

# Advance Braking System

<sup>1</sup>Shruti G. Pandore, Durga B. Kalamkar<sup>2</sup>, Poonam V.Ranode<sup>3</sup>, Gauri R.Gosavi<sup>4</sup>, Prof. Sandip V.Fartale<sup>5</sup>

*Department of mechanical engineering sanjivani college of engineering Kopargaon, India*

**Abstract**—A Magneto-Rheological (MR) fluid disc brake is a device that transmits a torque by the shear force of MR fluid. The fluid is inserted between the rotating and fixed discs and a magnetic field is imposed on the fluid. In this paper, a complete test rig for an MR fluid disc brake is introduced. Experiments are conducted to measure the braking torque and speed of shaft during braking process and the results are presented at different voltage input to the brake. Also theoretical analysis for both MR brake and the mechanical system is developed and is solved numerically using finite difference method and Matlab software. Effect of current input to the MR brake, viscosity of fluid and design parameters is taken into consideration. A validation of the theoretical results with CFD model is introduced. The experimental results are performed and both angular velocity and the braking torque are obtained as responses during the braking process. A comparison between braking torques obtained from theoretical and experimental work shows agreement when voltage is 2 V at speed of 150 rpm and also agreement when voltage is 2 and 3 V at speed of 250 rpm.

**Keywords**— leaf spring; composite; analysis, ANSYS, Finite element, Spring rate.

## I. INTRODUCTION

The automotive industry has a commitment to build safer, cheaper and better performing vehicles. For example a new type of brake is introduced for braking process and is classified as a magneto-rheological fluid brake (MRFB) which potentially has some performance advantages over conventional hydraulic brake (CHB) systems. A CHB system involves brake pedal, hydraulic fluid, transfer lines and brake actuators (e.g. disc or drum brakes). CHB has a number of limitations, including, delayed response time due to pressure build-up in the hydraulic lines, bulky size due to its auxiliary hydraulic components such as the master cylinder, brake pad wear due to its frictional braking mechanism, and low braking performance in high speed and high temperature situations. MR fluid is filling the gap between the two surfaces fixed and rotating disc. MR brake allows for continuous control of torque. When there is no

magnetic field the torque is caused by viscosity of carrier liquid, bearings and seals. Sarkar and Hirani [1] designed a squeeze film magneto rheological brake considering compression enhanced shear yield stress of magneto rheological fluid. To validate the theoretical design and its findings, a prototype of single-plate squeeze film MR disc brake has been developed. Experimental test set-up helped to illustrate braking torque under different control currents (0.0–1.25 A). Zainordin et al. [2] introduced a Modelling and validation of magneto rheological brake response using parametric approach. Applying magnetic field increased the yield strength of the MR fluid where this fluid was used to decrease the speed of the rotating shaft. Rossa et al. [3] presented design considerations for magneto rheological Brakes. The model assigned a desired magnetic flux density over the fluid surface. The magnetic circuit dimensions and the necessary power can be calculated in consequence. The analysis is focused on a single disc and on a single drums brake and highlighted the interdependence of the measures of performance as a function of the dimensions. Park et al. [4] introduced performance evaluation of an automotive magneto rheological brake design with a sliding mode controller. The proposed brake system consisted of rotating discs immersed in MR fluid and enclosed in an electromagnet, in which the yield stress of fluid varies as a function of the magnetic field applied by the electromagnet. Li and Du [5] designed and tested a new magneto rheological (MR) brake prototype. Firstly, rheological properties of MR fluids, in particular of dynamic yield stress, were experimentally investigated based on a Bingham plastic model. Finally, this was followed by an analysis of an electromagnet using the finite element method. Tsubata and Kikuchi [6] introduced a bicycle simulator with cylindrical magneto rheological fluid brake. They developed a pedal torque converter with a microcontroller. According to the results, the developed controller adequately performed pedal torques on the basis of the required conditions. Poznic and Casniji [7] described an analysis of a cylindrical magneto rheological fluid

brake. An MR rotary disc brake has the property that its braking torque changes quickly in response to an external magnetic field strength. The theoretical considerations of the design alternative for usual simple MR fluid brake are put into consideration.

