MAT JOURNALS

Journal of Automation and Automobile Engineering
Volume 2 Issue 3

Design of Combined Braking System

KapilTathod
(Mechanical Engineering), Institute of Engineering and Technology, Devi AhilyaVishwavidyalaya , Indore, India.
kapiltathod10@gmail.com

Dr. AsheshTiwari
Head of Department, Mechanical Engineering Department, Institute of Engineering and Technology, Devi AhilyaVishwavidyalaya, Indore, India.

Abstract
The current tendencies in automotive industry need intensive investigation in problems of interaction of active safety systems with brake system equipment. Many applications need different types of brakes. One such is eddy current. It's difficult to stop the motion of the high RPM machine using one such system only. Conventional disc brakes suffer from problems like wear of disc, fading of brakes etc. One the other hand implementing eddy current system on conventional systems is not easy and also it takes much time to stop the rotating wheel. This paper focuses on the design of the Combined Braking System for high RPM machines which overcomes the disadvantage of both braking system and increases reliability. This system not only reduces braking effort but also increases the life of the braking system with less maintenance. The model is designed taken into the optimization and factor of safety. Use of this system will be user friendly and its manufacturing is feasible.

Keywords: *Eddy, Optimization, Durability, Reliability, Braking Torque*

INTRODUCTION
METHODOLOGY
Several steps were taken in practical in order to reach the goal

- Study of braking systems
- Market survey
- Selection of various components
- Designing of various components
- Reference CAD model prepared
- ANSYS report
- Final assembly using Creo Parametric 2.0
- Materials procured.
- Fabrication

THEORY OF BRAKES
THEORY OF BRAKES
What Is BRAKE????
Brake is a device which absorbs energy from a moving or rotation system to inhibit any kind of motion. It is used by almost every moving machine to control the pace.

Types of Braking Systems
1. Friction
2. Pumping
3. Electromagnetic

Electromagnetic and Hydraulic brakes (which employ the principle of friction) are generally used. But both have some limitations which do not allow them to be used in high RPM machines.

If hydraulic brake is alone employed to stop the high speed machine then there would be great loss of components due to wear, tear and heat. Furthermore, electromagnetic braking is a contactless braking but takes more time to completely stop the motion.

This paper comes up with an idea to overcame the consequences of each by designing Combined Braking System

COMBINED BRAKING SYSTEM

- A link between Hydraulic braking system & eddy current braking system incorporating the positive side of both the system, minimizing the flaws.
- Combined braking system can be used to control very high RPM which is difficult to achieve by conventional braking system.

WORKING PRINICIPLE

When a brake lever is triggered, electromagnetic brake will act and due to the presence of magnetic field the speed of the rotating component will slow down. Once it acquire a slow pace, then hydraulic brake will completely stop the motion. So in this way, the proposed system ensures safety and reliability.

OBJECTIVES

To overcome the following flaws of hydraulic braking system

- Abrasion of disc
- Pumping losses
- Abrupt failure due to leakage
- Brake fluid boiling

To overcome the following flaws of eddy current braking system

- Inefficient panic braking
- Poor braking on lower RPM
- Infinite stopping time
- To make the braking system more reliable due to dependence on dual braking.
- To minimize human braking effort.

DESIGNING

The process involves designing of 2 separate systems and then combining them into 1 unit so that a compact assembly is obtained with less weight.

NOTE- First Braking Torque was calculated for each system and then according to their value components were designed

Eddy Current Brake System Calculations

For calculations, consider one disk and a magnet. When the motion of rotating disk is hindered, using a magnetic field current is generated which opposes its cause and thus a braking torque (T_e) is generated. It is measured in [mN]. It can theoretically be derived from the formula

$T_e = (n*\pi*\sigma*D2 \quad *t*B2R2\omega)/4$… **Equation (1)**

Where

N= No of magnets

R = Effective Radius (m)

D = Diameter of the magnet (m)

d = Thickness of the disk (m)

σ = Specific Conductivity of the material ($\Omega^{-1} \cdot m^{-1}$)

θ= Instantaneous angular velocity (rad/s)

B= Magnetic Field (Tesla)

By various iterations to get the desired results following parameters were fixed.

Parameters

- No of magnets (N) =16
- Magnetic field (B)= 0.01T
- Time constant (τ)= 1.6901 sec
- Specific Conductivity (σ) = $35.5*10^6$ S/m
- Radius (R)=120 mm
- Thickness of Disk (d) = 10mm

  For the above equation all the variables (except angular velocity) were fixed.

