FRICTIONLESS BRAKING SYSTEM

A project report submitted
In partial fulfilment of the requirement for the award of the degree of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

Submitted By

PENTAKOTA VARSHINI (317126520158)

MANYALA RAJU (317126520151)

RAVURI SREE VATSA (317126520171)

MAJJI JAYA SURYA (317126520149)

KOTHALA WILLIAM KERI (317126520145)

Under the esteemed guidance of

Mr I. Pavan Kumar

Assistant Professor

Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY AND SCIENCES
(Approved by AICTE, Permanently Affiliated to A.U., & Accredited by NBA and NAAC with 'A' Grade) Sangivalasa, Bheemunipatnam Mandal, VISAKHAPATNAM-531162

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (A)

(Affiliated to Andhra University, Approved by AICTE, Accredited by NBA & NAAC with A grade)
SANGIVALASA, VISAKHAPATNAM (District) – 531162

PRAGNANAM BRAHMA
ANITS

CERTIFICATE

This is to certify that the Project Report entitled **"FRICTIONLESS BREAKING SYSTEM"** being submitted by PENTAKOTA VARSHINI (317126520158), MANYALA RAJU (317126520151), SREEVATSA RAVURI (317126520171), KOTHALA WILLIAM KERI (317126520145), MAJJI JAYA SURYA (317126520149) in partial fulfillments for the award of degree of **BACHELOR OF TECHNOLOGY** in **MECHANICAL ENGINEERING**. It is the work of bona-fide, carried out under the guidance and supervision of **MR.I.PAVAN KUMAR**, Assistant Professor, Department Of Mechanical Engineering, ANITS during the academic year of 2017-2021.

PROJECT GUIDE

(MR.I.PAVAN KUMAR)
Assistant Professor
Mechanical Engineering Department
ANITS, Visakhapatnam.

Approved By

HEAD OF THE DEPARTMENT

(Dr. B. Naga Raju)
Head of the Department
Mechanical Engineering Department
ANITS, Visakhapatnam.

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCE
Sangivalasa-531 162 VISAKHAPATNAM Dist A P

ACKNOWLEDGMENT

We express our gratitude to our guide Mr. I. Pavan Kumar, Assistant Professor, Mechanical Engineering Department, Anil Neerukonda Institute of Technology and Sciences, for his inspiration, guidance and plentiful support in bringing out this project. In spite of his busy schedule he shared his valuable time for fruitful discussion and guidance.

We respectfully acknowledge our gratitude to Prof. T.V. HanumanthaRao (PRINCIPAL), Dr. B. Nagaraju (Head of the Department) Anil Neerukonda Institute of Technology and Sciences for his dynamic counselling, encouragement, perennial approachability and for extending his help for completion of the project.

Finally we sincerely thank all the staff members of the department for giving us their heart full support in all stages of this project.

PENTAKOTA VARSHINI (317126520158)

MANYALA RAJU (317126520151)

RAVURI SREE VATSA (317126520171)

MAJJI JAYA SURYA (317126520149)

KOTHALA WILLIAM KERI (317126520145)

LIST OF CONTENTS

LISTS OF FIGURES

ABSTRACT

Frictionless brake is a new and revolutionary concept. This system is a combination of electro-mechanical concepts. Frictionless Braking system uses Magnetic force to engage the brake, but the power required for braking is transmitted manually. These brakes can be incorporated in heavy vehicles as an auxillary brake. The frictionless brakes can be used in commercial vehicles by controlling the current supplied to produce magnetic flux. The working principle of this system is that when the magnetic flux passes through and perpendicular to the rotating wheel the eddy current flows opposite to the rotating wheel direction. This eddy current trying to stop the rotating wheel . This result in the rotating wheel comes to rest. The reason for implementing this brake in automobiles is to reduce wear in brakes as it is friction less. Due to this, they are more durable and have longer life span. Less maintenance and less lubrication are needed. Frictionless brake gives a better performance, which is today's need. To produce same amount of Braking force as in disc brakes, with the same size of disc, the electromagnetic brakes should have 621 turns of copper wire on solenoid. Heat generated in disc brakes (54,270 J) is way greater than heat generated in electromagnetic brakes (33.08 J). By using electromagnetic brakes we can reduce heat generation greatly. The cost estimation for disc brakes is around 71,600 Rs. The cost estimation for electromagnetic brakes is around 66,200 Rs. By increasing number of turns of copper wire in solenoid we can increase braking force, whereas there is more complexity in increasing braking force in disc brakes. Frictionless braking system is found to be more reliable as compared to other braking systems.

CHAPTER-I

INTRODUCTION

1.1 INTRODUCTION

1.1.1 AUTOMOBILES

An automobile is a wheeled passenger vehicle that carries its own motor as shown in fig 1.1.

FIG 1.1 Benz Auto, 1886

1.1.2 HISTORY OF AUTOMOBILES

Development started as early as the 17th century with the invention of the first steam-powered vehicle, which led to the creation of the first steam-powered automobile capable of human transportation, built by Nicolas-Joseph Cugnot in 1769. Inventors began to branch out at the start of the 19th century, creating the de Rivas engine, one of the first internal combustion engines and an early electric

motor. Samuel Brown later tested the first industrially applied internal combustion engine in 1826.Development was hindered in the mid-19th century by a backlash against large vehicles, yet progress continued on some internal combustion engines. The engine evolved as engineers created two- and four-cycle combustion engines and began using gasoline as fuel. Production vehicles began appearing in 1887, when Karl Benz developed a petrol or gasoline-powered automobile and made several identical copies. Recent automobile production is marked by the Ford Model T, created by the Ford Motor Company in 1908, as shown in fig 1.2 which became the first automobile to be mass-produced on a moving assembly line

FIG 1.2 The Ford Model T (foreground) and Volkswagen Beetle (background)

1.2 MAIN PARTS OF AUTOMOBILE

An automobile has several numbers of parts. But there are four essential components of automobile. These are:

1. The Chassis.

2. The Engine.

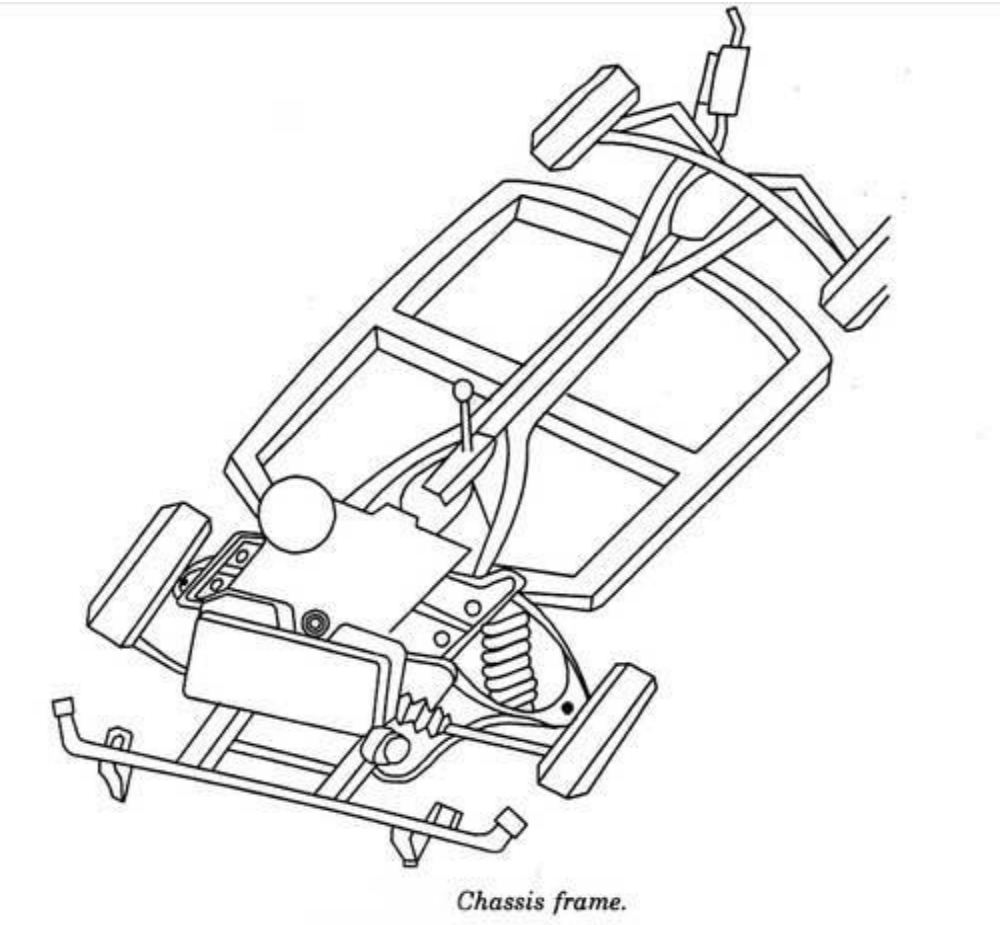
3. The Transmission System.

