A

Dissertation Report On

FRICTIONLESS BRAKING SYSTEM OF WIND TURBINE

Submitted in partial fulfillment of the requirements for
The degree of

BACHELOR OF ENGINEERING

In

ELECTRICAL

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NEW PANVEL – 410 206

(Affiliated to University of Mumbai)

Academic Year 2015-2016

FRICTIONLESS BRAKING SYSTEM OF WIND TURBINE

REPORT OF PROJECT WORK

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DECLARATION

I declare that the project report on **“Frictionless Braking System Of Wind Turbine”** written submission represents my ideas in my own words and where other’s ideas or words have been included , I have adequately cited and referenced the original sources.

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This is to certify that **Mr. Khan Mohd Rehman, Mr. Gosai Bhavesh, Mr. Patel Adnan & Mr. Shaikh Ayaz** has satisfactorily carried out the dissertation work entitled **"Frictionless Braking System Of Wind Turbine"** and submitted in the partial fulfillment of the requirement for the degree of **Bachelor of Engineering** in **Electrical** to the **University of Mumbai.**

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ACKNOWLEDGEMENT

We express our gratitude towards **Prof. Iftekar Patel**, Anjuman-I-Kalsekar Technical Campus, School of Engineering and Technology, New Panvel, who guided us in our project work. He has been very supportive and patient throughout the process. We felt motivated and encouraged every time we attended his meeting. Without his encouragement and guidance this project would not have materialized.

We thank our **Director Dr. Abdul Razzak Honnutagi** for his continuous encouragement throughout the process.

We extend our thanks to the Head of Department Prof. Sayed Kaleem who gave us suggestions and guided us whenever required.

We would like to thank our friends as well as our colleagues in AIKTC who helped us in our project. It would have been impossible for us to complete our project without the encouragement and support of our family members.

ABSTRACT

Frictionless braking of wind turbine is a robust technique which is used in order to provide effective braking for wind turbines which is a non-conventional source. It provides safety against failures like over-speeding of wind turbines. It is advantageous because it provides suitable braking by frictionless brake. Most of the braking systems utilize friction forces to transform the kinetic energy of a moving body into heat that is dissipated by the braking pads. The over use of friction-type braking systems causes the temperature of the braking pads to rise, reducing the effectiveness of the system. There relative motion between the magnet and the metal (or alloy) conductor produces an eddy current that induces a reverse magnetic field and results in deceleration. This braking is provided by generation of eddy current phenomena. This eddy current is produce in the stationary plate which opposes the rotary motion of rotating plate and finally rotating plate is being stopped.

The many of advantages it having non-contact, no wear, no electric actuation ,light in weight so it can be very useful for wind turbine. Without using friction, an eddy-current braking system transforms the kinetic energy of the moving body into heat energy that is dissipated through the eddy current in the conductor.

This concept is used for the braking of wind turbine to avoid the failure of wind turbine.

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CHAPTER 1

INTRODUCTION

Most of the braking systems utilize friction forces to transform the kinetic energy of a moving body into heat that is dissipated by the braking pads. The over use of friction-type braking systems causes the temperature of the braking pads to rise, reducing the effectiveness of the system. There relative motion between the magnet and the metal (or alloy) conductor produces an eddy current that induces a reverse magnetic field and results in deceleration.

An eddy current is a swirling current set up in a conductor in response to a changing magnetic field. By **Lenz's law**, the current swirls in such a way as to create a magnetic field opposing the change; to do this in a conductor, electrons swirl in a plane perpendicular to the magnetic field. Because of the tendency of eddy currents to oppose, eddy currents cause energy to be lost. More accurately, eddy currents transform more useful forms of energy, such as kinetic energy, into heat, which is generally much less useful. In many applications the loss of useful energy is not particularly desirable, but there are some practical applications. One is in the brakes of some trains. During braking, the metal wheels are exposed to a magnetic field from an electromagnet, generating eddy currents in the wheels. The magnetic interaction between the applied field and the eddy currents acts to slow the wheels down. The faster the wheels are spinning, the stronger the effect, meaning that as the train slows the braking force is reduced, producing a smooth stopping motion.

Without using friction, an eddy-current braking system transforms the kinetic energy of the moving body into heat energy that is dissipated through the eddy current in the conductor. However relative velocities between the magnet and the conductor are required to activate an eddy-current braking system. Because of the simplicity of this mechanism, it can be used as a decelerator or auxiliary braking system to ensure the safety of system. Studies on the actuation of electro-mechanical machines using an eddy current can be traced back to the early 20thcentury. The mathematical description of the eddy current induced in a conductor under varying magnetic fields is rather complicated.

Therefore, in developing eddy current braking systems, designers usually make certain assumptions to allow a simple mathematical representation of the magnetic field.

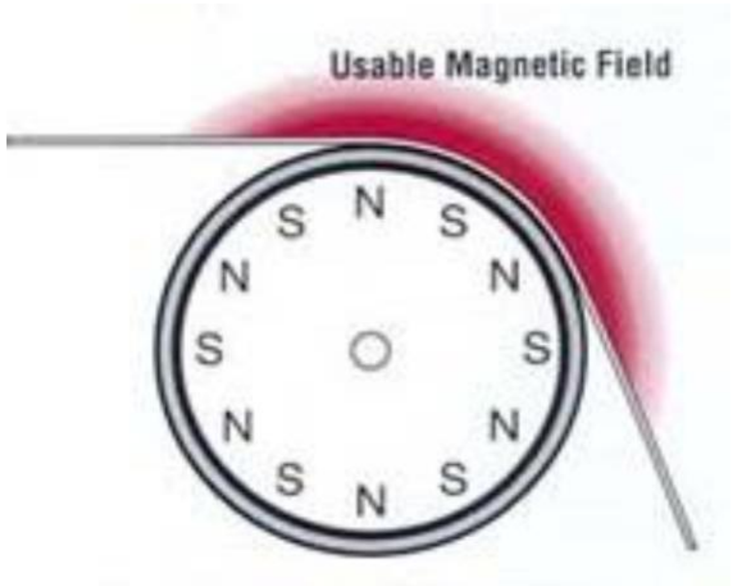

Fig.1.1 Magnetic field on running plate

This makes it possible to derive the analytic solution of the induced eddy current distribution caused by the interaction between the moving conductor and the magnetic field. In this study, four systematic engineering design scenarios to design a braking system are presented as constant magnetic field, an optimal magnetic field distribution, piecewise constant magnetic fields and a section-wise guide rail with a constant magnetic field. The constant magnetic field is the simplest and easiest design to implement.Fig.1.2 indicates the rotating plate carries the magnets on periphery connected to wind turbine shaft and stationary plate connected to generator.

Magnets passing through the conductor induce an eddy current in the copper or Al, inducing drags that decreases motion. To achieve better performance, the smaller gaps between the copper and magnets are required.