## II. LITERATURE REVIEW

the brake-disc is an integral element of the braking system, with the primary function of slowing or stopping the vehicle's wheels and the secondary function of dissipating the heat generated by the braking process. Here, the brake pads are pressed onto the braking discs using mechanical means. The study's goal is to use CATIA V5 to simulate a disc brake, do "finite element analysis (FEA)" using ANSYS 19, and then evaluate the results against the data from the original experiments. In this investigation, we used ANSYS software to undertake a computational thermo-mechanical analysis of disc brake installation inside a hydraulic braking system. The purpose of this study is to shed light on the mechanics of heat movement within and outside of a brake disc via testing and simulations. Both of these incidents have been thoroughly examined. The simulation models may be validated by conducting experimental assessments of a hydraulic braking system. Ten consecutive brakes are tested numerically and experimentally. The results provide a means of checking the accuracy of the models by contrasting numerical with experimental temperatures.

ICMMT-22 Journal of Physics: Conference Series 2484 (2023) 012034 IOP

Publishing doi:10.1088/1742-6596/2484/1/0120343

Zhang, Zhang, Wu, et al. [16] tested the stopping power of the "copper-based brake pads" with varying amounts of carbon fibre (CF) on a scaled-down dynamometer. The findings demonstrate that the addition of CF significantly alters the tribo-microhardness film's and plastic deformation resistance. Nano CFs have a greater "specific surface energy" than graphite and quickly react with iron to generate cementite. The high strength of cementite with iron particles in the "sub-friction surface" allows it to play a strong-supporting function on the friction surface, while cementite that is a constituent of the "tribo-film" also strengthens the tribo-film as well as decreases the oxidation degree of iron. Together, these factors help to create a tribo-film that is resistant to plastic deformation, which in turn imparts a low "tribo-film transfer" rate during

high-energy braking, helping to maintain a constant friction coefficient and minimise wear. For copper-based brake pads, the optimal range of "carbon fibre content" (CF) is between 0.4 & 1.2 weight percent; at this concentration, the friction coefficient remains relatively constant between 0.357 to 0.372 even during sustained, high-velocity braking. Sri Karthikeyan et al. [17] made many improvements to brakes in recent years. Asbestos fibre was widely used for decades in the production of brake pads despite the fact that it poses serious health risks for a variety of reasons. Asbestos wears down when brakes are used, releasing asbestos dust into the air. Furthermore, the brake housing might become a trap for asbestos particles. Workers may unknowingly inhale asbestos dust whenever the brake housing has to be opened, posing a health risk. Asbestos also presented a threat to employees in the industrial sector, whether via intentional or accidental exposure. As a result, a novel formulation including natural fibres like jute, KENAF, as well as aloe vera plus additives like epoxy resin as well as hardener is shown. Various analyses have shown that these fibres may be employed effectively in the future to produce brake pad material with the desired qualities. Rudramoorthy et al. [18] discovered that the brake disc surface might have reached a potentially-hazardous temperature due to frictional heat. The goal of this study is to identify a lightweight material that can replace the brake disc and evaluate the performance of such discs under severe braking conditions. Several sectors are now engaged in a cutthroat race to produce cutting-edge lightweight automobiles. In this work, we replace the brake disc's lightweight materials with those of high strength and stiffness, then analyse and compare the material's performance to that of conventional brake discs. Materials for disc brakes are chosen with the help of the CES granta material selection software. CES material selection software is responsible for the first material screening. Axisymmetric components in the ANSYS software are used to calculate the disc brake's temperature rise, stress distribution, and deformation throughout the disc brake. This study compares cast iron and steel to a metal matrix composite comprised of aluminium in terms of stiffness & strength, as well as the projected stress as well as temperature distributions in these materials. Gupta et al. [19] examined brakes, which, as a crucial part of vehicles, need the greatest research and development to improve safety on the road. It's

natural for brake use to cause a rise in temperature. In order to keep the brake disc at a steady temperature, this heat must be quickly dispersed. Due to the consistent temperature, thermal fatigue of the “brake disc material” is reduced. Analysis of “Grey cast Iron, Aluminum, and High speed steel” is being conducted on a domain that is a brake disc for an ATV. An commercial programme called "Ansys Finite volume based CFD Solver" is used to conduct the research. Disc surfaces of each material were also changed by drilling holes of different shapes into them, including circles, ellipses, oblique circles, oblique ellipses, and vanes. Abebe et al. [20] analysed the disc brake rotor is a crucial part of the disc brake system, which slows or stops the vehicle. The brake disc heats up and experiences thermal strains whenever the brakes are used. This means that the disc brake design & material selection must be meticulous if it is to last as long as possible. Both an analytical and a “finite element analysis” are used to the brake disc in an effort to better understand the temperature and thermal stress distribution in that component. Cast iron, aluminium metal matrix composites, maraging steel, as well as E-Glass were chosen as the four materials for this project. Brake torque, heat flow, and average temperatures during stops were all determined by plugging in data on the vehicles in question. In order to determine the highest possible

### III. METHODOLOGY

Design of MRB.