  For θ, new sets of equations were used which first involved the basic equation of Newton’s Second Law

$I\ddot{\theta} + b\dot{\theta} = 0$… **Equation (2)**

b= Damping Coefficient representing the integration of certain variables

$b= (n \pi \sigma D^2 d R^2 B^2) / 4$… **Equation (3)**

$I= ½ \rho d \pi R^4$… **Equation (4)**

When the above equations are combined, we get the expression for angular velocity

$\theta=\omega^{\circ}e^{-(b/I)t} = \omega^{\circ}e^{-(1/\tau)t}$**… Equation (5)**

τ = time constant

Putting all the values in the equation (1, 2, 3, 4, and 5) gives braking torque due to Eddy current

T_e**=236.38 mN**

Time required to slow down the rotating disc

Governing Equation

$w=w^{\circ}e^{\wedge}(-t\tau)$ **… Equation(6)**

Final RPM= $w^{\circ}/100$)**… Equation (7)**

(considering that the speed reduces by 100 times

On solving equation **6&7**

Time calculated = **3 sec**

Hydraulic Brake System Calculations

To calculate the hydraulic braking torque **(T_b)**, a pressure is applied on the brake lever connected to the master cylinder. This master cylinder then forces the brake fluid to travel through brake lines and compressing the pads present in the caliper to rub against the rotating object.

Parameters Fixed

- Disc diameter = 240mm
- Master cylinder bore diameter =15mm
- Hub PCD = 140mm
- Calliper bore diameter = 24mm

Governing Equation

$F*R=(caliper)*A(caliper)*R(disc)$**…**
Equation (8)

P= Pressure applied in N

A=Area of caliper

R=Radius of Disc

On putting the values of parameter in equation- (6), we get

Final value **(T_b)=153Nm**

So Total Braking Torque= Te + $\mathbf{T_b}$ **=389.58 mN at t=0**

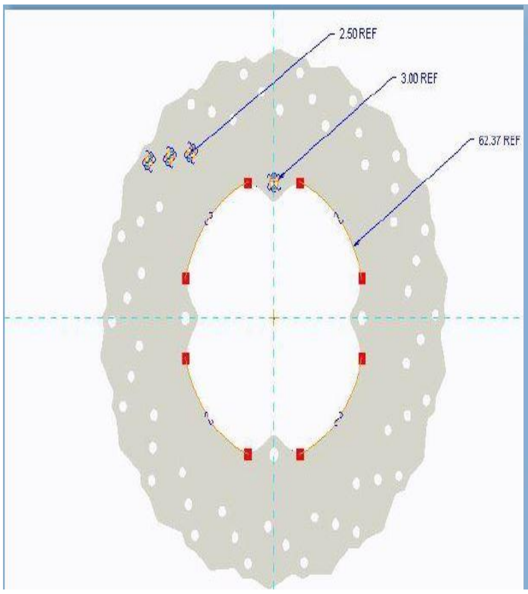
CAD MODELLING

Based on the final value of total braking torque and other parameters, cad models were prepared to verify the theoretical calculations with the aim of optimized weight.

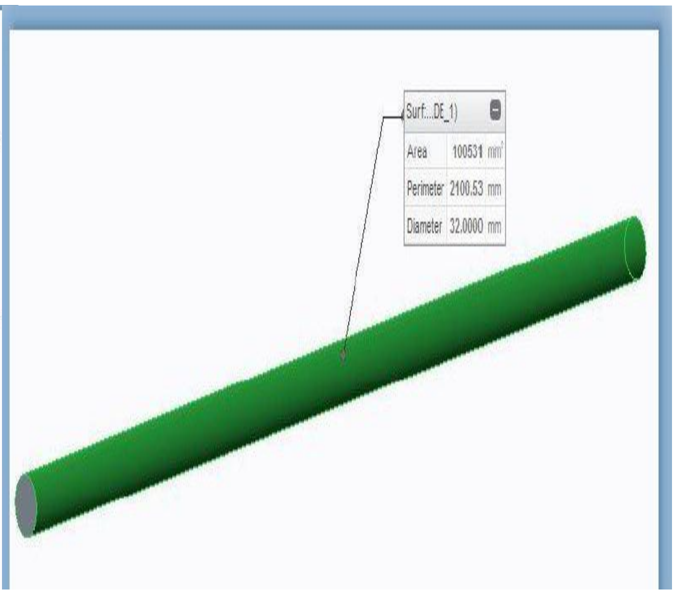
For this designing Software Creo Parametric 2.0 was used to make 3D models of components.

