DESIGN AND FABRICATION OF WATER-PUMPING WINDMILL

Session January 2023-December 2023

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(UGC And Govt. Approved)

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A thesis submitted for partial fulfillment of the requirements for the Degree of

Bachelor of Science

In

Mechanical Engineering

Project Supervisor

Department of Mechanical Engineering

Department of Mechanical Engineering

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(UGC And Govt. Approved)

Abstract

The design and model of a hybrid power system consisted of renewable energy sources (wind energy). It converts wind power into mechanical energy. The burden on the national grid over overcome, the electricity bill is reduced and we get energy in an environmentally friendly manner. This work explains the mechanism to utilize renewable energy as the first option, whether other conventional sources are available or not. For irrigation, farm, home, and community water supply. Excellent for filling lakes, reservoirs, and tanks. All mechanical design is simple and efficient. It is the perfect solution for providing a lifetime of free water. Wind energy systems used worldwide since 1970. Bangladesh has a huge renewable energy potential to meet its energy needs. This type of turbine is unusual and its application for obtaining useful energy from the air stream is an alternative to the use of conventional wind turbines. Simple construction, high startup and full operation moment, wind acceptance from any direction, low noise and angular velocity in operation, reduced wear on moving parts, and very low cost are some advantages of using this type of machine. In this research, a wind water pump is designed to supply drinking water to places. The design and model of the windmill consisted of renewable resources. This work explains the mechanism to utilize renewable energy as the first option whether conventional sources are available or not. It is simply based on wind. It ensures the optimum utilization of resources.

Keywords: Wind mill, Windmill pump

Declaration

I declare that the work contained in this thesis is my own, except where explicitly stated otherwise. In addition this work has not been submitted to obtain another degree or professional qualification.

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Acknowledgment

In the name of Allah, the Most Gracious and the Most Merciful.

All thanks and praise to Almighty Allah, who enabled us to complete our Bachelor's degree in Mechanical Engineering. We would like to thank our H.O.D Md. Mostofa Hossain for giving us the opportunity and motivation to do our thesis work.Special thanks to our Project Supervisor Md. Navid Inan (Lecturer) for his supervision during our work. We must express our gratitude to Laboratory staff for their continued support and cooperation, during laboratory work.

Last but not least, we would like to thank our parents for their unconditional support, both financially and emotionally throughout our Bachelor’s degree.

Dedication

Dedicated to our families.Special feelings of gratitude to our loving parents whose words of encouragement and push for tenacity ring in our ears. We also dedicate this dissertation to our friends and our teachers who supported us throughout the process.

Table of Contents

List of Figures

List of Tables

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CHAPTER 01

Introduction

1.1 Demand of Renewable Energy Today

Renewable energy is energy that is generated from natural processes that are continuously replenished. This includes sunlight, geothermal heat, wind, tides, water, and various forms of biomass. This energy cannot be exhausted and is constantly renewed. Alternative energy is a term used for an energy source that is an alternative to using fossil fuels. Generally, it indicates energies that are non-traditional and have a low environmental impact. The term alternative is used to contrast with fossil fuels according to some sources. By most definitions alternative energy doesn't harm the environment, a distinction which separates it from renewable energy which may or may not have significant environmental impact. Renewable energy is good for customers, the environment, and the bottom line of corporations that run their operations with it. In the United States, though, renewables (including solar, wind, hydropower, and biomass) account for only about 28 percent of all energy used – even as corporate contracts for renewable energy nearly triple by 2030. If there are challenges now, when capacity and use are low, what will happen to business models, technology, and financing when renewable power penetration reaches 50,60 or even 70 percent of the U.S. market? Since there’s plenty of corporate demand, the problem is supply, which in turn depends on adequate infrastructure to deliver it. Historically, U.S. utilities have decided what fuels to use to generate electricity, with a scant incentive to increase the percentage of renewables in the energy mix or to explore technology to encourage that kind of shift. We know there’s an appetite for many more gigawatts of renewable capacity, but it’s excessively difficult for large companies in the United States to buy as much renewable energy as they want. While retail customers in many states can arrange to buy solar or wind power from local utilities, companies need a large, sophisticated team to get access to renewable energy options at the scale they need – if those options are available at all. To change this picture, it’s time to look to the demand side, where multinational corporations are joining together to make their preference for more renewable power felt. Facebook and Microsoft, Amazon,Meta are among 60 companies and over 50 leading project developers and service providers participating in a new network, the Renewable Energy Buyers Alliance, known as REBA that aims to break down barriers to lower-carbon energy. The alliance aims to see 60 gigawatts – the same amount of total generating capacity of Turkey — of renewable energy deployed in the U.S. by 2025. That’s a huge jump from the 320 gigawatts of renewable power purchases companies signed in 2022, which was about triple the amount from the previous year.[1]

1.2 Wind Mill

A windmill is a rotary device that extracts energy from the wind. The windmill converts kinetic energy from the wind, also called wind energy, into mechanical energy. If mechanical energy is used to pump the water, the device may be called a water-pumping windmill. In the development of any economy, the use of natural resources is very important. Various types (horizontal & vertical axis) of Windmills are used for the same purpose. Generally, in the past horizontal-axis windmills were used. The multi-bladed wind pump or wind turbine atop a lattice tower made of wood or steel hence became, for many years, a fixture of the landscape throughout rural America. These mills, made by a variety of manufacturers, featured a large number of blades so that they would turn slowly with considerable torque in moderate winds and be self-regulating in high winds. A tower-top gearbox and crankshaft converted the rotary motion into reciprocating strokes carried downward through a rod to the pump cylinder below. Today, rising energy costs and improved pumping technology are increasing interest in the use of this once-declining technology.[2]