4. The Body.

5. The Control System.

1. The Chassis

The chassis of an automobile incorporates all the major assemblies consisting of an engine, components of transmission system such as clutch, gearbox, propeller shaft, axles, a control system such as brakes and steering, and suspension system of the vehicle as shown in fig 1.3. In other words, it is the vehicle without its body.



Chassis frame.

FIG 1.3 Chassis frame

2. The Engine

The engine is the source of motive power to an automobile. Obviously, it is a very important part of the automobile because in the absence of an engine, the automobile may not move at all, and its basic function of transporting passengers or goods would be defeated.

3. The Transmission System

The transmission system transmits power developed by the engine to the road wheels. The power available as output from the engine is in the form of rotation of the crankshaft This movement is to be transferred to the road wheels to cause their rotary motion. Their rotary motion makes possible the movement of the vehicle. The transmission system consists of different parts. These include clutch, gearbox, propeller shaft, differential and axle, live axle to be more precise as shown in fig 1.4.

Clutch

A clutch is a mechanical device that engages and disengages power transmission, especially from a drive shaft to a driven shaft. In the case of vehicles used for the transportation of goods, the smooth transmission process is essential as otherwise, it may cause damage to goods.

Gearbox

The gearbox is the component of the transmission system next to the clutch. It has got a gear train, and it provides different gear ratios. These ratios determine the rotary speed of output shaft from the gearbox. The torque transmitted to the road wheels gives rise to a propulsive force or (tractive effort) between these and the road. When starting from rest, a large tractive effort is required.

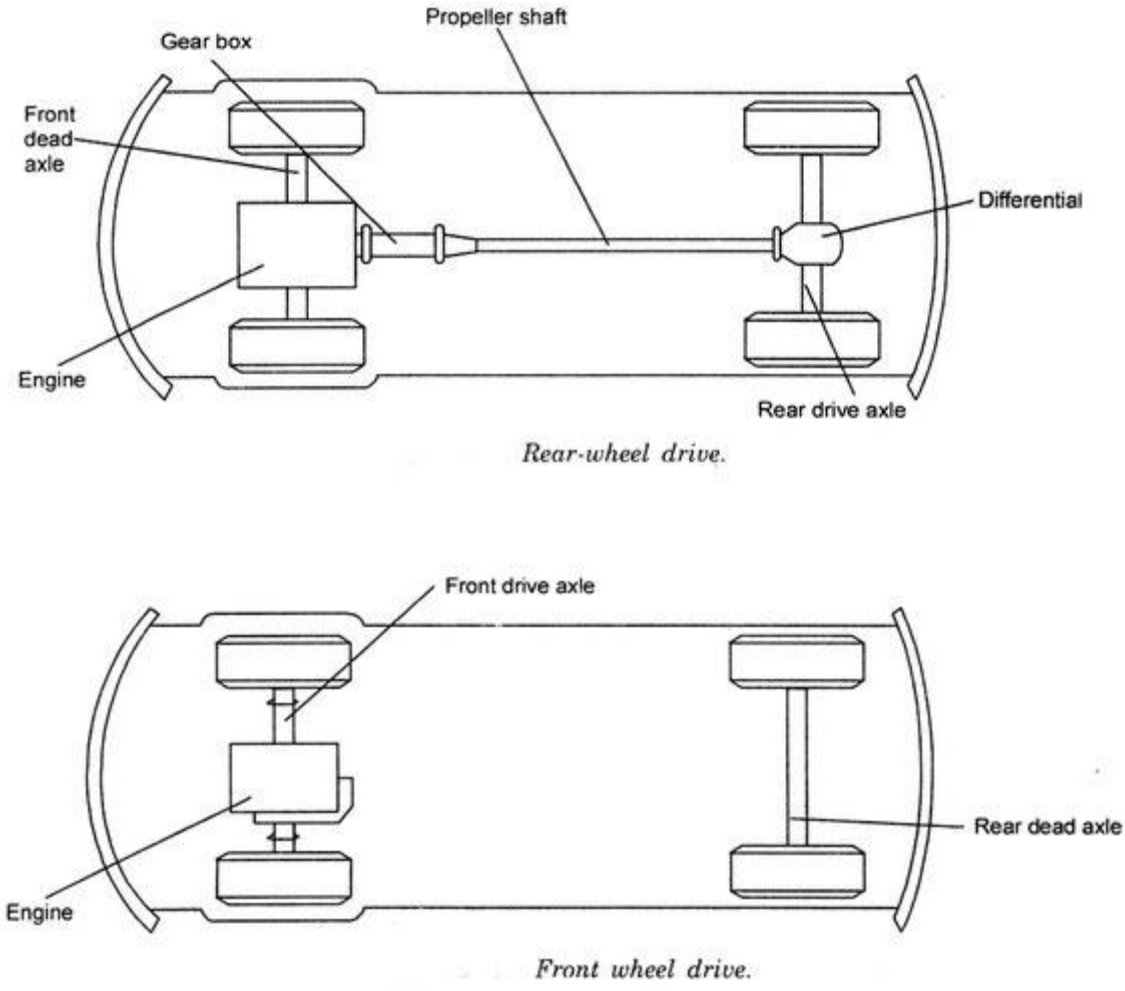


FIG 1.4 Rear wheel drive and Front wheel drive

Differential

The differential is the next component of the transmission system. The motion of propeller shaft is fed to the differential which turns it through 90 degrees. This is essential as the axle is at 90 degrees to the propeller shaft. The function is performed with the help of a pinion and a gear. Another important function of the differential is to reduce the speed of inner wheels and at the same time, enhance the speed of outer wheels by the same amount as shown in fig 1.5.

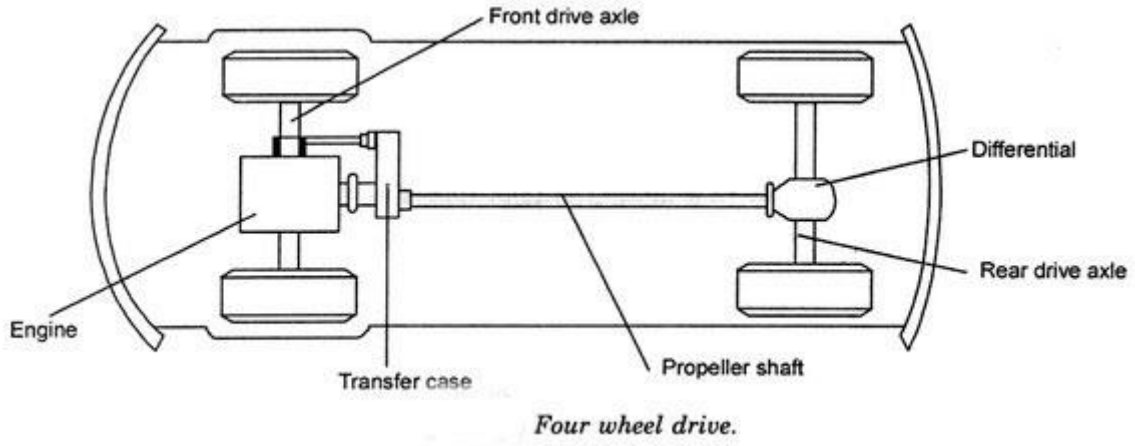


FIG 1.5 Four wheel drive

Axle

The axle is the next component of the transmission system. The axle receiving power from the engine is termed as ‘live’ axle. It is in two halves. The ends of the axle have road wheels connected to it. These road wheels are in direct contact with the road surface. The body of the automobile is above the axle. The axle also takes up the various loads including the weight of the automobile. It also transmits motion to the road wheels.

