ANALYSIS OF EDDY CURRENT BRAKING SYSTEM

Dushyant Sharma|14BME0406 | Dr. Narendrinath Babu T.| SMEC
Uddalak Datta | 14BME0844 | Adheesh Chatterjee | 14BME0855

Introduction

An enormous amount of energy is lost to overcome friction in usual mechanical braking system, eddy current braking system or electro-magnetic braking can prove to be a fulfilling solution for frictionless braking. Friction causes the disc and attached wheel to slow or stop. This leads to a great component of energy to waste whereas eddy current braking system can reduce this friction loss and help in improving the overall efficiency of the automobile. In an eddy current brake an electromagnetic force between a magnet and a nearby conductive object in relative motion induces eddy current in the conductor through electromagnetic induction which opposes the relative motion causing the change in magnetic field.

SCOPE of the Project

The purpose of the project is to propose a much better and efficient braking system then mechanical braking by use of electromagnetic braking. Eddy current braking system has following advantages over conventional braking system-

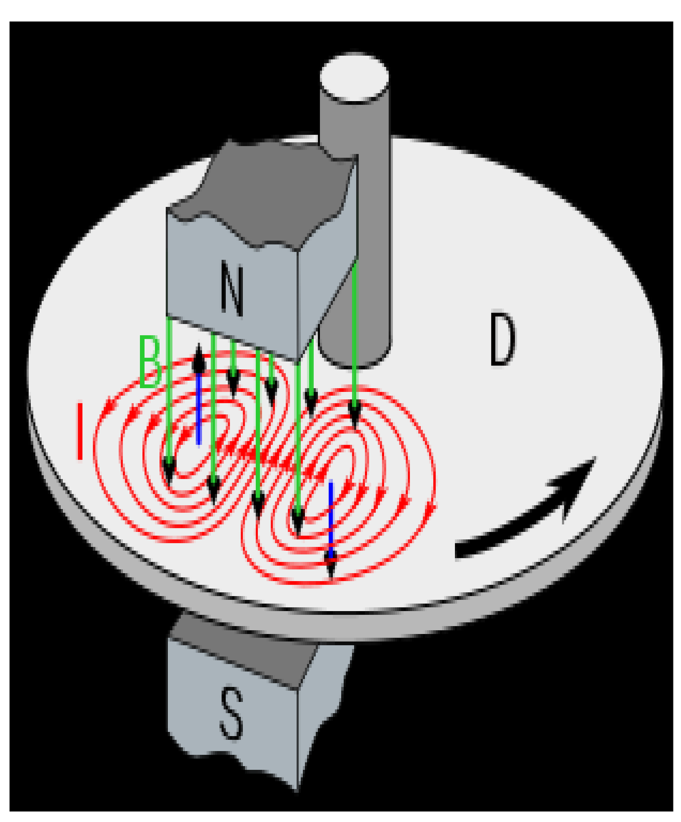
- These are non-mechanical, no moving parts hence no friction.
- Fully resettable, no parts need to be replaced
- Can be activated at will via electrical signal
- Low maintenance cost
- Operates at any rotational speed.

Methodology

The main purpose of this project is to conserve energy losses due to friction and how to improve it even farther with the use of electro-magnetic braking system.

Analysis of eddy current braking system is carried out on the basis of following factors-

- Thermal analysis of eddy current braking system and energy lost
- Variation of brake torque analysis with Air gap between the electromagnets
- Variation of brake torque analysis with thickness of electromagnetic disc



When a conducting object is passed through a Changing magnetic field, then eddy currents are induced in the conductor according to the **Faradays law of induction,**these eddy current inturn produces a magnetic field which opposes the origin of magnetic field causing the change(**By Lenz law).**Thus **the leading edge** of the disc will Produce a magnetic field that will oppose the Magnetic field of electromagnet thus eddy current flow in **counterclockwise** direction whereas at **the trailing edge** the decreasing magnetic field induces eddy current in **clockwise** direction to support the magnetic field and thus oppose the change of decreasing magnetic field.