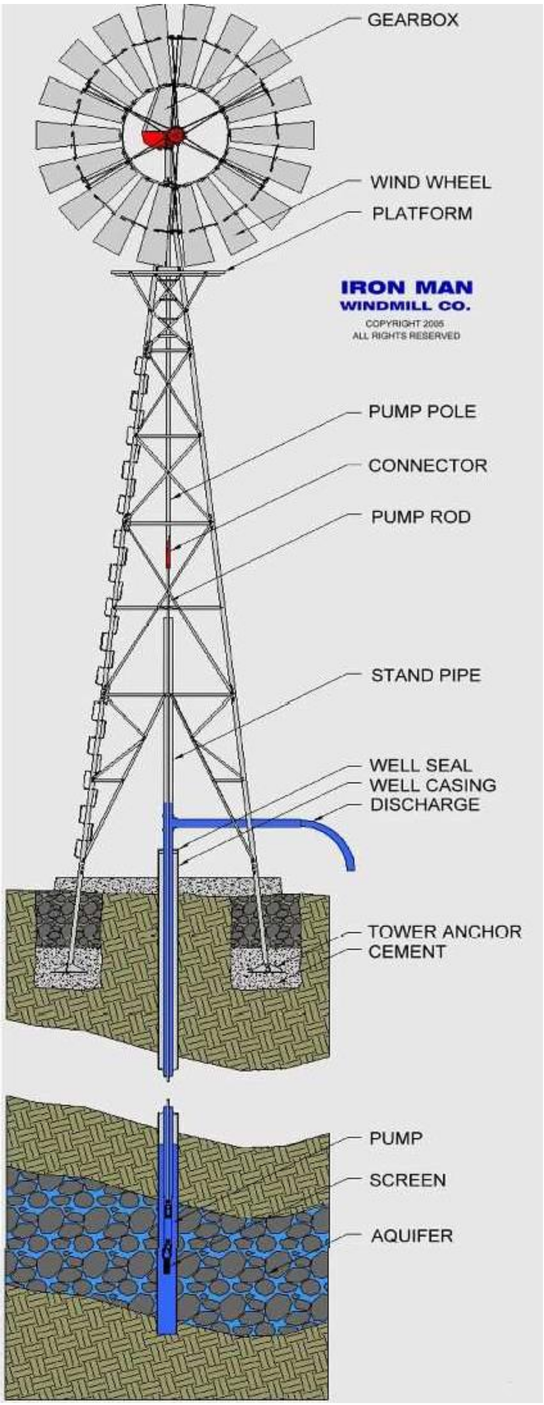

Figure 1.1 Windmill Sketch

1.3 Back Ground

Wind turbines were used in Persia (present-day Iran) about 500–900 A.D. The wind wheel of Hero of Alexandria marks one of the first known instances of wind powering a machine in history. However, the first known practical wind turbines were built in Sistan, an Eastern province of Iran, in the 7th century. Wind turbines first appeared in Europe during the Middle Ages. The first historical records of their use in England date to the 11th or 12th centuries and there are reports of German crusaders taking their windmill-making skills to Syria around 1190. By the 14th century, Dutch wind turbines were in use to drain areas of the Rhine delta. Advanced windmills were described by Croatian inventor Fausto Veranzio. In his book Machinae Novae (1595), he described vertical-axis wind turbines with curved or V-shaped blades. The first electricity-generating wind turbine was a battery-charging machine installed in July 1887 by Scottish academic James Blyth to light his holiday home in Marykirk, Scotland. Some months later American inventor Charles F. Brush was able to build the first automatically operated wind turbine after consulting local University professors and colleagues Jacob S. Gibbs and Brinsley Coleberd and successfully getting the blueprints peer-reviewed for electricity production in Cleveland, Ohio. Although Blyth's turbine was considered uneconomical in the United Kingdom electricity generation by wind turbines was more cost-effective in countries with widely scattered populations. In Denmark by 1900, there were about 2500 windmills for mechanical loads such as pumps and mills, producing an estimated combined peak power of about 30 MW. The largest machines were on 24-meter (79 ft) towers with four-bladed 23-meter (75 ft) diameter rotors. By 1908 72 wind-driven electric generators were operating in the United States from 5 kW to 25 kW. Around the time of World War I, American windmill makers were producing 100,000 farm windmills each year, mostly for water pumping. By the 1930s, wind generators for electricity were common on farms, mostly in the United States where distribution systems had not yet been installed. In this period, high-tensile steel was cheap, and the generators were placed atop prefabricated open steel lattice towers. A forerunner of modern horizontal-axis wind generators was in service at Yalta, USSR in 1931. This was a 100 kW generator on a 30-meter (98 ft) tower, connected to the local 6.3 kV distribution system. It was reported to have an annual capacity factor of 32 percent, not much different from current wind machines. In the autumn of 1941, the first megawatt-class wind turbine was synchronized to a utility grid in Vermont. The Smith-Putnam wind turbine only ran for 1,100 hours before suffering a critical failure. The unit was not repaired, because of a shortage of materials during the war. The first utility grid-connected wind turbine to operate in the UK was built by John Brown & Company in 1951 in the Orkney Islands. Despite these diverse developments, developments in fossil fuel systems almost eliminated any wind turbine systems larger than supermicro size. Organizing owners into associations and co-operatives lead to the lobbying of the government and utilities and provided incentives for larger turbines throughout the 1980s and later. Local activists in Germany, nascent turbine manufacturers in Spain, and large investors in the United States in the early 1990s then lobbied for policies that stimulated the industry in those countries. Later companies formed in India and China. As of 2012, Danish company Vestas is the world's biggest wind turbine manufacturer.[3]

1.4 Types of Windmill

Wind turbines can rotate about either a horizontal or a vertical axis, the former being both older and more common. They can also include blades (transparent or not) or be bladeless. Vertical designs produce less power and are less common.

1.4.1 Horizontal Axis

Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower and must be pointed into 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. Any solid object produces a wake behind it, leading to fatigue failures, so the turbine is usually positioned upwind of its supporting tower. Downwind machines have been built, because they don't need an additional mechanism for keeping them in line with the wind. In high winds, the blades can also be allowed to bend which reduces their swept area and thus their wind resistance. In upwind designs, turbine blades must be made stiff to prevent the blades from being pushed into the tower by high winds. Additionally, the blades are placed a considerable distance in front of the tower and are sometimes tilted forward into the wind a small amount.[4]

1.4.2 Vertical Axis

Vertical-axis wind turbines have the main rotor shaft arranged vertically. One advantage of this arrangement is that the turbine does not need to be pointed into the wind to be effective, which is an advantage on a site where the wind direction is highly variable. It is also an advantage when the turbine is integrated into a building because it is inherently less steerable. Also, the generator and gearbox can be placed near the ground, using a direct drive from the rotor assembly to the ground-based gearbox, improving accessibility for maintenance. However, these designs produce much less energy averaged over time, which is a major drawback. The key disadvantages include the relatively low rotational speed with the consequential higher torque and hence higher cost of the drive train, the inherently lower power coefficient, the 360-degree rotation of the aerofoil within the wind flow during each cycle and hence the highly dynamic loading on the blade, the pulsating torque generated by some rotor designs on the drive train, and the difficulty of modeling the wind flow accurately and hence the challenges of analyzing and designing the rotor before fabricating a prototype. [5]

1.4.3 Darrieus Wind Turbine

"Eggbeater" turbines, or Darrieus turbines, were named after the French inventor, Georges Darrieus. They have good efficiency but produce large torque ripple and cyclical stress on the tower, which contributes to poor reliability. They also generally require some external power source, or an additional Savonius rotor to start turning, because the starting torque is very low. The torque ripple is reduced by using three or more blades which results in greater solidity of the rotor. Solidity is measured by the blade area divided by the rotor area. Newer Darrieus-type turbines are not held up by guy wires but have an external superstructure connected to the top bearing.[6]

1.4.4 Giromill

A subtype of Darrieus turbine with straight, as opposed to curved, blades. The cycloturbine variety has a variable pitch to reduce the torque pulsation and is self-starting. The advantages of variable pitch are: high starting torque; a wide, relatively flat torque curve; a higher coefficient of performance; more efficient operation in turbulent winds; and a lower blade speed ratio which lowers blade bending stresses. Straight, V, or curved blades may be used..[7]

1.4.5 Twisted Savonius

Twisted Savonius is a modified Savonius, with long helical scoops to provide smooth torque. This is often used as a rooftop wind turbine and has even been adapted for ships. [8]

1.5 Problem Statement

A major hindrance in the growth of wind energy is fluctuation in the source of wind. The design must be sustainable and environmentally friendly and installed in areas having a proper supply of wind.