4. The Body

The use of a separate frame to which the body structure is attached is now almost obsolete except for some applications for heavy-duty commercial vehicles. Many heavy vehicles now use ‘sub-frames’ of simple construction to which the engine and gearbox are attached. It makes the vehicle compact, lightweight, and also its

cost is reduced. Some intermediate designs using a light chassis and a pressed steel body are also in use.

5. The Control Systems

The control systems are used to control the motion of an automobile and therefore are essential in an automobile. These include;

i. The steering system, and

ii. Braking system or brakes.

Steering system

The automobile, while moving, may be required to traverse a circular path. It has to be turned through some angle if the path is not straight. There may be other situations also when the road is turning towards left or right, and an automobile is required to turn to left or right. This turning of the automobile towards left or right or on the curved path is provided through steering mechanism. The steering system is required to be quite accurate as the automobile should turn accurately along with the path.

Braking system

This causes a reduction in speed of the vehicle and brings it to rest when necessary. Bringing an automobile to rest is as important as its movement.

Obviously, when we have reached our destination, we would like to stop; and therefore, the vehicle should come to rest. Also, there may be some kind of emergency and vehicle may be required to slow down or stop on the way. At that time, also its motion is to be controlled. This control on the motion is provided with the help of brakes.

1.3 BRAKES

A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction.

1.3.1 TYPES

Brakes may be broadly described as using friction, pumping, or electromagnetics. One brake may use several principles: for example, a pump may pass fluid through an orifice to create friction:

Frictional-

Frictional brakes are most common and can be divided broadly into "shoe" or "pad" brakes, using an explicit wear surface, and hydrodynamic brakes, such as parachutes, which use friction in a working fluid and do not explicitly wear. Typically, the term "friction brake" is used to mean pad/shoe brakes and excludes hydrodynamic brakes, even though hydrodynamic brakes use friction. Friction (pad/shoe) brakes are often rotating devices with a stationary pad and a rotating

wear surface. Common configurations include shoes that contract to rub on the outside of a rotating drum, such as a band brake; a rotating drum with shoes that expand to rub the inside of a drum, commonly called a "drum brake", although other drum configurations are possible; and pads that pinch a rotating disc, commonly called a "disc brake". Other brake configurations are used, but less often. For example, PCC trolley brakes include a flat shoe which is clamped to the rail with an electromagnet; the Murphy brake pinches a rotating drum, and the Ausco Lambert disc brake uses a hollow disc (two parallel discs with a structural bridge) with shoes that sit between the disc surfaces and expand laterally.

Pumping-

Pumping brakes are often used where a pump is already part of the machinery. For example, an internal-combustion piston motor can have the fuel supply stopped, and then internal pumping losses of the engine create some braking. Some engines use a valve override called a Jake brake to greatly increase pumping losses. Pumping brakes can dump energy as heat, or can be regenerative brakes that recharge a pressure reservoir called a hydraulic accumulator.

Electromagnetic-

Electromagnetic brakes are likewise often used where an electric motor is already part of the machinery. For example, many hybrid gasoline/electric vehicles use the electric motor as a generator to charge electric batteries and also as a regenerative brake. Some diesel/electric railroad locomotives use the electric

motors to generate electricity which is then sent to a resistor bank and dumped as heat. Some vehicles, such as some transit buses, do not already have an electric motor but use a secondary "retarder" brake that is effectively a generator with an internal short circuit. Related types of such a brake are eddy current brakes, and electro-mechanical brakes (which actually are magnetically driven friction brakes, but nowadays are often just called "electromagnetic brakes" as well).

1.3.2 CHARACTERISTICS

Brakes are often described according to several characteristics including:

- Peak force – The peak force is the maximum decelerating effect that can be obtained. The peak force is often greater than the traction limit of the tires, in which case the brake can cause a wheel skid.
- Continuous power dissipation – Brakes typically get hot in use and fail when the temperature gets too high. The greatest amount of power (energy per unit time) that can be dissipated through the brake without failure is the continuous power dissipation. Continuous power dissipation often depends on e.g., the temperature and speed of ambient cooling air.
- Fade – As a brake heats, it may become less effective, called brake fade. Some designs are inherently prone to fade, while other designs are relatively immune. Further, use considerations, such as cooling, often have a big effect on fade.

- Smoothness – A brake that is grabby, pulses, has chatter, or otherwise exerts varying brake force may lead to skids. For example, railroad wheels have little traction, and friction brakes without an anti-skid mechanism often lead to skids, which increases maintenance costs and leads to a "thump thump" feeling for riders inside.
- Power – Brakes are often described as "powerful" when a small human application force leads to a braking force that is higher than typical for other brakes in the same class. This notion of "powerful" does not relate to continuous power dissipation, and may be confusing in that a brake may be "powerful" and brake strongly with a gentle brake application, yet have lower (worse) peak force than a less "powerful" brake.
- Pedal feel – Brake pedal feel encompasses subjective perception of brake power output as a function of pedal travel. Pedal travel is influenced by the fluid displacement of the brake and other factors.
- Drag – Brakes have varied amount of drag in the off-brake condition depending on design of the system to accommodate total system compliance and deformation that exists under braking with ability to retract friction material from the rubbing surface in the off-brake condition.
- Durability – Friction brakes have wear surfaces that must be renewed periodically. Wear surfaces include the brake shoes or pads, and also the brake

disc or drum. There may be tradeoffs, for example, a wear surface that generates high peak force may also wear quickly.

- Weight – Brakes are often "added weight" in that they serve no other function. Further, brakes are often mounted on wheels, and unsprung weight can significantly hurt traction in some circumstances. "Weight" may mean the brake itself, or may include additional support structure.
- Noise – Brakes usually create some minor noise when applied, but often create squeal or grinding noises that are quite loud.

1.3.3 BRAKING SYSTEM

INTRODUCTION

“An object remains in its state of rest or in motion until and unless acted upon by an external force” Newton’s first law of motion, this law by Sir Isaac Newton gave rise to the development of braking system in an automobile, developing an automobile vehicle not only requires the power source but also the efficient braking system as higher the horse power higher will be the brake force required to stop or de accelerate that vehicle. This thought gave rise to many researches in the field of braking and results in its evolution due to which today we have flexibility in choosing a suitable braking system according to our need. So, let’s just start our article with the curiosity about the various types of braking system. In an automobile vehicle, a braking system is an arrangement of various linkages and components (brake lines or mechanical linkages, brake drum or brake disc, master

cylinder or fulcrums etc.) that are arranged in such a fashion that it converts the vehicle's kinetic energy into the heat energy which in turn stops or de accelerate the vehicle. The conversion of kinetic energy into heat energy is a function of frictional force generated by the frictional contact between brake shoes and moving drum or disc of a braking system.

1.3.4 NEED OF BRAKING SYSTEM

In an automobile vehicle braking system is needed –

- To stop the moving vehicle.
- To de accelerate the moving vehicle.
- For stable parking of a vehicle either on a flat surface or on a slope.
- As a precaution for accidents.
- To prevent the vehicle from any damage due to road conditions.

