DESIGN AND FABRICATION OF ELECTRO-MAGNETIC BRAKING SYSTEM

A Project report submitted in partially fulfillment of the requirement for the award of the Degree

BACHELOR OF TECHNOLOGY

IN

MECHAICAL ENGINNERING

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ABSTRACT

Majority of braking systems work on the principle of dissipation of kinetic energy to heat energy. This method has its own drawbacks and must be replaced with a more reliable braking system that is quick in response, doesn’t heat up and is maintenance free. In this project the design of an electro-magnetic braking system and optimization for various operational parameters has been done and the advantage of using the electromagnetic braking system in automobile is studied. These parameters have been previously iterated in cited projects and papers and also in the simulation models and are to be cross-checked with the experimental setup.

An Electromagnetic Braking system uses Magnetic force to engage the brake, but the power required for braking is transmitted manually. The wheel is connected to a shaft and the electromagnet braking unit is attached to one side of the wheel. Here the braking unit consists of a hollow circular steel plate and a stator which has 3 spokes made of iron wounded with copper wire (or) magnetic wire. Here the round steel plate which is attached to the wheel rotates when wheel rotates with the help of motor. when current is supplied to the stator the spokes gets magnetized and creates an magnetic field which tries to attract or oppose the motion of rotating circular plate with the help of magnetic field created. In this brakes there is no contact between the electro-magnetic coils and rotating circular plate (i.e 2mm gap between coil and circular plate) so this is also called as contactless braking system which is a main advantage in using this brakes. In this 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.

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INTRODUCTION

CHAPTER-1
INTRODUCTION

Brake Definition and Background

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

Most brakes commonly use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat, though other methods of energy conversion may be employed. For example, regenerative braking converts much of the energy to electrical energy, which may be stored for later use. Other methods convert kinetic energy into potential energy in such stored forms as pressurized air or pressurized oil. Eddy current brakes use magnetic fields to convert kinetic energy into electric current in the brake disc, fin, or rail, which is converted into heat. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel.

Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

Since kinetic energy increases quadratically with velocity ($KE=1/2\ mv^2$), an object moving at 10 m/s has 100 times as much energy as one of the same mass moving at 1 m/s, and consequently the theoretical braking distance, when braking at the traction limit, is 100 times as long. In practice, fast vehicles usually have significant air drag, and energy lost to air drag rises quickly with speed.

Almost all wheeled vehicles have a brake of some sort. Even baggage carts and shopping carts may have them for use on a moving ramp. Most fixed-wing aircraft are fitted with wheel brakes on the undercarriage. Some aircraft also feature air brakes designed to reduce their speed in flight. Notable examples include gliders and some World War II-era aircraft, primarily some fighter aircraft and many dive bombers of the era. These allow the aircraft to maintain a safe speed in a steep descent. The Saab B 17 dive bomber and Vought F4U Corsair fighter used the deployed undercarriage as an air brake.

Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake. When the brake pedal of a modern vehicle with hydraulic brakes is pushed against the master cylinder, ultimately a piston pushes the brake pad against the brake disc which slows the wheel down. On the brake drum it is similar as the cylinder pushes the brake shoes against the drum which also slows the wheel dow

1.1 Types of Brakes

- **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 brakes
  2. Hydraulic brakes
  3. Air or pneumatic brakes
  4. Vacuum brakes
  5. Magnetic brakes
  6. Electric brakes

- **On the Basis of Frictional Braking 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-

1. Internal expanding brakes (e.g.- drum brakes)
2. External contracting brakes(e.g. disc brakes)

- **On the Basis of Application-**

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

  1. Foot or service brakes
  2. Hand or parking brakes

- **On the Basis of Brake Force Distribution**

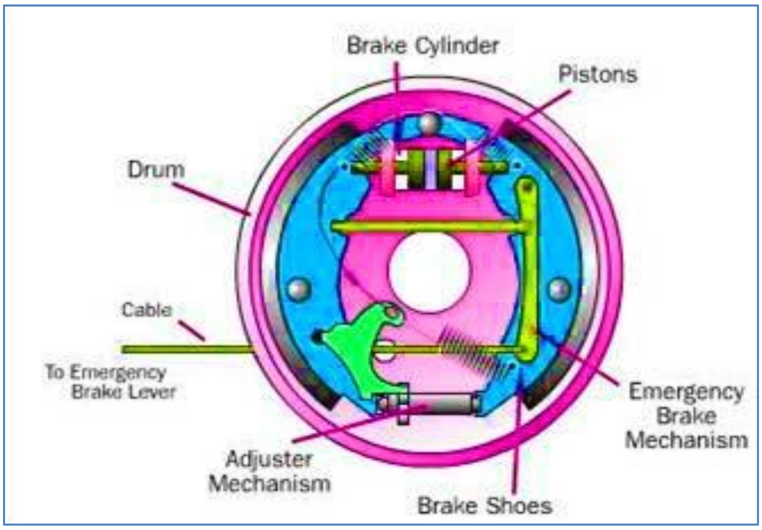
  1. Single acting brakes
  2. Dual acting brakes

1.1.1. On the Basis of Power Source

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.

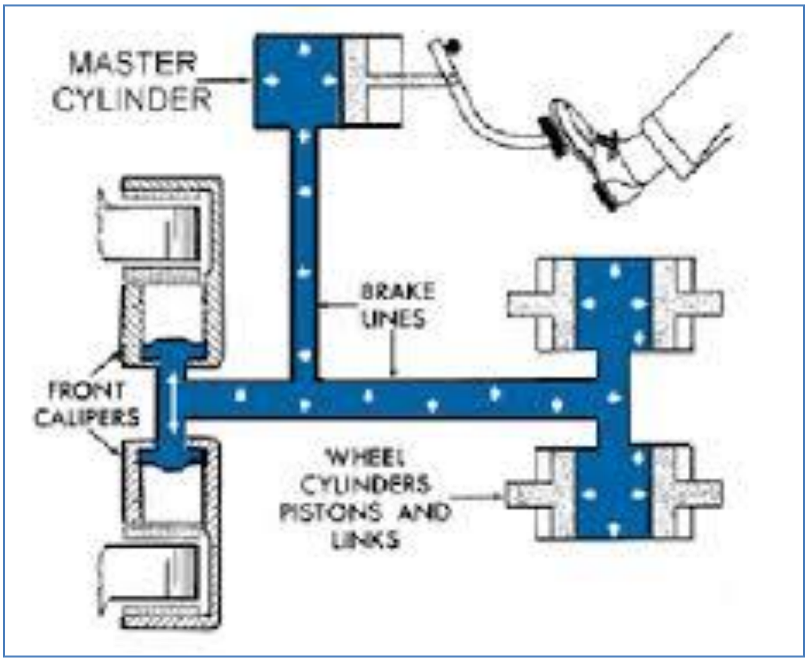


2. Hydraulic Brakes

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.



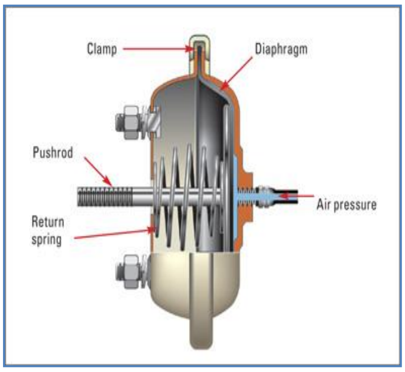
3. Air or Pneumatic Brakes

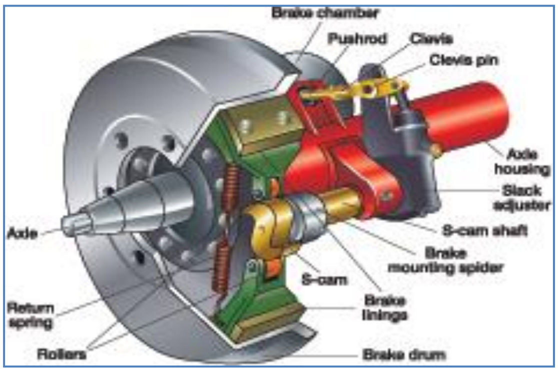
It is the types of braking system in which atmospheric air through compressors and valves is used to transmit brake pedal force from brake pedal to the final drum or disc rotor.

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.





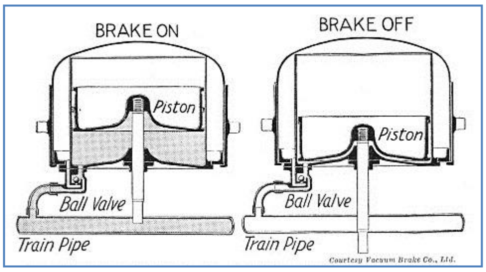
4. Vacuum Brakes

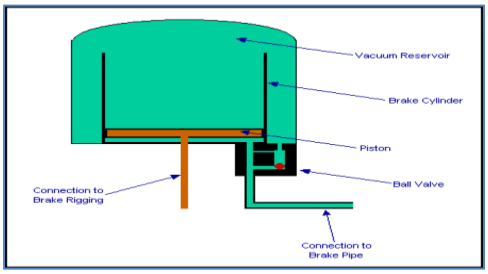
It is the conventional type of braking system in which vacuum inside the brake lines cause are brake pads to move which in turn finally stops or de accelerate the vehicle.

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 types 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.**

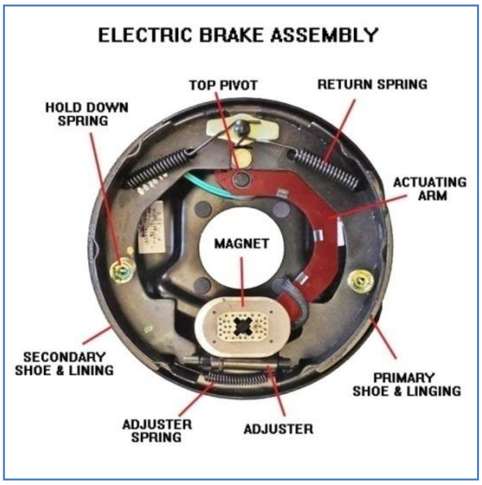
It is type of braking used in electric vehicle in which braking is produced using the electrical motors which is the main source of power in electric vehicles, it is further divided into 3 types-

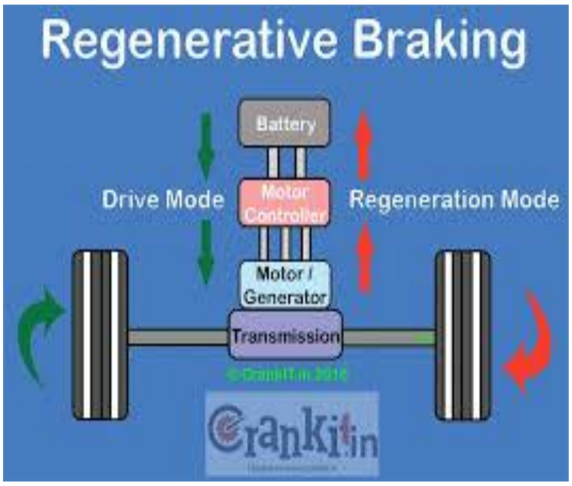
(i) Plugging Brakes. When the brake pedal is pressed in the electric vehicle equipped with plugging braking, the polarity of the motors changes which in turn reverses the direction of the motor and causes the braking.

(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.



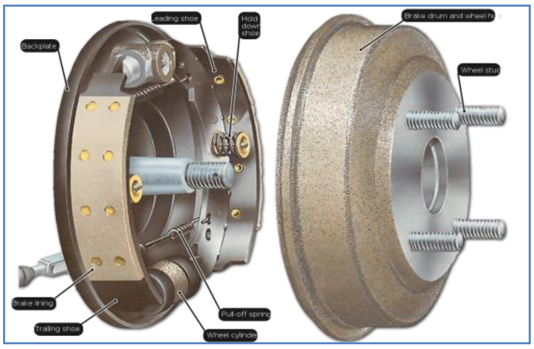


1.1.2 On Frictional Contact Basis

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.