1.6 Aims and Objectives

- To Design a water pump that can work without electricity.
- There is the possibility that this project will create a system that is more affordable than a standard water pump.
- To Provide water pumps to individuals living off the grid and in backward areas.

CHAPTER 2

Literature Review

2.1 Literature Review

A wind pump is a type of windmill which is used for pumping water. Wind mill operate on a simple principle. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which can convert wind energy into electrical and mechanical energy. In windmill pumps high solidity rotors are best used in conjunction with positive displacement (piston) pumps, because single-acting piston pumps need about three times as much torque to start them as to keep them going. Low solidity rotors, on the other hand, are best used with centrifugal pumps, water ladder pumps, and chain and washer pumps, where the torque needed by the pump for starting is less than that needed for running at design speed. A 16 ft. (4.8 m) diameter wind pump can lift up to 1600 US gallons (about 6.4 metric tons) of water per hour to an elevation of 100 ft. with a 15 to 20 mph wind (24–32 km/h). A common multi-bladed wind pump usefully pumps with about 4%–8% of the annual wind power passing through the area it sweeps. Wind Turbines are one of the recent machines for wind energy conversion. Wind turbines are mainly classified into horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). The horizontal axis wind turbines are mostly used for electricity generation and also for water pumping. However, to use the recent wind turbines for water pumping, the average wind velocity of the region should be greater than 4 m/s. Windmills are one of the oldest methods of harnessing wind energy to pump water. But currently, the technology has gone viral due to the increasing price of fossil fuel all over the world.[9]

2.2 Literature Survey

Omar Badran Statement

Omar Badran, [10] wind energy pumping systems are more reliable than diesel ones because they do not require frequent maintenance, are safer due to the auto stop features in case of failure, do not consume fuel, and do not pollute the environment. Also from the present study, we can conclude that research and development projects in the field of wind energy are of utmost importance to Jordan, despite the scarce financial resources and the high cost of R&D, because Jordan does not have any source of conventional energy. Research and Development organizations in Jordan should be encouraged to sponsor the development of electrical wind energy conversion systems packages. Availability in the local market, detail of fabrication processes, and available on-site technical assistance. The manufacturing of modern wind pumps locally will generally pump water at lower costs than imported classical multi-bladed windmills, which should be considered in assessing the potential of wind energy for water pumping. Also, it can be concluded from the present study that the water supply in Jordan for a man, his cattle, and his land could be safeguarded with the help of a windmill installation.

- Diameter of rotor = 7.5m
- Number of blades = 24
- Tower height = 12 m
- Rotational speed = 50rpm
- The solidity ratio is 54%

- Pump cylinder diameter =104 mm
- Pump stroke length =350 mm
- Power transmission is through crankshaft
- Average wind speed = 8 m/s.

Misrak Girma,Abebayehu Assefa Statement

Misrak Girma,Abebayehu Assefa, [11]. In this paper, the feasibility of a wind-powered water pumping system is conducted for three selected sites in Ethiopia. The designed system can supply daily average drinking water of 10, 12, and 15 m3/day for 500, 600, and 1000 people in Siyadberand Wayu, Adami Tulu, and East Enderta sites, respectively, with average per capita water consumption of 20 liters per day per person. The cost of pumping water is determined as 0.08, 0.05, and 0.036 $/m3 for the Siyadberand Wayu, Adami Tulu, and Enderta sites, respectively. The results indicate that replacing the existing expensive Diesel-based systems with wind-powered systems will play a significant role in achieving the country's MDG targets. If there is low and medium wind energy potential (greater than 2.8m/s) which can be applicable for water pumping. The size of wind mill always depends upon the diameter of the rotor**.**

- Diameter of rotor is 5.7 m
- No of blades =24
- It is direct single acting piston pump.
- Water consumption = 10m^3 / day
- Total head = 75 meter

- Density of air = .92 kg/m^3
- Reference area =P(hyd)/P(wind)=Ra=24.87
- Rotor Diameter = 5.63 m
- Pipe diameter = 25mm
- Pump diameter = 115mm
- Hydraulic power = 337 W
- Tower head = 16 m
- The transmission gear ratio is direct
- Its rotor is horizontal
- The transmission ratio is 1:1 direct driven

The annual discharge is 4850m^3 at the current location.

Arlos D`alexandria Bruni , Vânio Vicente Santos de Souza statement

Arlos D`alexandria Bruni , Vânio Vicente Santos de Souza, [12] the use of renewable energies for several purposes, such as the eolian energy is one of the maintainable technological directions for the future. This work describes the comparative study between two alternative prototypes of the Savonius windmill, made of two and three blades, both of small bodies and with a reception area of 1.8 m2, yet composed of two stages and blades made of polyethylene drums in order to optimize performance, assembly and maintenance easiness as well as the opening of new directions for the use of technologies of low cost. It’s clear that the prototype made of three blades in comparison to the conventional one proposed by Savonius in 1930 is

more efficient as evidenced through the potency curves rotations graphic versus natural wind speed.

Keywords: Savonius windmill, eolian energy, alternative windmill.

- The prototype built with three blades is, at least, 20% more efficient in terms of exit potency than the conventional;
- Savonius with the same material expense;
- The rotation of the three blades profile is, at least, 12% larger than the prototype of two blades;
- Starting from 4.0 m/s the torque of the three blades prototype is superior;
- The substitution of the foils of 1.5 mm instead of foils of 1.0 mm reduced the weight of the windmill, increasing its efficiency in the admission.
- The polyethylene used in the blades resisted the applied loads and slightly degraded in the presence of ultraviolet rays after one year of exposition, bringing no hazard to the blades;
- The use of reduction 4:1 was adapted for medium regimes of winds of 6.0 m/s;
- The amount of pumped water is satisfactory considering the mainly objective this work, that is the water pumping to consumption water box around 2.000 liters /day;
- The proportional cost of construction and pumped water is about 5% smaller than the implementation of a multi-blade American model;
- The Savonius windmill proposed present superior of assembly and maintenance easiness if compared to the conventional Savonius windmill made of metal;

The use of polyethylene for the manufacture of the blades is advantageous due to corrosion absence and satisfactory resistance.