1.3.5 CLASSIFICATION OF BRAKING SYSTEM

As we have already discussed the evolution of braking system from vintage carts to modern cars, from vintage carriages to modern trucks has given us various different purpose braking systems which are classified on the basis of various needs and purposes of an automobile vehicle. So let's just discuss them-

1. On the Basis of Power source

The power source which carries the pedal force applied by the driver on brake pedal to the final brake drum or brake disc in order to de accelerate or stop the vehicle the braking systems are of 6 types-

1. Mechanical braking system
2. Hydraulic braking system
3. Air or pneumatic braking system
4. Vacuum braking system
5. Magnetic braking system
6. Electric braking system

2. On the Basis of frictional contact

On the basis of the final friction contact made between the rotating brake components i.e., brake drum or disc rotor and the brake shoe the braking systems are of 2 types-

(i) Internal expanding brakes (e.g. drum brakes)

(ii) External contracting brakes (e.g. disc brakes)

3. On the Basis of Method of Application

On the basis of method of applying brakes, braking systems are of 2 types-

(i) Foot or service brakes

(ii) Hand or parking brakes

4. On the Basis of Brake Force Distribution

(i) Single acting brakes

(ii) Dual acting brakes

1.3.6 DETAILED DESCRIPTION OF DIFFERENT TYPES OF BRAKING SYSTEM ON POWER SOURCE BASIS

1. **Mechanical Brakes**-

It is the type of braking system in which the brake force applied by the driver on the brake pedal is transferred to the final brake drum or disc rotor through the various mechanical linkages like cylindrical rods, fulcrums, springs etc. In order to de accelerate or stop the vehicle. Mechanical brakes were used in various old automobile vehicles but they are obsolete now days due to their less effectiveness.

2. **Hydraulic Brakes**-

It is the type of braking system in which the brake force applied by the driver on brake pedal is first converted into hydraulic pressure by master cylinder (for reference read article on master cylinder) than this hydraulic pressure from master cylinder is transferred to the final brake drum or disc rotor through brake lines. Instead of mechanical linkages, brake fluid is used in hydraulic brakes for the transmission of brake pedal force in order to stop or de accelerates the

vehicle. Almost all the bikes and cars on the road today are equipped with the hydraulic braking system due to it high effectiveness and high brake force generating capability.

3. **Air or Pneumatic Brakes-**

It is the types of braking system in which atmospheric air through compressors and valves is used to transmit brake pedal force from brake pedal to the final drum or disc rotor. Air brakes are mainly used in heavy vehicles like busses and trucks because hydraulic brakes fails to transmit high brake force through greater distance and also pneumatic brakes generates higher brake force than hydraulic brake which is the need of the heavy vehicle. The chances of brake failure is less in case of pneumatic brakes as they are usually equipped with a reserve air tank which comes in action when there is a brake failure due to leakage in brake lines. High end cars these days are using air brakes system due to its effectiveness and fail proof ability.

4. **Vacuum Brakes-**

It is the conventional type of braking system in which vacuum inside the brake lines causes brake pads to move which in turn finally stops or de accelerate the vehicle. Exhauster, main cylinder, brake lines, valves along with disc rotor or drum are the main components that combines together to make a vacuum braking system. Vacuum brakes were used in old or conventional trains and are replaced

with air brakes now days because of its less effectiveness and slow braking. Vacuum brakes are cheaper than air brakes but are less safe than air brakes.

5. **Magnetic Brakes**-

In this type of braking system, the magnetic field generated by permanent magnets is used to cause the braking of the vehicle. It works on the principle that when we pass a magnet through a cooper tube, eddy current is generated and the magnetic field generated by this eddy current provide magnetic braking. This is the friction less braking system thus there is less or no wear and tear. This is the advanced technology in which no pressure is needed to cause braking. The response to the braking in this is quite quick as compared to other braking systems.

6. **Electrical Brakes**-

It is type of braking used in electric vehicle in which braking is produced using the electrical motors which is the main source of power in electric vehicles, it is further divided into 3 types-

(i) Plugging Brakes-When the brake pedal is pressed in the electric vehicle equipped with plugging braking, the polarity of the motors changes which in turn reverses the direction of the motor and causes the braking.

(ii) Regenerative Braking- It is the type of electrical braking in which at the time of braking, the motor which is the main power source of the vehicle becomes the generator i.e., when brakes are applied, the power supply to the motor cuts off due to which the mechanical energy from the wheels becomes the rotating force for the

motor which in turn converts this mechanical energy into the electric energy which is further stored in the battery. Regenerative braking saves the energy and are widely used in today's electric vehicles. Tesla Model-S provides the most effective regenerative braking.

(iii) Dynamic or Rheostat Braking- It is the type of electrical braking in which resistance provided by the rheostat causes the actual braking, in this type a rheostat is attached to the circuit that provides the resistance to the motor which is responsible for de acceleration or stopping of the vehicle.

1.3.7 DETAILED DESCRIPTION OF DIFFERENT TYPES OF BRAKING SYSTEM ON FRICTIONAL CONTACT BASIS

1. Drum Brakes or Internal Expanding Brakes-

It is the type of brake system in which a drum which is the housing of the brake shoes along with actuation mechanism is attached with the wheel hub in such a fashion that the outer part of the drum rotates with the wheel and inner part remains constant.

When brakes are applied the actuating mechanism (wheel cylinder or mechanical linkage.) causes the brake shoes to expand due to which the outer frictional surface of the brake shoes makes frictional contact with the rotating drum part which in turn stops or de accelerate the vehicle.

2. Disc Brake or External Contracting Brakes -

It is the types of braking system in which instead of a drum assembly a disc rotor attached to the hub of the wheel in such a fashion that it rotates with the wheel, this disc rotor is clamped in between the caliper which is rigidly fixed with the knuckle or upright of the vehicle. This caliper used is the housing of the brake shoes along with the actuation mechanism (mechanical linkages or caliper cylinder).When the brakes are applied, the actuation mechanism contracts the attached brake shoes which in turn makes the frictional contact with the rotating disc rotor and causes the braking of the vehicle.

1.3.8 DETAILED DESCRIPTION OF DIFFERENT TYPES OF BRAKING SYSTEM ON APPLICATION BASIS

1. Service Brake or Foot Brakes-

It is the type of brakes in which the brakes are applied when the driver presses the brake pedal mounted inside the cockpit or at the foot space of the vehicle with his foot, this pedal force applied by the driver is further multiplied and sent to the braking drum or disc either by mechanical linkages or by hydraulic pressure which in turn causes braking. In cars foot operated brakes are used and in bikes the combination of foot and hand operated brakes are used.

2. Hand Brake or Parking Brake–

This type of brakes are also known as emergency brakes as they are independent of the main service brake, hand brakes consists of a hand operated

brake lever which is connected to the brake drum or disc rotor through the metallic cable. When hand brake lever is pulled, tension is created in the metallic rod which in turn actuates the brake drum or disc rotor mechanism and final braking occurs. Hand brakes are usually used for stable parking of the vehicle either on flat road or slope that is why it is also called parking brakes.

1.3.9 DETAILED DESCRIPTION OF DIFFERENT TYPES OF BRAKING SYSTEM ON BRAKE FORCE DISTRIBUTION BASIS

1. Single Acting Brakes-

It is the type of braking in which brake force is transferred to either a pair of wheels(in cars) or to the single wheel(in bikes) through single actuation mechanism(mechanical linkages or master cylinder).This type of braking system is commonly used in bikes or in light purpose vehicles.

2. Dual Acting Brakes-

It is the type of braking in which the brake force is transferred to all the wheels of the vehicle through dual actuation mechanism (tandem master cylinder or mechanical linkages).This type of braking is used in cars as well as in heavy purpose vehicle.

1.3.10 APPLICATION OF DIFFERENT TYPES OF BRAKING SYSTEM

1. **Mechanical brakes-** Cars like Ford Model Y and bikes like Bajaj pulsar 180cc.
2. **Hydraulic brakes-** Modern cars like Maruti Suzuki swift and bikes like KTM Duke 390.
3. **Air brakes** – Volvo buses and various heavy vehicles
4. **Vacuum brakes-** old trains
5. **Magnetic brakes-** Bugati veyron and various hyper cars.
6. **Electric braking-** Tesla Model S Use regenerative type electric braking.
7. **Drum brake-** Old Maruti 800 and Tata 407
8. **Disc brake-** All modern cars like Hyundai i20.
9. **Hand brake and foot brake**– All automobile vehicles.
10. **Single acting** – TVS Appache 180 front disc.
11. **Dual acting-** All 4 wheel cars and trucks.