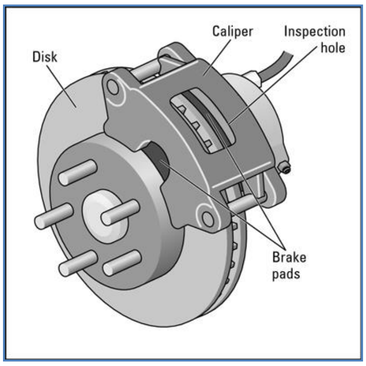


2. Disc Brake or External Contracting Brakes.

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



1.1.3 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 brake 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.

1.1.4 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).

- These types of braking system are 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.

1.1.1 Principle of Braking System

The principle of braking in road vehicles involves the conversion of kinetic energy into thermal energy (heat). When stepping on the brakes, the driver commands a stopping force several times as powerful as the force that puts the car in motion and dissipates the associated kinetic energy as heat. Brakes must be able to arrest the speed of a vehicle in short periods of time regardless how fast the speed is. As a result, the brakes are required to have the ability to generating high torque and absorbing energy at extremely high rates for short periods of time.

1.1.2 Types of Braking System

Electromagnetic Brake System

A rising style of brake system, electromagnetic brakes use an electric motor that is included in the automobile which help the vehicle come to a stop. These types of brakes are in most hybrid vehicles and use an electric motor to charge the batteries and regenerative brakes. On occasion, some buses will use it as a secondary retarder brake.

Frictional Brake System

A frictional brake system is found in many automobiles. They are service brakes, and typically found in two forms; pads and shoes. As the name implies, these brakes use friction to stop the automobile from moving. They typically include a rotating device with a stationary pad and a rotating weather surface. On most band brakes the shoe will constrict and rub against the outside of the rotating drum, alternatively on a drum brake, a rotating drum with shoes will expand and rub against the inside of the drum.

Hydraulic Brake System

A hydraulic brake system is composed of a master cylinder that is fed by a reservoir of hydraulic braking fluid. This is connected by an assortment of metal pipes and rubber fittings which are attached to the cylinders of the wheels. The wheels contain two opposite pistons which are located on the band or drum brakes which pressure to push the pistons apart forcing the brake pads into the cylinders, thus causing the wheel to stop moving.

1.1.3 Objective

Primary Objective

The main objective of our project is to design and fabricate an Electromagnetic Braking System model.

Secondary Objective

- Besides the main objective, following are our secondary objectives:
- To understand project planning and execution
- To understand the fabrication techniques in a mechanical workshop
- To understand the usage of various mechanical machine tools and also measuring tools
- To make day to day human life more easier by proper use of technology

1.1.4 Significance and Scope

- Electromagnetic brakes satisfy all the energy requirements of braking without the use of friction. They have better heat dissipation capability to avoid problems that friction brakes faces times.
- They can also be used as supplementary retardation equipment in addition to the regular friction brakes on heavy vehicles.
- These brakes's component cost is less so these brakes are cheap.
- They can be used as an alternative method for the future crisis of the crude oils.

Chapter-2

LITERATURE SURVEY

Chapter-2

Literature Survey

The following are the few journals in which the study was on electromagnetic braking system with different modifications

Innovative Electro Magnetic Braking System by Sevvel P and S Mukesh published in International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Volume-3 in April 2014, Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014) at Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore,Tamilnadu, India . Mr. Sevvel P and S Mukesh Et al find that the electromagnetic brakes can be used as an auxiliary braking system along with the friction braking system to avoid overheating and brake failure. ABS usage can be neglected by simply using a micro controlled electromagnetic disk brake system. When these brakes are combined with mechanical brakes, it increases the life of brake and act like fully loaded brakes. These electromagnetic brakes can be used in wet conditions which eliminate the anti-skidding equipment. Hence, the braking force produced in this is less than the disc brakes if can be used as a secondary or emergency braking system in the automobiles

Design & Fabrication of Eddy Current Braking System by Oscar Rodrigues, Omkar Taskar, Shrutika Sawardekar, Henderson Clemente, Girish Dalvi published in International Research Journal of Engineering and Technology (IRJET). The purpose of the study was to perform a comparative study of theoretical and practical braking time and establish a practical air gap limit beyond which the electromagnetic brakes lose their effectiveness. From theoretical calculations and experimented braking time values, a maximum reduction in braking time 23.97% is found and max air gap limit of 3 mm is obtained beyond with electromagnetic brakes are found to be ineffective. Further, a magnet of higher magnetic flux density can be used to minimize the braking time. Also, magnets can be positioned at different locations around the disc in radial arrangement to get better breaking torque distribution.

‘Modeling and control of electromagnetic brakes for enhanced braking capabilities or automated highway systems’ by M. Qian, and P. Kachroo, University of Nevada, LasVegas, IEEE Conference on Intelligent Transportation Systems, pp. 391396, January, 1997. A modified mathematical model is developed for electromagnetic brakes, is proposed to describe their static characteristics i.e. angular speed versus brake torque. This paper describes electromagnetic brakes as a supplementary system for regular friction brakes. This system provides better response time for emergency situations, and in general keeps the friction brake working longer and safer.

To control the brakes, a robust sliding mode controller is designed to maintain the wheel slip at a given value. Simulations show that the controller designed is capable of controlling the vehicle with parameter deviations and disturbances

Design and fabrication of electromagnetic braking system published International Review of Mechanical Engineering (I.RE.M.E.) by M.Z.Baharom, M. Z. Nuawi, S. M. Haris.

The behaviour of electromagnetic braking using eddy current was studied.Start edwith preliminary study investigating 3 difference materials of aluminum, copper and zinc to choose the best material as brake disc. It also looks on effects of increasing current induced into electromagnet. From the experiment that has been conducted, it can be concluded that aluminum is the best material compared to copper and zinc to be use as the disc brake for eddy current braking using electromagnetic. Besides that, we may conclude that A16061 is better than A17075 to be uses as the brake disc material for our electromagnetic braking system using eddy current project. Thicker disc will generate high torque which will approach the motor torque in order to stop the disc rotation which in this study disc of 5 mm is better than 4mm of thickness. Smaller air gap will produce high braking torque and give better performance to the electromagnetic braking which air gap of 1mm shows the best result compared to 3mm and 5mm is better than 4mm of thickness. Smaller air gap will produce high braking torque and give better performance. To the electromotive braking which air-gap of 1mm shows the best result compared to 3mm and 5mm gap. A16061 which has higher electrical conductivity than A17075 shows great performance of braking torque produced in the study. Therefore, finding of mentioned parameters from this study are parallel; with the theory and will be the guidance to extend this project for any potential application.

Chapter-3

ELECTRO-MAGNETIC BRAKING SYSTEM

Chapter -3
Electro-magnetic braking system

3.1 Background and Rational

Electromagnetic brakes (also called electro-mechanical brakes or EM brakes) slow or stop motion using electromagnetic force to apply mechanical resistance (friction). The original name was "electro-mechanical brakes" but over the years the name changed to "electromagnetic brakes", referring to their actuation method. Since becoming popular in the mid-20th century especially in trains and trams, the variety of applications and brake designs has increased dramatically, but the basic operation remains the same. Electromagnetic brakes are the brakes working on the electric power & magnetic power. They work on the principle of electromagnetism. These brakes are an excellent replacement on the convectional brakes due to their many advantages. The reason for implementing this brake in automobiles is to reduce wear in brakes as it frictionless. Electromagnetic brakes are of today’s automobiles. The working principle of this system is based on faradays first law of electromagnetic induction i.e when a magnetic flux linking with a conductor changes an emf is induced in the coil. An additional current is supplied to the coils so that it creates an opposing torque. This results in the rotating wheel or rotor comes to rest/ neutral.

History

It is found that electromagnetic brakes can develop a negative power which represents nearly twice the maximum power output of a typical engine, and at least three times the braking power of an exhaust brake. (Reverdin 1994). This performance of electromagnetic brakes make them much more competitive candidate for alternative retardation equipments compared with other retarders. By using by using the electromagnetic brakes are supplementary retardation equipment, the friction brakes can be used less frequently and therefore practically never reach high temperatures. The brake linings would last considerably longer before requiring maintenance and the potentially “brake fade” problem could be avoided. In research conducted by a truck manufacturer, it was proved that the electromagnetic brake assumed 80% of the duty which would otherwise have been demanded of the regular service brake (Reverdin 1974). Furthermore the electromagnetic brakes prevent the danger that can arise from the prolonged use of brake beyond their capability to dissipate heat. This is most likely to occur while a vehicle descending a long gradient at high speed. Ina study with a vehicle with 5 axles and weighting 40 tones powered by a powered by an engine of 310 b.h.p travelling down a gradient of 6% at a steady speed between 35 and 40 m.h.p, it can be calculated that the braking power necessary to maintain this speed ot the order of 450 hp. The brakes, therefore, would have to absorb 300 hp, meaning that each brake in the 5 axels must absorb 30 hp, that a friction brake can normally absorb with self destruction. The magnetic brake is wall suited to such conditions since it will independently absorb more than 300 hp (Reverdin 1974). It therefore can exceed the requirements of continuous uninterrupted braking, leaving the friction brakes cool and ready for emergency braking in total safety. The installation of an electromagnetic brake is not very difficult if there is enough space between the gearbox and the rear axle. If did not need a subsidiary cooling system. It relay on the efficiency of engine components for its use, so do exhaust and hydrokinetic brakes. The exhaust brake is an on/off device and hydrokinetic brakes have very complex control system. The electromagnetic brake control system is an electric switching system which gives it superior controllability.

3.2 Components of Electro-Magnetic Braking System

The electro-magnetic braking system consists of mainly the following parts. They are:-

- Base frame
- Shaft
- Belt and Pulleys
- Dc- motor
- Braking unit
- Tire(or) wheel
- Bearings
- Adapter

3.2.1 **Base Frame.**

The components require support during the operation. The base frame facilitates necessary support for this purpose.


3.2.2 Shaft

A **shaft** is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it.

One end of the shaft is connected to motor with the help of pulley and belts and the other end is connected to wheel so that it helps in transmitting motion from motor to wheel

Types

They are mainly classified into two types.

- Transmission shafts are used to transmit power between the source and the machine absorbing power; e.g. counter shafts and line shafts.
- Machine shafts are the integral part of the machine itself; e.g. crankshaft.

Materials

- The material used for ordinary shafts is mild steel. When high strength is required, an alloy steel such as nickel, nickel-chromium or chromium-vanadium steel is used.
- Shafts are generally formed by hot rolling and finished to size by cold drawing or turning and grinding.

Standard sizes

Machine shafts

- Up to 25 mm steps of 0.5 mm

Transmission shafts

- 25 mm to 60 mm with 5 mm steps
- 60 mm to 110 mm with 10 mm steps
- 110 mm to 140 mm with 15 mm steps
- 140 mm to 500 mm with 20 mm steps

The standard lengths of the shafts are 5 m, 6 m and 7 m

Stresses

The following stresses are induced in the shafts.

1. Shear stresses due to the transmission of torque (due to torsional load).
2. Bending stresses (tensile or compressive) due to the forces acting upon the machine elements like gears and pulleys as well as the self weight of the shaft.
3. Stresses due to combined torsional and bending loads.

3.2.3 Belt and Pulleys

A **pulley** is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable or belt, or transfer of power between the shaft and cable or belt.

A belt and pulley system is characterized by two or more pulleys in common to a belt. This allows for mechanical power, torque, and speed to be transmitted across axles. If the pulleys are of differing diameters are used different speeds can be obtained

3.2.4 **DC-Motor:**

A **DC motor** is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor.

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

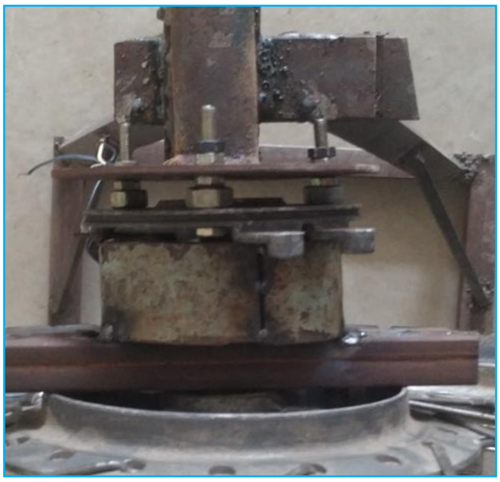
Power ratings are 160-24 volts, maximum current is 2.0A and the speed is 0-1425 rpm.

3.2.5 Braking Unit

The braking unit consists of a permanent magnet and a stator which has 3 spokes made of iron having copper wires windings.