Ronak D Gandhi, Pramod Kothmir statement

Ronak D Gandhi, Pramod Kothmir,[13] studying this paper we observe that blade length is proportional to swept area, for a larger blade greater swept area, it will catch more wind they produce more torque. Here bevel gears are used to transfer power made of plastic material. These gears convert rotatory motion into linear motion. there are 14 teeth and the bore diameter is 10 mm, The small-scaled windmills have different aerodynamic behavior than their large-scale windmills. Poor performance of small windmills is due to laminar separation and in turns on the rotor blades because of low Reynolds number (Re) resulting from low wind speeds and small rotor capacity Low Reynolds number airfoils permit starting at lower wind velocity, increasing the starting torque and thus improving the overall performance of the turbine .Designing the rotor of the windmill will include optimizing the rotor and its components to achieve maximum power coefficient and efficiency. The pitch twist and allotment of chord length are optimized based on the conservation of angular momentum and the theory of aerodynamic forces on an airfoil. Blade Element Momentum (BEM) theory is first derived and then used to conduct a parametric study that will determine if the optimized values of blade pitch and chord length create the most efficient blade geometry.

G. M. Bragg, W.L. Schmidt statement

G. M. Bragg, W.L. Schmidt, [14] a procedure is presented that allows the optimum selection of pumps and windmills for a given water pumping situation. When information on the wind, pump characteristics, and windmill characteristics is available, the best pump and windmill for the application may be selected, and the design and off-design performance of the complete system may be predicted. Roto-dynamic pump is used. Generally, a pump of low specific speed has a relatively low rpm. low flow rate and high head operation is best operating system.

Juan.Enciso Statement

Juan.Enciso,[15].in.this.case.windmill.consists.of.a.very.large.fan.with.15 to 40 steel or galvanized blades . This mechanism converts the rotary motion. The propeller must have many blades to develop a high starting torque, which is needed to start the piston pump. Generally, windmills begin working when the wind speeds exceed 7 mph. The wind blows more during the spring, when the average monthly wind speed varies from 11.5 to 13.4 mph at a 33-foot height in West and Northwest Texas. In the summer, the average wind speed decreases, ranging from 9.8 to 11.5 mph. In autumn, it slightly increases from 11.5 to 12.5, especially in the northwest part of Texas. In winter, the wind speed varies from 11.5 to 12.5 mph. Although these average wind speeds seem about the same, a small increase in wind will greatly increase the wind power. In fact, the wind power increases by a cube (power of 3) of the wind speed. For instance, a 12.6 mph wind speed has twice the power of a 10 mph wind speed. A windmill’s pumping output is affected by three factors: wind speed, wheel or blade diameter, and the diameter of the cylinder. The power available from the wind is proportional to the cube of the wind speed. This means that when the wind speed doubles, the power increases eight times.

N-Agraw And R-Fooster Statement

N-Agraw And R-Fooster, [16] concluded that the air density decreases with increases in temperature and altitude, and power in the wind machine is directly proportional to the wind speed and air density in the axial flow pumps. For example, at 3,000 meters

(10,000 feet), the density of air decreases by 30%. Air density also varies 10%–%15 from season to season. Axial flow pumps are designed at 2.5–25.0 m3/min discharge and 1.5–3.0 meters head for vertically mounted applications. However, by adding additional impellers (stages) the pump can lift up to 10 meters. Axial flow pumps are generally used in canal irrigation. Schemes where large volumes of water must be lifted to 2–3 meters. However, when high heads and low flow rates are required, radial flow impellers are the most suitable.

National Renewable Energy Laboratory Statement

National Renewable Energy Laboratory,[17] adding the counterbalance weight on the sucker rod or springs and using variable-stroke technique are the main factors that have improved the mechanical wind pumps in use today.

Now-a-days windmills have 6–8 blades of true airfoils, The Australian-made Southern Cross machine has an available rotor diameter as long as 8 meters. Modern wind pumps are thus twice as efficient as traditional wind pumps, but they are still bulky and are best suited for light wind regions.

The so-called third generation windmills use a direct drive mechanism rather than a geared transmission. They are designed to produce high torque at low wind speeds and provide rotor speed control at high wind speeds. The main objective of this design is to reduce the starting torque. This is possible because of the counterbalance attached to the actuating pump beam, which is designed to reduce the starting rotor torque to start pumping. A report by the University of Calgary, Canada, shows that a direct drive-type wind pump (similar to an oil- field jack pump) can start pumping at 50% lower rotor torque (or 30% less wind speed) relative to a system with no counterbalance. These types of wind pumps are promising because they do not require gearboxes for power transmission from the rotor to the shaft. The windmill uses a reciprocating or piston pump, or positive displacement pump. For these pumps to start pumping, the wind pump crank force needs enough force on the pump rod to lift the weight of the pump rods, the piston and the water in the piston, and the friction. The amount of water delivered by the pump for a given pumping head depends on the diameter of the.pump and on the wind speed. The size of the pump determines the starting wind speed for a given wind pump and pumping head because bigger pumps require larger starting torque. A pump fitted to a windmill should generally be sized to run at about three-quarters of the local mean wind speed. This allows the wind pump to run frequently enough and to achieve better water output at stronger winds.

One of the main disadvantages of a mechanical wind pump is that it must be located directly over the borehole so the pump rod is directly connected with the rising main and the pump. The best water resource location is at lower ground, which is generally a poor location for winds, so mechanical wind pumps are typically limited to flat and arid regions. Efforts have been made to locate the windmills further from the borehole by using remote electrical, pneumatic, hydraulic, and mechanical transmissions.

Pneumatic transmission wind pumps operate on the principle of compressed air by using a small industrial air compressor to drive an airlift pump or pneumatic displacement pumps. (No mechanical transmission from the windmill to the pump)

Power transmission using hydraulic means is another option for water pumping.

Commercialized mechanical wind pumps are good for low wind speeds because of their high solidity rotors, which limit the piston pump speed to 40–50 strokes per minute. The overall conversion efficiency of mechanical pumps using an average wind speed is 7%–27%.

Muhammad Mehtar Hussain And Mushtaq Ahmad Statement

Muhammad Mehtar Hussain And Mushtaq Ahmad,[18] the windmill actuated bore-well pumping unit consisting of a tall tower structure made of two parallel bamboo posts supported by two inclined bamboo posts each. An iron shaft made from iron pipe is mounted on bearings near the top of the tower, the ends of which rest on the parallel bamboo posts on either side. At the Centre of the shaft, a wind turbine with four blades is mounted. The shaft is connected to the hand pump handle on the ground through mechanical linkages (crank lever mechanism). As the turbine rotates, due to the motion of the wind, the shaft also rotates. Through the mechanical linkages, the rotary motion of the shaft is converted to the reciprocating motion of the lever of the hand pump, which in turn pumps water from the tube well continuously.

- Hub diameter of the turbine= 58 cm
- Tip diameter of the turbine= 382 cm
- No. of blades= 4 (Four)
- Blade dimensions= Trapezium (160-143-160-36) cm
- Blade Material= Aluminum
- Thickness of the Blade = 0.5 mm
- Blade Angle= 7.23 degree
- Construction Material=Wood, Bamboo, Aluminum, Mild Steel
- Wind Direction=East-West
- Crank Length=20 cm
- Wind turbine height from ground= 325 cm

CHAPTER 03

Design of Water Pumping Windmill

3.1 Design Challenges

The goal of this project was to design a windmill that could generate power under relatively low wind velocities. To accomplish this goal, the objective was to.

