WINDMILL DRIVEN WATER PUMP

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Abstract:

This project is a design and builds a water pumping system driven by a wind. After we did a field study with farmers and rural places found that many people sufferers lack clean and running water. The intention is that local people should be able to use windmill. Important throughout the project has been to minimize cost and to only use material that can get hold of. Building and assembling of the wind turbine were then performed by the calculations of windmills and materials available to our results.

The major problem for the agriculturists at the present scenario is the energy crisis and the major source of water for the fields is wells and bore wells. People use pumps to pump out water from wells and bore wells so this process involves a lot of energy consumption every day. Our project deals with the process of pumping out water from wells and bore wells by designed wind mill. Our setup does not require any electrical devices and thus thereby the losses are avoided.

الملخص :

هذا المشروع هو عبارة عن تصميم وبناء توربين هوائي يعمل على تشغيل مضخة ماء ميكانيكية،وذلك بعد عمل زيارات ميدانية للمزارعين والاماكن الريفية كذلك المدن في فلسطين وجد حاجة كبيرة الى استخدام مضخات الماء في عديد من التطبيقات الحياتية خاصة في الاماكن التي يصعب فيها الحصول على الكهرباء، بناء على ذلك تم تطبيق هذا المشروع لتلبية حاجة المجتمع واستغلال اكبر طاقة ممكنة من الرياح حيث ان التصميم إعتمد على سرعة الرياح المتاحة في فلسطين واتجاهها وبناء على ذلك تم اختيار المضخة وتصميم ابعاد التوربين الهوائي لضمان افضل نتيجة واستغلال للطاقة وكانت نقطة مهمة ان يتم عمل المشروع بأقل تكلفة ومن مواد متوفرة .

المشكلة الرئيسية التي يعاني منها العالم هي أزمة الطاقة ايضا فان المياه هي مصدر رئيسي للحياة ويتم استخراجها من الابار وذلك عن طريق مضخات وبشكل يومي وهذا يمثل استهلاك كبير للطاقة، يتعامل مشروعنا مع عملية ضخ المياه من الابار والابار الجوفية عن طريق تشغيلها بتوربين هوائي يقوم باستغلال طاقة الرياح وذلك بدون اي استخدام للتحويلات الكهربائية وبذلك نكون استفدنا بشكل اكبر من طاقة التوربين.

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Chapter One

Introduction

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1.1 Introduction:

Power has been extracted from the wind over hundreds of years with historic designs, known as windmills, constructed from wood, cloth and stone for the purpose of pumping water or producing electrical power.

Historic designs, typically large, heavy and inefficient, were replaced in the 19th century by fossil fuel engines and the implementation of a nationally distributed power network. A greater understanding of aerodynamics and advances in materials, particularly polymers, has led to the return of wind energy extraction in the latter half of the 20th century. Wind power devices are now used to produce electricity, and commonly termed wind turbines, now it's the world's fastest growing energy source; it's a clean and renewable source of energy that has been in use for centuries in Europe and more recently in the United States and other nations. And today's world wind is one of the cheapest and cleanest energy source figure (1.1) illustrate the percentage of the energy source distributed over the world.

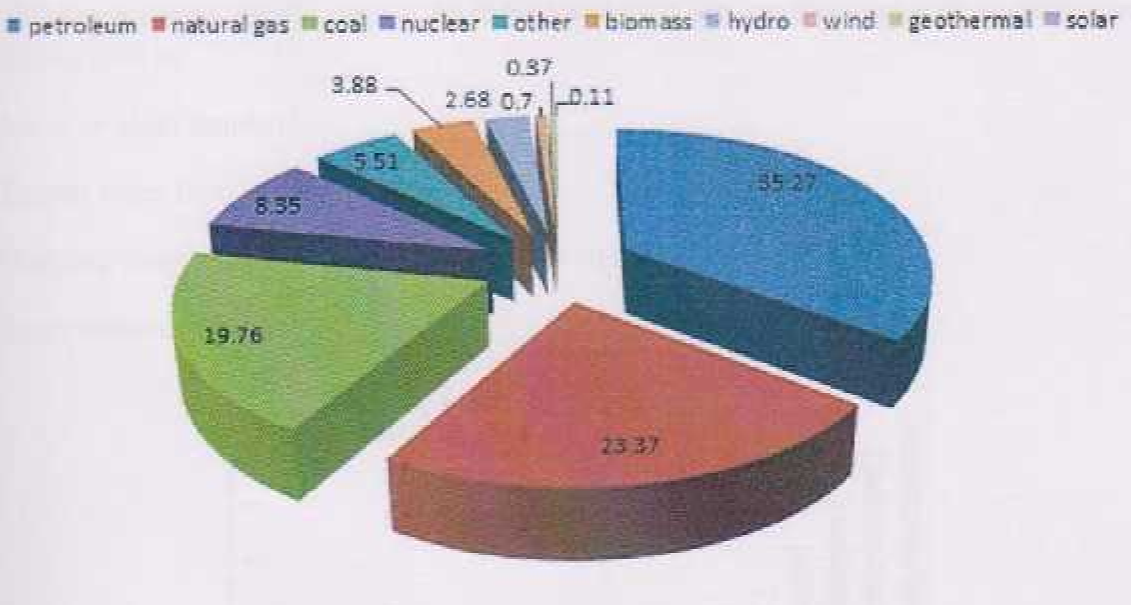

Figure 1.1 Energy source over the world

1.2 Background:

In the last decade, crisis of energy has been considered as one of the biggest problems around the world. In particular, and Palestine suffers from the lack of traditional resources, including energy Moreover; it witnesses an increase in consecutive consumption of non-renewable sources in various fields of life. Among the critical political situation, the siege imposed, the need to an alternative source of energy is vital, that's lead us to think in a different way to produce energy by using wind energy for driving a water pump, and this project will be readily accessible and easily for everyone.

1.3 Scope of project:

The project scope can be applied in multiple places, because of its compatible size, so water can be delivering to rural where there is no electricity or energy, also it used as a substitute for water pumps which operate on fuel, or anywhere that use water pump. The global wind power cumulative capacity is increased as we see in figure (1.2), so that the currencies of the wind power over the world increase by years.

In this project many people can use the turbine and there are some examples of places the project could be used in:

* Large or small farmland

* Extract water from wells

* Outlying areas, from city centers can use it as an energy source

* Everywhere using pump.

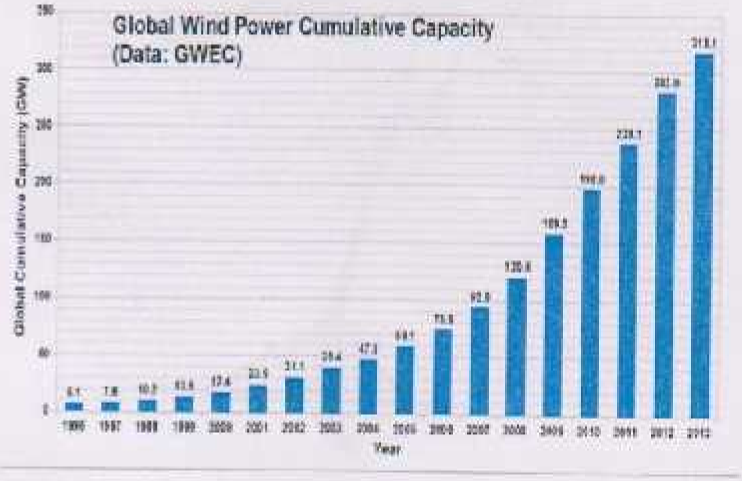

Figure 1.2 Global wind power cumulative capacity

1.4 Objective:

The main objective of the project is to design and build a wind turbine driven water pumping system to enable people who do not have them household electricity or possibility is not available to them from the provision of electricity to run the water pump and people who use fossil fuels to run water pump so the reliance on fossil fuels will decrease and this project will be an environmentally friendly.