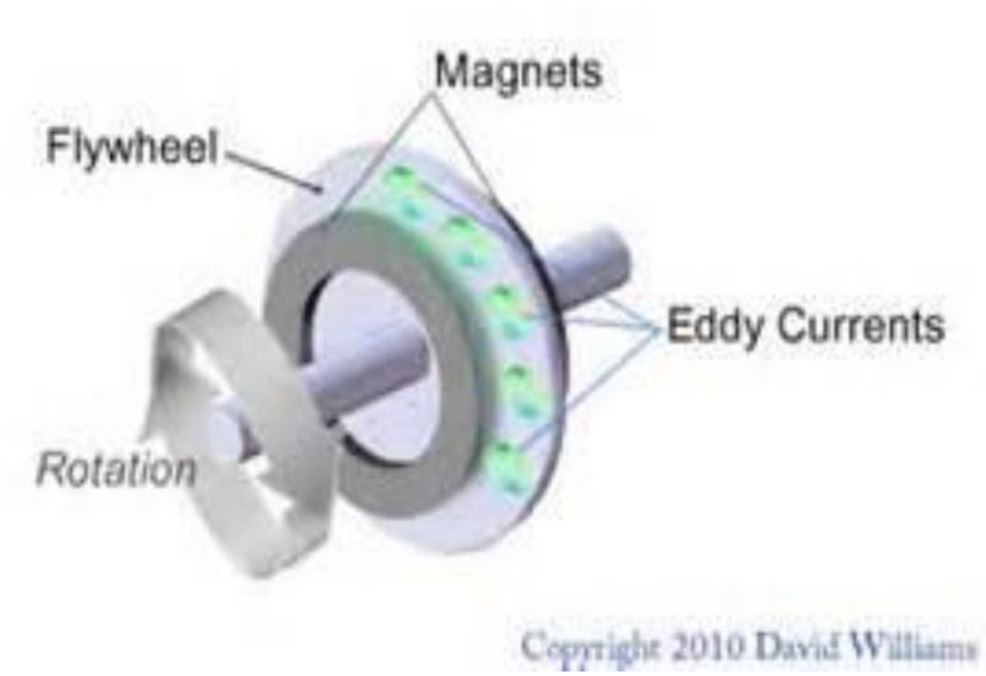

Fig.1.2 Frictionless braking system mechanism

To reduce the deformation of the copper strips, they are divided into sections. Based on the magnetic braking system above, we used the approximate mathematic model of the magnetic field to derive the braking force caused by the eddy current.

CHAPTER 2

PROBLEM DEFINITION

2.1 Motivation

The conventional braking system having frictional contact between two surfaces in order to achieve braking action it may be disc brake or hydraulic brake same for all. Ultimately the wear of two surfaces takes place during the braking action. So day by day the effectiveness of the brake goes on reducing continuously which means the life of brake due to contact falling down while bodies are in relative motion. Also the kind of power required for the same is little more during actuation. Some of the brake required auxiliary equipment which leads to a vibration.

The specifically for wind turbine disc brake & hydraulic brake are used which lead to an some of problem such as **more power consumption**, **less effective with time travel due to contact**, **noise &vibration**, also heavy weight not easy control design for optimum case, so in order to minimize this problem we required to design the braking system that lead to minimize most of problem.

Magnetic brakes are a relatively new technology that is beginning to gain popularity due to their **high degree of safety**. Rather than slowing a train via friction (such as fin or skid brakes), which can often be affected by various elements such as rain, magnetic brakes rely completely on certain magnetic properties and resistance. In fact, magnetic brakes never come in contact with the train.

Magnetic brakes are made up of one or two rows of neodymium magnets. When a metal fin (typically copper or a copper/aluminum alloy) passes between the rows of magnets, eddy currents are generated in the fin, which creates a magnetic field opposing the fin's motion. The resultant braking force is directly proportional to the speed at which the fin is moving through the brake element.

2.2 Objective

The Objectives of our Project work are listed below:

1. To **eliminate wear**.
2. **Reduced human effort** for brake assistance.
3. **Faster control** dynamics.
4. Easier integration with anti-lock, traction, and dynamic stability controls.
5. Easy braking control.

6. It required **zero electricity for braking**.
7. No noise or smell.
8. Adjustable brake force.

2.3 Scope

The Frictionless brakes having many of advantages so frictionless brakes are best substitute for ordinary brakes, which is used in road vehicle. Frictionless brakes are very much useful in high speed passengers and goods vehicle in mountain area where continuous braking is required for long time. It also used for slow down the trolleys of faster roller coaster.

Apart from the all advantages & application the other area is being need to work. The Frictionless Brake is not used for low speed application. The design is to done for such kind of application & also other usual area where the easy assessment of this brake is being possible.

CHAPTER 3

LITERATURE REVIEW

Hong Mei Sun, LiWei Hu(2014)-the proposed concept behind the paper as location of spindle brake for wind turbine. The different kind of brakes having there assembly for the braking action. They would give the idea about the selection of position for their actuation. So the few of them has been studied & there position for braking is to be find out. In that the spindle position is to be design for different position with respective actuation. The kind of stresses developed &that of the actuation force required is to be calculated.

Ren He, Xuejun Liu, and Cunxiang Liu(2013)-This paper introduces an eddy current and electro-hydraulic hybrid brake system to solve problems such as wear, thermal failure, and slow response of traditional vehicle brake system. Mathematical model was built to calculate the torque of the eddy current brake system and hydraulic brake system and analyze the braking force distribution between two types of brake systems. A fuzzy controller on personal computer based on Lab view and Mat lab was designed and a set of hardware in the loop system was constructed to validate and analyze the performance of the hybrid brake system. Though lots of experiments on dry and wet asphalt roads, the hybrid brake system achieves perfect performance on the experimental bench, the hybrid system reduces abrasion and temperature of the brake disk, response speed is enhanced obviously, fuzzy controller keeps high utilization coefficient due to the optimal slip ratio regulation, and the total brake time has a smaller decrease than traditional hydraulic brake system.

Michael E, David.C.Planchard(2012)- This Major Qualifying Project (MQP) is directed at creating an integrated electric motor and eddy current brake. This combination is designed to be used in the automotive industry as an electric all wheel drive system that can be managed by available traction and stability control technology. This project does not address the control aspect of the system; it addresses the physical concept of using an induced electromagnetic field to slow the proposed vehicle. The goal is lessening the lifetime maintenance of a vehicle and eliminating several high maintenance items. This system is designed as a “frictionless” system and although it is not completely frictionless it eliminates the need for standard hydraulic brake pads and rotors which wear and fail due to friction material loss. This saves the consumer time and money in maintenance

Der-Ming Ma, Jaw-Kuen Shiau(2011)-studied things by author were focus on the optimum braking force required during the operation. The concept of eddy current has related with the reverse current flow during the travel of electricity from one object to another object. They studied the whole theories of electricity &finally conclude with Lenz law. The analogies were applied with eddy current phenomenon in transformer. The optimum kind of force gives the sufficient kind dimension of the braking system.