1) Analyze how different geometry of windmill within various enclosures affect windmill's output.

2) Test how vibrations caused by rotations of blades affect the structure of the windmill. To meet these objectives, the tasks were to:

   - Complete background research on windmill
   - Design blades for testing
   - Create experimental setup
   - Manufacture parts and built model house
   - Develop future design recommendations

3.2 Effect of Number of Blade[19]

Comparison of coefficient of efficiency between two blades and three blades. three, six, and twelve-blade systems. The major factors involved in deciding the number of blades include:

1. The effect on power coefficient;

2. The design TSR (tip-speed ratio);

3. The means of yawing rate to reduce the gyroscopic fatigue.

3.2.1 Effect Of Blade Number, On Aerodynamic Performance[19]

Various experiment results were published on the internet or in books what is the exact number of blades that have good aerodynamic performance? The solidity of material, kind of material, coefficient of friction on the blade surface, chord (width) of blade turbine, and many others. One that is very interesting to make a conclusion and discuss is the relation between the number of blades and the coefficient of performance of wind turbine machines. The best blades number from 3 to 12 When designing a number of blades, the number of blades that we choose influences aerodynamic performance like the coefficient of performance. Modern wind turbines are neither built with many rotor blades nor with very wide blades even though turbines with high solidity (defined as the ratio between the actual blade areas to the swept area of a rotor) have the advantage of enabling the rotor to start rotating easily because more rotor area interacts with the wind initially. Since our current goal is to convert wind energy into electricity, rotors will not benefit from high solidity because it is neither cost-effective nor efficient. The number of blades of a turbine has a great impact on its performance. The picture below shows the coefficient of performance between 3,6, and 12 blades with the same solidity and same speed 5 m/s, from this picture we can conclude that 3 blades have the most efficient number of blades, as we know almost 70% of modern wind turbine use 3 blades.

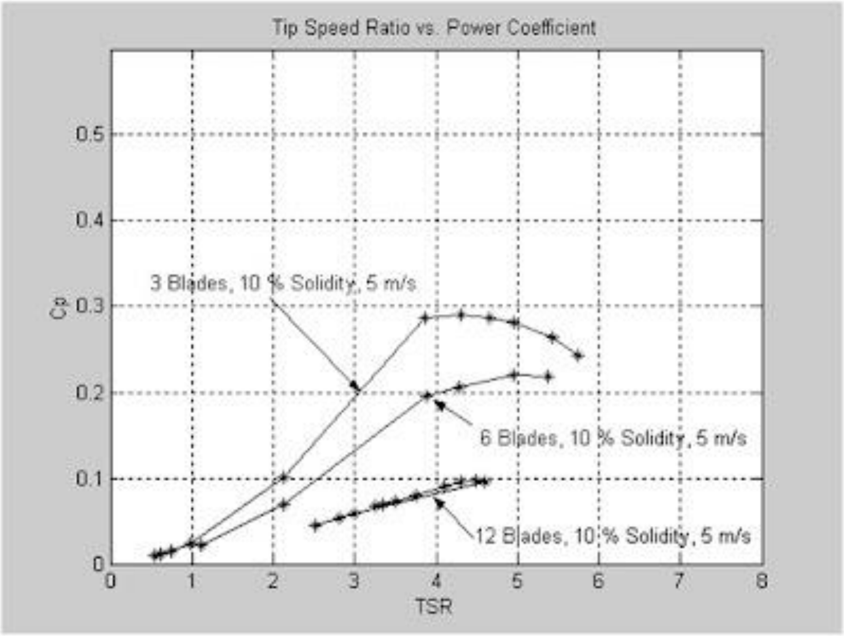

Figure 3.1: Tip Speed vs Power Coefficient

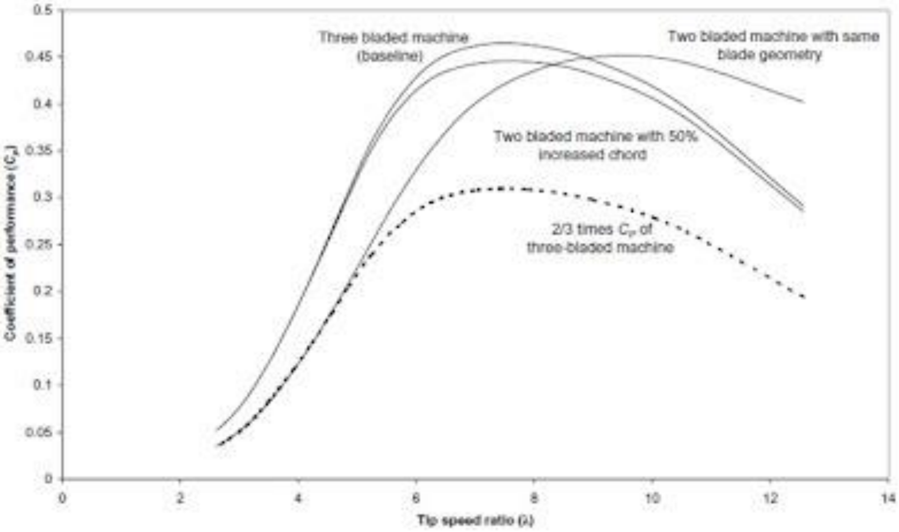

Figure 3.2: Coefficient of Performance vs Tip Speed Ratio

3.3 Design Procedure

Assumptions:

The following assumptions are taken for designing the rotor of the windmill turbine:

The wind is flowing at a constant speed of 4 m/s.

The coefficient of wind power Cp is 0.25[The power coefficient (Cp) is defined as the ratio of the power extracted by the wind turbine relative to the energy available in the wind stream.]

The rated discharge and rated head for the pump is .00000665m^3/s and 3.048m.

The pump operational average time is 8 hours/day. The efficiency of the pump is 85-94%.

Table 3.1: Power Losses In Wind Mill [20]

Factor	**Typical Efficiency**
Rotor to shaft	**92-97%**
Pump	**85-94%**
Efficiency of windmill	**55-65%**

3.3.1 Power Calculations

3.3.1.1 Power Required To Pump Water

$P=\rho g Q h$

Density of water=1000kg/m^3

g = 9.81m/s^2

Head of water=10 feet

h=head of water=3.048m

Q =.00000665m^3/s

P = 1000*9.81*3.048*.00000665

P = 0.20 watt

3.3.1.2 Power Required To Drive Pump

Efficiency = 85%

Efficiency = (output/input)*100

Input = (.20/85)*100 = .235 watt

This is power required to drive pump.

3.3.1.3 Power Required Rotor To Shaft

Rotor to shaft efficiency is 92%.