1.5 Description for project idea:

The idea of the project based on the work of a true model of the system pumping water driven by wind turbine that to utilization wind energy, which through design a Piston mechanical pump and turbine blades to match the air in speed in West-Bank area and a connection mechanical design intended to compatibility between the piston pump motion and the rotation of wind turbine, work Stretched water tank to maintain the water pressure.

The rotor blade is on the front of a wind as wind passes by, the kinetic energy (energy of movement) it contains makes the blades spin around (usually quite slowly). The blades have a special curved shape so they capture as much energy from the wind as possible the second part is a rotor center transmit the rotational speed from turbine to gear which transmit the motion and convert it to the pump as see in figure(1.3).

Figure 1.3-The final project

1.6 Time table:

Table 1.1- Time table for first semester

Task/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project selection and proposal	■	■	■													
Information gathering				■	■											
Writing introduction						■	■									
Power and design calculation								■	■	■	■					
Windmill system												■	■			
Review the project book														■		
Printing final copy															■	■

Table 1.2- Time table for second semester

Task/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Correction on project book	■															
Drawing the project		■														
Blade calculation			■	■	■	■										
Pump calculation							■	■								
Craving the wood									■	■	■					
Select pump												■	■			
Welding and assemble														■	■	
Result																■

1.7 Budget:

Table 1.3- Budget

Component	Price (usa $)
Piston pump	100
Basic of turbine	70
Wood	200
Pipeline and tank	30
Cutting wood	300
Disc and rod	50
Bearing	20
Tower	80
	Total cost =850$

1.8 Method:

As a start, a project plan was outlined that considered the delimitation and time frame. A Gantt chart was used to visualize the deadlines for the project. An important part of the project was the field study to Palestine, to realize the windmill construction and gather data for designing the system.

Information was gathered in different ways. Internet searches and literature studies were conducted during the whole project to find the information needed. Knowledge about Palestine, the project area, culture and other conditions was mostly acquired by talking to local people and farmers and working with them. The information was verified by other sources, such as different books, websites or people, to avoid misinterpretations and prevent misunderstandings due to language difficulties.

CHAPTER TOW

Theory of turbine and pump

2.1 Palestine region:

Is a geographic region in Western Asia between the Mediterranean Sea and the Jordan River It is sometimes considered to include adjoining territories. The name was used by Ancient Greek writers.

Its Border extends longitudinally from north to south at about four degrees View, where stretches between latitudes 29.30 and 33.15 north, between latitudes 34.15 and 35.40 East Longitude, an area of 26 990 km 2, including the Sea of Galilee and a half sea dead. It bounded on the west Mediterranean coast length of 224 km, on the east by Syria, Jordan, Lebanon and the north, to the south by Egypt and the Gulf of Aqaba. And Palestine rectangular length from north to south and 430 km, and the display in the north ranges between 51-70 km, and in the center 72-95 km at Jerusalem, while in the south, the supply can accommodate up to 117 km at the Rafah and Khan Younis to the Dead Sea. The region has a very diverse land, divided geographically into four regions, namely from west to east coastal plain, and the hills, and mountains (the Galilee Mountains and the mountains of Nablus and Jerusalem Mountains and the mountains of Hebron) and the Jordan Valley (the Jordan Valley) figure(2.1) show Palestine west bank region. In the far south there Negev desert. Between Nablus Mountains and the mountains of Galilee it is located Jerzeel Valley and cut Mount Carmel, which runs from the mountains to the north west of Nablus, the coastal plain. Elevations ranging from 417 meters below sea level in the Dead Sea (the lowest point on the surface of the world's land) to 1204 meters above sea level on Mount Merion summit [1].

Figure 2.1- Palestine region[1]

2.2 Wind:

Wind primarily occurs because of temperature differences in the air caused by sun radiation. When air is heated it becomes less dense and therefore rises. The pressure at ground level decreases, and because air always flows from high pressure to low pressure, thermal circulation is then developed.

One example of this thermal circulation is the sea breeze; a local wind found in coastal areas or at large lakes. It occurs on relatively clear days when the sun heats the land more than the sea, causing the air above the land to rise and flow out over the water. The air cools off, sinks, and flows back in over land. The sea breeze can occur all year round in the tropics, and can reach a speed of 5-10 m/s at ground level. It is most extensive during the afternoons when the sun has heated the ground to a high temperature.

Wind speed and wind direction are the most required factors to identifying the power which generated from wind, and total wind energy production is growing rapidly and has reached around 4% of worldwide electricity usage.

2.3 Density of Air:

The kinetic energy of a moving body is proportional to its mass. The kinetic energy in the wind depends on the density of the air, i.e. its mass per unit of volume.

In other words, the "heavier" the air, the more energy is received by the turbine. At normal atmospheric pressure and at 15°C, the density of air is 1.225 kg/m^3, which increases to 1.293 kg/m^3 at 0°C and decreases to 1.164 kg/m^3 at 30°C. In addition to its dependence upon temperature, the density decreases slightly with increasing humidity. At high altitudes (in mountains), the air pressure is lower, and the air is less dense [9].

Air density varies with temperature and elevation. Warm air is less dense than cold air. Any given wind turbine will produce less in the heat of summer than it will in the dead of winter with

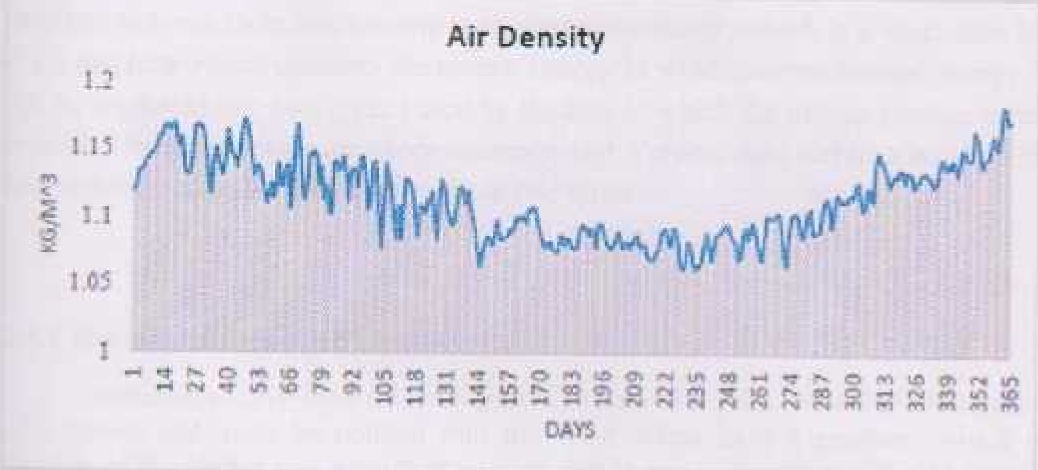

Figure 2.2- Air density

Figure (2.2) shows the average air density in Hebron city at 900-meter elevation while the annual average is 1.1141 $kg/m3$.

2.3.1 Wind power:

Wind energy or wind power is extracted from air flow using wind turbines or sails to produce mechanical or electrical energy. Windmills are used for their mechanical power, wind pumps for water pumping, and sails to propel ships. Wind power as an alternative to fossil fuels,

is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, and uses little land. The net effects on the environment are far less problematic than those of nonrenewable power sources. It can also produce disturbing noise while running.
Wind power technology has come forward since the 12th century when the first windmills were built in Europe for grinding grains into flour. In 19th century America, windmills were used for pumping water at farms. Today's wind power stations are very advanced and use complex technology, but the old-fashioned type of windmill is still being built and used. It is common all over the world, especially in developing countries, but also among famers in America and Australia [2].

