or no of maintenance. During this paper, it's found that electromagnetic brakes structure approximately 80percentage of all of the facility applied brake applications. Electromagnetic brakes are used as supplementary retardation equipment additionally to the regular friction brakes on heavy vehicles. The frictions brakes are often used less frequently and thus practically never reach high temperatures. The brake linings would last considerably longer before requiring maintenance and therefore the potentially brake fade problem might be avoided. This enhanced braking system not only helps in functional braking but also helps in avoiding the accidents and reducing the frequency of accidents to a minimum. Furthermore, the electromagnetic brakes prevent the danger which will arise from the prolonged use of brake beyond their capability to dissipate heat. [2]

Potapov L.A., Fedyaeva G.A., Smorudova T.V. (2016) has done research work on Modeling Electromagnetic Processes in Electromagnetic Brakes and Slip Clutches with Hollow Ferromagnetic Rotors. During this research work they stated that a mathematical and a computer model are obtained; the instant of electromagnetic brakes with a hollow ferromagnetic rotor has been estimated supported these models. Mechanical characteristics derived from these equations match with experimental ones after introduction of the sting effect factor. The equation enables researches of impacts of varied structural parameters on the instant of electromagnetic brakes and slip clutches and to enhance the planning of those devices. The analysis of obtained models has revealed features of electromagnetic processes within the hollow electromagnetic rotor which features a non-linear magnetic characteristic. The characteristic curves provided illustrate effect of rotation frequency on non-uniform distribution of current density and magnetic induction over the rotor section.[3]

G.L. Anantha Krishna1* K.M. Sathish Kumar (2018) has done research work on Experimental Investigation of Influence of varied Parameters on static magnet Eddy Current Braking System. During this research work they stated that Investigations on static magnet eddy current braking system were administered with Neodymium Iron Boron (NdFeB) magnets of 12.5 mm thickness and 50 mm diameter. Investigations were administered with Copper, Aluminium, Brass discs of 4 mm, 6 mm and eight mm thickness at 2000 rpm, 3000 rpm and 4000 rpm totalling to 27 experiments. It's observed that Copper disc 6 mm thickness in percentages of 84.8, 86.3, 81.8 speed reduction. Time taken for speed reductions are 16 seconds, 15 seconds and 22.5 seconds respectively. Aluminium disc of 8 mm thickness was observed to possess 70.6, 86 and 85.1 speed reduction. Time taken for speed reductions are 3.3 it's observed that percentage of speed reduction is more and time taken is a smaller amount in Aluminium disc of 8mm thickness. This is often thanks to higher permeability, positive susceptibility and better depth of penetration in Aluminium disc. However, in Copper disc of 6 mm thickness it's observed that percentage of speed reduction is more but time taken is more as compared with Aluminium disc. This is often thanks to negative susceptibility, lesser depth of penetration of induced magnetism and low permeability of Copper.[4]

Yusuf Yasaa, Eyyup Sincarb, BarisTugrul, Ertugrulb, Erkan Mese (July 2016) has done research work on A multidisciplinary design approach for electromagnetic brakes. during this study, a comprehensive design for EM brakes is achieved. Critical steps in design and optimization are highlighted. Simple and functional analytical models are derived to understand the time domain electrical performance of EM brake. Flux linkage and induced magnetism as a function of ampere-turn and air gap are analysed and determined by utilizing FEA software. A thermal model of EM brake is formulated analytically and also EM brake thermal behaviour is investigated through 3D FEA software. An algorithm is made up to optimize EM brake performance by making the required trade-off between requirements and parameters. A proto-type of the brake is produced and experimental tests are conducted on the prototype to verify the planning. Good compatibility between test results and analytical models is satisfied. Production tolerances and difference between spring constants cause fluctuations within the current waveform leading to armature imbalance which has an impact on brake reaction time and reduced brake performance. it's observed that, the symptoms about parallelism in brake are detected from the present waveform in production stage which enables to spot problems at an early phase. it's detected that magnetic flux and lining friction capacity are degraded with elevated coil temperature which results in decreasing torque capacity of EM brake. Housing with coils can be filled up with some epoxy resins with high thermal conductivity to improve the thermal performance of EM brake.[5]

3. CONSTRUCTION

The system consists of a rectangular shaped frame, made up of mild steel. the roller bearings are mounted on the frame by welding. The shaft is being hold in between the bearings. The wheel and the aluminium disc is mounted on the shaft at a specific distance. Two AC type electromagnets are situated near the aluminium disc and mounted on the frame. The torque is provided to the shaft through chain drive, which is driven by a motor, mounted on the frame. The system is also equipped with the ultrasonic sensor unit, which is operated by ECU unit, which senses the presence of obstacle and retards the motion.