Virendra Kumar Maurya, Rituraj Jalan1, H.P. Agarwal(2011)-This paper presentation explores the working principle of eddy current brake mechanism, which can be analyzed by Maxwell 3D Transient solver. An eddy current brake, like a conventional friction brake, is responsible for slowing an object, such as a train or a roller coaster etc. Unlike the friction brakes, which apply pressure on two separate objects, eddy current brakes slow an object by creating eddy currents through electromagnetic induction which create resistance, and in turn either heat or electricity. In this paper, linear Halfback magnetized mover is applied to eddy current braking system for high speed. For such a breaker, we give analytical formulas considering end effects for its magnetic field, eddy current distribution, forces according to the secondary relative permeability, and conductivity. The results given here are purely analytic & applicable.

Abdelaziz Arbaoui, Mohamed Ashbin(2010)-in this paper they given the wind turbine preliminary design .by study of forces on different part of the wind turbine .each part was with the specified kind of resistance for their moment. The strength & stresses of structure were taken into account with finite element & modal analysis. Some tools of used in order simulate the Aerodynamic characteristics of wind turbine. The objective behind the study part of this paper is to maximize the performance of wind turbine.

Frank Jepsen, Anders Søborg(2010)-This paper discusses control of the brake torque from the mechanical disc brake in a wind turbine. Brake torque is determined by friction coefficient and clamp force; the latter is the main focus of this paper. Most mechanical disc brake sare actuated by hydraulics, which means that controlling caliper pressure is the key to controlling clamp force. A pressure controller is implemented on a laboratory-sized test system and uses a disturbance estimator to reject disturbances in order to track a reference curve. The estimator is capable of estimating both input equivalent disturbances and disturbances caused by brake disc irregularities. The controller can reject input equivalent disturbances and a strategy for cancelling the disturbance from the brake disc is proposed.

M.Z.Baharom, M.Z. Nuawi(2010)-An eddy current braking experiment was conducted to study the behavior of three different materials to be used as brake disc which are aluminium, copper and zinc. The experiment also aimed to see the effects of increasing the current induced into electromagnet which produce drag force that will slow down the motion. Results from the experiment have been recorded using optical tachometer connected to PULSE analyzer which captured the speed (RPM) and time (s). A few graph been presented in this paper to show the best material to be used as the brake disc for electromagnetic braking system using eddy current project. This preliminary result will leads to a deeper research in field of electromagnetic braking and its potential application.

Andrew H.C. Gosline(2008)-He describe the design of an eddy current brake for use as programmable viscous damper for haptic interfaces. Unlike other types of programmable brakes, eddy current brakes can provide linear, programmable physical damping that can be modulated at high frequency. These properties make them well suited as dissipative actuators for haptic interfaces. We overview the governing physical relationships, and describe design optimization for inertial constraints. A prototype haptic interface is described, and experimental results are shown that illustrate the improvement in stability when simulating a stiff wall that is made possible using programmable eddy current dampers.

D. Corbus and M. Meadors(2005)This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

Manuel I Gonzalez(2004)-A moderate-cost experimental setup is presented to help students to understand some qualitative and quantitative aspects of eddy currents. The setup operates like an eddy current brake, a device commonly used in heavy vehicles to dissipate kinetic energy by generating eddy currents. A set of simple experiments is proposed to measure eddy current losses and to relate them to various relevant parameters. Typical results for each of the experiments are presented, and comparisons with theoretical predictions are included. The experiments, which are devoted to first-year undergraduate students, deal also with other pedagogically relevant topics in electricity and magnetism, such as basic laws, electrical measurement techniques, the sources of the magnetic field and others.

CHAPTER 4

WIND ENERGY

A wind turbine is a machine for converting the kinetic energy in wind into mechanical energy. Wind turbine captures the natural wind in our atmosphere and converts it into mechanical energy then electricity. People started using wind power centuries ago with windmills, which pumped water, ground grain, and did other work. Today's wind turbine is a highly evolved version of a windmill. Modern wind turbines harness wind's kinetic energy and convert it into electricity. Most wind turbines have three blades and sit atop a steel tubular tower, and they range in size from 80-foot-tall turbines that can power a single home to utility-scale turbines that power hundreds of homes.

Wind is a type of renewable energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is then converted to electricity, the machine is called a wind generator.

Utility-scale wind, wind turbines larger than 100 kilowatts are developed with electricity delivered to the power grid and distributed to the end user by electric utilities or power system operators. Distributed or "small" wind, which uses turbines of 100 kilowatts or smaller to directly power a home, farm or small business as it primary use; Offshore wind, which are wind turbines erected in bodies of water around the world, but not yet in the United States.

When wind blows past a turbine, the blades capture the energy and rotate. This rotation triggers an internal shaft to spin, which is connected to a gearbox increasing the speed of rotation, which is connect to a generator that ultimately produces electricity. Most commonly, wind turbines consist of a steel tubular tower, up to 325 feet, which supports both a "hub" securing wind turbine blades and the "nacelle" which houses the turbine's shaft, gearbox, generator and controls. A wind turbine is equipped with wind assessment equipment and will automatically rotate into the face of the wind, and angle or "pitch" its blades to optimize energy capture.

Wind turbines often stand together in a windy area that has been through a robust development process in an interconnected group called a wind project or wind farm, which functions like a wind power plant. These turbines are connected so the electricity can travel from the wind farm to the power grid. Once wind energy is on the main power grid, electric utilities or power operators will deliver the electricity where it is needed. Smaller transmission lines called distribution lines will collect the electricity generated at the wind project site and transport it to larger "network" transmission lines where the electricity can travel across long distances to the locations where it is needed, when finally the smaller "distribution lines" deliver electricity directly to your town and home. Learn more about transmission.

The current estimate of wind energy potential is 10 times the amount of electricity consumption for the entire country. This strong wind resource varies across the country by region and topography. Wind energy projects are developed by companies that seek out the areas with the strongest wind resource but also review other critical factors like access to land, access to the transmission lines, ability to sell the electricity, and public engagement other significant development factors. Once a site is identified, a developer will conduct wind resource assessment, permitting, transmission studies over a period of several years. The majority of wind projects are located on private land, where the developer leases the land from the original landowner providing lease payments. After early stages of development, a developer will seek out a contract with a purchaser of electricity, raise capital from the finance markets, order wind turbines, and hire a specialized construction company to build the project. Once a project is built and delivering electricity to the power grid, a project owner or operator will maintain the project for its 20 to 30 year life.