One disadvantage with wind power is that it is unreliable, as the wind cannot be controlled. Hills and trees can reduce wind speed and cause the wind to change direction. With a suitable location and with good wind conditions, wind power is a good energy source.

2.4 Wind turbine:

A wind turbine is a rotary engine that extracts energy from the flow of wind. The simplest turbines have one moving part, a rotor assembly, which is a shaft with blades attached. It's a machine which converts the kinetic energy in wind into mechanical energy. Wind turbines can be separated into two types based by the axis in which the turbine rotates; turbines that rotate around a horizontal axis are more common and Vertical-axis turbines are less frequently used and in next section we will discuss these two types.

2.4.1 Horizontal axis wind turbines:

Horizontal-axis wind turbines (HAWT) have the main rotor shaft and gear box at the top of a tower, and must be pointed into the wind. 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. Since a tower produces turbulence behind it, the turbine is usually pointed upwind of the tower.

Turbine blades are 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 up a small amount.
Downwind machines have been built, despite the problem of turbulence, because they don't need an additional mechanism for keeping them in line with the wind, and because in high winds the blades can be allowed to bend which reduces their swept area and thus their wind resistance.
Since cyclic (that is repetitive) turbulence may lead to fatigue failures most HAWTs are upwind machines as it show in figure 6(b).

HAWT Advantages:

- 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 moves 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:

- Massive tower construction is required to support the heavy blades, gearbox, and generator.
- Components of a horizontal axis wind turbine (gearbox, rotor shaft and brake assembly) being lifted into position.
- 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.
- HAWTs generally require a braking or yawing device in high winds to stop the turbine from spinning and destroying or damaging itself.

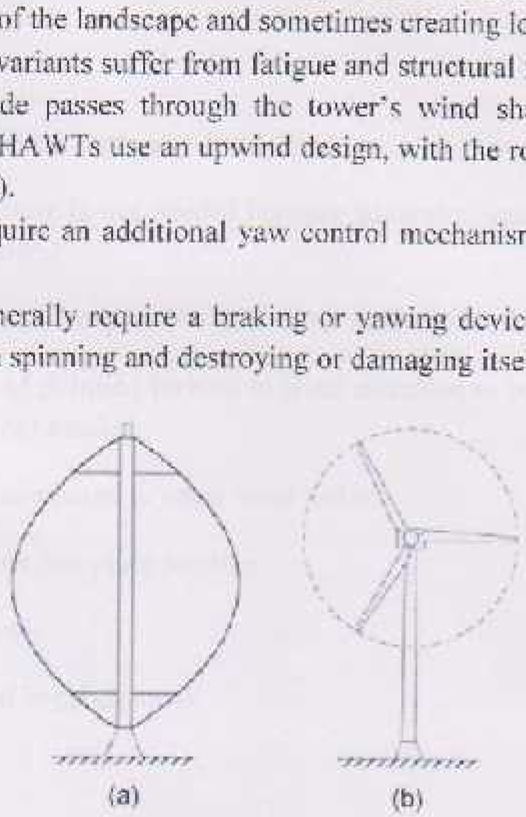

Figure 2.3 Types of Turbine

2.4.2 Vertical axis wind turbines:

Vertical axis wind turbines, as shortened to VAWTs, have the main rotor shaft arranged vertically. The main advantage of this arrangement is that the wind turbine does not need to be pointed into the wind. This is an advantage on sites where the wind direction is highly variable or has turbulent winds. With a vertical axis, the generator and other primary components can be placed near the ground, so the tower does not need to support it, also makes maintenance easier. The main drawback of a VAWT is it generally creates drag when rotating into the wind. It is difficult to mount vertical-axis turbines on towers, meaning they are often installed nearer to the base on which they rest, such as the ground or a building rooftop. The wind speed is slower at a lower altitude, so less wind energy is available for a given size turbine. Air flow near the ground and other objects can create turbulent flow, which can introduce issues of vibration, including noise and bearing wear which may increase the maintenance or shorten its service life. However, when a turbine is mounted on a rooftop, the building generally redirects wind over the roof, thus doubling the wind speed at the turbine. If the height of the rooftop mounted turbine tower is approximately 50% of the building height, this is near the optimum for maximum wind energy and minimum wind turbulence we can see this type in figure (2.3-a).[6]

VAWT Advantages:

- They can produce electricity in any wind direction.
- Strong supporting tower in not needed because generator, gearbox and other components are placed on the ground.
- Low production cost as compared to horizontal axis wind turbines.
- As there is no need of pointing turbine in wind direction to be efficient so yaw drive and pitch mechanism is not needed.
- Easy installation as compared to other wind turbine.
- Easy to transport from one place to other.
- Low maintenance costs.
- They can be installed in urban areas.

VAWT Disadvantages:

- As only one blade of the wind turbine works at a time, efficiency is very low compared to HAWTS.
- They need an initial push to start; this initial push that to make the blades start spinning on their own must be started by a small motor.
- When compared to horizontal axis wind turbines they are very less efficient because of the additional drag created when their blades rotate.
- They have relative high vibration because the air flow near the ground creates turbulent flow.
- Because of vibration, bearing wear increases which results in the increase of maintenance costs.
- They can create noise pollution.
- VAWTs may need guy wires to hold it up (guy wires are impractical and heavy in farm areas).

2.5 Pumps:

A hydraulic pump is a mechanical source of power that converts mechanical power into hydraulic energy (hydrostatic energy i.e. flow, pressure), It generates flow with enough power to overcome pressure induced by the load at the pump outlet. Hydraulic pumps are used in hydraulic drive systems and can be hydrostatic or hydrodynamic. There are three general types of water pumps: centrifugal pumps and Gear pump and piston pumps. These types follow the same purpose, which is to move water from one point to another continuously and it will illustrate each pump in the next sections.

2.5.1 Centrifugal pumps:

A centrifugal water pump uses a rotating impeller to move water into the pump and pressurize the discharge flow. Standard, trash and submersible models are three different alternatives to centrifugal water pumps. All liquids can be pumped using centrifugal water pumps, even liquid with low viscosity. These pumps work great with thin liquids and high flow rates see figure (2.4) that illustrate the centrifugal pump.

Speed of this pump equal from 3000 to 1200 rpm and the from 135 to 800 bar and the efficiency 90-98%.

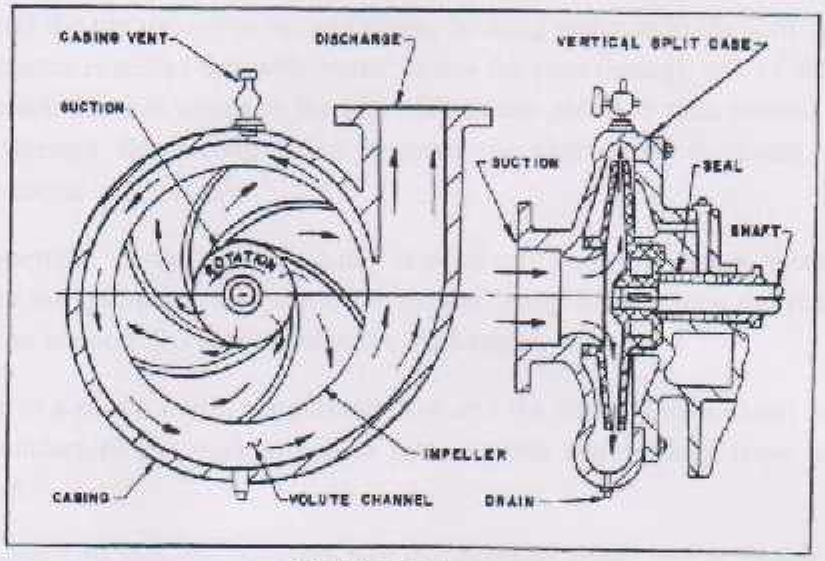

Figure 2.4- Centrifugal pump

2.5.2 Gear pump:

Positive displacement designs are the ones which deliver a fixed amount of flow through the mechanical contraction and expansion of a flexible diaphragm. These pumps are ideal in many industries that manage high viscosity liquids, or where sensitive solids are also present. Recommended water pumps to be used for low flow and high pressure combination or other

Speed of this pump equal from 1200 to 2500 rpm and from 130 to 200 bars and the efficiency 80-90%.