Input = (.235/92)*100

Input = .255 watt

3.3.1.4 Power Required To Drive Windmill

Efficiency of windmill = 55%

Input=(1.24/55)*100=.463 watt

3.3.2 Design Parameter Of Windmill

3.3.2.1 Wind Power

$P= (1/2)\, \rho\, A\, v^3$

Density of water = 1000kg/m^3

A=Area of rotor in m^2

V= Wind velocity in

m/s

3.3.2.2 Swept Area

The swept area is the plane of wind intersected by the generator. As such, the height of the blades times the diameter of rotation will produce the square meters or feet of the swept area.

$$A_s = (\pi /4) D^2$$

3.3.2.3 Tip Speed Ratio (λ)

It is the ratio of speed of windmill rotor tip, at radius R when ω

rotating at Radians per second to the speed of wind V m/s.

$$\lambda = \frac{\omega R}{V}$$

R= Radius of rotor in

m V = Velocity of

wind

3.3.2.4 Power Coefficient (C_p)

It is the ratio of power of turbine to total power of wind

$$C_p = P_t/P_w$$

3.3.2.5 Material Selection:

Aluminum which is light weight is used to fabricate blades by bending process.

3.3.2.6 Design of Blades:

In this project, four blades with horizontal shafts are used. The angle of the blades is 20 degrees.

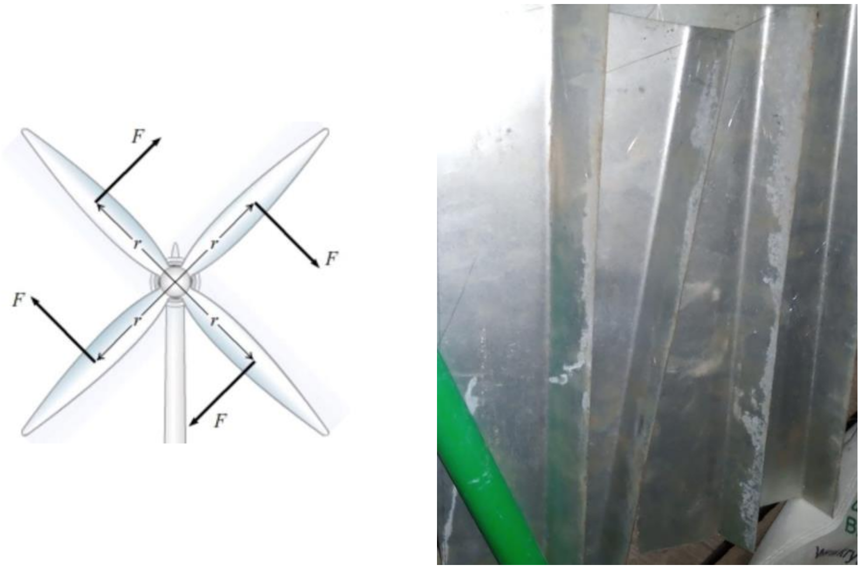

Figure 3.3: Blades

3.3.2.7 Design Of Shaft

While designing the shaft it was in mind that the hub would be connected with blades at one end and also fitted to the shaft on the other end. So the rotation of blades can cause water at the outlet. The shaft is made of mild steel.

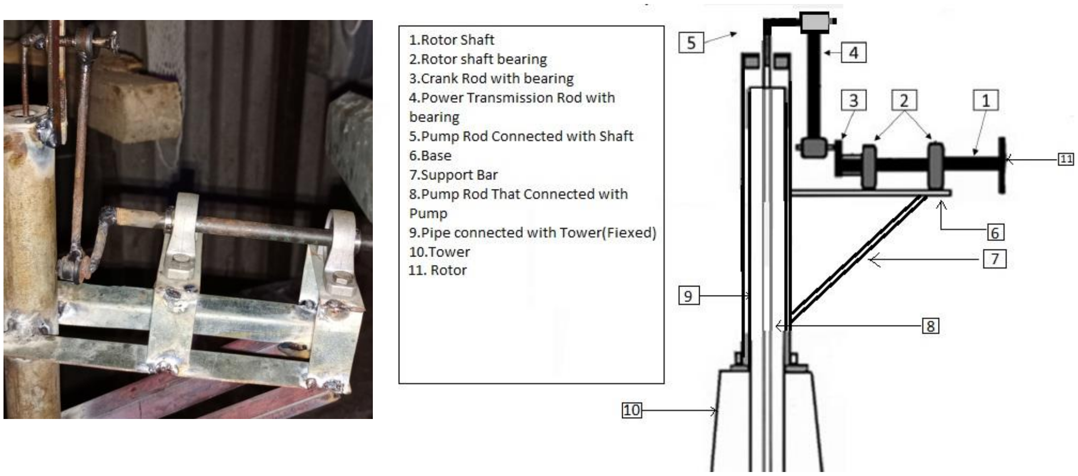

Figure 3.4: Crank Shaft And Connecting Rod

3.3.2.8 Hub

Hub is made of mild steel.

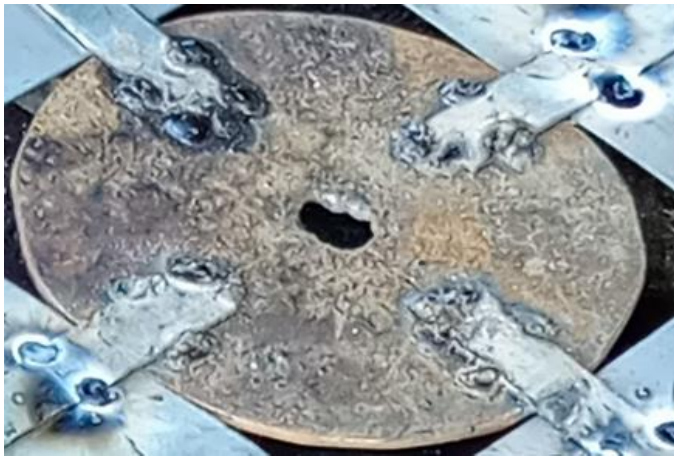

Figure 3.5: Hub

3.4 Complete Mechanical Design

The complete design includes ,4 Blades, Hub, Cylinder, Non returning valve, Socket, Connecting Rod, Tail,Screws, Nuts, and Bolts.