1.4 FRICTION

Friction is the force resisting the relative motion of solid surfaces, fluid layers, and material elements sliding against each other. When surfaces in contact move relative to each other, the friction between the two surfaces converts kinetic energy into thermal energy.

1.5 ELECTROMAGNETS

An electromagnet is a type of magnet in which the magnetic field is produced by an electric current. Electromagnets usually consist of wire wound into a coil. A current through the wire creates a magnetic field which is concentrated in the hole, denoting the center of the coil. The magnetic field disappears when the current is turned off. The wire turns are often wound around a magnetic core made from a ferromagnetic or ferrimagnetic material such as iron; the magnetic core concentrates the magnetic flux and makes a more powerful magnet. The main advantage of an electromagnet over a permanent magnet is that the magnetic field can be quickly changed by controlling the amount of electric current in the winding. However, unlike a permanent magnet that needs no power, an electromagnet requires a continuous supply of current to maintain the magnetic field.

Electromagnets are widely used as components of other electrical devices, such as motors, generators, relays, loudspeakers, hard disks, MRI machines, scientific instruments, and magnetic separation equipment. Electromagnets are also employed in industry for picking up and moving heavy iron objects such as scrap iron and steel. A simple electromagnet consisting of a coil of wire wrapped around an iron core as shown in fig 1.6. A core of ferromagnetic material like iron serves

to increase the magnetic field created. The strength of magnetic field generated is proportional to the amount of current through the winding

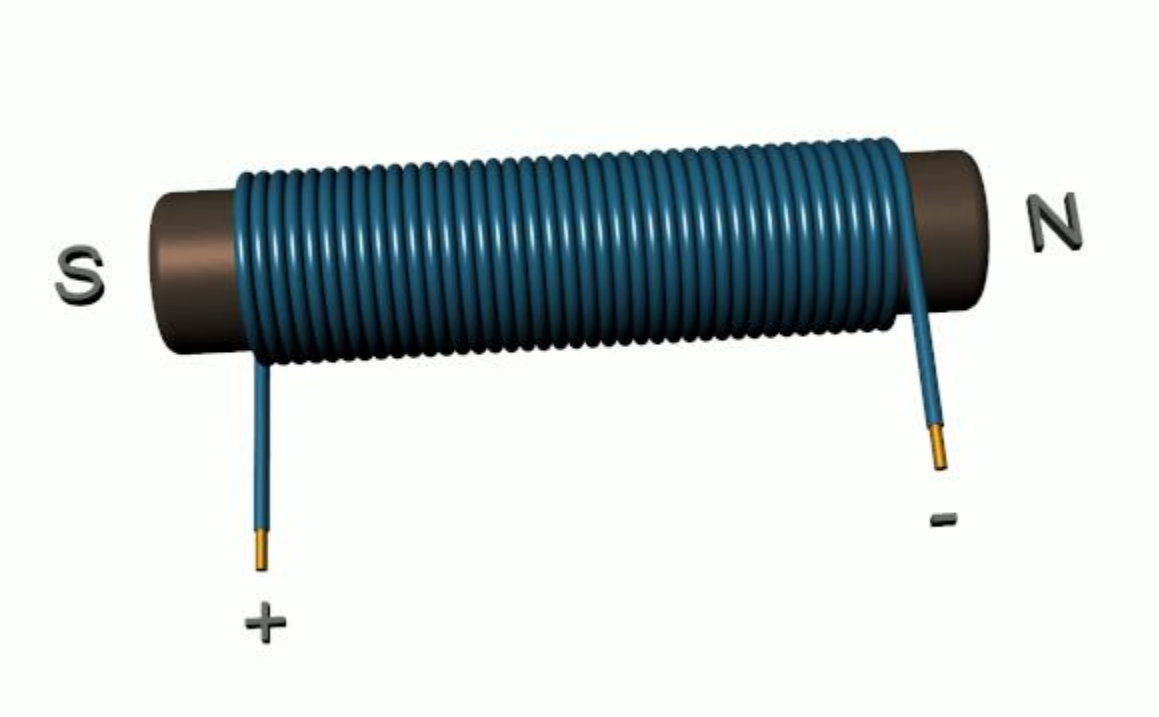


FIG 1.6 Electromagnet

1.5.1 SOLENOIDS

A common tractive electromagnet is a uniformly-wound solenoid and plunger. The solenoid is a coil of wire, and the plunger is made of a material such as soft iron. Applying a current to the solenoid applies a force to the plunger and may make it move. The plunger stops moving when the forces upon it are balanced. For example, the forces are balanced when the plunger is centered in the solenoid. Some improvements can be made on the basic design. The ends of the stop and plunger are often conical. For example, the plunger may have a pointed end that

fits into a matching recess in the stop. The shape makes the solenoid's pull more uniform as a function of separation. Another improvement is to add a magnetic return path around the outside of the solenoid (an "iron-clad solenoid"). The magnetic return path, just as the stop, has little impact until the air gap is small as shown in fig 1.7.

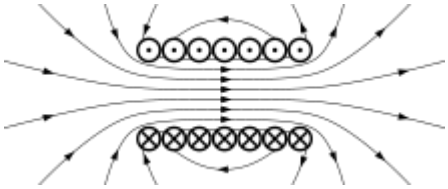


FIG 1.7 Magnetic Field

Magnetic field produced by a solenoid (coil of wire). This drawing shows a cross section through the center of the coil. The crosses are wires in which current is moving into the page; the dots are wires in which current is moving up out of the page.

1.5.2 APPLICATIONS OF ELECTROMAGNETS

A portative electromagnet is one designed to just hold material in place; an example is a lifting magnet. A tractive electromagnet applies a force and moves something. Electromagnets are very widely used in electric and electromechanical devices, including:

- Motors and generators
- Transformers

- Relays
- Electric bells and buzzers
- Loudspeakers and headphones
- Actuators such as valves
- Magnetic recording and data storage equipment: tape recorders, VCRs, hard disks
- MRI machines
- Scientific equipment such as mass spectrometers
- Particle accelerators
- Magnetic locks
- Musical instrument pickups
- Magnetic separation equipment, used for separating magnetic from nonmagnetic material, for example separating ferrous metal from other material in scrap.
- Industrial lifting magnets
- magnetic levitation, used in a maglev train or trains
- Induction heating for cooking, manufacturing, and hyperthermia therapy

CHAPTER-II

LITERATURE REIVEW

[1] The behavior of electromagnetic braking using eddy current was studied in this paper. An experiment was conducted in order to choose the best material among aluminium, copper and zinc as brake disc. Aluminium performs better than copper and zinc. Two different series of aluminium which are Al6061 and Al7075 used. A few parameters been varied such as air-gap, brake disc thickness, number of turns on electromagnet and voltage supplied to DC motor. And concluded that Al6061 have greater performance than Al7075 as the brake disc material. Also founded that the thicker the disc, small air-gap, large number of electromagnet turns and increasing the current induced will increase the performance of this electromagnetic braking. This is concluded from the research paper of **(M.Z. Baharom *et.al*2007)**

[2] The design of eddy current brakes is presented in this paper. In this study, four systematic engineering design scenarios to design a braking system are presented: a constant magnetic field, an optimal magnetic field distribution, piecewise-constant magnetic fields and a section-wise guide rail with a constant magnetic field. Although the simulation results show that the

optimal magnetic field is better than the constant magnetic field. The sudden increase in current could cause wire overload. The piecewise constant magnetic field has the advantages of a preset terminal speed and predictable wire current but it produces a higher speed. Alternatively, it is much easier to keep the magnetic field constant and select the proper conductor materials. A nearly maintenance-free system can be achieved if permanent magnet is utilized to establish the magnetic field. These results are studied from the thesis paper of **(Der-Ming Ma *et.al*2010)**