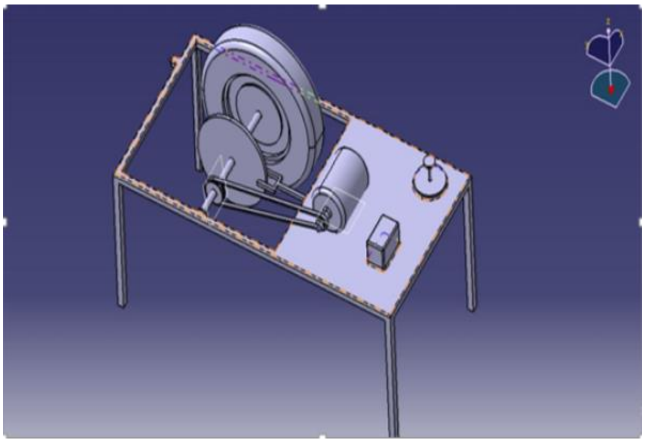

Fig -1: 3D CAD Model of Electro-magnetic Braking System

4. WORKING

Electromagnetic brakes operate electrically, but transmit torque mechanically. this is often why they are utilized to refer as electro-mechanical brakes. Over the years, Electromagnetic brakes became referred to as electromagnetic, pertaining to their actuation method. the variability of applications and brake designs has increased dramatically, but the essential operation of braking remains same. Single face electromagnetic brakes structure approximately 80 percent of all of the facility applied brake applications. The electromagnet is energized by the AC supply where the magnetic flux produced is employed to supply the braking mechanism.

When the electromagnet isn't energized, the rotation of the disc is free and accelerates uniformly under the action of weight to which the shaft is connected. When the electromagnet is energized, magnetic flux is produced thereby applying brake by retarding the rotation of the disc and therefore the energy absorbed is appeared as heating of the disc. So, when the armature is interested in the sector the stopping torque is transferred into the sector housing and into the machine frame decelerating the load. The AC motor makes the disc to rotate through the shaft by means of pulleys connected to the shaft. Ultrasonic sensor is situated ahead of the frame of braking system. This ultrasonic sensor emits the ultrasonic waves of specific frequency, which are wont to detect the thing nearby. When a object comes within the range of 5 to 10 meters of frame then ultrasonic sensors detects the subsequent object and activates the breaking system to right away apply the brakes.

Fig -2: Working Model of Electro-magnetic Braking System

5. DESIGN AND ANALYSIS

- **Design of shaft:**

Firstly, we have select the material for shaft is Mild Steel Material selection for shaft is steel i.e., 1090

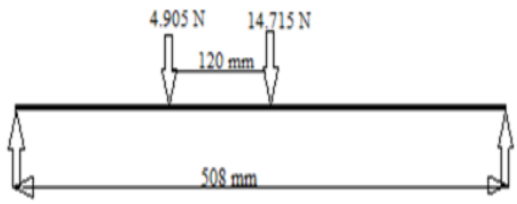

Fig -3: FBD of shaft.