Applications figure (2.5).

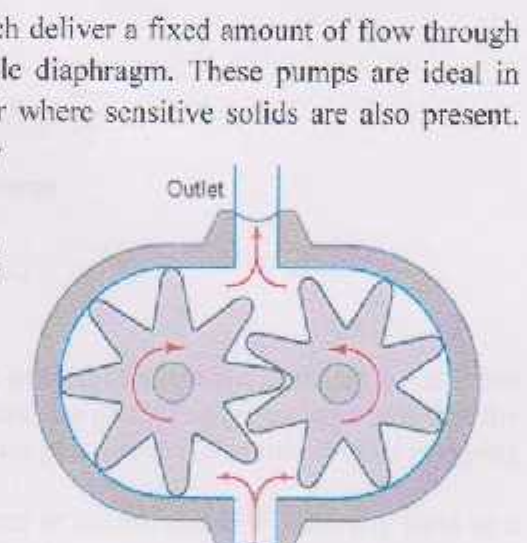

Figure 2.5- Gear pump

2.5.3 Piston pump:

A piston pump is a simple construction. It consists of a cylinder pipe with a piston inside and two non-return valves placed opposite each other. When mechanical work is exerted on the connecting rod the piston moves up and down, sucking water in to the pipe and then pumping it out. As the piston is pulled upwards, water enters the pipe through one of the valves because of the low pressure that has arisen in the pipe. When the piston is then pushed down, the water is forced out through the second valve because the first valve is closed. By repeating this movement water is transported

The torque required to start a piston pump is relatively high, because it needs to overcome both the weight of the pump rod and that of the water being lifted. Once the rotor is turning, wind speed can drop to about 2/3 compared to the start speed.

The capacity of a piston pump is relatively low and the water flow will not be constant, but it is cheap to manufacture and easy to use. A piston pump can produce large head even with low rotation speed.

A piston pump Test required pressure and the required speed and is almost 200 m and do not require a large mechanical ability to operate and also simple figure (2.6) show piston pump.

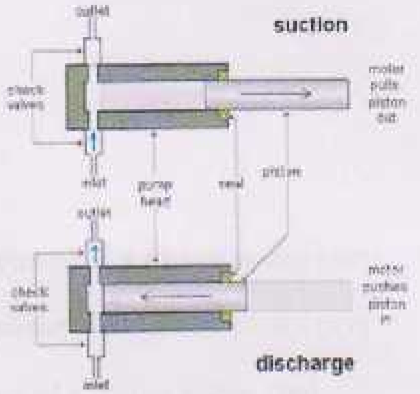

Figure 2.6- Piston pump

2.5.3.1 Semi rotary pump:

A semi-rotary pump works like a piston pump, but instead of a straight connecting rod it has a lever. The lever is rotated back and forth in a semi-circular path. The leverage means that the semi-rotary pump does not need as much force as a piston pump to perform the work of pumping liquids.

It is suitable for liquids with low viscosity, such as water or diesel, and it is generally used as a hand pump. Since it is sensitive to dirt that may come in the system it is not optimal to use this type of pump for irrigation.

Chapter Three

Pumps Selection

3.1 Introduction

3.2 Operating speed

3.3 Performance

3.3.1 Mechanical efficiency of a piston pump (ηm)

3.3.2 Volumetric efficiency of a piston pump (ηv)

3.3.3 Overall efficiency of a piston pump (ηo)

3.4 Sizing

3.5 Reciprocating pump

3.1 Introduction

Choosing the right pump in this project is very important; where the power delivered to the pump is not constant so the selection depends on the required flow rate and the angular velocity which delivers from the turbine and as we know the output speed from turbine is not constant and the range of speed doesn't high so we need a pump where could run and deliver pressure at these condition, as we discus in the previous chapter , the choose were on the piston pump which could work over all these conditions and it's the best pump for this project, which could give flow under small and higher input speed.

Note that, we were not used other pump because they required a high input speed for working some of pumps needs more than 1000 rpm to run, the design depends on many properties which it discussed in the next sections.

3.2 Operating speed

The operating speed in pumps; is the range between minimum running speed and maximum, it's an important specification to choosing the pump in this project, also Minimum speed is less than the input speed and goes from idle state. Operating at less than the minimum speed limits the ability of the pump to maintain adequate flow, Maximum speed is the highest operating speed permitted. Exceeding maximum speed reduces from pumps life and can cause loss of hydrostatic power and braking capacity and it could make a failure.

3.3 Performance:

3.3.1 Mechanical efficiency of a piston pumps (η_m):

Mechanical efficiency of a pump (η_m) is the ratio of theoretical power that must be supplied to operate the pump to the actual power delivered to the pump. Mechanical efficiency can be used to determine the power loss in bearings and other moving parts of a piston pump [3]. It determines the actual power that must be supplied to a piston pump for desired result

$$\text{Mechanical efficiency } (\eta m) = \frac{\text{Theoretical power that must be delivered to a pump}}{\text{Actual power delivered to the pump}} \times 100\,\% \qquad \text{..........(1)}$$

3.3.2 Volumetric efficiency of a piston pumps (η_v):

Volumetric efficiency of a pump (η_v) is defined as the ratio of the actual flow rate delivered by the pump to the theoretical discharge flow rate (flow rate without any leakage) that must be produced by the pump [3].

Volumetric efficiency can be used to determine the amount of loss of liquid due to leakage in a pump during the flow.

$$\text{Volumetric efficiency } (\eta v) := \frac{\text{Actual flow rate produced by a pump}}{\text{Theoretical flow rate that must be produced by the pump}} \times 100\,\%$$

.........(2)

3.3.3 Overall efficiency of a piston pumps (η_o):

Overall efficiency of a pump (η_o) is the ratio of the actual power output of a pump to the actual power input to the pump. It is the efficiency that determines the overall energy loss in a piston pump [3].

Overall efficiency of a piston pump is the product of the volumetric efficiency and mechanical efficiency of a piston pump.

Overall efficiency of a piston pump (η_o) = (η_m) × Volumetric efficiency (η_v) ....(3)

figure (3.1) show a general chart for pumps efficiency .