[3] 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. This is concluded from research paper of **(McConnell*et.al*1954)**

[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. These results are studied from the thesis paper of **(Tatsuya YAMASAKI 2007)**

[5] In this paper, we study the advantages and implements needed to be done in Electromagnetic Braking system using Magnetic force to engage the brake, but the power required for braking is transmitted manually. These brakes can be incorporated in heavy 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. But disadvantages like dependence on battery power to energize the brake system drains down the battery much fasterand due to residual magnetism present in electromagnets, the brake shoe takes time to come back to its original position. We gathered this information from the research paper of **(Sevvel P *et.al*2014)**

[6] This paper presents a procedure for the calculation of braking force at poles of given dimensions and at given flux- density. In the course of the

solution, Ritz process based on variational principles is presented for the calculation of stationary conductive fields excited by motional induction, and a technique is formulated for treating singular excitations which improves the convergence of the numerical procedure. An alternative method based on an infinite number of images for the solution of the problem is also presented thus permitting the examination of the Ritz process. Finally, the results of the measurements carried out to check the calculations are presented. The effect of motor dimensions on braking force is examined. These research papers are the work of **(P.HANYECZ*et.al* 1982)**

[7] In this project, a frictionless braking system is proposed by using eddy current phenomenon. This phenomenon is administrated by FARADAY'S law of electromagnetic induction and LENZ' law. This paper concludes that Frictionless braking produces effective braking with small wear and tear with very low cost and wreckage formed in braking is small due to no friction and hence is eco friendly while skidding is eliminated as the wheel does not get locked. This paper explains how it is suitable for high speed and how it works on the electricity and takes up very little amount of power for a small time period. This work is appreciated from the research of **(Akash Sawant *et.al*2017)**

All papers which have been studied show significant effects to be considered in developing electromagnetic braking to replace the conventional braking system.

CHAPTER-III

METHODOLOGY

3.1 AUTOCAD

3.1.1 INTRODUCTION

AutoCAD is a software application developed by Autodesk that enables computer-aided design (CAD) and drafting. The software is used to produce 2D and 3D drawings. AutoCAD software allows users to conceptualize ideas, produce designs and drawings to the required levels of technical accuracy, and even perform rapid design calculations and simulations; across a wide range of industries.

3.2 THE ORIGINS OF AUTOCAD

The company behind AutoCAD, Autodesk was founded in 1982 by John Walker. He and the other 15 co-founders intended to develop five different desktop automation applications, hoping that one of the applications would take off. Their flagship product turned out to be AutoCAD. They launched AutoCAD at the COMDEX trade show in Las Vegas as the first CAD program in the world to run on a PC. By March 1986, only four years after it was introduced, AutoCAD had become the most widely used design application worldwide, a position it still holds today.

In its 35 years, AutoCAD has grown substantially. In fact, there has been 31 versions since the first release in December 1982. Over the years, Autodesk added new features and programs to appeal to different professions. The software supports APIs for customization and automation, which enabled the creation of vertical products such as AutoCAD Architecture, AutoCAD Electrical and AutoCAD Civil 3D. In the last five years, Autodesk has also created mobile and cloud-based apps, including AutoCAD 360, Fusion 360, and A360 Viewer. These programs couple design and documentation tools together with the ability to share and collaborate via the Internet.

3.3 AUTOCAD'S APPLICATIONS

AutoCAD was initially created for mechanical engineers, but very quickly extended to encompass a range of fields. In fact, AutoCAD's success is largely due to its mass adoption by a wide range of design professionals, including architects, project managers, animators and engineers.

Construction

The main industry in which AutoCAD is used is construction. Autodesk Building Design Suite provides a 3D building design software portfolio that combines Building Information Modeling (BIM) and CAD tools to help construction engineers design, visualize, simulate and build more efficiently.

One example of how AutoCAD has successfully helped a project is the construction of the Shanghai Tower. The tower is a vastly complicated structure and the developers soon realized that traditional building methods, tools and other design software were incapable of carrying out the project successfully. So, the developers turned to the advanced tools offered by BIM, which allowed the design team to visualize the tower in 3D and to perfectly capture the twisting structure of the tower.

Using BIM also allowed the team to analyze the design for improved decision-making; to monitor the building energy analysis in order to create a more environmentally friendly skyscraper; and helped to save building materials. The tower's owner and developer credits BIM and AutoCAD for the building's successful construction. "From a property owner's perspective, BIM provides an excellent tool for the design, construction, management and investment control of the entire project."

Animation

It is not just in the construction sector where AutoCAD has seen regular use. The Entertainment Creation suites can produce high quality entertainment content by using 3D animation software. With an array of specialized creative toolsets integrated to form a modern, flexible graphic pipeline, the suites allows animators,

visual effects artists and modelers to push the boundaries of their creative abilities, increase their productivity and meet tight deadlines.

3.4 COMMANDS

3.4.1 Draw Command Tools

i. **Line:** With the Line command you can draw a simple line from one point to another as shown in fig 3.1.

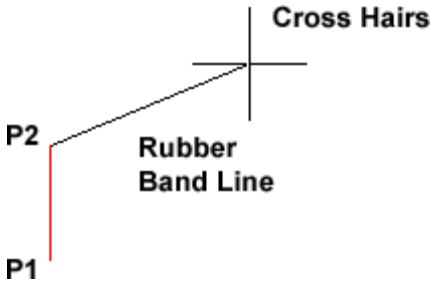


FIG 3.1 Line

ii. **Construction Line:** The construction line commands creates a line of infinite length which passes through two picked point.

iii. **Polyline:** The Polyline command is similar to the line command except that the resulting object may be composed of a number of segments which form a single object.

iv. **Rectangle:** The Rectangle command is used to draw a rectangle

whose sides are vertical and horizontal. The position and size of the rectangle are defined by picking two diagonal corners as shown in fig 3.2.

FIG 3.2 Rectangle

3.4.2 Modify Command Tools

i. **Offset:** Create a duplicate object parallel with the original object. If this object is a Polyline or a Circle, the duplicate shape will be transformed inwards or outwards.

ii. **Trim:** With the trim option objects can be shortened or lengthened with the edges of other objects. Objects can exactly be fitted between these objects.

iii. **Extend:** With the extend option you can shorten or lengthen objects to meet the edges of other objects. For example a line can be exactly fitted between objects. Extending an object works in the same way as trimming.

iv. **Fillet:** You can use the fillet tool to connect two objects with an arc with a specified radius. The inside corner is called a fillet and an outside corner is called a round as shown in fig 3.3.

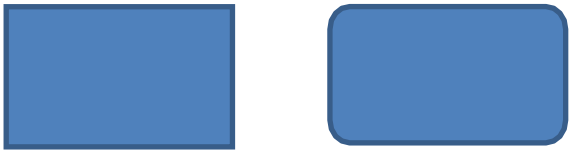


FIG 3.3 Fillet

3.5 3D MODELING

i. **Cylinder:** The cylinder was created using a center point (1), a point on the radius (2), and a point for the height (3). The base of the cylinder is always on a plane parallel with the workplane as shown in fig 3.4.

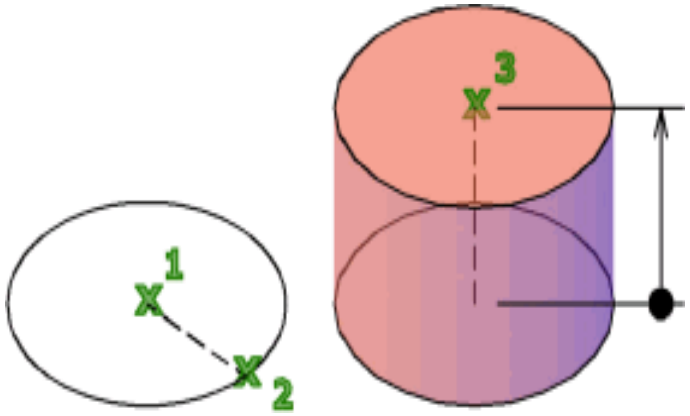


FIG 3.4 Cylinder

ii. **Sphere:** Specifies the center point of the sphere. When you specify the center point, the sphere is positioned so that its central axis is parallel to the Z axis of the current user

coordinate system (UCS) as shown in fig 3.5. Defines the radius or diameter of the sphere.