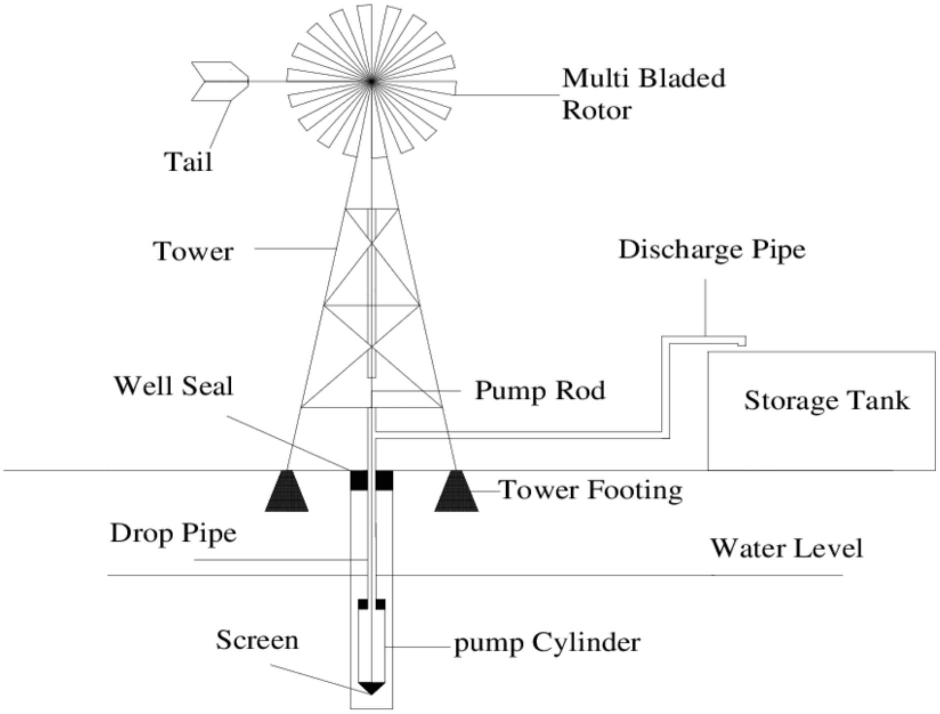

Figure 3.6 : Complete Design

CHAPTER 04

Fabrication

4.1 Parts Detail

4.1.1 Blades

Four Blades of Alumimiun alloy.

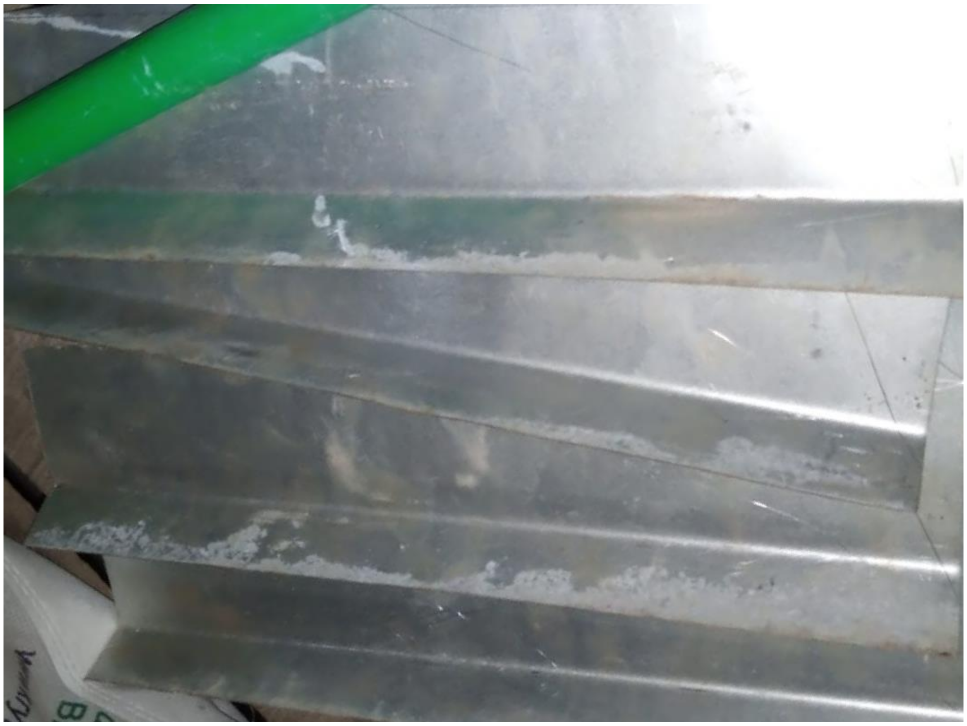

Figure 4.1: Blades

4.1.2 Hub

A Hub of mild steel on which blades are attached.

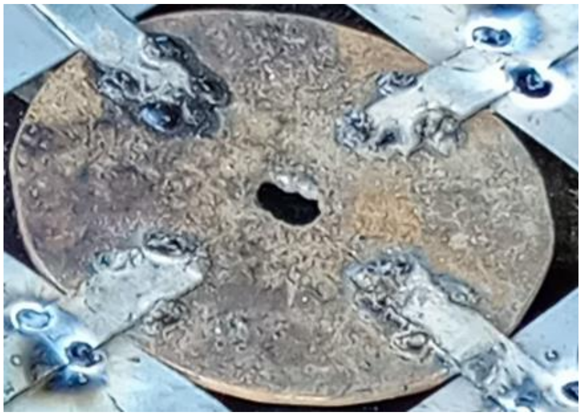

Figure : 4.2 Hub

4.1.3 Crank Shaft And Connecting Rod Crank shaft with connecting rod of alloy steel.

Figure 4.3: Crank Shaft

4.1.4 Non-Returning Valve

Non-returning valve made of cast iron to block the backflow.

Figure 4.4: Non Returning Valve

4.1.5 Angle For Tower

¾ angle pipes for support Tower.

Figure 4.5: ¾ angle pipes

4.1.6 Without Blades

Hub and cylinder assembly for connection without the blades.

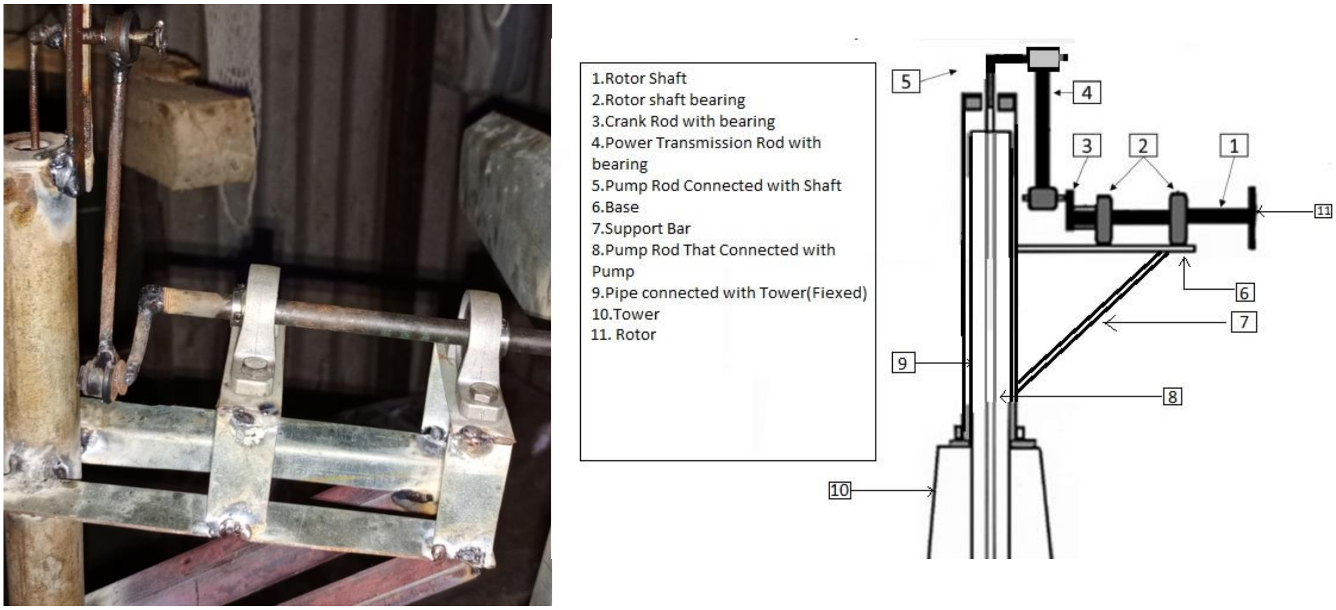

Figure 4.6: Without Blade

4.1.7 Vain Or Tail and Braking System(Only Theory)

A fantail is a small windmill mounted at right angles to the sails, at the rear of the windmill, and which turns the cap automatically to bring it into the wind.