Some of them are:

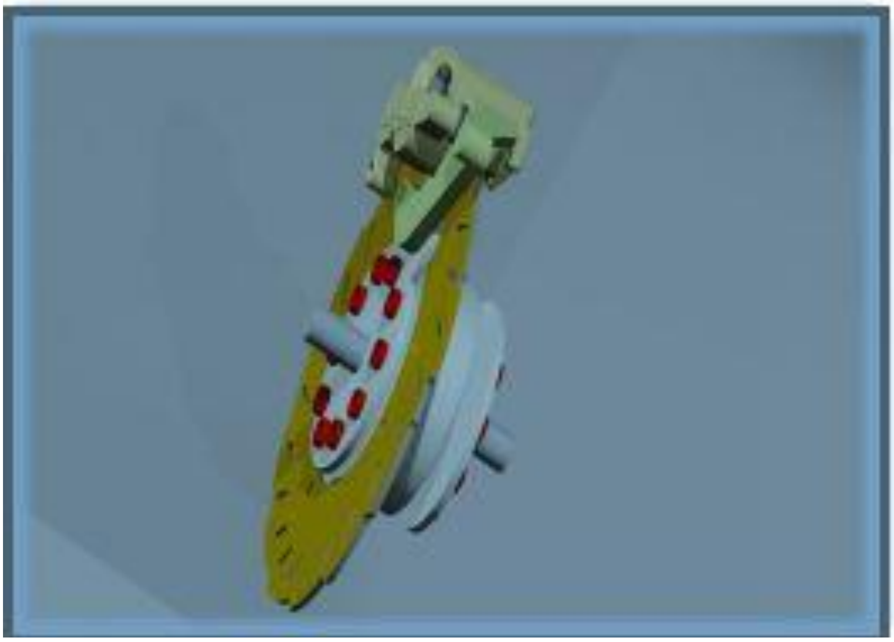
DISC



SHAFT



DISC ASSEMBLY



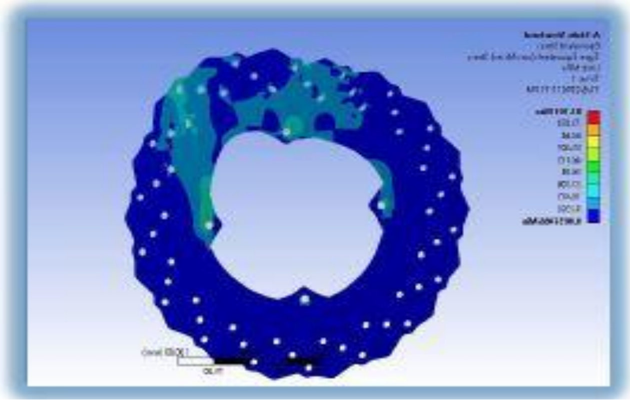
A PROTOTYPE

SIMULATION USING ANSYS WORKBENCH

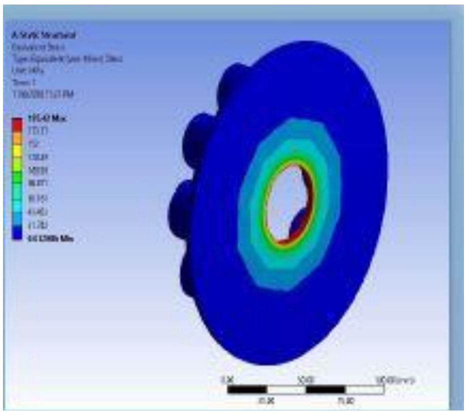
After the 3D Modeling, stresses on each component were analyzed using software with a safety factor of atleast2. Critical parts were analyzed and design was changed for components who failed to sustain the external force or torque.

Few modifications were made on the calculated outputs in order to increase the efficiency and reliability. Iterations were made on different materials to ensure the identification of a material with sufficient strength and less weight. Effect of external factors such as friction, heat dissipation was also kept in mind so that the mechanism does not fail in the practical use.