FORMULA USED-

$$B = \frac{\mu_o n i}{l_g}$$

$$J = \sigma(R\,\dot{\theta} \times B)$$

$$T_b = \left(\frac{P_d}{\dot{\theta}}\right)$$

$$P_d = \rho J^2 \times \text{Volume} = \sigma R^2 S d \dot{\theta}^2 B^2$$

$$T_b = \sigma R^2 S d \dot{\theta} \left(\frac{\mu_o n}{l_g}\right)^2 i^2$$

Design parameters for the experiment setup

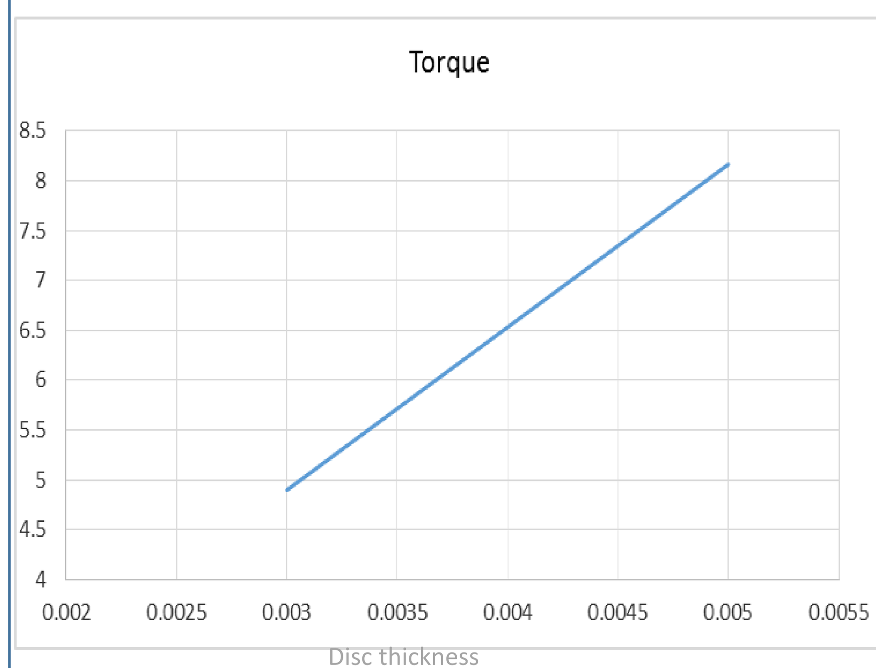
Aluminium disc radius, r	190 [mm]
Air gap, l_g	1, 3, 5 [mm]
Number of electromagnet turns, n	250
Disc thickness, d	4, 5 [mm]
Pole diameter	60 [mm]
Distance between center of disc and center of pole, R	70 [mm]
Pole area, S	$S = \pi(0.03)^2 = 2.828 \times 10^{-3}\,[m^2]$

μ_o been taken as $12.568 \times 10^{-7}\,N.A^{-2}$

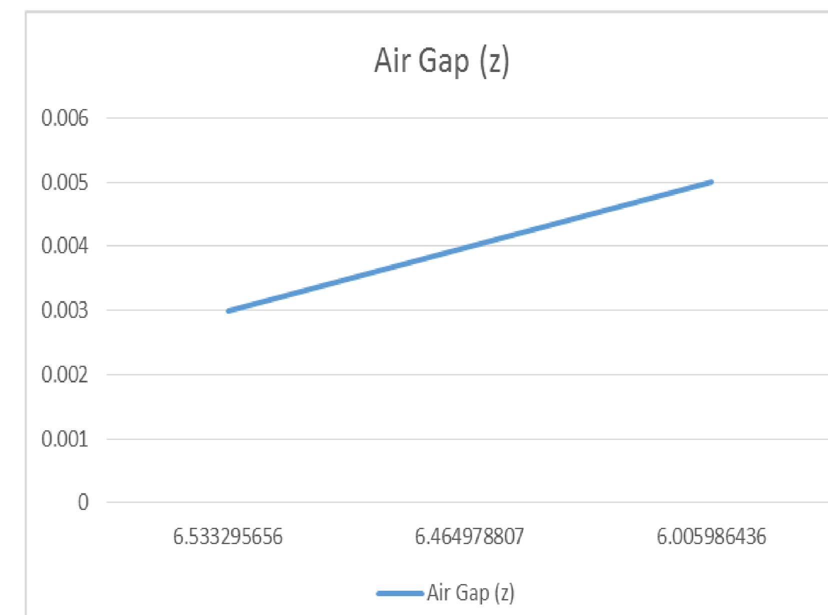
σ and $\dot{\theta}$ are the electrical conductivity and angular velocity of the brake disc.