Use components high magnetic permeability

Total load on vehicle (Assume four wheeler)(T<sub>w</sub>)

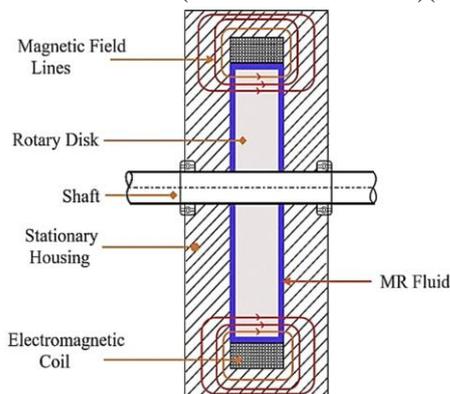


Fig 1.4 Design of brake

Total weight of vehicle = 2000 kg (take maximum)

Total weight on single wheel = 2000/4=500kg

Passenger or Loaded weight

Specifications of system

Shaft diameter = 20mm

Shaft bearing (inner diameter = 48mm)

(Outer diameter = 5mm)

Distance of bolt centre to centre of shaft = 5cm

Abbreviations

MRB – Magneto rheological brake

d – Diameter

σ<sub>t</sub> – Tensile strength

T – Torque

x – Distance

t - Time

V - Velo

### CALCULATIONS

1) Shaft

material : Silicon steel

Consider ultimate tensile strength = 500 mpa

$$\sigma_t = \frac{F}{\left(\frac{\pi}{4}\right) d^2}$$

$$500 = \frac{1000}{\left(\frac{\pi}{4}\right) d^2}$$

$$d = 50.46\text{mm}$$

Therefore ,We will take material strength in calculation

$$\sigma_t = 1400 \text{ mpa}$$

1

$$\sigma_t = \frac{F}{\left(\frac{\pi}{4}\right) d^2}$$

$$d = 30.15\text{mm}$$

As per standard dimensions we will take shaft diameter as 20mm

Now we will check safety of design

$$d = 20 \text{ mm}$$

$$F = 1000 \text{ KN}$$

$$\sigma_t = ?$$

$$\sigma_t = \frac{1000 * 10^3}{\left(\frac{\pi}{4}\right) 20^2}$$

$$\sigma_t = 3.183 \text{ KN/mm}^2$$

Therefore ,Induced stress in material is very very less . If we take hardened mild steel ten design is safe.

$$67400 \gg 3.183 \text{ induced } \sigma_t$$

Therefore ,

Possible to increase diameter upto d = 35mm

$$\sigma_t = \frac{1000 * 10^3}{\left(\frac{\pi}{4}\right) 35^2} = 1039 \text{ N/mm}^2$$

$$d = 50$$

$$\sigma_t = \frac{1000 * 10^3}{\left(\frac{\pi}{4}\right) 50^2} = 509 \text{ N/mm}^2$$

Therefore d = 55mm we can increase

2) Standard dimension of brake components

Shaft bearing (inner diameter = 48mm)  
(Outer diameter = 5mm)

3) Distance from bolt center to center of shaft = 5.1cm

4) Braking torque calculations

$$T = \frac{n \cdot 150 \cdot 0.2 \cdot ((0.2)^2 - (0.1)^2)}{2} = 329.8 \text{ N/m}^2$$

For vehical

Now we will check breaking torque

$$\text{Work done} = \left(\frac{1}{2}\right)mv^2$$

V = 90 rpm  
M = 1000 kg

$$KE = 8.1 \cdot 10^3$$

$$329.86 \cdot x = 8.1 \cdot 10^3$$

$$X = 24.55 \text{ meters (Distance)}$$

Speed = 90 rpm  
Distance covered = 24.55 meters

Time required to stop vehical

$$\left(\frac{V}{t}\right) = x$$

$$t = 3.66 \text{ sec}$$

TIME REQUIRED TO STOP VEHICAL WITH SPEED OF 90 RPM IS 4 SECONDS

### SELECTION OF MATERIAL

Brake components

Material used – Soft iron and silicon steel

Silicon addition –

Improve hardness and strength,

magnetisim increased

resistance oxidation

increase fluidity,

increase wear strength

Electrical conductivity

Lower density

Improve thermal stability

Normal 2-4 %

Soft iron core –

Malleable, ductile, low electrical resistivity , high density corrosion , magnetic shield