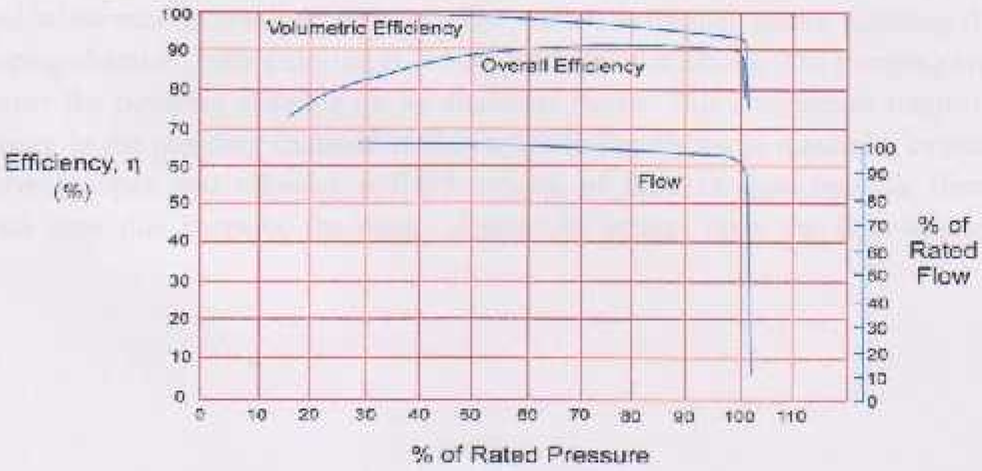

Figure 3.1- Pump performance curve[3]

3.4 Sizing:

Sizing of a pump is the maximum ability of the system before failed and to determine that we must to know the flow rate of liquid the pump is required to deliver and the total differential head the pump must generate to deliver the required flow rate, in this small turbine project we will not need to calculate the sizing cause the turbine don't deliver a very high speed and it will never reach to failure.

3.5 Reciprocating Pumps :

By definition a reciprocating pump is any machine using reciprocating motion to cause fluid to be moved from one location to another, the most common form of reciprocating pump is the positive displacement type.

This type of pump traps a fixed volume of fluid and displaces it from suction conditions to discharge conditions by means of check valves placed in series, with at least one on the suction side and at least one on the discharge side. These check valves ensure fluid movement is in one direction from pump suction toward the pump discharge as we can see in figure(3.2) . Since a fixed volume of fluid is displaced, the rate of flow is directly proportional to speed. Using a pump with multiple plungers or pistons can also increase capacity. Pump speed and number of plungers/pistons available is limited by mechanical considerations. As a result of the fixed displaced volume per pump revolution and the fact that pressure is independent of pump speed and flow rate. When the pump starts on suction stroke, the pumping element begins to withdraw from the pumping chamber (area between suction and discharge valves), and pumping chamber pressure drops below suction manifold pressure. The suction valve then opens, allowing flow to enter the pumping chamber, before closing at the end of the suction stroke. The pumping element begins to reenter the pumping chamber on its discharge stroke. This compresses trapped fluid until the pressure in the pumping chamber is above that in the discharge manifold, causing the discharge valve to open and allowing a fixed volume of fluid to flow into tile discharge manifold. Each time this happens, the pump element is 'acting' upon the fluid that causes pumping.

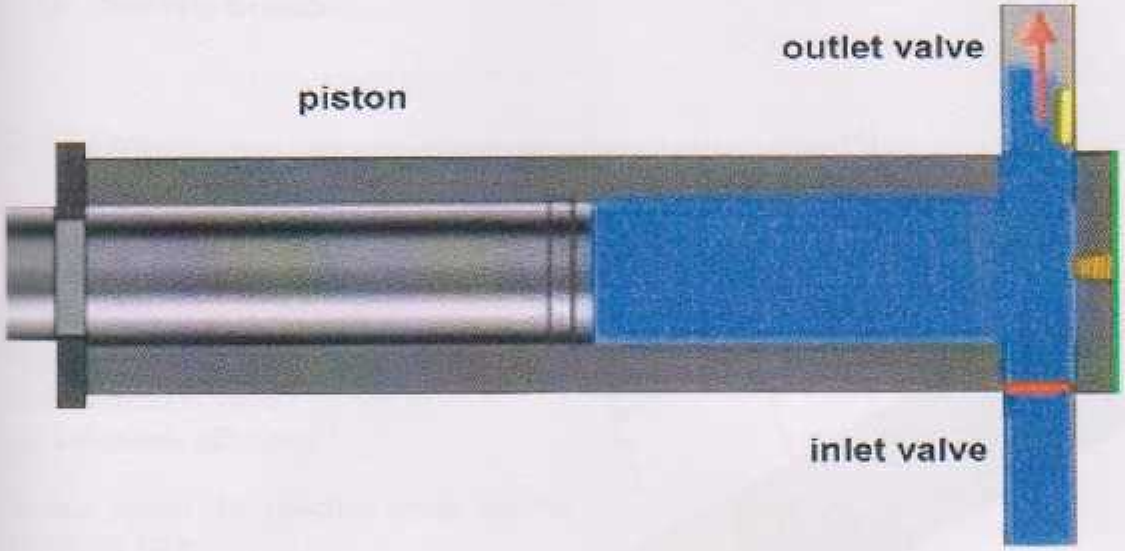

Figure 3.2- Piston reciprocating pump

A common type of reciprocating pump is piston pump , the main operating component of the piston pump is cylinder in which piston is moving. The piston reciprocates by means of crank mechanism, thus providing consistent variation of operating chamber volume. In one complete turn of crank from the end point the piston makes full forward stroke (discharge) and reverse stroke (suction). During discharge in cylinder the piston creates overpressure, under the action of which suction valve opens and discharge valve closes, and fluid being pumped is delivered to the delivery pipeline. During suction reverse process takes place, during which vacuum is created in cylinder through piston backward movement; discharge valve closes preventing return flow of pumped fluid, and suction valve opens and cylinder is filled through it. Real performance capacity of piston pumps is somewhat different from theoretical, which is related to a number of factors, such as fluid leakages, degassing of gases dissolved in pumped fluids, delays in opening and closing of valves, etc.

For single-acting piston pump the calculation design will be as the next point.

- **flow rate formula :**

$Q = F \cdot S \cdot n \cdot \eta_v$ .... (4)

Where:

Q: flow rate
F: piston cross-sectional area
S: piston stroke length
n: shaft rotation speed
η_v: volumetric efficiency

In this project the selection pump has the following value:

$F = 0.000192 m^2$
$S = 0.135 m$
$N = 200 rpm$
$\eta V = 95\%$
$Q_{theoretical} = 50 L/min$

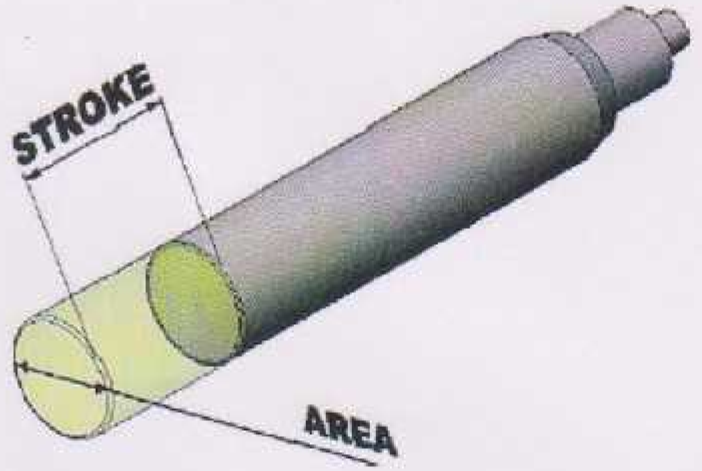

Figure 3.3- Piston pump parts

- **Calculation of head :**

As it was stated above, the head is not geometrical characteristic and cannot be identified with height to which pumped fluid has to be lifted. The required head value is composed of several summands, with each of them having its own physical sense.