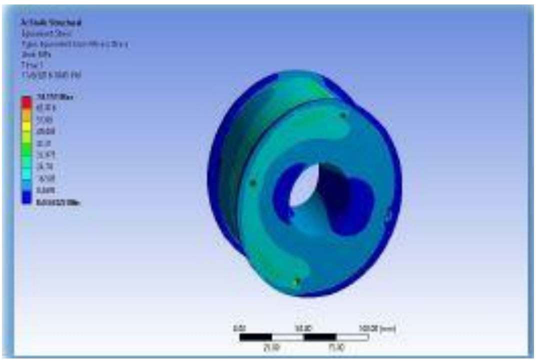
ANALYSIS OF DISC



COIL MOUNTING

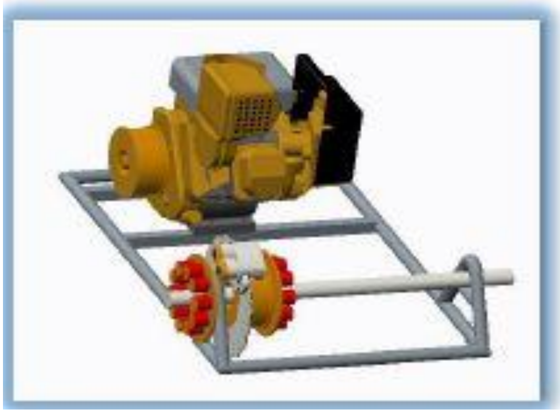


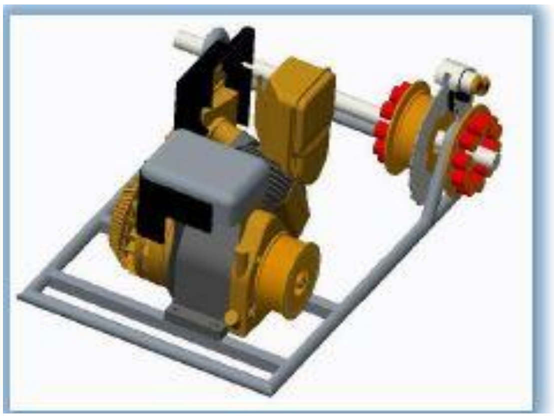
HUB

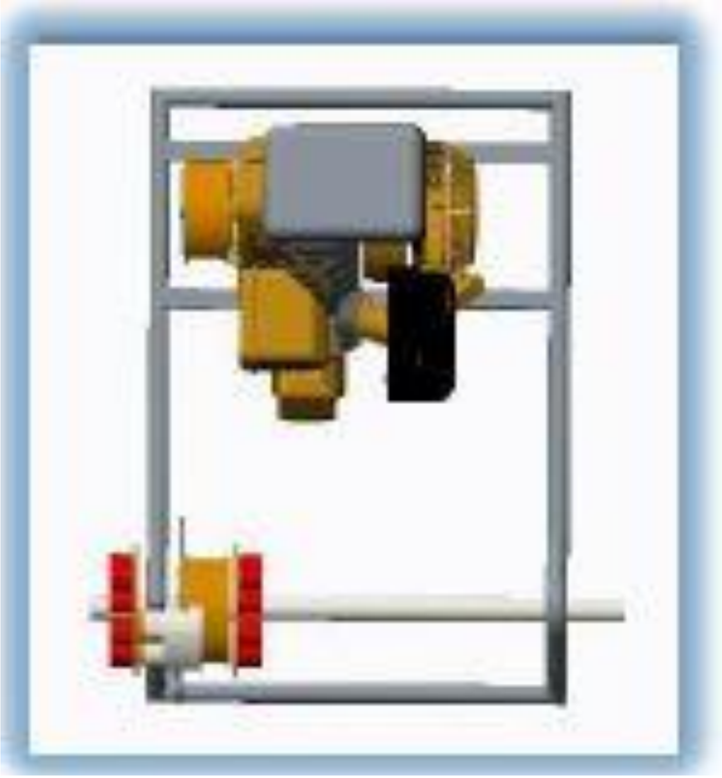


After the parts were finalized, an assembly was designed which occupies less space and can be used in different types of machines.

FINAL MODEL







EXPECTED OUTCOMES

- Reduced braking efforts in high rpm machines.
- Reduced wear in disc of hydraulic braking.
- Eddy current brakes can slow the machines but they're unable to completely stop the disc in short time. Combined brakes overcome this drawback.
- A brake with increased braking torque.
- Reduced stopping time due to hydraulic braking
- Lower toxicity due to limited use brake fluids.
- Suitable system for very high inertia and rpm like.
- Automobile
- Turbines
- Lifts

- Cranes
- Increased safety against impact loads in chains.

CONCLUSION

Machines which involves high speed still lacks in proper mechanism for braking. A single system may work but will be efficient for a short time only that is its durability is not satisfactory. However, this Combined Braking System may find an excellent use in this direction. With the eddy currents slowing down the speed and hydraulic stopping the moving body,completely brings more reliability. Moreover, this can be easily employed as design and fabrication process is not complex and within the nominal budget. The design only involves fewer modification in the whole assembly than the conventional system and achievable with the available technology. It has several benefits such as less wear in disc, less heat generation and increased braking torque. Such a concept may be promising in the future in the industrial sector.

REFERENCES

1. Research paper on “Eddy Current Brake Design for Operation with Extreme Back-drivable Eddy Current Motor” by Hollowell, Thomas Culver; Michigan University on 2010.
2. EdoardoRivado,AmbrogioGirotto, Giorgio Colombo, “Automotive Design of a Press Brake for Sheet Metal Bending ICED: 2005,PP 15-18.
3. Research paper on “Eddy Current Brake System” by John C Leask, publication number US5254061 A on 1993.
4. Report on “A parametric model of an **eddy current** electric machine for automotive **braking** applications” by IEEE published in IEEE Transactions on Control Systems Technology **Volume 12 Issue 3 on 2004.**
5. Book on “Simulation of Linear Eddy Current Brakes” by Michael Bartsch.
6. Book on “Automotive Engineering” by Kripal Singh.