Assumptions,
Brinell hardness number (BHN)=255
Weight of pulley (Wp) =4.905 N
Weight of Tyre (Wt) = 14.715 N
(Forces along Y direction) = reaction at bearing A - weight of tyre weight of pulley + reaction at bearing B. ΣF y=Ra - Wt - Wp + Rb
=Ra+Rb=19.62N Moment about pt. A ,
ΣM a=(134*4.905) + (254*14.715) - (Rb*508)
Reaction at B (Rb) = 8.651N
Reaction at A (Ra) = 10.96N
Resultant reaction (R) = $(Ra^2 + Rb^2)$ = 195.31N
Maximum moment,
M=Ra*134
=10.96*134
=1468.64 N. mm
Maximum Torque,
T= F*Dp/2
=195.13*432/2
=42148.08 N.mm

Table -1: values of shock and fatigue factors

SR.NO	Application	Kb	Kt
1	Load gradually applied.	1.5	1.0
2	Load applied with minor shock.	1.5-2.0	1.0-1.5
3	Load applied with heavy shock.	2.0-3.0	1.5-3.0

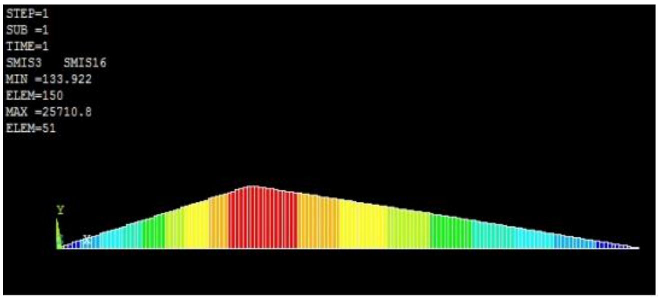

Fig -4: Bending Moment Diagram.

Select the value of shock and fatigue factors, i.e. Kb and Kt for heavy shock.

Kb=2 Kt=1.5 ....[6]

Equivalent torque,

$Te=((KbM)^2) + ((KtT)^2)$

=63290.315 N.mm

Allowable shear stresses,

τ all=0.3Syt

or (Whichever is smaller)

0.18Sut

τ all=74.1

or

=151.38

τ all=74.1 N/mm^2

Maximum torque,

$\tau max=(16Te/\pi d^3)$

d = 17.48 mm 18 mm

Diameter of the shaft (d) = 18 mm

- **Design of Bearing:**

According Diameter of shaft is 18 mm

Table -2: dimensions and static and dynamic load capacities of bearing.

Dia. of shaft (d)	Outer Dia. of bearing (D)	Inner Dia. of bearing (b)	Dynamic load capacity (C)	Static load capacity (Co)	Designation
18	24	5	1560	815	61802
18	32	9	5850	2850	6002
18	35	11	7800	3550	6202
18	42	13	11400	5400	6302

Given: D=32 mm b= 9mm

Co=2.85 KN C=5.85 KN ....[6]

Radial force (Fra) = 180.88 N

Axial force (Fa) = 90.44 N

Fa/Fra=0.5 Fa/Co=0.0317

Fa/Fr> e

Table -3: X and Y factors for bearing.

(Fa/Co)	(Fa/Fra)>e	(Fa/Fra)> *e*	e
0.025	0.56	2.0	0.22
0.040	0.56	1.8	0.24
0.070	0.56	1.6	0.27

From Table,

X=0.0317 Y=?

X1=0.025 Y1=2 ....[6]

X2=0.04 Y2=1.8

So by Interpolation,

(0.0317-0.025)/(0.04-0.025) = (Y-2)/(1.8-2)

Y=1.910 X=0.0317

Equivalent dynamic load,

Pe = (XVFr+YFa)*Ka

=267.71 N.

Rated bearing life (in million revolutions),

$L10=(Lh10*60*N)/(10^6)$

=300 Million revolution.

Using Load Life Relationship

$L10=(C/Pe)^a$

Here a=3 (for Ball bearing)

$(300)^1/3 * 267.71 = C$

=1.792

1.792< 5.85

Hence, the design is safe.

- **Design of Chain:**

Rated Torque- 3.9 kg-cm

Motor RPM=200

Power= $2\pi NT/60$ =8.013 W

Simple Roller Chain with One Strand

Centre Distance a = 200mm

No. Of teeth = 22

Service Factor (Ks)

Therefore we have select Ks=1.3

For single strand chain K1=1

For 22 No. teeth, tooth correction factor K2=1.29

KW Rating of chain = (KW to be transmitted)*(Ks) / (K1*K2)

=8.075*10Γ − 3KW

For such power rating, we have selected chain no. 04B.