In optimum design the major and manor losses take as one and multiply the height of pipes with a factor which is 1.5 that's how we get the height losses in pipe, where we have 10 meter height after multiply by factor 1.5 it will be 15 meter head from tank to maximum height.[8]

- **Calculation of pump power consumption :**

Several kinds of power are singled out according to transmission losses taken into account by different efficiency coefficients. Power spent directly on transmission of pumped fluid energy is calculated by the formula:

$N_{II} = \rho \cdot g \cdot Q \cdot H$ .... (5)

Where :

NΠ – useful power
ρ – density of the pumped medium
g – gravity acceleration
Q – flow rate
H – total head

In this project the theoretical variable value is:
$\rho = 1000 kg/m^3$
$g = 9.81 m/s^2$
$Q = 0.000833 m^3/s$
$H = 10 m$
$P_{out} = 81.4 watt$

Power developed on pump shaft is larger than the useful one, and its excess is consumed for compensation of pump power losses. Interrelation between useful power and shaft power is set by pump efficiency. The pump efficiency includes leakages through seals and openings (volumetric efficiency), losses of head while pumped medium is flowing inside pump (hydraulic efficiency), and friction losses between moving parts of the pump, such as bearings and glands (mechanical efficiency).

$\eta_{II} = N_{II} / N_B$ .... (6)

where :

NB – power on pump shaft
NΠ – useful power
ηΠ – pump efficiency

As we see the power input is equal 126.18watt and the output is 81.4watt , so the theoretical efficiency for the pump is 64%.

Chapter four

Basic design for turbine

4.1 Wind Speed and Power:

Before venturing into the dynamics of wind flow, we should first differentiate between wind speed and wind power.

4.1.1 Wind Speed:

Wind speed is the rate at which air flows past a point above the earth's surface. Wind speed can be quite variable and is determined by a number of factors, also local airport and weather stations can sometimes provide us with this information. The National Renewable Energy Laboratory in Golden, also Windyty.com publishes an excellent wind Energy Resource for free, The Available data is for 5 years range at elevation of 900-meter above sea, figure (4.1) shows the average wind speed per months.

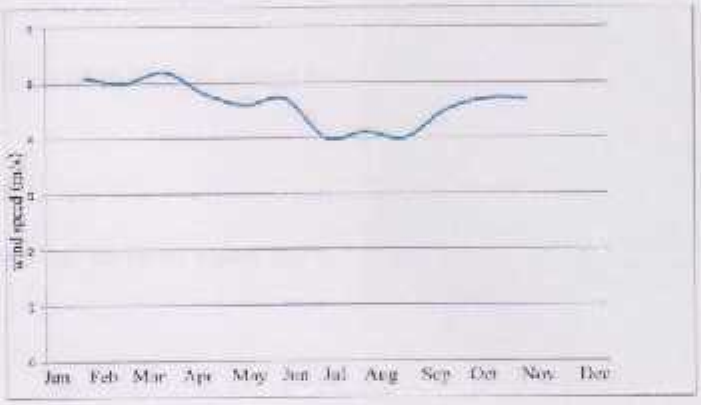

Figure 4.1- Mean wind speed in Hebron over moths

and figure (4.2) show the wind speed in Hebron on Saturday 5/12/2015 at 7PM the wind speed is 4.6 m/s.

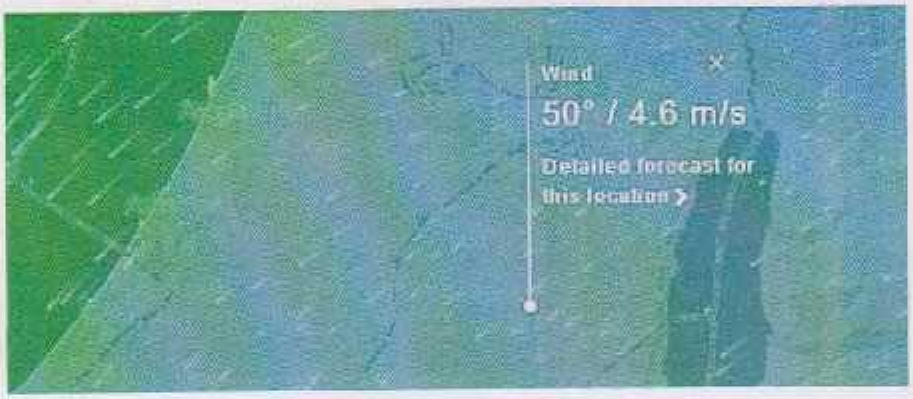

Figure 4.2- Wind speed in Hebron

4.1.2 Turbine Wind Power:

Wind power is a measure of the energy available in the wind. It is a function of the cube (third power) of the wind speed. If the wind speed is doubled, power in the wind increases by a factor of eight from the equation :

Power in the Wind = $\frac{1}{2}\rho C_P A V^3$ .... (7)

Where:

ρ: Effect of air density.

C_P power coefficient "Turbine efficiency".

A: Effect of swept area.

Swept Area: $A = \pi R^2$ Area of the circle swept by the rotor (m^2).

V: Effect of wind speed.

In this project the theoretical variable value are :
ρ=1.12kg/m^3
C_P=35%
A=7.065m^2
V=91.125m/s
P_{wind}=126.18watt

And Figure(4.3)illustrate the equations parameter.

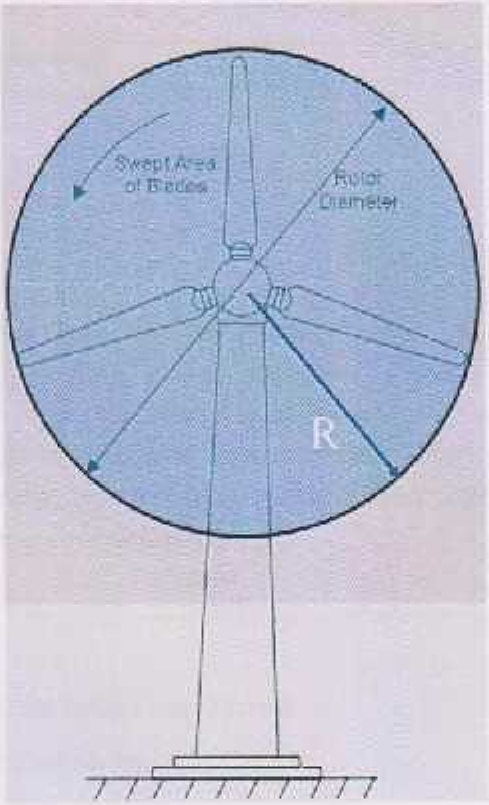

Figure 4.34- wind turbine parameter

This equation states that the power is equal to one-half, times the air density, times the rotor area, times the cube of the wind speed. Air density varies according to elevation, temperature and weather fronts and the figure(4.4) show the power output at each wind speed.

The power coefficient describes that fraction of the power in the wind that may be converted by the turbine into mechanical work. It has a theoretical maximum value of 0.593 (the Betz limit) which is talked about in the next section.