Results

Using the various components modelled on Solidworks a complete assembly of the wrench was made.

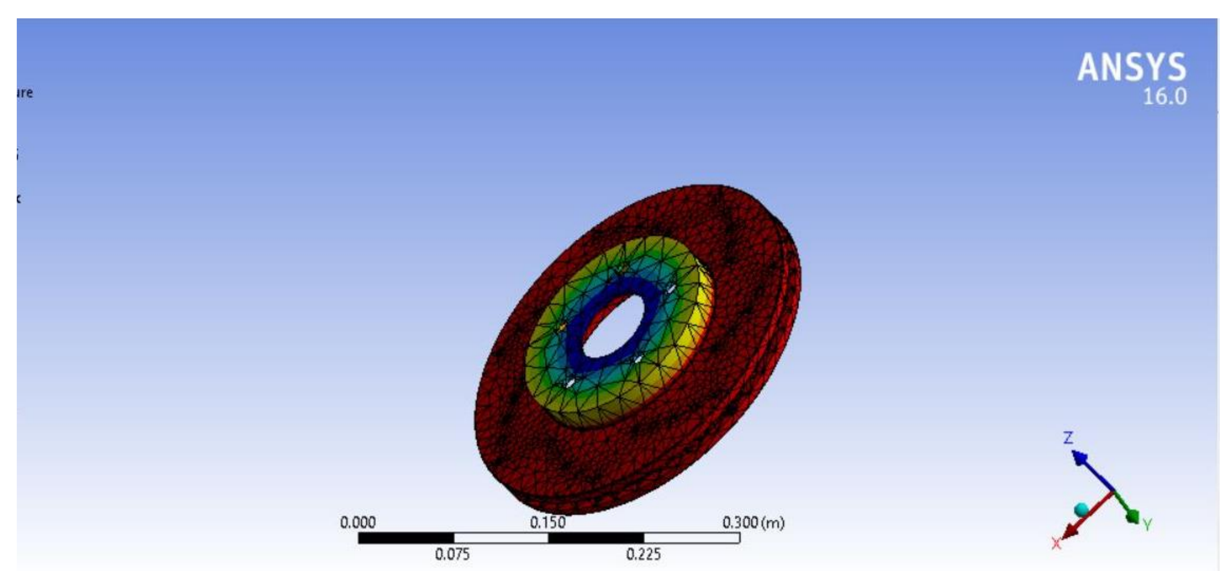


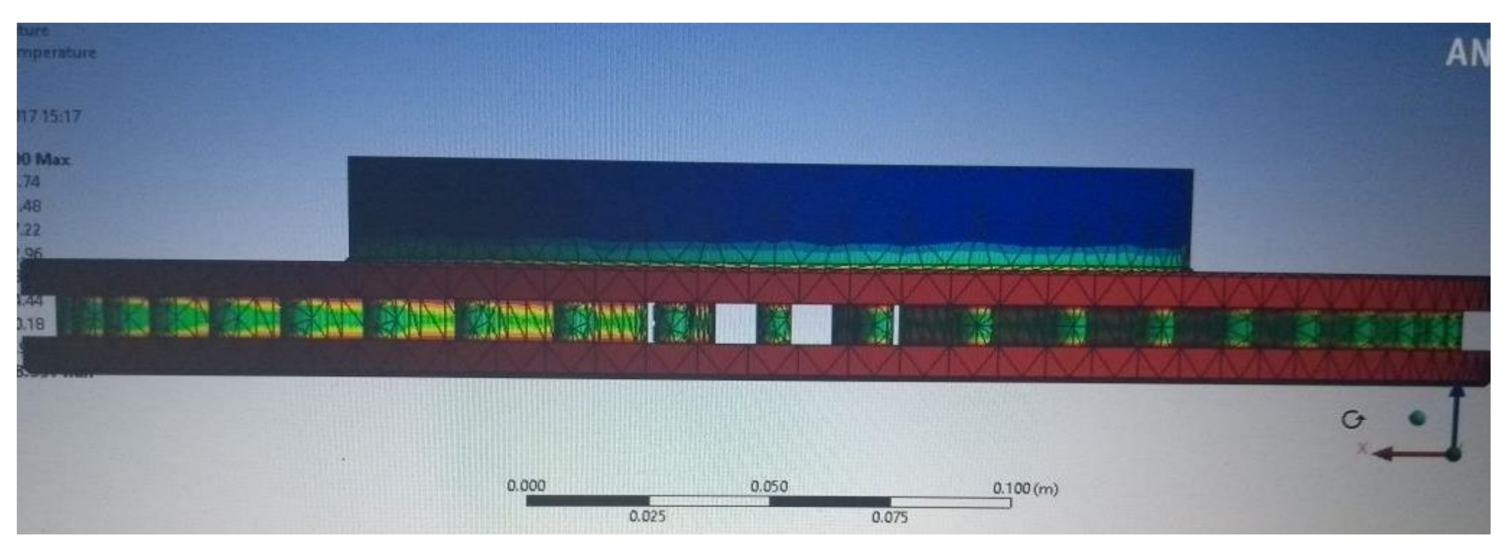
The Brake torque was calculated with varying Disc thickness while keeping the Air Gap constant.



The Brake torque was calculated with varying Air Gap while keeping the Disc Thickness constant.

The analysis was performed on ANSYS





	R (Distance between disc and pole)	θ (Angular Velocity of Disc	σ (Electric Conductivity)	S (Pole Area)				
	0.07	15.789	2.73E+07	2.82E-03				
Permeability of Air (M)	Number of Electromagnetic Turns (n)	I	Air Gap (z)	Magnetic Flux density (β)	Disc Thickness	Current Density (J)	Potential Diff. (PD)	Torque (Tu)
1.26E-06	250	5	0.003	0.523666667	0.003	15800478.6	77.36565384	4.899971742
					0.004	15800478.6	103.1515787	6.53312931
					0.005	15800478.6	128.9394734	8.166411641
Permeability of Air (M)	Number of Electromagnetic Turns (n)	I	Air Gap (z)	Magnetic Flux density (β)	Disc Thickness	Current Density (J)	Potential Diff. (PD)	Torque (Tu)
1.26E-06	250	5	0.003	0.523666667	0.04	15800478.6	103.1542051	6.533295656
1.26E-06	250	5	0.004	0.39275	0.04	11850358.95	58.02424038	6.464978807
1.26E-06	250	5	0.005	0.3142	0.04	9480287.162	37.13551384	6.005986436

Conclusion

We can deduce from this design project that the braking torque in the Eddy Current Braking System varies with Disc thickness and Air gap.

We also observe that the Eddy current braking system is more efficient as well as economical than a conventional Mechanical braking system.

Contact Details

Uddalak.datta2014@vit.ac.in,Dushyant.sharma2014@vir.ac.in,Adheesh.chatterjee2014@vit.ac.in

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Electomagnetic Fields in Electrical Engineering-Andrzej Krawczyk,S.Wiak