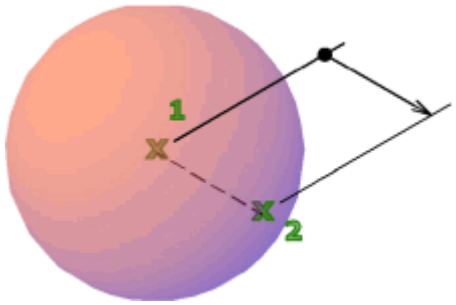


FIG 3.5 Sphere

iii. **Wedge:** The direction of the taper is always in the positive *X*-axis direction of the UCS as shown in fig 3.6.

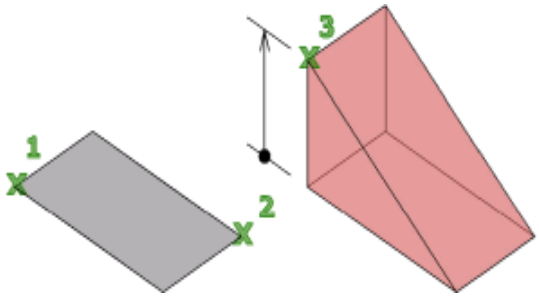


FIG 3.6 Wedge

iv. **Extrude:** Objects can be extruded orthogonally from the plane of the source object, in a specified direction, or along a selected path as shown in fig 3.7. You can also specify a taper angle.

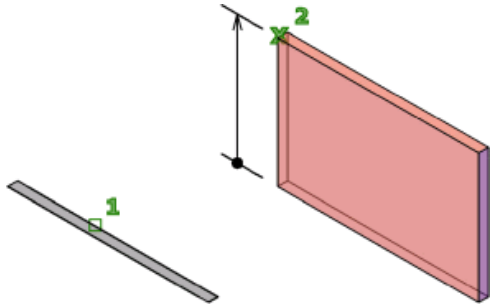


FIG 3.7 Extrude

3.6 3D MODEL OF ELECTROMAGNETIC BRAKE

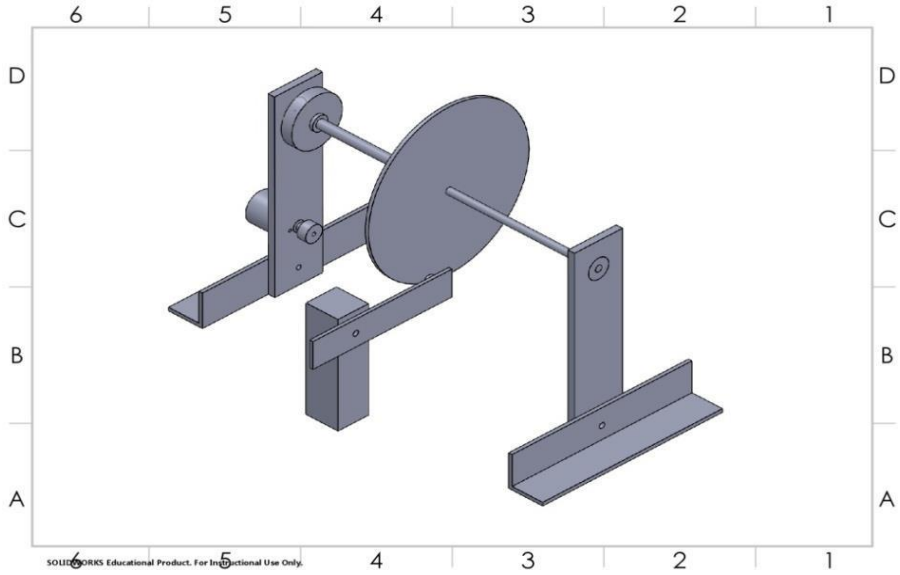


FIG 3.8 CAD model of electromagnetic braking system

The above fig 3.8 is a simple electromagnetic braking system model drawn in AutoCAD. The 2D wireframe model is drawn in Drafting and Annotation workspace using commands circle, line, rectangle. The metal disc is drawn using circle command and then extruded in 3D modeling using extrude command. Angled bar frames are drawn using draw commands and modify command.

Other parts like metal support, shaft, bearings, liver block are drawn in 2D wireframe and then extruded using extrude command. All the parts are assembled using commands like 3D rotate, coincidence, move, copy.

Switch on the power supply given to the motor, which rotates the belt that connecting motor and pulley. Therefore pulley is rotated continuously. A steel plate is connected along with pulley and hence is rotated in front of electromagnet. For applying brake, switch on power supply to the electromagnet. So, voltage is applied on electromagnet. Hence a magnetic field is produced. As the disc is rotating in magnetic field, an induction force is developed which opposes the motion of disc, thereby acting as braking force. Springs are used as medium to hold the armature winding of electromagnet. When voltage is removed, the metal disc is free to rotate. Slippage occurs during deceleration only but there should not be slippage once the brake comes to a full halt.

CHAPTER IV

CALCULATIONS

4.1 CONVENTIONAL BRAKE CALCULATIONS

Disc brake specifications:

i) Radius of brake discs, r= $\frac{287}{2}$ = 143.5mm = 0.1435m

ii) Coefficient of friction between pad and disc, μd = 0.38

iii) Area of Caliper piston bore – Aw

iv) Area of Master cylinder bore- Am

For Ford Mustang, The value of $\frac{Aw}{Am}$ is 3:2:1= 3.2

v) Pedal Ratio, Rp = 4:1 = 4

vi) Pedal force – f

. Total Braking Force, F = $\frac{r\times2\times\mu d\times Aw\times Rp\times f}{R\times Am}$

. Tire- 255/40R19

Radius of wheel = 19 inches= $\frac{19\times25.4}{2}$ = 241.3mm

Aspect ratio = $\frac{40}{100}\times 255 = 102$

For radius, it is 102/2 = 51mm

.: Radius of Tyre, R= 241.3 + 51= 292.3mm

= 0.2923m

.: Braking Force, F = $\frac{0.1435\times2\times0.38\times4\times3.2\times640}{0.2923}$ = 3056.52 N

4.2 ELECTROMAGNETIC BRAKE CALCULATIONS

To produce same amount of force, with the same size of disc, the electromagnetic brakes have

$$F = \frac{(NI)^2 \mu A}{(2G)^2}$$

F- Force produced = 3056.52 N

μ- Permeability of free space = $4\pi\times10^{-7}$

N- Number of turns

I – Current in Amps = 5 Amps

A – Area of disc = $\frac{\pi}{4}$ (143.5) = 64692.46 mm^2

G – Gap between Solenoid and metal disc = 10mm

.: $N^2 = \frac{3056.2\times(2\times10)^2}{(5)^2\times64692.46\times4\pi\times10}$

=>N = 620.8 = 621 turns

.: We should use 621 turns of copper wire on solenoid.

4.3 HEAT GENERATION CALCULATIONS

Let the car (Ford Mustang) is moving with a initial velocity of 90kmph (25m/s) and the practical values suggest that the stopping distance is 35.51m (.: deceleration is 8.8 m/sec^2)

Stopping Distance

$$v^2-u^2 = 2ad$$

$$0^2- (2S)^2 = 2(-8.8) d$$

$$d= 35.51m$$

Braking Time (t)

$$v = u + at$$

$$0 = 25 – 8.8t$$

$$T = \frac{25}{8.8} = 2.841 \text{ sec}$$

Heat generated:-

i) In Disc brakes:-

Frictional work = F× d

= 3056.52 × 35.51

= 108.54 KJ

We know that heat is generated from the friction. And it is at least more than 50%.