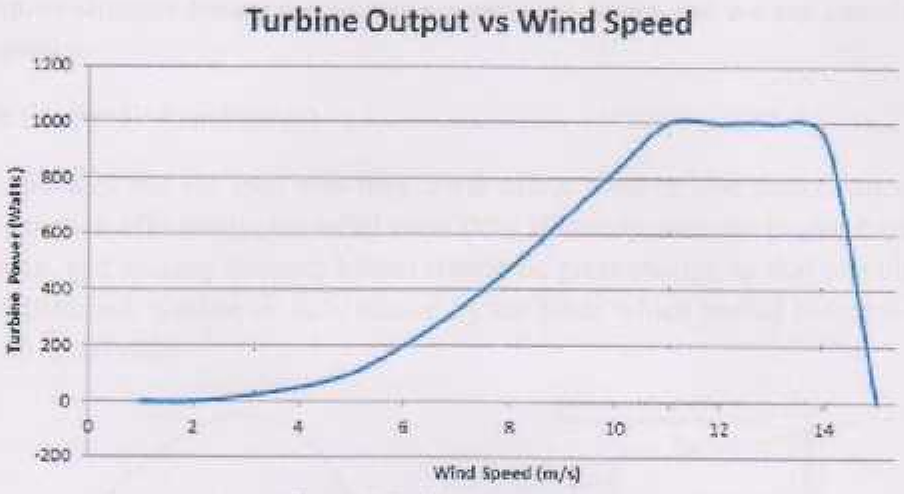

Figure4.5- Turbine Power curve

4.1.3 Betz' Law:

Betz's law calculates the maximum power that can be extracted from the wind, independent of the design of a wind turbine in open flow. It was published in 1919, by the German physicist Albert Betz. The law is derived from the principles of conservation of mass and momentum of the air stream flowing through an idealized "actuator disk" that extracts energy from the wind stream. According to Betz's law, no turbine can capture more than 16/27 (59.3%) of the kinetic energy in wind as the following equation illustrate:

$$P_o = \frac{1}{2}\ mass\ flow\ rate\ per\ second.\{V^2 - V_o^2\} \qquad (8$$

Where P_o = mechanical power extracted by the rotor, i.e., the turbine output power.

V = upstream wind velocity at the entrance of the rotor blades.

V_o = downstream wind velocity at the exit of the rotor blades.

This factor 16/27 (0.593) is known as Betz's [4] coefficient. Practical utility-scale wind turbines achieve at peak 75% to 80% of the Betz limit.

4.1.4 tip-speed ratio:

The tip-speed ratio "λ" or TSR for wind turbines is the ratio between the tangential speed of the tip of a blade and the actual velocity of the wind. The tip-speed ratio is related to efficiency, with the optimum varying with blade design. Higher tip speeds result in higher noise levels and require stronger blades due to large centrifugal forces and we can calculate the ratio from the equation:

TSR = (Blade tip speed)/ (wind speed) .... (9)

The number of blades and the total area they cover affect wind turbine performance. For a lift-type rotor to function effectively, the wind must flow smoothly over the blades figure (4.5). To avoid turbulence, and spacing between blades should be great enough so that one blade will not encounter the disturbed, weaker air flow caused by the blade which passed before it figure (4.5) illustrate the tip speed ratio.

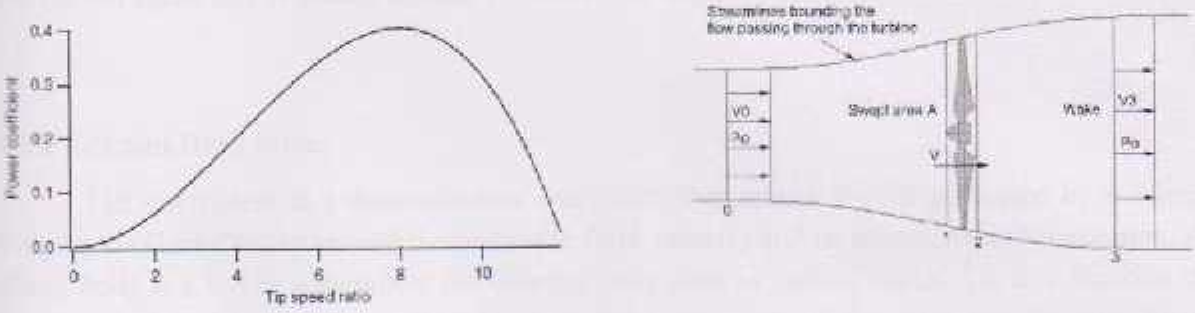

Figure 4.5- Tip speed ratio

4.1.5 Cut-in Speed:

At very low wind speeds, there is insufficient torque exerted by the wind on the turbine blades to make them rotate. However, as the speed increases, the wind turbine will begin to rotate. The speed at which the turbine first starts to rotate and gears rotate is called the cut-in speed and is typically 3 meters per second figure (4.6) shows the speed to power curve and cut-in speed.

4.1.6 Rated output power and rate output wind speed:

As the wind speed rises above the cut-in speed, the level of electrical output power rises rapidly as shown. However, typically somewhere between 12 and 17 meters per second, the power output reaches the limit that the power generator is capable of. This limit to the power output is called the rated power output and the wind speed at which it is reached is called the rated output wind speed. At higher wind speeds, the design of

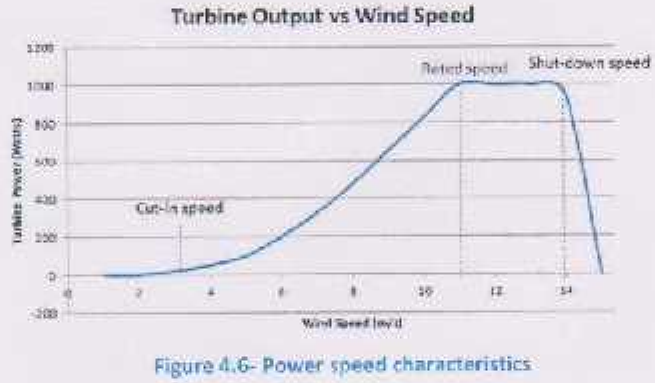

Figure 4.6- Power speed characteristics

the turbine is arranged to limit the power to this maximum level and there is no further rise in the output power figure (4.6) show the rated power curve with wind speed and turbine power.

4.1.7 Shut-down speed:

Cut-out or shut-down speed, as the speed increases above the rate output wind speed, the forces on the turbine structure continue to rise and, at some point, there is a risk of damage to the rotor. As a result, a braking system is employed to bring the rotor to a standstill. This is called the cut-out speed and is usually around 25 meters per second.

4.1.8 Lift and Drag force:

Lift coefficient is a dimensionless coefficient that relates the lift generated by a lifting body to the fluid density around the body, the fluid velocity and an associated reference area. A lifting body is a foil or a complete foil-bearing body such as turbine blades. CL is a function of the angle of attack. Lift force is defined as the component of the total aerodynamic force perpendicular to the flow direction and it refers to the dynamic lift characteristics of a two-dimensional foil section, with the reference area replaced by the foil chord, as in the following equation

$F_L = 1/2\ C_L\ \rho\ v^2\ A$ ....(10)

where:

F_L: the left force and equal 6.5 kN

ρ: fluid density

v: air speed

A: plane area which equal the chord multiply by blade length

C_L: lift coefficient

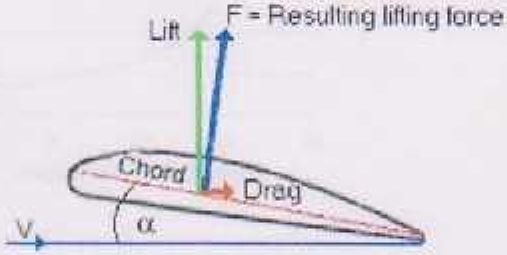

Figure 4.7- Forces parameter

And drag force is the same, figure(4.7) show the variable at chord but it's the component parallel to the flow direction dynamic and its formula look as the following :

$F_D = ½\, C_d\;\, A\, r\, V^2$ .... (11)

where:

F_D: Drag force and equal 1.12 kN

A: plane area which equal the chord multiply by blade length.

C_d: Drag coefficient.

V: relative Velocity.

ρ: Density of fluid.

Also the figure (4.8) show the relation between lift and drag coefficients and angle of attack.