4.1 Benefits of wind energy

Wind energy is a clean, renewable form of energy that uses virtually no water and pumps billions of dollars into our economy every year. Since 2008, the U.S. wind industry has generated more than $100 billion in private investment. Furthermore, wind energy is a drought-resistant cash crop in many parts of the country, providing economic investment to rural communities through lease payments to landowners. Wind energy helps avoid a variety of environmental impacts due to its low impact emitting zero greenhouse gas emissions or conventional pollutants and consuming virtually no water.

Though modern technology has made dramatic improvements to the efficiency of windmills which are now extensively use for electricity generation, they are still dependent on the vagaries of the weather. Not just on the wind direction but on the intermittent and unpredictable force of the wind. Too little wind and they can't deliver sufficient sustained power to overcome frictional losses in the system. Too much and they are susceptible to damage. Between these extremes, cost efficient installations have been developed to extract energy from the wind.

4.2 History of wind turbine

Using wind energy is not a new concept. It was being using from long past but for different purposes other than producing electricity. It was long before invention of electricity, the Chinese and Persian people used windmill for pumping water, breaking up grain and sawing lumber etc. It was long before invention of electricity.

There are mainly two types of wind turbine, namely vertical axis and horizontal axis turbine. The first wind turbine was designed as vertical axis where a number of sails attached around the vertical axes produce ration of rotor along the vertical axis of the system. The figure below shows a very old design of vertical axis wind turbine.

After that horizontal axis wind mill was designed in the British Isles, Northern Europe. Horizontal axis wind mills were most popularly utilized in Holland in 14_{th} century. These windmills carried out lots of tasks for example timber milling, pumping water for farming etc. Netherlands is another European country which utilized windmill popularly at that time.

In the late 19th century in the American mid-west farmers came to put your faith in a leaner design characteristic a trestle tower topped by wooden or steel paddle-type blades. Between 1850 and 1970, more than six million mostly small means 1 horsepower or less mechanical output wind turbines were installed in the U.S. only and the most important use was water-pumping and the major purpose were store water for home water needs. In 1891 Danish meteorologist, Poul La Cour designed an electrical output wind turbine replicating the aerodynamic design principles that were used in European tower mills. In Denmark, 1900 the biggest machines were on 24 meter (79 ft) tower with four-bladed 23 meter (75 ft) diameter rotors and generating 30 MW. In the 1920s, wind generated electrical systems began to follow the design of airplane propellers and monoplane wings.

In 1950's the world's first alternating current wind turbines comes in the picture and credit goes to Johannes Juul, he is the best student of Paul La Cour (great scientist and known as his work on wind power). After that John Brown & Company in 1951, developed a first convenience grid-connected wind turbine which operated in the UK (United Kingdom).

4.3 Types of wind turbines

There are two types of wind turbines:

1.**Vertical axis wind turbines** and

2. **Horizontal axis wind turbines**

We know that there is enough wind globally to satisfy much, or even most, of humanity's energy requirements – if it could be harvested effectively and on a large enough scale.

4.3.1 Vertical axis wind turbines

Fig.4.1 VAWT

Vertical axis wind turbines(**VAWT**s), which may be as efficient as current horizontal axis systems, might be practical , simpler and significantly cheaper to build and maintain than horizontal axis wind turbines (**HAWT**s). They also have other inherent advantages, such as they are always facing the wind, which might make them a significant player in our quest for cheaper, cleaner renewable sources of electricity. VAWTs might even be critical in mitigating grid interconnect stability and reliability issues currently facing electricity producers and suppliers. Additionally, cheap VAWT's may provide an alternative to the rain forest destruction for the growing of bio-fuel crops. This paper describes some research findings of a particular original VAWT design and argues for increased research and development of this technology.

Vertical axis wind turbines (VAWTs) in addition to being simpler and cheaper to build have the following advantages:

- They are always facing the wind – no need for steering into the wind.
- Have greater surface area for energy capture – can be many times greater.
- Are more efficient in gusty winds – already facing the gust
- Can be installed in more locations – on roofs, along highways, in parking lots.
- Do not kill birds and wild – life – slow moving and highly visible.
- Can be scaled more easily – from milliwatts to megawatts.
- Can be significantly less expensive to build – are inherently simpler.
- Can have low maintenance downtime – mechanisms at or near ground level

- Produce less noise – low speed means less noise
- Are more esthetically pleasing – to some.

4.3.2 HORIZONTAL AXIS WIND TURBINES

Fig.4.2 HAWT

Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and may be pointed into or out of the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator.

HAWT Advantages

- Variable blade pitch, which gives the turbine blades the optimum angle of attack. Allowing the angle of attack to be remotely adjusted gives greater control, so the turbine collects the maximum amount of wind energy for the time of day and season.
- The tall tower base allows access to stronger wind in sites with wind shear. In some wind shear sites, every ten meters up, the wind speed can increase by 20% and the power output by 34%.
- High efficiency, since the blades always move perpendicularly to the wind, receiving power through the whole rotation. In contrast, all vertical axis wind turbines, and most proposed airborne wind turbine designs, involve various types of reciprocating actions, requiring airfoil surfaces to backtrack against the wind for part of the cycle. Backtracking against the wind leads to inherently lower efficiency.

HAWT Disadvantages

- The tall towers and blades up to 90 meters long are difficult to transport. Transportation can now cost 20% of equipment costs.
- Tall HAWTs are difficult to install, needing very tall and expensive cranes and skilled operators.
- Massive tower construction is required to support the heavy blades, gearbox, and generator.
- Reflections from tall HAWTs may affect side lobes of radar installations creating signal clutter, although filtering can suppress it.
- Their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape and sometimes creating local opposition.
- Downwind variants suffer from fatigue and structural failure caused by turbulence when a blade passes through the tower's wind shadow (for this reason, the majority of HAWTs use an upwind design, with the rotor facing the wind in front of the tower).
- HAWTs require an additional yaw control mechanism to turn the blades toward the wind.

CHAPTER 5

BRAKING SYSTEM

Most of the braking systems utilize friction forces to transform the kinetic energy of a moving body into heat that is dissipated by the braking pads. The over use of friction-type braking systems causes the temperature of the braking pads to rise, reducing the effectiveness of the system. There relative motion between the magnet and the metal (or alloy) conductor produces an eddy current that induces a reverse magnetic field and results in deceleration.

5.1 Magnetic brakes

Magnetic brakes are a relatively new technology that is beginning to gain popularity due to their high degree of safety. Rather than slowing a train via friction (such as fin or skid brakes), which can often be affected by various elements such as rain, magnetic brakes rely completely on certain magnetic properties and resistance. In fact, magnetic brakes never come in contact with the train.

Magnetic brakes are made up of one or two rows of neodymium magnets. When a metal fin (typically copper or a copper/aluminum alloy) passes between the rows of magnets, eddy currents are generated in the fin, which creates a magnetic field opposing the fin's motion. The resultant braking force is directly proportional to the speed at which the fin is moving through the brake element. This very property, however, is also one of magnetic braking's disadvantages in that the eddy force itself can never completely hold a train in ideal condition. It is then often necessary to hold the train in place with an additional set of fin brakes or "kicker wheels" which are simple rubber tires that make contact with the train and effectively park it.