The stator may consist of 2 to 18 spokes depending upon the application. The copper wires may be of different gauges. On increasing the no.of turns of copper windings the braking effect can be increased due to passage of more current through the coils.





3.2.6 Tire (or) Wheel

A **wheel** is a circular block of a hard and durable material at whose center has been bored a circular hole through which is placed an axle bearing about which the wheel rotates when a moment is applied by gravity or torque to the wheel about its axis, thereby making together one of the six simple machines.

3.2.7 Bearings

A **bearing** is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

Rotary bearings hold rotating components such as shafts or axles within mechanical systems, and transfer axial and radial loads from the source of the load to the structure supporting it. The simplest form of bearing, the plain bearing, consists of a shaft rotating in a hole. Lubrication is often used to reduce friction. In the ball bearing and roller bearing, to prevent sliding friction, rolling elements such as rollers or balls with a circular cross-section are located between the races or journals of the bearing assembly. A wide variety of bearing designs exists to allow the demands of the application to be correctly met for maximum efficiency, reliability, durability and performance.

The purpose of Bearing is to reduce rotational friction and support radial and axial loads

Types of bearings

There are at least 6 common types of bearing, each of which operates on different principles:-

- Plain bearing, consisting of a shaft rotating in a hole. There are several specific styles: bushing, journal bearing, sleeve bearing, rifle bearing, and composite bearing.
- Rolling-element bearing, in which rolling elements placed between the turning and stationary races prevent sliding friction. There are two main types
    - Ball bearing, in which the rolling elements are spherical balls
    - Roller bearing, in which the rolling elements are cylindrical, taper and spherical rollers
- Jewel bearing, a plain bearing in which one of the bearing surfaces is made of an ultra hard glassy jewel material such as sapphire to reduce friction and wear
- Fluid bearing, a noncontact bearing in which the load is supported by a gas or liquid,
- Magnetic bearing, in which the load is supported by a magnetic field
- Flexure bearing, in which the motion is supported by a load element which bends.

3.2.7 Adapter.

An (electrical) **adapter** is a device that converts attributes of one electrical device or system to those of an otherwise incompatible device or system. Some modify power or signal attributes, while others merely adapt the physical form of one electrical connector to another.

Power ratings are 12 volts and maximum current 10A.

3.3 Construction of Electro-Magnetic Braking System:

The motor is placed on the bottom of the frame and the motion transmission from motor to shaft is done with the help of pulleys and belt i.e one end of the shaft is connected to a pulley and the shaft pulley is connected is to the motor pulley with the help of belt so that when motor pulley rotates due to the power supply the shaft pulley rotates and the shaft pulley rotates and the shaft rotates which is mounted on the frame with the help of bearings. Here the other end of the shaft is connected to one side of the wheel so that when shaft rotates wheel also rotates. The braking unit consists of permanent magnet, stator which has 3 spokes of iron winded with copper wires. The permanent magnet is attached to the other side of the wheel and the stator outer frame is welded to the base frame.

3.4 Working of Electro-Magnetic Braking System: There are two methods of operations of the braking system.

(i) Braking system with EMF generation effect.

In this type an alternator of bikes is used as an braking unit. The braking unit consists of permanent magnet and stator which has three spokes of iron material winded with copper wires or magnetic wires. The permanent magnet and stator are connected to the equipment as mentioned in the construction above.

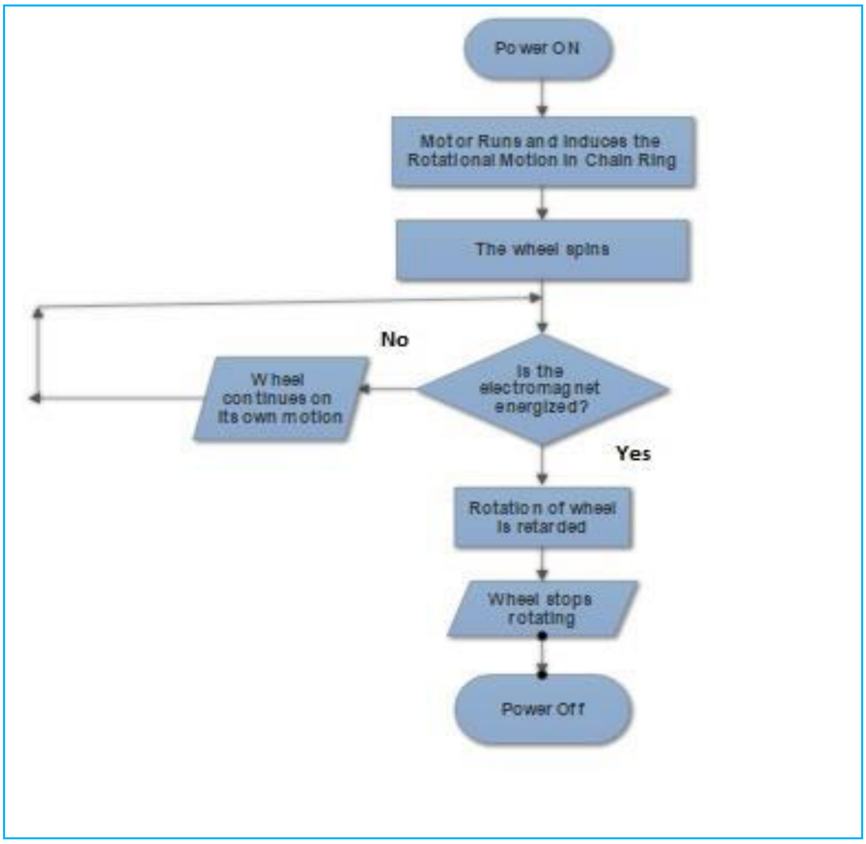
When magnet which is attached to the wheel rotates an EMF is generated in the coils according to Faraday's Law of Electromagnetic Induction, This generated EMF can be used to charge batteries with the help of rectifier and regulator because the output EMF is in AC form. So this process of generating EMF when wheel is freely rotating is known as EMF generating effect. In order to apply brakes a reverse current is supplied from the adaptor which should be more than the produced EMF so that the electro magnetic poles gets interchanged and creates an opposing torque to the rotating wheel and tries to stop the wheel.

But in this method of operation the EMF generated is more than the reverse current which we are supplying from adaptor. So the brakes are not making the wheel stop. To avoid this either we have to increase the adaptor specifications (current and voltage) or to stop the EMF generating effect. If we change the adaptor specifications i.e. increasing current and voltage the coils in the electromagnet gets damaged due to coils gauge and less no. of turns. So we have done this experiment in second method of operation which is to eliminate EMF generating effect is as follows.

(ii) Braking system without EMF generation.

The construction details are same as the first method. But only difference is the magnetic replaced by circular steel plate in the braking unit. So when electromagnet is energized by supplying current from adaptor it creates a magnetic field which attracts the rotating circular steel plate creating an opposing torque to stop the rotation of the wheel. In this there is a gap of 2mm between the steel plate and electromagnet so this is frictionless braking system which is major advantage. As the rotating circular plate does not produce any EMF, so the brakes are applied without any EMF generation.

So we used 2nd method of operation to apply brakes in order to overcome the difficulties obtained in the first method.



3.4 Advantages of Electro-Magnetic Braking System

- We can use these brakes to charge batteries with the help of rectifiers and regulators
- Problems of drum distortion at widely varying temperatures.
- Which is common for friction-brake drums to exceed 500 °C
- surface temperatures when subject to heavy braking
- demands, and at temperatures of this order, a reduction in the coefficient of friction ("brake fade") suddenly occurs
- This is reduced significantly in electromagnetic disk brake systems.
- Potential hazard of tire deterioration and bursts due to friction is eliminated.
- There is no need to change brake oils regularly.
- There is no oil leakage
- The electromagnetic brakes have excellent heat dissipation efficiency owing to the high temperature of the surface of the disc which is being cooled.
- Due to its special mounting location and heat dissipation mechanism, electromagnetic brakes have better thermal dynamic performance than regular friction brakes.

- Burnishing is the wearing or mating of opposing surfaces .This is reduced significantly here. 11)
- In the future, there may be shortage of crude oil; hence by-products such as brake oils will be in much demand. EMBs will overcome this problem.
- Electromagnetic brake systems will reduce maintenance cost.
- The problem of brake fluid vaporization and freezing iseliminated.
- Electric actuation, no fluid.
- Easy individual wheel braking control

3.5 **Disadvantages of Electro-Magnetic Braking System**

- Failure to act as a holding device
- Usage of electric power for braking
- Less effective under very low velocities..
- It cannot use grease or oil.
- Dependence on battery power to energize the brake system drains down the battery much faster.
- Due to residual magnetism present in electromagnets, thebrake shoe takes time to come back to its original position.
- The installation of an electromagnetic brake is very difficult if there is not enough space between the gearbox and the rear axle.

3.6 Applications

- Already in use under some railway system
- Can be used for any road vehicles
- Equally applicable to heavy and light vehicles
- Can be used as additional retarder for aircrafts
- May also find application in virtually any rotating system which have metallic parts
- This brake system can be use in two wheeler.
- Electromagnetic braking system can be used as a modern technology of braking in automobile.

- Electromagnetic braking system will be used in all types of light motor vehicle like car and heavy motor vehicle.

Chapter-4
CALCULATIONS

Chapter-4
Calculations

The specifications of the components selected for the model are listed in the below table:

Sl.No	Parts	Specifications
1.	Base Frame	
2.	DC Motor	Voltage:160-240 Volts Current: 2A HP:0.25 Power : 180W Maximum Speed: 1425 RPM No .of Poles: 2 Frequency: 50HZ
3.	Adapter	Power Ratings: Voltage: 12V Current: 10A
4.	Braking Unit	Stator having 3 poles with copper winding No of turns in the copper winding: Diameter of circular plate:
5.	Pulleys	Motor Pulley Diameter: 3.3cm Shaft Pulley Diameter: 10.5 cm Center to center distance between pulleys = 37cm
6.	Shaft	Diameter:2cm Material : Mild Steel
7.	Bike Tire (or) Wheel	Mass :7kg Diameter :60.94cm
8.	Bearings	2cm Diameter Plain Bearing

4.1 STANDARD CALCULATIONS

- **Base frame:**

A) dimensions are

Length

Width

Height

- **Dc motor:**

A) Used to rotate the wheel by using belt and pulley arrangement when power supply is given

B) Voltage = 160-240 Volts

C) Current = 2A

D) HP = 0.25

E) Power = 180W

F) Maximum Speed = 1425 RPM

- **Braking Unit**

A) Stator having 3 poles with copper winding

B) No of turns in the copper winding:

C) Diameter of circular plate:

4.2 Design Calculations

- **Max speed**

N x D = n x d

1425 x 3.3 = n x 10.5

N = (1425 x 3.3) / 10.5

N = 457.85 RPM

- **Checking the center to center distance between pulley**

$C \geq (D + d) / 2$

37 > (10.5+3.3) / 2

37cm > 6.79cm

- **Arc of contact between belt and pulley**

$$A = 180 - \frac{(D - d)}{C} \times 60^0$$

$$A = 180 - \frac{(10.5 - 3.3)}{37} \times 60^0$$

$A = 168.32^0$

- **Length of the belt**

$$L = 2C + \pi \frac{(D + d)}{2} + \frac{(D-d)^2}{4C}$$

$$L = (2 \times 37) + \pi \frac{(10.5 + 3.3)}{2} + \frac{(10.5 - 3.3)^2}{4 \times 37}$$

$L = 74 + 21.67 + 0.3502$

$L = 96.02$cm

- **Actual length**

$L_a = L - (1\% \text{ of } L)$

$L_a = 96.02 - 0.96$

$L_a = 95.059$cm

4.3 Braking torque and braking time

- **Formula for Braking Torque**

We know that

Power = Force x distance per minute ------ (1)

$$\text{Force} = \frac{\text{Torque}}{\text{Radius}} \quad \text{------ (2)}$$

Now distance per revolution = Radius x 2 π

Distance per minute = Radius x 2 π x RPM----- (3)