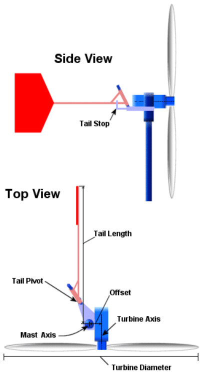

Figure 4.7: Tail.

Figure 4.8: Tail

Aerodynamic Braking System:

Tip Brakes The primary braking system for most modern wind turbines is the aerodynamic braking system, which essentially consists of turning the rotor blades about 90 degrees along their longitudinal axis (in the case of a pitch-controlled turbine or an active stall-controlled turbine) or turning the rotor blade tips 90 degrees (in the case of a stall controlled turbine). These systems are usually spring-operated, in order to work even in case of electrical power failure, and they are automatically activated if the hydraulic system in the turbine loses pressure. The hydraulic system in the turbine is used to turn the blades or blade tips back in place once the dangerous situation is over.

Figure 4.9: Aerodynamic Braking System

Mechanical Braking System

The mechanical brake is used as a backup system for the aerodynamic braking system, and as a parking brake, once the turbine is stopped in the case of a stall-controlled turbine.Pitch-controlled turbines rarely need to activate the mechanical brake (except for maintenance work), as the rotor cannot move very much once the rotor blades are pitched 90 degrees.

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Figure 4.10 : Mechanical Braking System

4.2 Fabrication Processes

4.2.1 Bending Process

Bending is a manufacturing process that produces a V-shape, U-shape, or channel shape along a straight axis in ductile materials, most commonly sheet metal. Commonly used equipment includes box and pan brakes, brake presses, and other specialized machine presses.

Figure 4.11: Bending Process

4.2.2 Cutting Process

A process that is used to remove material from a metal workpiece through the process of shear deformation. Single-point tools are used to remove material by means of one cutting edge, in shaping, turning, planning, and other similar operations.

Figure 4.12: Cutting Process

4.2.3 Welding Process

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing fusion, which is distinct from lower-temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal.

Figure 4.13: Welding Proces

4.2.4 Drilling Process

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multipoint. The bit is pressed against the workpiece and rotated at rates from hundreds to thousands of revolutions per minute.

Figure 4.14: Drilling Process

4.3 Assembly

An assembly line is a manufacturing process (most of the time called a progressive assembly) in which parts (usually interchangeable parts) are added as the semi-finished assembly moves from workstation to workstation where the parts are added in sequence until the final assembly is produced.

4.3.1 Blades

Four Blades of Aluminium

Figure 4.15: Blades Are Ready

4.3.2 Mounting of Blades On Hub

Blades are ready and connected with the hub

Figure 4.16 Join Blades With Hub

4.3.3 Tower and Inside shaft

Tower is connected with the pipe .It is made of mild steel.

Figure 4.17: Tower and Inside Shaft

4.3.5 Connect The Hub With Shaft And Crank Shaft

Hub is connected with the shaft.

Figure 4.18 Connect The Hub With Shaft And Crank Shaft

4.3.6 Water Pumping Process

Hand pumps are manually operated pumps; they use human power and mechanical advantage to move fluids or air from one place to another. They are widely used in every country in the world for a variety of industrial, marine, irrigation, and leisure activities. There are many different types of hand pumps available, mainly operating on a piston, diaphragm, or rotary vane principle with a check valve on the entry and exit ports to the chamber operating in opposing directions. Most hand pumps are either piston pumps or plunger pumps and are positive displacement. We can also use two check valves for water lifting.

Figure 4.19 Water Pumping Mechanism

4.3.7 Assembly of Parts

The blades, Hub, Connecting rod, Cylinder, Crank shaft, and Tail(Only Theory) are ready for the working.

Figure 4.20: Assembly

4.4 Final Model Picture

All parts are joind together.

Figure 4.21: Final Model

CHAPTER 05

Result and Analysis

5.1 Design Parameters

We have achieved some of the following design parameters for our windmill after a literature review.

- No of blades
- Swept area
- Aspect ratio
- Tip speed ratio
- Angular velocity and acceleration
- Moment of inertia
- Torque
- Shaft RPM
- Power

- Angle of attack

- Angle between blades=90

- Overlap ratio=0

5.2 Power

5.2.1 Power Required To Pump Water

P=ρgQh

Density of water=1000kg/m^3

g = 9.81m/s^2

Head of water=10 feet

h=head of water=3.048m

Q =.00000665m^3/s

P = 1000*9.81*3.048*.00000665

P = 0.20 watt

5.2.2 Power Required To Drive Pump

Efficiency = 85%

Efficiency = (output/input)*100

Input = (.20/85)*100=.235Watt

This is power required to drive pump.

5.2.3 Power Required Rotor To Shaft

Rotor to shaft efficiency is 92%.

Input = (.235/92)*100

Input = 0.255 watt

5.2.4 Power Required To Drive Windmill

Efficiency of windmill = 55%

Input=(.255/55)*100= 0.463 watt

5.3 Discharge

Q =V/t

Q= A d/t , A is the cross sectional area of a section of

pipe d/t = v

Q = A v

d/t = It is the length of the volume of fluid divided by the time, it took the fluid to flow through its length which is just speed.

A = πr^2

r = 0.0065 m

π= 3.1416

v=d/t = 0.025 m/s

r^2 = 0.000133

Q = A v = π r^2v

Q = 0.000133× 0.025

Q = .000003325m^3/s

If we consider blade rotate at 120 R.P.M then Discharge will be,

Q = .000003325m^3/s*2

Q = .00000665m^3/s

Or Q=6.65 ml/s

5.4 Experimental Values

Table 5.1: Experimental Values (Discharge Calculation)

R.P.M	Time(s)	Discharge(ml/s)	Total Discharge(ml/min)
120	60	2.2	132
100	60	1.9	114

Conclusions

Our work is to show that the horizontal axis wind energy conversion system is practical and potentially very contributive. Thus we have used our new design of wind turbine to pump out water. This will provide liters of water for drinking purposes. At the low wind velocity in the range below 3 m/s, the discharge is not so effective, however with increased speed of wind energy considerably enhanced to the rate of v3, therefore discharge becomes high.

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