Magnetic brakes can be found in two configurations:

- The brake elements are mounted to the track or alongside the track and the fins are mounted to the underside or sides of the train. This configuration looks similar to frictional fin brakes.
- The fins are mounted to the track and the brake elements are mounted to the underside of the train. This configuration can be found on Intamin's Accelerator Coasters (also known as Rocket Coasters) such as Kingda Ka at Six Flags Great Adventure.

Magnetic brakes are silent and are much smoother than friction brakes, gradually increasing the braking power so that the people on the ride do not experience rapid changes in deceleration. Many modern roller coasters, especially those being manufactured by Intiman, have utilized magnetic braking for several years. Another major roller coaster designer implementing these brakes is Bollinger & Maxillary in 2004 on their *Silver Bullet* inverted coaster, making it the first suspended roller coaster to feature magnetic brakes, and again used them on their newer projects, such as Leviathan at Canada's Wonderland. These later applications have proven effectively comfortable and relevant for these inverted coasters which often give the sense of flight. There also exist third party companies such as Magnatar tech. which provide various configurations of the technology to be used to replace and retrofit braking systems on existing roller coasters to increase safety, improve rider comfort, and lower maintenance costs and labor.

5.2 Types of brakes

Various types of braking exist when dealing with roller coasters, some of which have been recently developed due to technological advancements in design.

Skid brakes

Skid brakes essentially involve a long piece of material, often ceramic-covered, situated in the middle of the track parallel to the rails. When the brake is engaged, the skid raises and friction against the underside of the train causes the train to slow and eventually stop. Skid brakes were one of the first advancements in roller coaster braking and are typically not utilized in modern creations with the exception of Twister at Knoebels Amusement Park in Elysburg, PA and the Matterhorn at Disneyland in California.

Side mounted brakes are common on Schwarzkopf designed roller coasters, such as Scorpion.

Fin brakes

Fin brakes involve a metal fin being attached to the underside of a train. The track is fitted with two computer-controlled squeezing mechanisms which upon closing, squeeze the fin and either slow or stop the train. Fin brakes are the most common form of brakes on roller coasters today. Sometimes they are thick metal box beams (mostly on Bolliger & Mabillard roller coasters), others are thin metal plates. They slide between pairs of friction pads similar to automotive brake pads . Fin brakes are designed to be fail-safe, so that a loss of power will cause them to engage. Brakes are constructed according to a certain measure of redundancy, meaning the ride is usually fitted with one extra set of brakes to bring the train to a hold even if one brake fails. Closing is done by a bellow type of air operated actuator. Each set of brakes is fitted with its own air supply system and normally opened supply valves which actuate the brake in a closed position in case a power down occurs. A heavy springs, usually made of steel, is used to open the brake.

Magnetic brakes on the same roller coaster shown above, located before the friction brakes. These track mounted fins can be retracted to allow the train to pass without slowing it down.

A disadvantage of magnetic brakes is that they cannot completely stop a train, and as such cannot be used as block brakes. They also cannot be conventionally disengaged like other types of brakes. Instead, the fins or magnets must be retracted so that the fins no longer pass between the magnets. Accelerator Coasters, for example, have a series of magnetic brake fins located on the launch track. When the train is launched, the brakes are retracted to allow the train to reach its full speed. After the train is launched, the brake fins are raised to safely slow the train down in the event of a rollback.

5.3 Eddy current

Eddy currents (also called **Foucault currents)** are circular induced within conductors by a changing magnetic field in the conductor, due to electric current faradays law of induction. Eddy currents flow in closed loops within conductors, in planes perpendicular to the magnetic field. They can be induced within nearby stationary conductors by a time-varying magnetic field created by an AC electromagnet or transformer, for example, or by relative motion between a magnet and a nearby conductor. The magnitude of the current in a given loop is proportional to the strength of the magnetic field, the area of the loop, and the rate of change of flux, and inversely proportional to the resistivity of the material.

By Lenz's law, an eddy current creates a magnetic field that opposes the magnetic field that created it, and thus eddy currents react back on the source of the magnetic field. For example, a nearby conductive surface will exert a drag force on a moving magnet that opposes its motion, due to eddy currents induced in the surface by the moving magnetic field. This effect is employed in eddy current brakes which are used to stop rotating power tools quickly when they are turned off. The current flowing through the resistance of the conductor also dissipates energy as heat in the material. Thus eddy currents are a source of energy loss in alternating current (AC) inductors , transformers , electric motors and generators, and other AC machinery, requiring special construction such as laminated magnetic cores to minimize them. Eddy currents are also used to heat objects in induction heating furnaces and equipment, and to detect cracks and flaws in metal parts using eddy- current testing instruments.

5.4 Types of eddy current brakes

Real eddy current brakes are a bit more sophisticated than this, but work in essentially the same way. They were first proposed in the 19th century by the brilliant French physicist Jean-Bernard Léon Foucault (also the inventor of the Foucault pendulum and one of the first people to measure the speed of light accurately on Earth). Eddy current brakes come in two basic flavors—linear and circular.

5.4.1 Linear brakes

Fig.5.1 Linear brakes

Linear brakes feature on things like train tracks and roller coasters, where the track itself (or something mounted on it) works as part of the brake.

The simplest linear, eddy-current brakes have two components, one of which is stationary while the other moves past it in a straight line. In a rollercoaster ride, you might have a series of powerful, permanent magnets permanently mounted at the end of the track, which produce eddy currents in pieces of metal mounted on the side of the cars as they whistle past. The cars move freely along the track until they reach the very end of the ride, where the magnets meet the metal and the brakes kick in.

This kind of approach is no use for a conventional train, because the brakes might need to be applied at any point on the track. That means the magnets have to be built into the structure that carries the train's wheels (known as the bogies) and they have to be the kind of magnets you can switch on and off (electromagnets, in other words). Typically, the electromagnets move a little less than 1cm (less than 0.5 in) from the rail and, when activated, slow the train by creating eddy currents (and generating heat) inside the rail itself. It's a basic law of electromagnetism that you can only generate a current when you actually move a conductor through a magnetic field (not when the conductor is stationary); it follows that you can use an eddy current brake to stop a train, but not to hold it stationary once it's stopped (on something like an incline). For that reason, vehicles with eddy current brakes need conventional brakes as well.

5.4.2 Circular brakes

Fig.5.2 Circular brakes

Like linear eddy current brakes, circular brakes also have one static part and one moving part. They come in two main kinds, according to whether the electromagnet moves or stays still. The simplest ones look like traditional brakes, only with a static electromagnet that applies magnetism and creates eddy currents in a rotating metal disc (instead of simple pressure and friction) that moves through it. (The Shinkansen brakes work like this.) In the other design, the electromagnets move instead: there's a series of electromagnet coils mounted on an outer wheel that spins around (and applies magnetism to) a fixed, central shaft. (Telma frictionless "retarder" brakes, used on many trucks, buses, and coaches, work this way.)