Substituting equation (2) & (3) in (1) then we get

$$\text{Power} = \frac{\text{Torque} \times \cancel{\text{Radius}} \times 2\pi \times \text{RPM}}{\cancel{\text{Radius}}}$$

$$= \text{Torque} \times 2\pi \times \text{RPM}$$

Divide both sides by 33000 to find HP in Pb then we get

$$\text{HP} = \frac{\text{Torque} \times \text{RPM} \times 2\pi}{33000}$$

$$\text{HP} = \frac{\text{Torque} \times \text{RPM} \times 6.2831}{33000}$$

$$\text{HP} = \frac{\text{Torque} \times \text{RPM} \times 1}{5252}$$

$$\text{Torque} = \frac{\text{HP} \times 5252}{\text{RPM}}$$

- **Formula for Braking Time in Imperial Units**

$$T = I\,\alpha$$

$$T = W \times R^2 \times \alpha$$

$$T = \frac{M}{g} \times R^2 \times \alpha \quad (\text{Since } W = Mg)$$

and $\alpha = \omega / t$

Here g is in m/sec^2
and 1m = 3.2208 ft
then 10m = 32.2 ft
g in ft / sec^2 is
10 m/sec^2 = 32.2 ft /sec^2

$$T = \frac{M}{32.2} \times R^2 \times \frac{\omega}{t}$$

$$\omega = \frac{2\pi N}{60}$$

$$T = \frac{M \times R^2 \times 2\pi \times N}{60 \times t}$$

$$T = \frac{M \times R^2 \times N}{308 \times t}$$

$$t = \frac{M \times R^2 \times N}{308 \times T}$$

- **Theoretical calculations:-**

1.) At speed N = 150 rpm

$$T = \frac{5252 \times 0.25}{150}$$

T = 8.753 ft-pb

Here M = 7 kg
R = 0.3047 m
$MR^2 = 7 \times 0.3047^2$
$= 0.6498$ kg- m^2
1 kg-m^2 = 23.73 Pb Ft^2
Then 0.6498 kg-m^2 = 15.422 Pb-Ft^2

$$t = \frac{15.422 \times 150}{308 \times 8.753}$$

t = 0.857 sec

2.) At speed N = 200 rpm

$$T = \frac{5252 \times 0.25}{200}$$

T = 6.565 ft-pb

$$t = \frac{15.422 \times 200}{308 \times 6.565}$$

t = 1.52 sec

3.) At speed N = 250 rpm

$$T = \frac{5252 \times 0.25}{250}$$

T = 5.252 ft-pb

$$t = \frac{15.422 \times 250}{308 \times 5.252}$$

t = 2.38sec

4.) At speed N = 300 rpm

$$T = \frac{5252 \times 0.25}{300}$$

$T = 4.3767$ ft-pb

$$t = \frac{15.422 \times 300}{308 \times 4.3767}$$

$t = 3.5$ sec

5.) At speed N = 350 rpm

$$T = \frac{5252 \times 0.25}{350}$$

T 3.751 ft-pb

$$t = \frac{15.422 \times 350}{308 \times 3.751}$$

$t = 4.671$ sec

6.) At speed N = 400 rpm

$$T = \frac{5252 \times 0.25}{400}$$

T 3.28 ft-pb

$$t = \frac{15.422 \times 400}{308 \times 3.28}$$

$t = 6.1$ sec

7.) At speed N = 450 rpm

$$T = \frac{5252 \times 0.25}{450}$$

$T = 2.917$ft-pb

$$t = \frac{15.422 \times 450}{308 \times 2.917}$$

$t = 7.772$ sec

Assumptions

1. The wheel is considered as solid disc for calculating the moment of inertia of wheel above central axis

2. Assuming the Torque produced by the brake is equal to Torque given by the motor for calculation purpose. Since the torque from the brake is difficult to calculate experimentally

Chapter-5

3D MODEL DESIGN OF ELECTRO-MAGNETIC BRAKING SYSTEM USING CATIA

Chapter-5
3D MODEL DESIGN OF ELECTRO-MAGNETIC BRAKING SYSTEM USING CATIA

5.1. Catia Introduction.

CATIA, (an acronym of **computer-aided three-dimensional interactive application**) is a multi-platform software suite for Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Computer-Aided Engineering (CAE), PLM and 3D, developed by the French company Dassault Systems.

Scope of Application

Commonly referred to as a 3D Product Lifecycle Management software suite, CATIA supports multiple stages of product development, including conceptualization, design (CAD), engineering (CAE) and manufacturing (CAM). CATIA facilitates collaborative engineering across disciplines around its 3DEXPERIENCE platform, including surfacing & shape design, electrical, fluid and electronic systems design, mechanical engineering and systems engineering.

CATIA facilitates the design of electronic, electrical, and distributed systems such as fluid and HVAC systems, all the way to the production of documentation for manufacturing.

Mechanical Engineering

CATIA enables the creation of 3D parts, from 2D sketches, sheet metal, composites, molded, forged or tooling parts up to the definition of mechanical assemblies. The software provides advanced technologies for mechanical surfacing & BIW. It provides tools to complete product definition, including functional tolerances as well as kinematics definition. CATIA provides a wide range of applications for tooling design, for both generic tooling and mold & die. In the case of Aerospace engineering an additional module named the aerospace sheet metal design offers the user combine the capabilities of generative sheet metal design and generative surface design.

Design

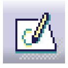
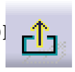
CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether started from scratch or from 2D sketches (blueprints)

GEOMETRY FORMATION

CATIA is one of the world's leading high-end CAD/CAM/CAE software packages. CATIA (computer aided three dimensional interactive application) is a multi-platform PLM/CAD/CAM/CAE commercial software suite developed by Dassault systems and marketed worldwide by IBM. CATIA is written in the C++ programming language. CATIA provides open development architecture through the use of interfaces, which can be used to customize or develop applications. The applications in programming interfaces supported visual basic and C++ programming languages.

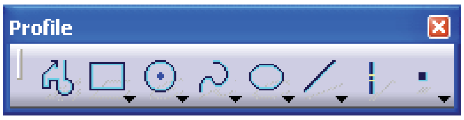
Commonly referred to as 3D product lifecycle management (PLM) software suite, CATIA supports multiple stages of product development. The stages range from conceptualization, through design (CAD) and manufacturing (CAM), until analysis (CAE). Each work bench of catiaV5 refers and each stage of product development for different products. CATIA V5 features a parametric solid/surface-based package which uses NURBS as the core surface representation and has several work benches but provide KBE (knowledge based engineering) support.

The Sketcher Workbench

The Sketcher workbench is a set of tools that helps you create and constrain 2D geometries. Features (pads, pockets, shafts, etc...) may then be created solids or modifications to solids using these 2D profiles. You can access the Sketcher workbench in various ways. Two simple ways are by using the top pull down menu (Start – Mechanical Design – Sketcher), or by selecting the Sketcher icon  . When you enter the sketcher, CATIA requires that you choose a plane to sketch on. You can choose this plane either before or after you select the Sketcher icon. To exit the sketcher, select the Exit Workbench icon  . The Sketcher Work bench contains the following standards work bench specific

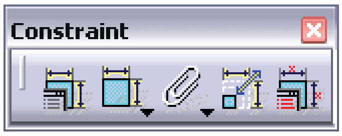
Tool Bars

- <u>Profile Toolbar.</u> The commands located in toolbar allow you to create simple geometries (rectangle, circle, line, etc.,) and more complex geometries (profile, spline, etc.,)

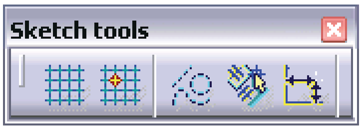


- <u>Operation Toolbar:</u> Once a profile has been created, it can be modified using commands such as trim, mirror, chamfer, and other commands located in the Operation toolbar.

- <u>Constraint Toolbar:</u> Profiles may be constrained with dimensional (distances, angles, etc...) or geometrical (tangent, parallel, etc...) constraints using the commands located in the Constraint toolbar.

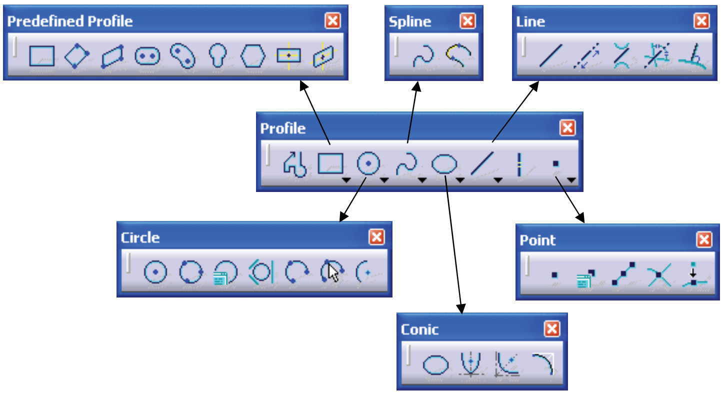


- <u>Sketch Tools Toolbar:</u> The commands in this toolbar allow you to work in different modes which make sketching easier.



- <u>User Selection Filter Toolbar</u>: Allows you to activate different selection filters.

Profile Toolbar



The Profile toolbar contains 2D geometry commands. These geometries range from the very simple (point, rectangle, etc...) to the very complex (splines, conics, etc...). The Profile toolbar contains many sub-toolbars. Most of these sub- toolbars contain different options for creating the same geometry. For example, you can create a simple line, a line defined by two tangent points, or a line that is perpendicular to a surface. Reading from left to right, the Profile toolbar contain the following commands.

Profile Toolbar

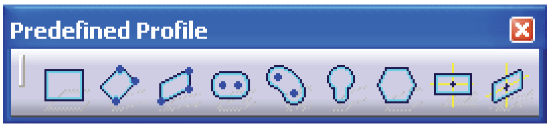
- Profile: This command allows you to create a continuous set of lines and arcs connected together.
- Rectangle / Predefined Profile toolbar: The default top command is rectangle. Stacked underneath are several different commands used to create predefined geometries.
- Circle / Circle toolbar: The default top command is circle. Stacked underneath are several different options for creating circles and arcs.
- Spline / Spline toolbar: The default top command is spline which is a curved line created by connecting a series of points.
- Ellipse / Conic toolbar: The default top command is ellipse. Stacked underneath are commands to create different conic shapes such as a hyperbola.
- Line / Line toolbar: The default top command is line. Stacked underneath are several different options for creating lines.

- Axis: An axis is used in conjunction with commands like mirror and shaft (revolve). It defines symmetry. It is a construction element so it does not become a physical part of your feature.

- Point / Point Toolbar: The default top command is point. Stacked underneath are several different options for creating points.

Predefined Profile Toolbar

Predefined profiles are frequently used geometries. CATIA makes these profiles available for easy creation which speeds up drawing time. Reading from left to right, the Predefined Profile toolbar contains the following commands.



- Rectangle: The rectangle is defined by two corner points. The sides of the rectangle are always horizontal and vertical.
- Oriented Rectangle: The oriented rectangle is defined by three corner points. This allows you to create a rectangle whose sides are at an angle to the horizontal.
- Parallelogram: The parallelogram is defined by three corner points.
- Elongated Hole: The elongated hole or slot is defined by two points and a radius.
- Cylindrical Elongated Hole: The cylindrical elongated hole is defined by a cylindrical radius, two point and a hole radius.
- Keyhole Profile: The keyhole profile is defined by two center points and two radii.
- Hexagon: The hexagon is defined by a center point and the radius of an inscribed circle.
- Centered Rectangle: The centered rectangle is defined by a center point and a corner point.
- Centered Parallelogram: The centered parallelogram is defined by a center point (defined by two intersecting lines) and a corner point.

Circle Toolbar

The Circle toolbar contains several different ways of creating circles and arcs. Reading from left to right, the Circle toolbar contains the following commands.

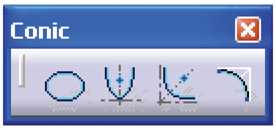
- Circle: A circle is defined by a center point and a radius.
- Three Point Circle: The three point circle command allows you to create a circle using three circumferential points.
- Circle Using Coordinates: The circle using coordinates command allows you to create a circle by entering the coordinates for the center point and radius in a Circle Definition window.
- Tri-Tangent Circle: The tri-tangent circle command allows you to create a circle whose circumference is tangent to three chosen lines.
- Three Point Arc: The three point arc command allows you to create an arc defined by three circumferential points.
- Three Point Arc Starting with Limits: The three point arc starting with limits allows you to create an arc using a start, end, and midpoint.
- **Arc**: The arc command allows you to create an arc defined by a center point, and a circumferential start and end point.