.: Emin thermal = 108.54/2

= 54.27 KJ

ii) In Electromagnetic Brakes:-

Here, heat is produced due to current flowing in wire.

Specification of wire:-

ρ – resistivity of copper wire $= 1.7\times 10^{-8}$ m

Length of wire L = 13.8

Cross section area of wire A= 0.503 m^2

Resistance $R = \rho L/A = 1.7\times10^{-8}\times 13.8/0.50$

$R = 0.466\ \Omega$

Heat generated:-

$Q = I^2Rt = (5)^2(0.466)(2.84)$

Q = 33.08J

54,270 J >> 33.08 J

.: By using electromagnetic brakes, we can reduce heat generation greatly.

.: Wear and tear and material life loss are also can be reduced.

4.4 COST ANALYSIS

Disc brake

Parts:	**Rs:**
Pads (front) –	25,500
Brake Shoes (back) –	24,000
Disc turning –	2500
Disc (front) –	4800×2 = 9600

Disc (back) – 5000×2 = 10000

71,600

* For all parts warranty will be given for 1 year only.

Electro magnetic brake

1.69 Nm 24V dc disc with magnet – 22,000×2 = 44,000

Luminous 220 Ah battery – 22,000

66,200

* Here, warranty will be given for 3 years.

* Although, the price variation is not high, in long run disc brakes may fail faster than electromagnetic brakes because of rupture with pads.

CHAPTER V

RESULTS AND DISCUSSIONS

- To produce same amount of Braking force as in disc brakes, with the same size of disc, the electromagnetic brakes should have 621 turns of copper wire on solenoid.
- Heat generated in disc brakes (54,270 J) is way greater than heat generated in electromagnetic brakes (33.08 J). By using electromagnetic brakes we can reduce heat generation greatly.
- The cost estimation for disc brakes is around 71,600 Rs.
- The cost estimation for electromagnetic brakes is around 66,200 Rs.
- By increasing number of turns of copper wire in solenoid we can increase braking force, whereas there is more complexity in increasing braking force in disc brakes.

CHAPTER VI

CONCLUSION

- Frictionless braking for automobiles like bike, car has an effective braking system. In addition, by using these electromagnetic brakes, we can increase the life of the braking unit.
- Frictionless braking system is found to be more reliable as compared to other braking systems.
- In addition, it is found that frictionless brakes make up approximately 80% of all of the power applied brake applications.
- The brake linings would last considerably longer before requiring maintenance and the potentially “brake fade” problem could be avoided.
- Wear and tear can also be reduced.

CHAPTER VII

REFERENCES

[1]. M.Z Baharom, Gigih Priyandoko, "Eddy current braking experiment using brake disc from aluminium series of A16061 and A17075", 2015.

[2]. Der-Ming Ma "The Design of Eddy-Current Magnet brakes" Department of Aerospace Engineering, Tamkang University, Danshuei, Taiwan 25137, Republic of China, December, 2010.

[3]. Mcconnell, H.M., ''Eddy-current phenomena in ferromagnetic material,'' AIEE Transactions, Vol. 73, part I, pp. 226–234, July, 1954.

[4]. Tatsuya YAMASAKI, M. E., Development of an Electromechanical Brake.NTN Global, 2007.

[5]. Sevvel "Innovative Electro Magnetic Braking System" IJIRSET Volume 3, Special Issue 2, April, 2014.

[6]. P. Hanyecz, "Calculation of Braking force in Eddy current brakes", Department of Theoretical Electricity, Technical University Budapest, 1982.

[7]. Akash Sawant, Frictionless braking system, Department of Mechanical Engineering, DBIT, University of Mumbai, Mumbai, Maharashtra, India.

[8]. A.Aravind , V.R.Akilesh , S.Gunaseelan , S.Ganesh "Eddy current embedded conventional braking system" - IJIRSET Volume 5, Special Issue 7, April 2016.

[9]. K. Kukutschovaa, V. Roubi ceka, K. Malachovab, Z.Pavli ckovab, R. Holu sab, J. Kuba ckovac, V. Mi ckac, D.MacCrimmond, P. Filip, Wear Mechanism in Automotive Brake Materials, Wear Debris and its Potential Environmental Impact, International Journal of Wear, 2009.

[10]. O. Uexkull, S. Skerfving, R. Doyle, M. Braungart. Carbide Antimony in brake pads—a carcinogenic component, J. Cleaner Prod, 2005.

[11]. Er shivanushrivastava "A Parametric Analysis of Magnetic Braking – The Eddy Current Brakes – For High Speed and Power Automobiles and locomotives" IJAREEIE Vol. 3, Issue 8, August, 2014.

[12]. Akshyakumar S Puttewar "Enhancement of Braking System in Automobile Using Electromagnetic Braking" IJAREEIE, 2010.

[13]. "Design of an Innovative Car Braking System using Eddy Currents"- David Jose Torres Cruz- Bachelor in Aerospace Engineering, Instituto Superior Tecnico (IST), 2002 & master of applied science in the Department of Mechanical Engineering. University of Victoria .

[14]. "Experiments with eddy currents: the eddy current brake"- Manuel I Gonzalez- Departamento de Fisica, Universidad de Burgos, 09006 Burgos, Spain.

[15]. Sumit Patel," Development of the Electro-Magnetic Brake", IJIRST – International Journal for Innovative Research in Science & Technology| Volume 1, Issue 12 , May, 2015.

[16]. Oriano Bottauscio, Mario Chiampi, Alessandra Manzin, "Modeling analysis of the electromagnetic braking action on rotating solid cylinders", Science Direct, December, 2006.

[17]. AkshayKumar S. Puttewar, Nagnath U. Kakde, Huzaifa A. Fidvi, Bhushan Nandeshwar, "Enhancement of braking system in automobile using Electromagnetic Braking", IOSR- JMCE.

[18]. Warrendale, Brake technology, ABS/TCS, and controlled suspensions Society of Automotive Engineers, & SAE World Congress. (2001). PA: Society of Automotive Engineers.

[19]. Gagarin, G., Kroger, U. and Saunweber, E., ''Eddy-current magnetic track brakes for high- speed trains,'' Joint ASME/IEEE/AAR Railroad Conference, pp. 95–99, 1987.

[20]. Ohyma, T., ''Adhesion at higher speeds, its basic characteristic, its improvement and some related problem,'' Japanese Railway Engineering, Vol. 108, 1988.

[21]. Kesavamurthy, N., ''Eddy-current in solid iron due to alternating magnetic flux,'' The Institution of Engineers Monograph, No. 339U, pp. 207–213, June, 1959.

[22]. Biro, O. and Preis, K., ''Finite element analysis of 3-D eddy current,'' IEEE Transactions on Magnetics, Vol. 26, No. 2, pp. 418–423, Mar, 1990.

[23]. Heald, M.A., ‘‘Magnetic braking: improved theory,’’ American Journal of Physics, Vol. 56, No. 6, pp. 521–522, 1988.

[24]. Jaw-Kuen Shiau, Der-Ming Ma, and Min Jou, ‘‘Analysis and experiments of eddy current brakes with moving magnets,’’ Materials Science Forum, Vols. 575–578, pp. 1299–1304, 2008.

[25]. Ross Robert, B, Metallic Materials Specification Handbook, 4th edition, Springer, 1991.

[26]. Donald E. Kirk, Optimal Control Theory*:* An Introduction, Prentice-Hall, 1970.

[27]. Frank L. Lewis and Vassilis L. Syrmos, Optimal Control, 2nd edition, John Wiely & Sons, 1995.

[28]. Josef Stoer and Roland Bulirsch, Introduction to Numerical Analysis, Springer-Verlag, 1980.

[29]. James F. Parker and Vita R. West, Bioastronautics Data Book, 2nd edition, NASA SP-3006, 1973.

[30]. Md Shujauddin , Design and Fabrication of Frictionless Braking System, School of Mechanical Engineering, REVA University, Bangalore.