How do these things work in practice? Suppose you have a high-speed factory machine that you want to stop without friction. You could mount a metal wheel on one end of the drive shaft and sit it between some electromagnets. Whenever you wanted to stop the machine, you'd just switch on the electromagnets to create eddy currents in the metal wheel that bring it quickly to a halt. Alternatively, you could mount the electromagnet coils on the rotating shaft and have them spin around or inside stationary pieces of metal.

With a linear brake, the heat generated by the eddy currents can be dissipated relatively easily: it's easy to see how it would disappear fairly quickly in a brake operating outdoors over a relatively long section of train track. Getting rid of heat is more of an issue with circular brakes, where the eddy currents are constantly circulating in the same piece of metal. For this reason, circular eddy current brakes need some sort of cooling system. Air-cooled brakes have metal meshes, open to the air, which use fan blades to pull cold air through them. Liquid-cooled brakes use cooling fluids to remove heat instead.

5.5 Uses of eddy current brakes

Despite being invented over a century ago, eddy current brakes are still relatively little used. Apart from roller coasters, one area where they're now finding applications is in high-speed electric trains. Some versions of the German Inter City Express (ICE) train and Japanese Shinkansen ("bullet train") have experimented with eddy-current brakes and future versions of the French TGV are expected to use them as well. You'll also find eddy current brakes in all kinds of machines, such as circular saws and other power equipment. And they're used in things like rowing machines and gym machines to apply extra resistance to the moving parts so your muscles have to work harder.

5.6 Advantages and Disadvantages of eddy current brakes

On the plus side, eddy-current brakes are quiet, frictionless, and wear-free, and require little or no maintenance. They produce no smell or pollution (unlike friction brakes, which can release toxic chemicals into the environment). All this makes them much more attractive than noisy friction brakes that need regular inspection and routinely wear out. It's been estimated that switching an electric train from friction brakes to eddy-current brakes could halve the cost of brake operation and maintenance over its lifetime.

The drawbacks of eddy current brakes are more to do with how little experience we have of using them in real-world settings. As Jennifer Schykowski noted in an excellent review of the technology for *Railway Gazette* in 2008, the electromagnetic parts of eddy current brakes have sometimes caused problems by interfering with train signaling equipment. Although heat dissipation in rails should not, theoretically, be an issue, if there's a busy section of track where many trains brake in quick succession (something like the approach to a station), the heating and expansion of rails could prove to be an issue, either reducing the effectiveness of the brakes or leading to structural problems in the rails themselves. Another important question is whether eddy-current brakes will ever become widespread, given the growing interest in regenerative brakes that capture and store the energy of moving vehicles for reuse (a much more energy-efficient approach than turning energy into useless heat with eddy currents). Some of the latest Shinkansen trains (series E5) use regenerative brakes where earlier models used eddy-current technology.

CHAPTER 6

SCHEME IMPLEMENTATION

6.1 Methodology

1. The wind Turbine having rpm depends upon the intensity of wind so study the maximum wind intensity.
2. To study the maximum forces acting on wind turbine by making prototype model.
3. Design the disc of magnet for required braking force.
4. By analysis of wind turbine for different speed to see the required braking Force for respective speed.
5. Set the optimum speed beyond which the braking action need to start in order to avoid damage.
6. An experimental setup has to develop for wind turbine for effective braking.

6.2 Project Set Up

The project consists of Turbine Blades which is Circular in shape mounted on Rotor. This Vertical Wind turbine is mounted on shaft which is further connected with Generator where it receives kinetic energy (K.E) of turbine into Electrical energy. Now one supporting plate is mounted below the Generator in order to take load and provide the support to another part of set-up, two Bearings are mounted on shaft in order to give rotary motion and support to shaft. After the Bearing the actual Breaking mechanism is start where one circular disc is mounted on wind turbine shaft at the end. This plate (Running plate)consist of permanent magnet which is mounted on plate in circular manner and along the same axial direction the another plate (Stationary plate) is mounted on different shaft which is made up of Aluminium. The gap is maintain between this two similar dimension plate for the actuation of brake for braking action. The movement of Stationary plate is done by Lead Screw. The whole set-up is in vertical manner so vertical support is given to it which is shown in Fig.6.1

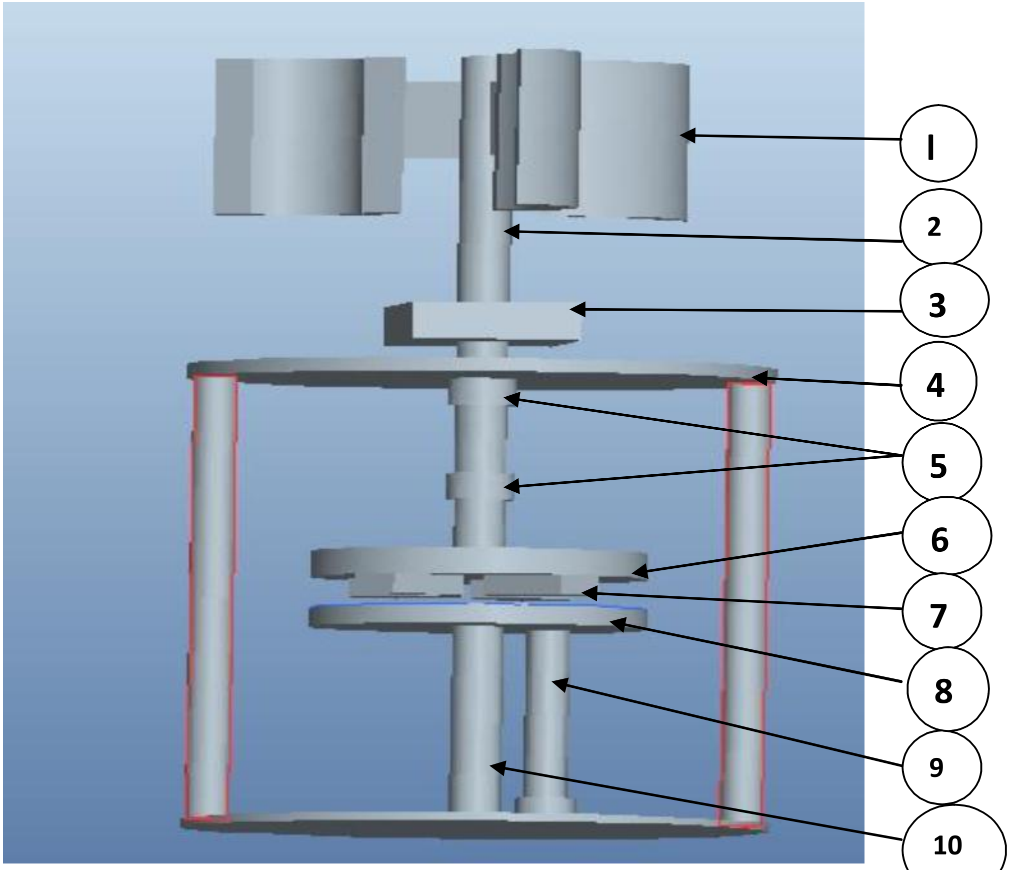

Fig.6.1 Project Set-Up

Where,

1:Blade of wind Turbine, 2:Wind turbine shaft,
3:Generator, 4:Supporting plate, 5:Bearings,
6:Running plate with permanent magnets,
7:Permanent magnets, 8:Stationary plate,
9:Lead screw, 10:Stationary plate shaft