Spline Toolbar

Reading from left to right, the Spline toolbar contains the following commands.

- Spline: A spline is a curved profile defined by three or more points. The tangency and curvature radius at each point may be specified.
- Connect: The connect command connects two points or profiles with a spline.**Conic Toolbar**

Reading from left to right, the Conic toolbar contains the following commands.



- Ellipse: The ellipse is defined by center point and a major and minor axis points.
- Parabola by Focus: The parabola is defined by a focus, apex and a start and end point.
- Hyperbola by Focus: The hyperbola is defined by a focus, center point, apex and a start and end point.
- Conic: There are several different methods that can be used to create conic curves. These methods give you a lot of flexibility when creating above three types of curves.

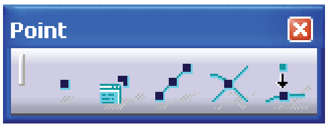
Line Toolbar

The Line toolbar contains several different ways of creating lines. Reading from left to right, the Line toolbar contains the following commands.

- Line: A line is defined by two points.
- Infinite Line: Creates infinite lines that are horizontal, vertical or defined by two points.
- Bi-Tangent Line: Creates a line whose endpoints are tangent to two other elements.
- Bisecting Line: Creates an infinite line that bisects the angle created by two other lines.

Point Toolbar

- The Point toolbar contains several different ways of creating points. Reading from left to right, the Point toolbar contains the following commands.

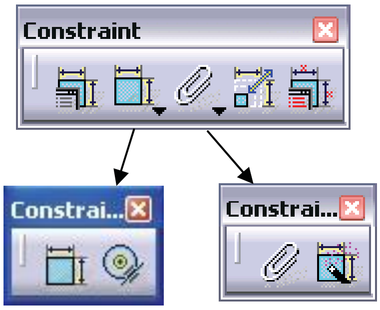


- Point by Clicking: Creates a point by clicking the left mouse button.
- Point by using Coordinates: Creates a point at a specified coordinate point.

- Equidistant Points: Creates equidistant points along a predefined path curve.
- Intersection Point: Creates a point at the intersection of two different elements.
- Projection Point: Projects a point of one element onto another.

Constraint Toolbar

Constraints can either be dimensional or geometrical. Dimensional constraints are used to constrain the length of an element, the radius or diameter of an arc or circle, and the distance or angle between elements. Geometrical constraints are used to constrain the orientation of one element relative to another. For example, two elements may be constrained to be perpendicular to each other. Other common geometrical constraints include parallel, tangent, coincident, concentric, etc... Reading from left to right:



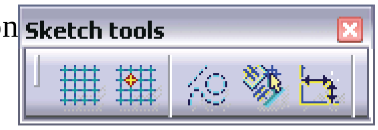
- Constraints Defined in Dialoged Box: Creates geometrical and dimensional constraints between two elements.
- Constraint: Creates dimensional constraints.
- Contact Constraint: Creates a contact constraint between two elements.
- Fix Together: The fix together command groups individual entities together.
- Auto Constraint: Automatically creates dimensional constraints.
- Animate Constraint: Animates a dimensional constraint between to limits.
- Edit Multi-Constraint: This command allows you to edit all your sketch constraints in a single window.

- **Visualization Toolbar**: Allows you to, among other things to cut the part by the sketch plane and choose lighting effects and other factors that influence how the part is visualized.

- Tools Toolbar, Allows you to, mono go the other things to analyze a sketch for problems , and create a datum

The Sketch Tools Toolbar

The Sketch tools toolbar contains icons that activate and deactivate different work modes. These work modes assist you in drawing 2D profiles. Reading from left to right, the toolbar contains the following work modes; (Each work mode is active if the icon is orange and inactive if it is blue.)



- Grid: This command turns the sketcher grid on and off.
- Snap to Point: If active, your cursor will snap to the intersections of the grid lines.
- Construction / Standard Elements: You can draw two different types of elements in CATIA a standard element and a construction element. A standard element (solid line type) will be created when the icon is inactive (blue). It will be used to create a feature in the Part Design workbench. A construction element (dashed line type) will be created when the icon is active (orange). They are used to help construct your sketch, but will not be used to create features.
- Geometric Constraints: When active, geometric constraints will automatically be applied such as tangencies, coincidences, parallelisms, etc...

Dimensional Constraints: When active, dimensional constraints will automatically be applied when corners (fillets) or chamfers are created, or when quantities are entered in the value field. The value field is a place where dimensions such as line length and angle are manually entered

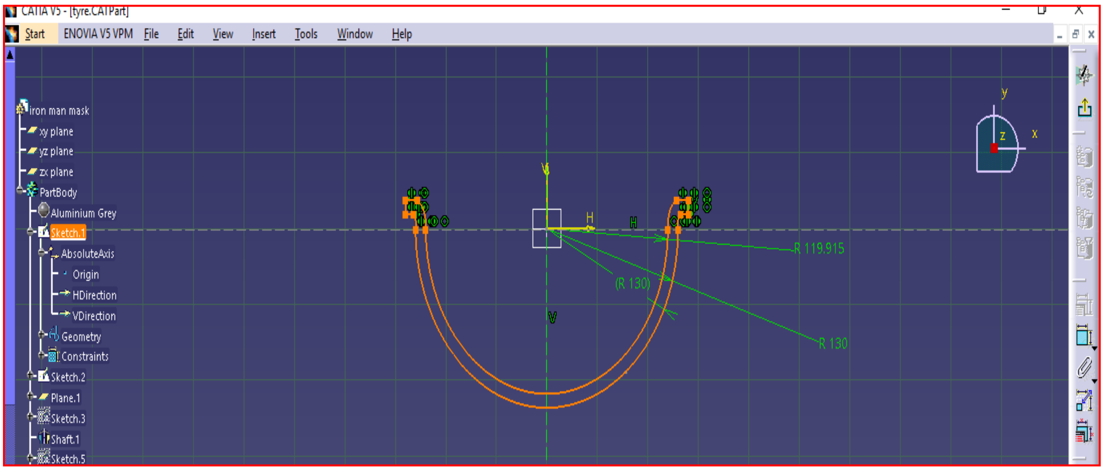
5.2. 3D DESIGN OF ELECTRO MAGNETIC BRAKING SYSTEM

3D COMPONETNS ARE

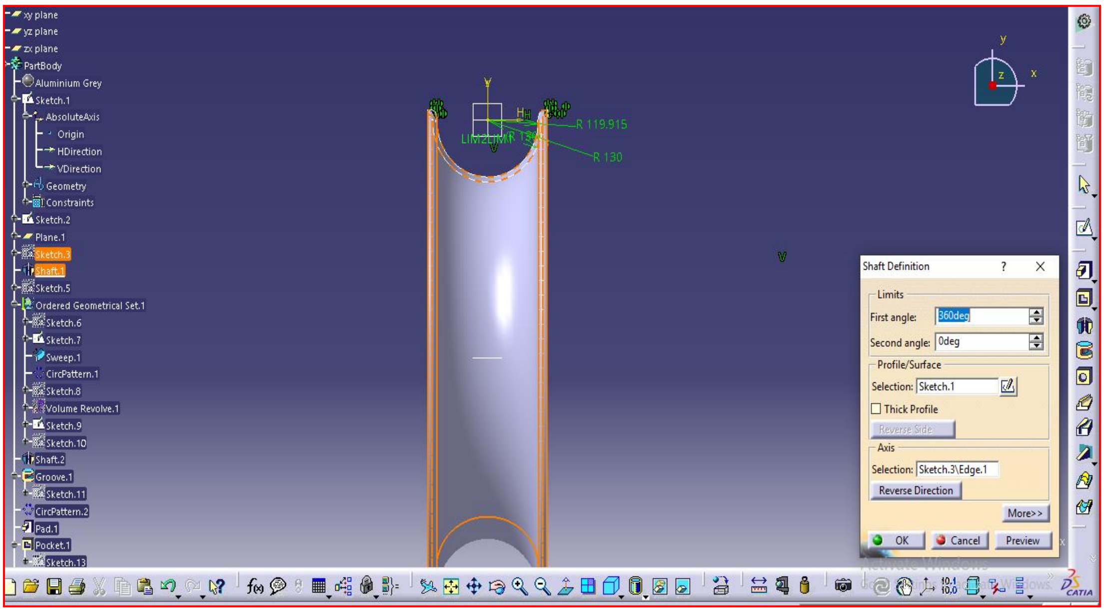
1. TYRE
2. MOTOR
3. BASE FRAME
4. BEARING

5.2.1. DESIGN OF TYRE

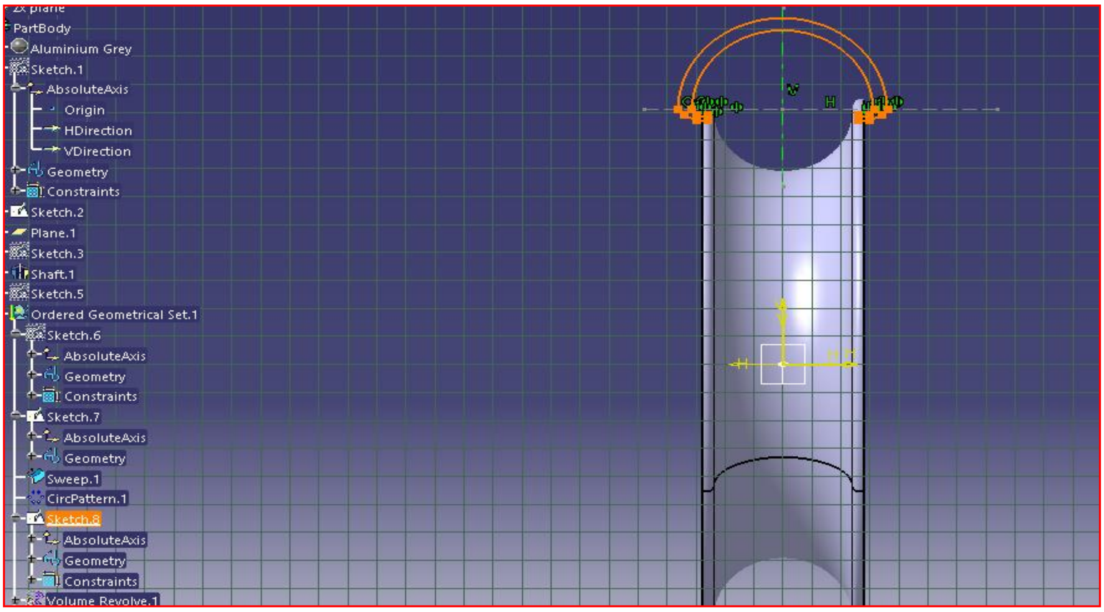
STEP-1: DRAW THE PROFILE OF THE RIM USING SPLINE COMMAND, CIRCLE COMMAND FROM PROFILE TOOL BAR AS SHOWN IN THE FIGURE



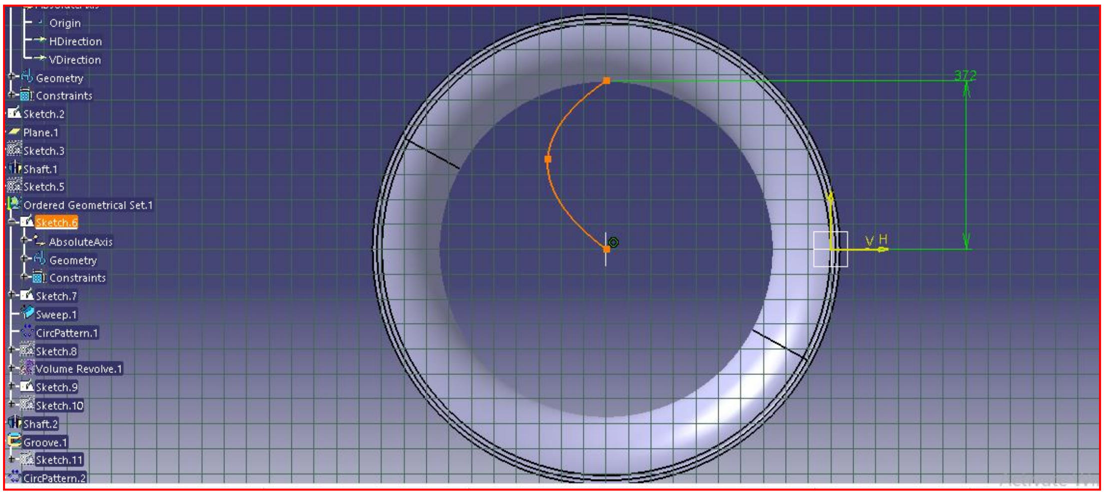
STEP-2: BY USING SHAFT COMMAND WE HAVE EXTRUDED THE ABOVE PROFILE 360^0 MENTIONED IN THE STEP-1 AS SHOWN IN THEFIGURE