### DESIGN OF MRB

Use components high magnetic permeability

Total load on vehicle (Assume four wheeler)(Twv)

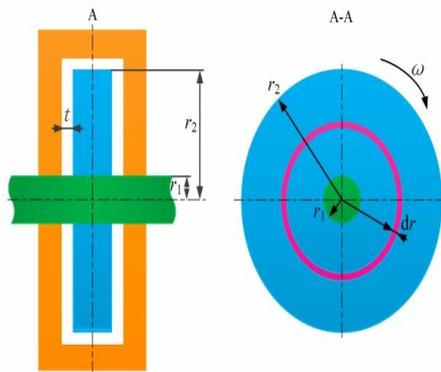


Fig 1.4 Design of brake

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Passager or Loaded weight

Specifcations of syetem

Shaft diameter = 20mm

Shaft bearing (inner diameter = 48mm)

(Outer diameter = 5mm)

Distance of bolt centre to centre of shaft = 5cm

Test of set-up



### IV. ADVANTAGES

Fast Response:

MR brakes can react quickly to changes in braking demands, according to ResearchGate.

Reduced Components:

They can have a simpler design compared to traditional hydraulic brakes, leading to fewer mechanical parts.

Easy Control:

The braking force is easily controlled by adjusting the magnetic field, according to ScienceDirect.com.

No Friction:

MR brakes utilize MR fluids, eliminating metal-to-metal friction in the braking process.

Low Power Requirement:

They require less power to operate.

Disadvantages:

High Mass: MR brakes can be heavier than conventional brakes, which may be a concern for weight-sensitive applications.

Potential Lack of Sensitivity: Some MR brakes may not be as sensitive at low speeds, potentially impacting braking feel, says Tires Plus.

Complex System: The overall system may be more complex than traditional brakes due to the need for MR fluid, magnetic field control, and sensors.

High Cost: MR brakes can be more expensive than conventional brakes.

Dependence on Power: They rely on an external power source to operate, unlike mechanical brakes.

Specialized Repairs: Repairs may require specialized knowledge and equipment.

## V. CONCLUSION

Magneto rheological fluid brake with single disk for all vehicles is designed as an alternative to the current conventional hydraulic brakes. The proposed system utilizes Bingham plastic model to calculate the total shear stress developed in ATV brakes. It is found that MRF 241 ES is better for brakes compared to MRF 132 DG. The geometry of MR brake is optimised using Taguchi method and designed using COMSOL multi-physics. This brake design converts the conventional braking system to a controllable braking system, thus eliminating the drawbacks of conventional braking system. The proposed design reveals better performance in terms of braking torque compared to conventional braking system.

This work can be extended on different fronts. One interesting and important way is to perform the dynamic analysis of the new design in order to determine its expected service life. Optimization with respect to cost considerations can also lead to easier implementation of MR brakes in ATVs.

As a disc is connected with shaft are rotating with rotary motion. As we apply electricity to electro magnet which induce magnetic field. As magnetic field induce viscosity of MR fluid change. As change in viscosity, rotary motion of a disc gradually decrease until come to rest. And its change in future braking system of automobile as well as mechanical industries vehicle and machines braking system. With the help of MR fluid its easy to maintain and reducing its cost

## VI. FUTURE SCOPE

Magnetorheological (MR) fluids have many potential applications in the future of braking systems, including: Improved response time

MR brakes can have a faster response time than conventional braking systems because they are electronically controlled.

Reduced power requirements MR brakes require less power than conventional braking systems.

Easy integration MR brakes can be easily integrated with other technologies, such as anti-lock braking systems (ABS), electronic parking brakes (EPB), and vehicle stability control (VSC).

Improved performance MR fluids can be improved by applying pressure to them, which can increase their yield strength up to ten times in shear mode.

Lower sedimentation rate Dimorphic MR fluids, which contain nanowires, have a lower sedimentation rate than conventional MR fluids. MR fluids are smart materials that can rapidly change their rheological properties when exposed to a magnetic field. In an MR brake, the fluid changes from a liquid to a semi-solid state when an electromagnet is energized, generating braking torque

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