CHAPTER 7

EXPERIMENTAL & DESIGN CONSIDERATION

7.1 Experimental Consideration

The Frictionless Braking system is being depends upon the intensity of wind which will provide the information about speed at which the braking action is to start for actuation at optimum speed. The variable consider for Experiment that provide idea about the required actuation at optimum speed are Kinetic Energy of wind turbine shaft (K.E), Distance between the Rotating plate & Stationary plate (δ_d), Time required for Braking Action (T), Angular speed of wind Turbine shaft, Braking force (F) and this parameter can be check at different Linear speed of wind Turbine shaft (V). The gap is being maintained in mm. Now the kinetic energy of running plate or wind Turbine shaft is being measured by Anemometer and Angular speed of wind turbine shaft is measured by Tachometer. The different graph are plotted that showing the variation of one parameter with different, that give the actual task of braking system.

7.2 Design Consideration

1) Eddy current brakes provide non-contact means to produce braking forces required to decelerate the motion of a moving object.
2) 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.
3) Although the simulation results above show that the optimal magnetic field is better than the constant magnetic field, a deceleration peak of 9 g it is not suitable for most people.
4) Further, 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.
5) Alternatively, it is much easier to keep the magnetic field constant and select the proper conductor materials. The advantages of these last two designs using different materials along the guide rail are tolerable deceleration; and easy manufacturing.

6) A nearly maintenance-free system can be achieved if permanent magnet is utilized to establish the magnetic field. It should be noted that the simulation results show in the paper are based on the assumption of using infinite conducting plate.
7) For finite dimensional conducting plate, the required magnetic field has to be increased so that the same design results (velocity and deceleration) can be maintained. The amount of increase on the magnetic field depends on the physical dimension.

CHAPTER 8

DESIGNING & COST ESTIMATION

8.1 Bill of materials

SR. NO.	PART NAME	MATERIAL	QTY.
1	FRAME	MS(MILD STEEL)	20 kg
2	MAGNET	NEODYMIUM	10 NOS
3	SHAFT DIA 20 MM	EN8	5 kg
4	DYNAMO	STD	1 NOS
5	PULLEY	CI	1 NOS
6	PULLEY	NYLON	1 NOS
7	FLYWHEEL	MS	1NOS
8	ALUMINUM WHEEL	AL	1 NOS
9	PEDESTAL BEARING P204	CI	2NOS
10	FREE WHEEL	STD	1 NOS
11	STUD	MS	1 M
12	PIPE	PVC	5 M
13	SQUARE PIPE	MS	1 M
14	POP RIVIT	STD	30
15	MS FLAT BAR	MS	1 KG
16	NUT BOLT WASHER M 10	MS	8 NOS
17	WELDING ROD	-	150 NOS
18	COLOUR	-	2 LIT

8.2 Cost estimation

Cost estimation may be defined as the process of forecasting the expenses that must be incurred to manufacture a product. These expenses take into a consideration all expenditure involved in a design and manufacturing with all related services facilities such as pattern making, tool, making as well as a portion of the general administrative and selling costs.

Purpose of cost estimating:

1. To determine the selling price of a product for a quotation or contract so as to ensure a reasonable profit to the company.
2. Check the quotation supplied by vendors.
3. Determine the most economical process or material to manufacture the product.
4. To determine standards of production performance that may be used to control the cost.

Basically the budget estimation is of two types:

1. Material cost
2. Machining cost

8.2.1 Material cost estimation

Material cost estimation gives the total amount required to collect the raw material which has to be processed or fabricated to desired size and functioning of the components.

These materials are divided into two categories:

1. Material for fabrication:

In this the material in obtained in raw condition and is manufactured or processed to finished size for proper functioning of the component.

2. Standard purchased parts:

This includes the parts which was readily available in the market like allen screws etc. A list is forecast by the estimation stating the quality, size and standard parts, the weight of raw material and cost per kg. for the fabricated parts.

8.2.2 Machining cost estimation

This cost estimation is an attempt to forecast the total expenses that may include manufacturing apart from material cost. Cost estimation of manufactured parts can be considered as judgment on and after careful consideration which includes labour, material and factory services required to produce the required part.

Procedure for calculation of material cost:

The general procedure for calculation of material cost estimation is:

1. After designing a project a bill of material is prepared which is divided into two categories.
   a. Fabricated components
   b. Standard purchased components
2. The rates of all standard items are taken and added up.
3. Cost of raw material purchased taken and added up.

Labour cost:

It is the cost of remuneration (wages, salaries, commission, bonus etc.) of the employees of a concern or enterprise.

Labour cost is classifies as:

1 Direct labour cost

2 Indirect labour cost

Direct labour cost:

The direct labour cost is the cost of labour that can be identified directly with the manufacture of the product and allocated to cost centers or cost units. The direct labour is one who counters the direct material into saleable product; the wages etc. of such employees constitute direct labour cost. Direct labour cost may be apportioned to the unit cost of job or either on the basis of time spend by a worker on the job or as a price for some physical measurement of product.

Indirect labour cost:

It is that labour cost which cannot be allocated but which can be apportioned to or absorbed by cost centers or cost units. This is the cost of labour that doesn't alters the construction, confirmation, composition or condition of direct material but is necessary for the progressive movement and handling of product to the point of dispatch e.g. maintenance, men, helpers, machine setters, supervisors and foremen etc.

The total labour cost is calculated on the basis of wages paid to the labour for 8 hours per day.

Cost estimation is done as under:

Cost of project = (A) material cost + (B) Machining cost + (C) labour cost.