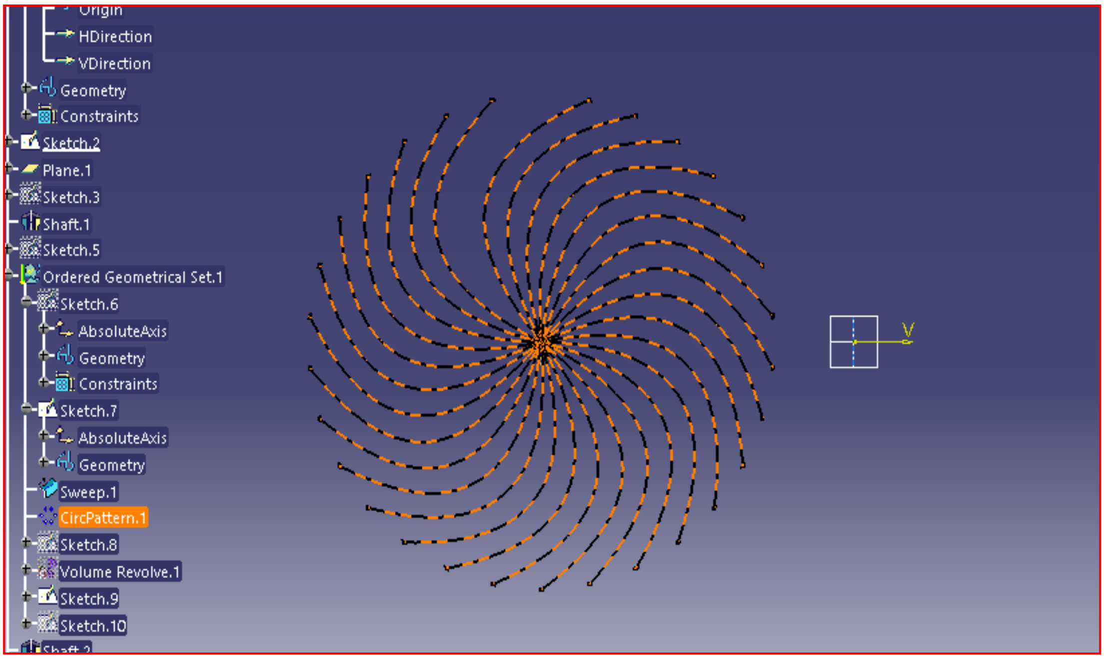


STEP-3: DRAW THE PROFILE OF TYRE USING SPLINE AND CIRCLE COMMAND FROM PROFILE TOOL BAR AS SHOWN IN FIGURE

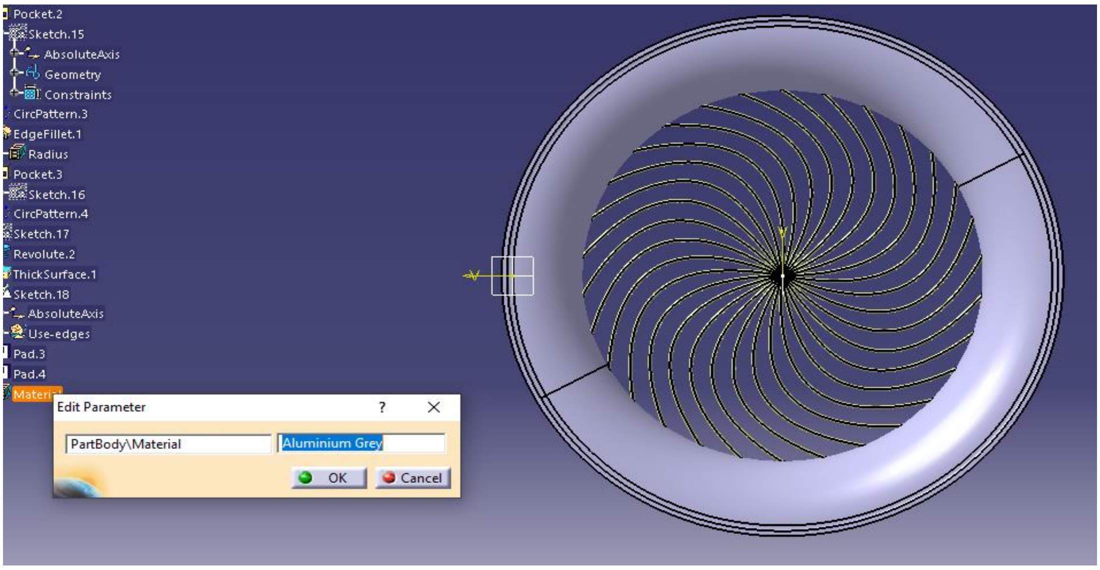


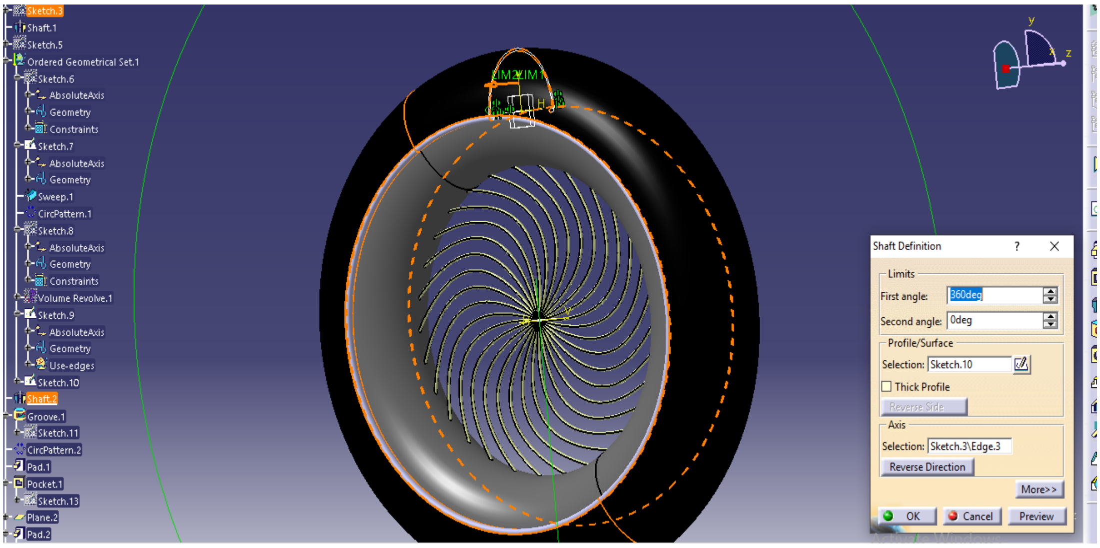
STEP-5: DRAW THE SPOKES OF THE TYRE USING SPLINE COMMAND FROM THE CENTRE OF THE TYRE AND USING CIRCULAR PATTERN COMMAND OBTAIN THE REQUIRED SPOKES ARE AS SHOWN IN THE FIGURE





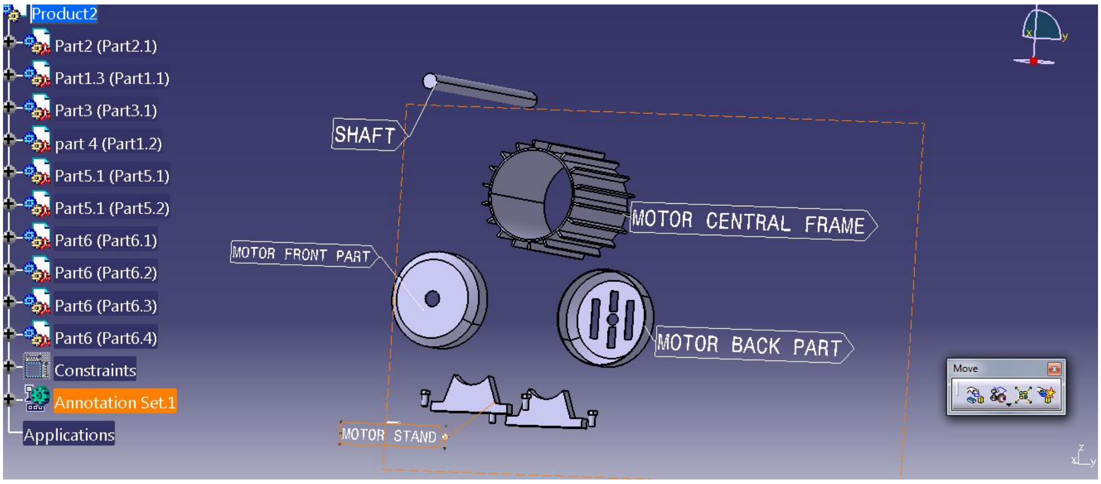
STEP-6: SELECTION OF MATERIAL OF RIM AND COLOUR OF TYRE





5.2.2. DESIGN OF MOTOR

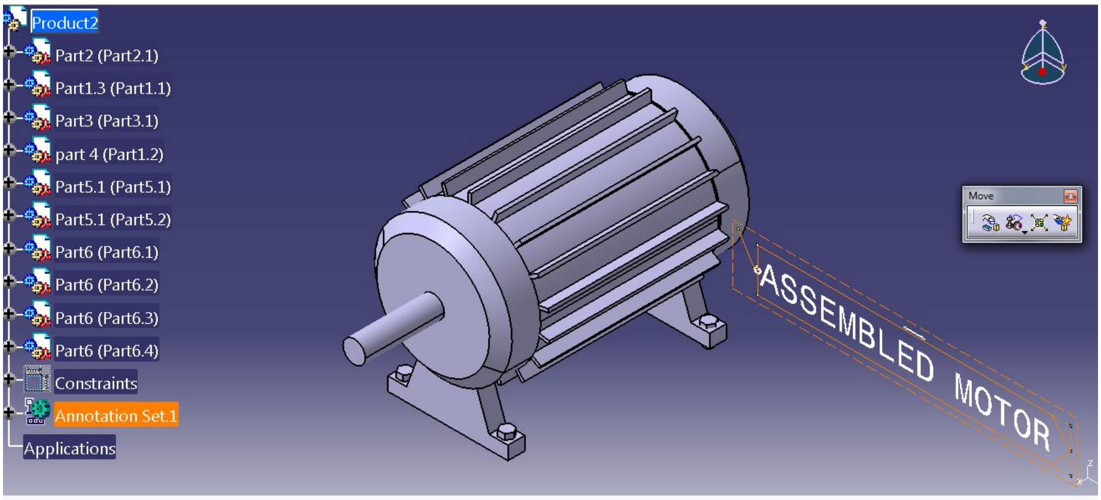
STEP-1: DRAW THE MOTOR BY CREATING MOTOR FRONT,BACK PART,STAND AND CENTRAL FRAME USING PROFLE TOOL BAR AND APPLY REQUIRED DIMENSIONS USING CONSTRAINT TOOL BAR



STEP-2: USE COINCIDE COMMAND TO COINCIDE THE AXIS OF MOTOR FRONT, BACK AND CENTRAL PART.