For 04B chain,

Pitch P=6 mm

Roller dia. A=4 mm

Nominal Dia. Of sprockets =55 mm

Table -4: service factor (Ks)

Type of Load	IC engine with hydraulic drive	Electric motor	IC engine with mechanical drive
Smooth shock	1	1	1.2
Moderate shock	1.2	1.3	1.4
Heavy shock	1.4	1.4	1.7

No. of Teeth on driven sprocket Z1=22
No. of teeth on driver sprocket Z2=22
No. of link in chain (Ln) =2*(a/P) + (Z1+Z2)/2+[(Z2-Z1)/2)]^2 * (P/a)
=86.66
=87 mm
Length of Chain:
L=Ln*P =522 mm

Table -5: Tooth correction factor (K2)

No. Teeth on sprocket	K2
20	1.18
21	1.26
22	1.29

- **Magnetic Strength:**

1. Magnetic force produced (B) = IN
=4*10 *2*550 =0.00138 T which is magnetic force produced by one electromagnet as we are using two electromagnets so our total force will be Total Magnetic force
(B) = 2*B =0.00276 T.
2. Total Force produced (F) = (B*B*A)/(G*G)
=0.00276*226.194/50.265 =171.396N
3. Resistance of wire(R) = L/A
=1.7*10 *13.8/0.503 =0.466
4. Heat produced (H)=I*I*R*T
=2*2*0.466*60 =112 J

6. FUTURE SCOPE

The many new technologies are arriving in world. They create tons of effect. Most industries got their new faces thanks to this arrival of technologies. industry is additionally one among them. there's a boom in World's industry. Therefore, many researches is additionally going here. As a crucial a part of automobile, there also are innovations in brakes. Electromagnetic brake is one among them. This enhanced braking system not only improves 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 which will arise from the prolonged use of brake beyond their capability to dissipate heat.

7. CONCLUSION

Electromagnetic braking system is found to be more reliable and more effective as compared to other braking systems. In oil utilized braking system or air utilized braking system even, a small leakage may lead to complete failure of brakes. While in electromagnetic braking coils and firing circuits are connected separately on each wheel, even any one of the coils damaged or fails the brake does not completely fails as the remaining three coil works properly. And this system requires very little maintenance. In addition, it is found that electromagnetic brakes make up approximately 80 and of all of the power applied brake applications. Electromagnetic brakes have been used as supplementary retardation equipment in addition to the conventional friction brakes on heavy automobiles. The frictions brakes can be used less frequently and therefore practically never reach at very high temperatures. The brake linings would last considerably longer before requiring larger maintenance and the potentially brake fade problem could be avoided and hence highly economic.

REFERENCES

[1] Umang S. Modi1, Swapnil C. Bhavasar (June-2015) Current trends in Electromagnetic Braking System.
[2] SagarWagh, Aditya Mahakode, Abhishek Mehta and Vaneela Pyla (June- 2017) have done research work Electromagnetic Braking System in Automobile.
[3] Potapov L.A., Fedyaeva G.A., Smorudova T.V. (2016) have done research work on Modeling Electromagnetic Processes in Electromagnetic Brakes and Slip Clutcheswith Hollow Ferromagnetic Rotors.
[4] G.L. Anantha Krishna1, K.M. Sathish Kumar (2018) have done research work on Experimental Investigation of Influence of Various Parameters on Permanent Magnet Eddy Current Braking System.
[5] Yusuf Yasaa, Eyyup Sincarb, BarisTugrul ,Ertugrulb, Erkan Mese (July 2016) have done research work on A multidisciplinary design approach for electromagnetic brakes.
[6] Sudarshan T A, Sefeej, Swathin, Nikith T (June 2018) have done research on design and fabrication of Electromagnetics Bending Machine.
[7] Purohit Harish Laljibhai, Thakor Divyang Javansinh, Vnkar Dipak Dahyabhai, Prajapati Jaimin Rameshbhai (2018) have worked on Electromagnetic Braking System.
[8] Design Data Book by V.B. Bhandari.
[9] Braking System-Wikipedia.