(A) Material cost is calculated as under :

i) Raw material cost

ii) Finished product cost

i) Raw material cost:

It includes the material in the form of the Material supplied by the " Steel authority of India limited" and 'Indian aluminum co.,' as the round bars, angles, square rods , plates along with the strip material form. We have to search for the suitable available material as per the requirement of designed safe values. We have searched the material as follows:-

Hence the cost of the raw material is as follows:-

8.3 Costing

SR. NO.	PART NAME	MATERIAL	QTY.	COST
1	FRAME	MS	20 kg	1200
2	MAGNET	NEODYMUM	10 NOS	2000
3	SHAFT DIAMETER 20mm	EN 8	5 kg	300
4	DYNAMO	STD	1 NOS	300
5	PULLEY	CI	1 NOS	250
6	PULLEY	NYLON	1 NOS	70
7	FLYWHEEL	MS	1NOS	800
8	ALUMINUM WHEEL	AL	1 NOS	650
9	PEDESTAL BEARING P204	CI	2NOS	600
10	FREE WHEEL	STD	1 NOS	120
11	STUD	MS	1 M	100
12	PIPE	PVC	5 M	200
13	SQUARE PIPE	MS	1 M	30
14	POP RIVIT	STD	30	30
15	MS FLAT BAR	MS	1 KG	60
16	NUT BOLT WASHER M10	MS	8 NOS	75
17	WELDING ROD	-	150 NOS	150
18	COLOUR	-	2 LIT	100
			TOTAL	**Rs.7035**

8.3.1 Direct labour cost

SR. NO.	OPERATION	HOURS	RATE / LABOUR	AMOUNT
1.	Turning	10	150	1500
3.	Drilling	7	100	700
4.	Welding	16	175	2800
5.	Grinding	3	60	180
6.	Tapping	3	40	120
7.	Cutting	8	40	320
8.	Gas cutting	8	50	400
9.	Assembly	2	100	200
10.	Painting	2	100	200
			TOTAL	**Rs.6420/-**

8.3.2 Indirect cost

Transportation cost = 500/-

Coolant & lubricant = 100/-

Drawing cost = 500/-

Project report cost = 2000/-

Total indirect cost =Rs.3100/-

Total cost:

Raw Material Cost + STD Parts Cost + Direct Labour Cost +Indirect Cost

Total cost of project = 7035 + 6420 + 3100

<u>TOTAL COST OF PROJECT = Rs.16555 /-</u>

8.4 Dimensions

Overall frame length = 530mm.

Overall frame breadth = 530mm.

Overall frame height = 1240mm.

Frame rod width = 23mm.

Frame rod thickness = 3mm.

Shaft material = EN8.

Shaft diameter = 20mm.

Boss material = MILD STEEL(M.S)

Boss diameter = 40mm.

Boss width = 40mm.

Box pipe = 20*20*2 (length*width*thickness).

Outer box of box pipe = 25*25*2 (length*width*thickness).

All Nuts and Bolts are of size 10mm (M10).

Dynamo rating = 12V, 300 r.p.m,6 W.

Diameter of Stud = 9mm.

Handle of Stud = 12mm.

Support angle = 30*30*3.

Ferrous material (M.S) = 4mm in thickness.

Non-ferrous material (Aluminium) = 3mm in thickness.

Linkage width = 25mm.

Support angle = 20*20 (length*breadth).

HOLLOW PIPE.

Outer diameter = 25mm.

Inner diameter = 22mm.

Thickness = 3mm.

8.5 Calculations

Wind Power depends on:

- amount of air (volume)
- speed of air (velocity)
- mass of air (density)

Let,

K.E. = Kinetic energy of wind

m = Mass

δ = Air density

A = Swept area

P = Power output

The kinetic energy of a moving mass is:

$E = K.E. = 0.5\ mv^2$

$P = dE/dt = 0.5*(dm/dt)*v^2$

$Mass(m) = \delta*volume = \delta*A*L$

$dm/dt = \delta*A*(dL/dt) = \delta*A*v$

Therefore,

$P = 0.5*\ \delta*A*v*v^2$

$\mathbf{P = 0.5*\ \delta*A*v^3}$

Power generated by wind turbine= $0.5*\delta*A*v^3*C_p$

Where,

δ = Density of air.

A= swept area of wind turbine

v = velocity of air in m/s.

C_p= power coefficient

A German physicist Albert Betz concluded in 1919 that no wind turbine can convert more than 16/27 (59.3%) of the kinetic energy of the wind into mechanical energy turning a rotor. To this day, this is known as the **Betz Limit** or **Betz'Law.** The theoretical maximum **power efficiency** of *any* design of wind turbine is 0.59 (i.e. no more than 59% of the energy carried by the wind can be extracted by a wind turbine). This is called the “power coefficient” and is defined as: $\boldsymbol{C_{p=}}$ **0.59**

Let,

$\delta=1.2kg/m^3$

$A=L*D=0.61*0.970=0.5917m^2$

v=6m/s.

C_p=0.35.

Power generated $=0.5*1.2*0.5917*6^3*0.35610$

=27.307 W.

Drag force=0.5*δ*A*v^2*C.D

(C.D is coefficient of drag force=2.3 which depend upon the material selected)

=0.5*1.2*0.5917*6^2*2.3.

=29.39 N.

Designing of shaft:

Torque (T) = Force*perpendicular distance(R)

T= (π/16)*f_s*d^3.

Where, f_s= Shearing stress

d= 20mm.(Diameter)

Ultimate strength= σ_{ut} = 320 N/mm^2.(From PSG standards of material)

$f_{t_{(all)}} = f_{b_{(all)}} = \frac{\sigma_{ut}}{F.O.S} = \frac{320}{2}$ =180 N/mm^2.

$f_{t_{(all)}}$ = Allowable tensile stress.

$f_{b_{(all)}}$ = Allowable bending stress.

F.O.S = Factor of safety= 2

$f_{s_{(all)}}$ = Shearing stress allowable = 0.5*$f_{t_{(all)}}$

=80 N/mm^2

CHAPTER 9

CONCLUSION & FUTURE SCOPE

9.1 Conclusion

The wind turbine is being non-conventional source so in order provide the effective braking system which provides the safety against failure and advantage over the other system. The kind of requirement the best suitable brake is frictionless brake. The many of advantages it having non-contact, no wear, no electric actuation ,light in weight so it can be very useful for wind turbine.

The braking system is being totally depends upon the Eddy Current phenomenon. This phenomenon tells by Lenz's law. It shows that when rotating disc (or plate) is with magnetic induction come to close with the Non-ferrous material disc (or plate) which is Stationary ,then Eddy current is produce in Stationary plate ,such eddy current oppose to rotary motion of rotating plate and finally it is stop. Now this concept is being used for the wind Turbine for braking purpose in order to avoid the failure of wind turbine.

9.2 Future Scope

The Frictionless brakes having many of advantages so frictionless brakes are best substitute for ordinary brakes, which is used in road vehicle. Frictionless brakes are very much useful in high speed passengers and goods vehicle In mountain area where continuous braking is required for long time. It also used for slow down the trolleys of faster roller coaster.

Apart from the all advantages & application the other area is being need to work. The Frictionless Brake is not used for low speed application. The design is to done for such kind of application & also other usual area where the easy assessment of this brake is being possible.

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