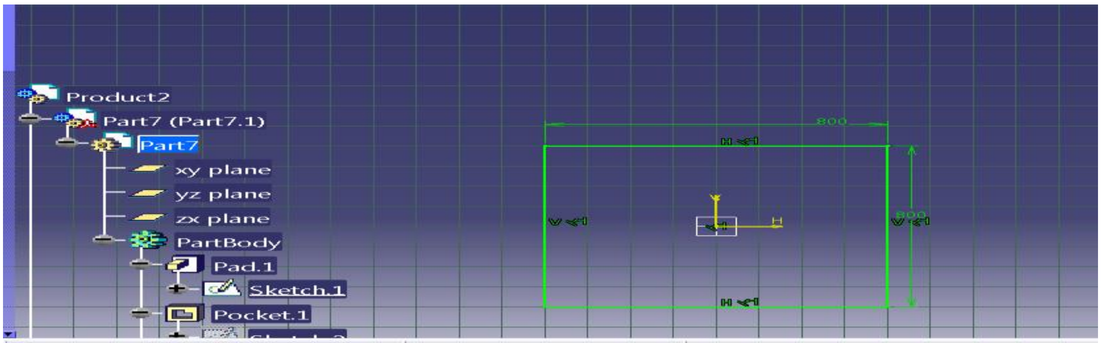
STEP-3: USE OFFSET OR CONTACT COMMAND TO ASSEMBLE MOTOR CENTRAL FRAME, MOTOR FRONT, BACK PART AND MOTOR STAND.

STEP-4: THE OBTAIN ASSEMBLE MOTOR IS SHOWN IN THE FIGURE BELOW

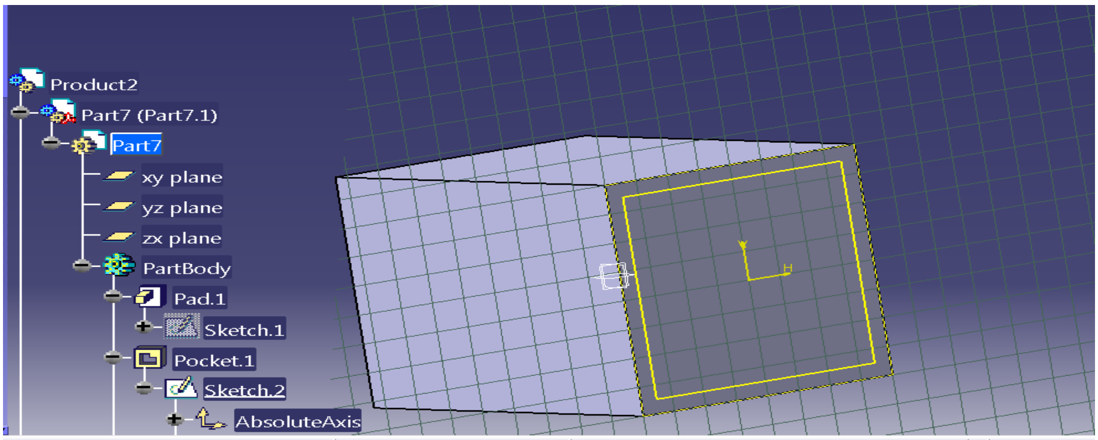


5.2.3. DESIGN OF FRAME:

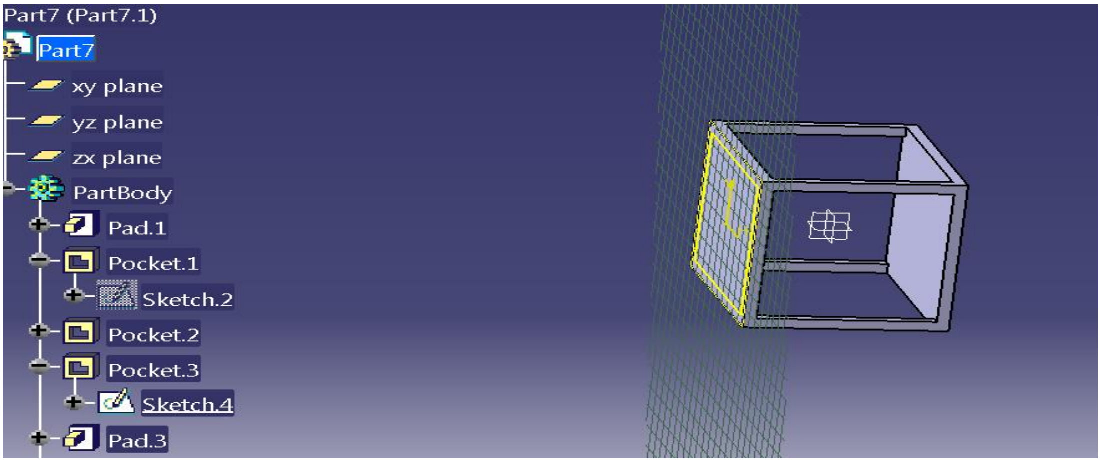
STEP-1: DRAW A RECTANGLE OF REQUIRED DIMENSIONS USING PROFILE TOOL BAR AND CONSTRAINT TOOL BAR.



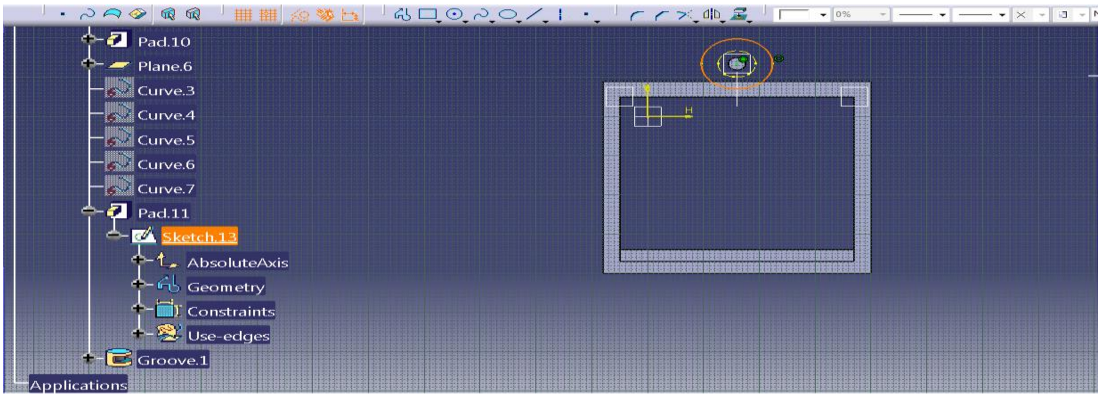
STEP-2: USE PAD COMMAND TO EXTRUDE THE ABOVE SKETCH OF REQUIRED THICKNESS



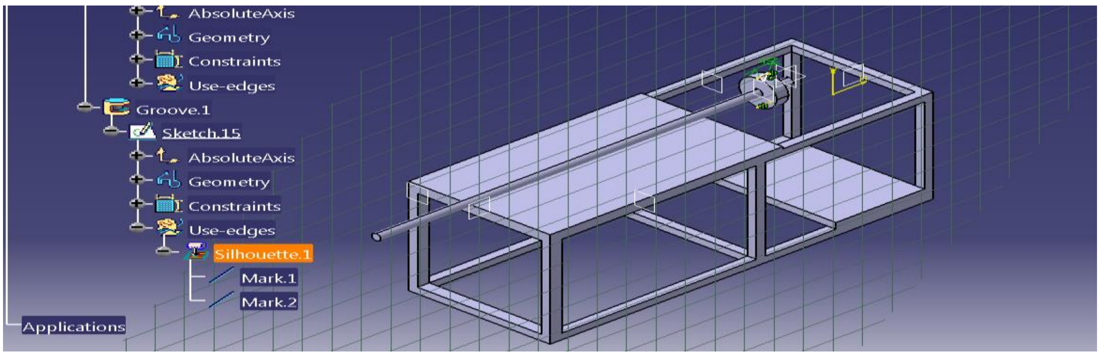
STEP-3: USE POCKET COMMAND TO GET A HOLOW SECTIONAL FRAME



STEP-4: SKETCH A CIRCLE ON THE TOP OF THE FRAME AT REUIRED POSTION TO OBTAIN THE PULLEY AND SHAFT

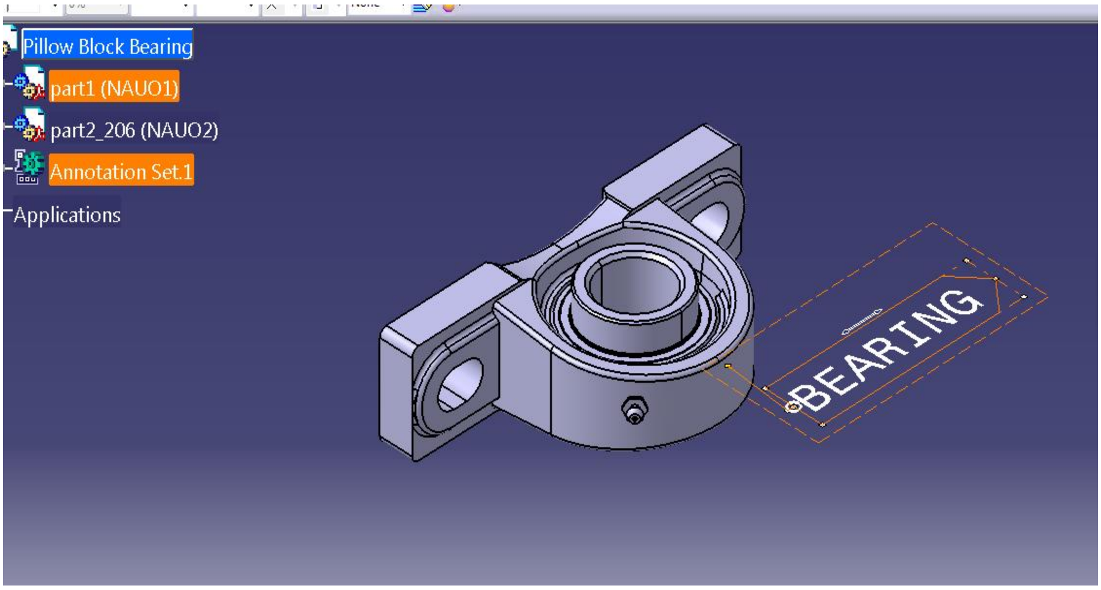


STEP-5: THE ENTIRE FRAME IS CREATED AS SHOWN IN FIGURE



5.2.4. DESIGN OF BEARING:

USING SKETCHER TOOL BAR AND ASSEMBLE COMMANDS THE BEARING AS DRWN AS SHOWN IN THE FIGURE



5.2.5. ASSEMBLY OF COMPONENTS

ASSEMBLE THE ABOVE PARTS AT REQUIRED POSTIONS USING CONTACT, OFFSET, COINCIDE, AND ANGLE COMMANDS

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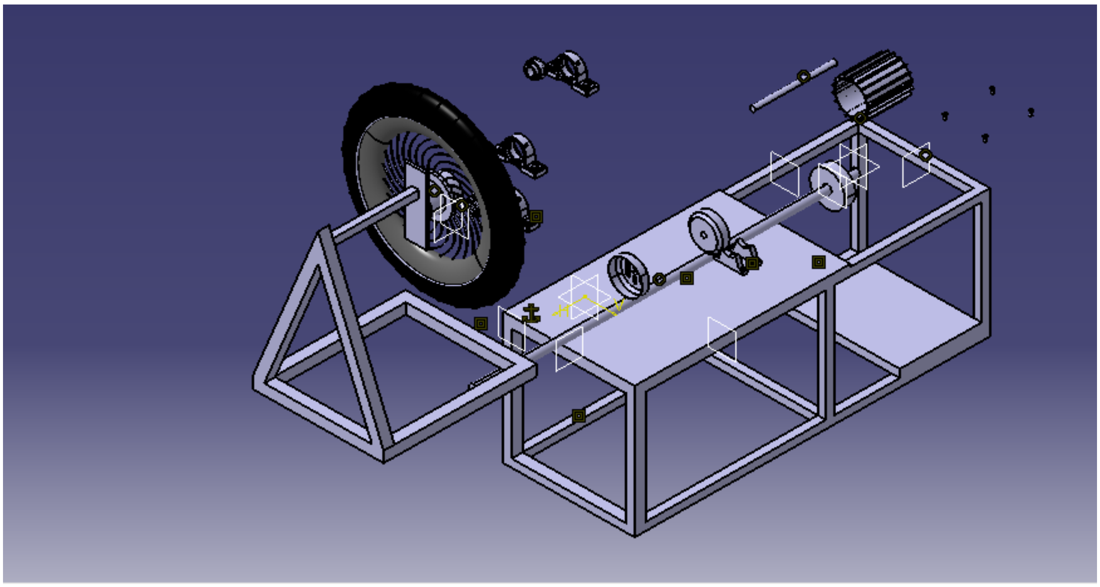
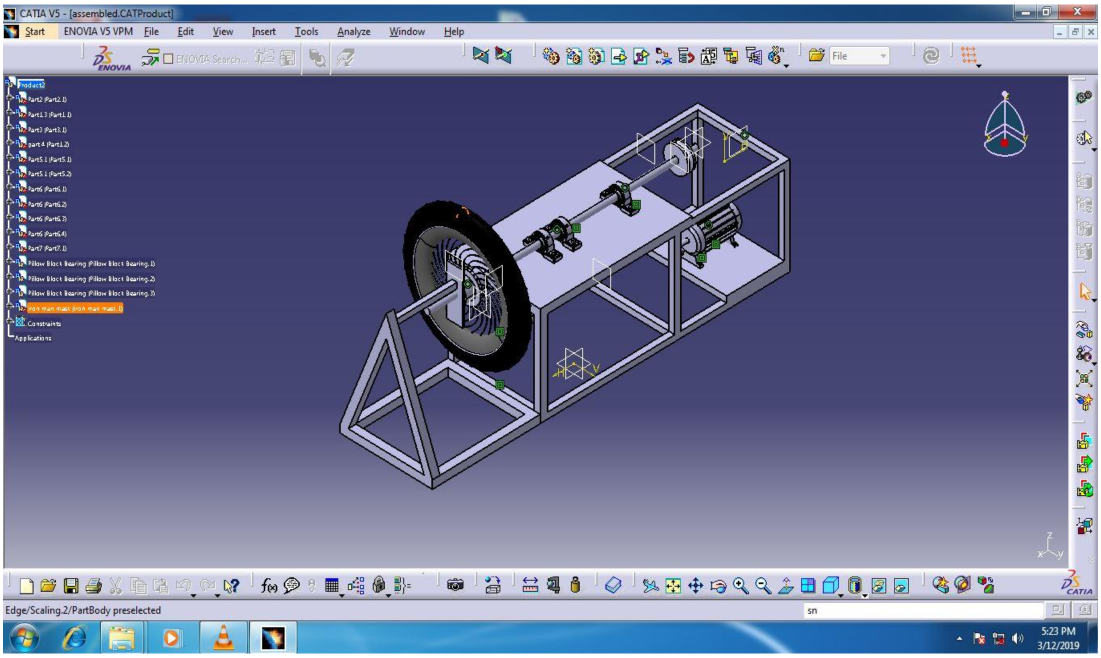
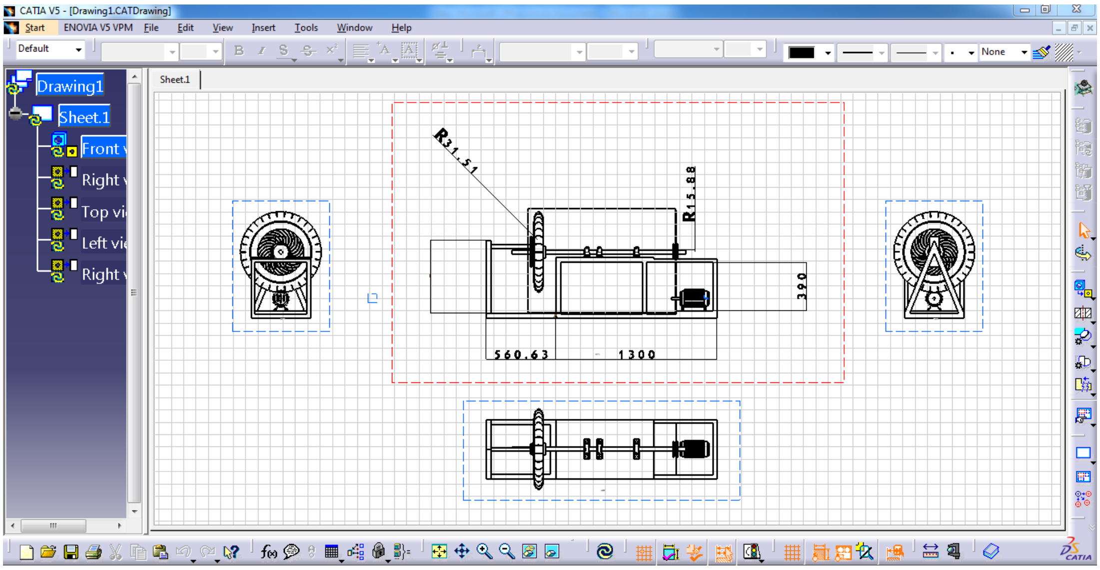




2D LAYOUT OF THE TOTAL DESIGN:



Chapter - VI

RESULTS AND DISCUSSION

Chapter - VI
RESULTS AND DISCUSSION

The Theoretical braking time is obtained from the formulas mentioned in the previous chapter at suitable speeds by taking some assumptions. The experimental braking time is calculated by taking readings from fabricated model using stop watch at required speeds. These experimental and theoretical values are compared in this experiment.

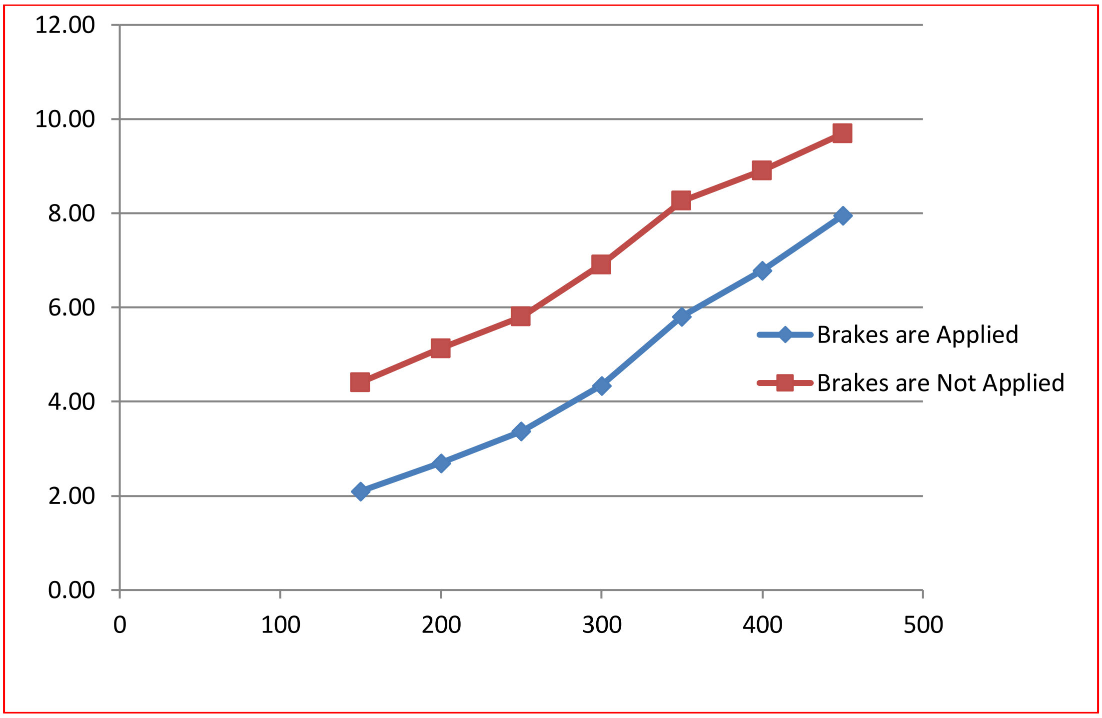
The values of time taken by the wheel to stop when brakes are applied, when brakes are not applied and also theoretically are shown in the table. And graphs are plotted for speed of the wheel and theoretical experimental braking time, speed of the wheel and time taken by the wheel to stop and when brakes are applied , when brakes are not applied as shown in the graph

The value variation between speed of the wheel and braking time are observed in XY plane which shows that the time taken by the wheel to stop increases within increase in speed of the wheel. From the graph it is shown that these brakes are most effective at high speeds.

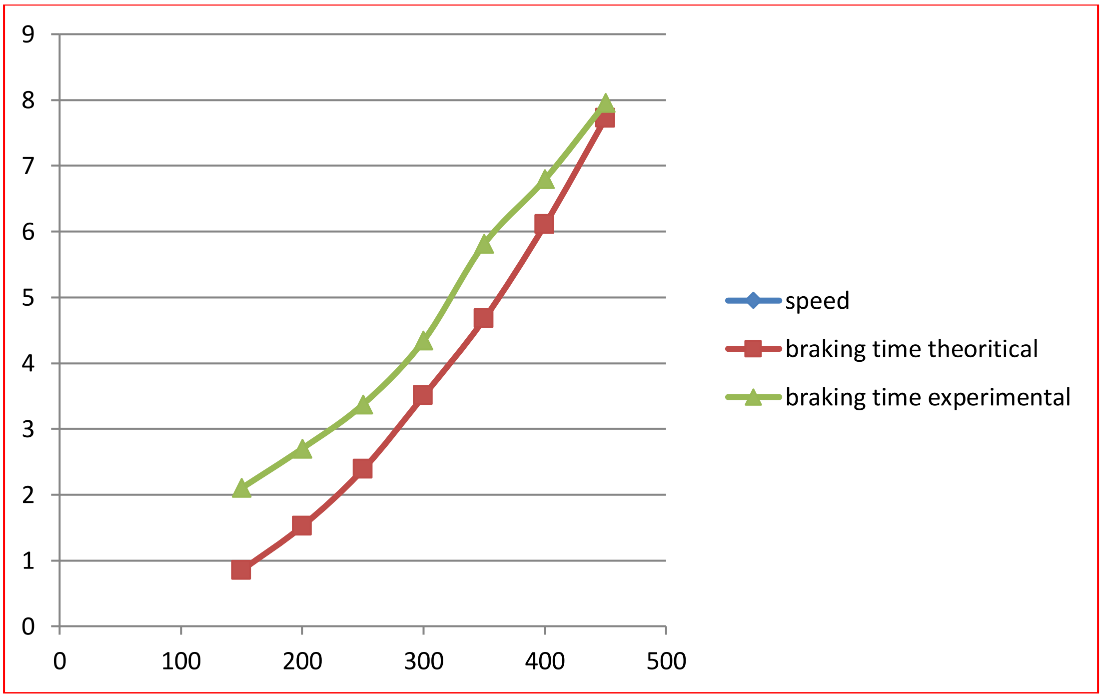
Table 6.1: Experimental and Theoretical braking time varying with speed of the wheel.

Sl.No.	Speed	Experimental Time taken when		Theoretical Time taken
		Brakes are applied	Brakes are not applied	
1.	150	2.10	4.41	0.85
2.	200	2.70	5.13	1.52
3.	250	3.37	5.80	2.38
4.	300	4.34	6.91	3.50
5.	350	5.81	8.26	4.67
6.	400	6.79	8.91	6.10
7.	450	7.95	9.69	7.72

Graphs



12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
100
200
300
400
500
Brakes are Applied
Brakes are Not Applied



9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
speed
braking time theoritical
braking time experimental

CHAPTER-VII

CONCLUSIONS AND FUTURE SCOPE

CHAPTER-VII

CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION

Electromagnetic brakes are important supplementary retardation equipment in addition to the regular friction brakes. They have been used in heavy vehicles such as coaches, buses, trucks under conditions such as reducing speed in motorways and trunk roads and braking for prolonged periods during down slope operations. New types of electromagnetic brakes have been under development for lighter vehicles as well. Regular friction brakes have an outstanding and vital load absorbing capability if kept cool. Electromagnetic brakes help friction brakes to retain this capability under all conditions by absorbing energy at a separate location based on a totally different working principle.

This report presents the performance of an electromagnetic braking system which includes various components with its cost effectiveness and efficient methodologies to utilize the supplied energy. With the application of the effective and strong electromagnet we can have greater efficient braking system.

The concept designed by us is just a prototype and needs to be developed more because of the above mentioned disadvantages. These electromagnetic brakes can be used as an auxiliary braking system along with the friction braking system to avoid overheating and brake failure. ABS usage can be neglected by simply using a micro controlled electromagnetic disk brake system .These find vast applications in heavy vehicles where high heat dissipation is required. In rail coaches it can used in combination of disc brake to bring the trains moving in high speed. When these brakes are combined it increases the life of brake and act like fully

7.2 FUTURE SCOPE

CHAPTER-VIII

REFERENCES

CHAPTER-IX

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