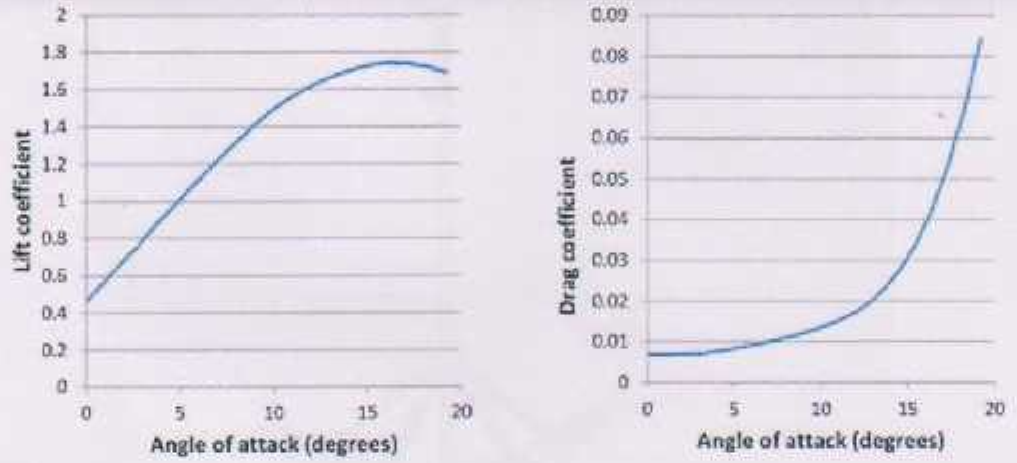

Figure 4.8- lift and Drag forces vs angle of attack

4.2 Tower:

A wind turbine tower is not just a support structure. It raises the wind turbine so that its blades safety clears the ground and so it can reach the cleaner, stronger winds at higher elevations. As a

Figure 4.9-Turbine component

general rule it is better to go for as high a tower as makes economic sense. At higher elevations the wind is usually much stronger. Power output from a wind turbine is a function of the cube of the wind speed so even small increases in wind speed from a taller tower can have a huge impact on energy production. The decision of what height tower to use will be based on the cost of taller towers versus the value of the increase in energy production resulting from their use. Usually when you buy a small wind system it comes packaged with a wind tower which is a good match for the size and scale of the turbine. These towers represent 30% – 65% of the turbine weight and therefore account for a large percentage of the turbine transportation costs figure(4.9) show the turbine component include the tower. So the use of lighter materials in the tower could greatly reduce the overall transport and construction cost of wind turbines, however the stability must be maintained and it's important that works as support structure.

4.2.2 Turbine steel tower:

The tubular steel tower is a proven concept that delivers short installation time, optimized logistics, and excellent cost efficiency. Steel segments tower with diameter 0.08 meter and 180 meter height which stacked and joined at the construction site as show in figure(4.10).

Figure 4.10- Turbine Steel tower

The base tower connected to another tower by joints and bearing the other rod tower have a diameter with 0.03 meter and height of 1.2 meter are stacked and joined to the base tower as show, this design allow the turbine to rotate owing to the bearing connected in the tower as figure(4.10) illustrate.

4.3 Aerodynamic consideration:

The primary application of wind turbines is to extract energy from the wind. Hence, the aerodynamics is a very important aspect of wind turbines. Like many machines, there are many different types all based on different energy extraction concepts. Similarly, the aerodynamics of one wind turbine to the next can be very different

Overall the details of the aerodynamics depend very much on the topology. There are still some fundamental concepts that apply to all turbines. Every topology has a maximum power for a given flow, and some topologies are better than others. The method used to extract power has a strong influence on this. In general all turbines can be grouped as being lift based, or drag based with the former being more efficient. The difference between these groups is the aerodynamic force that is used to extract the energy [5]

The governing equation for power extraction is given below:

$$P = f * v \quad \text{.......} \quad (12)$$

Where:

P: the power

F: the force vector

V: the velocity of the moving wind turbine part.

The force F is generated by the wind interacting with the blade. The primary focus of wind turbine aerodynamics is the magnitude and distribution of this force. The most familiar type of aerodynamic force is drag. The direction of the drag force is parallel to the relative wind. Typically, the wind turbine parts are moving, altering the flow around the part. An example of relative wind is the wind one would feel cycling on a calm day.

To extract power, the turbine part must move in the direction of the net force. In the drag force case, the relative wind speed decreases subsequently, and so does the drag force. The relative wind aspect dramatically limits the maximum power that can be extracted by a drag based wind turbine. Lift based wind turbine typically have lifting surfaces moving perpendicular to the flow. Here, the relative wind will not decrease in fact it increases with rotor speed. Thus the maximum power limits of these machines is much higher than drag based machines

4.4 Airfoil geometry and classification:

Airfoil is the shape of a wing, blade of a propeller, rotor, or turbine, or sail, an airfoil-shaped body moved through a fluid produces an aerodynamic force figure (4.11) show airfoil pieces. The component of this force perpendicular to the direction of motion is called lift. The component parallel to the direction of motion is called drag. Subsonic flight airfoils have a characteristic shape with a rounded leading edge, followed by a sharp trailing edge, often with a symmetric curvature of upper and lower surfaces.

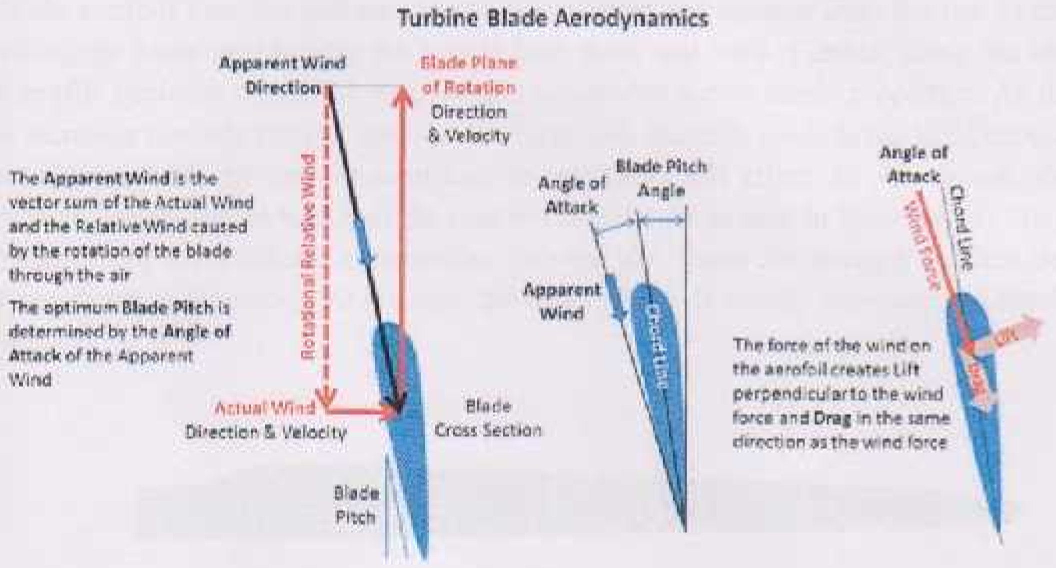

Figure 4.11- Aerodynamic characteristic at blade section

4.5 Blade Characteristics:

The design of the outer contour of a wind turbine rotor blade is based on aerodynamic considerations. The cross-section of the blade has a streamlined asymmetrical shape, with the flattest side facing the wind. Once the aerodynamic outer contour is given, the blade is to be designed to be sufficiently strong and stiff. The blade profile has two faces the upper on the suction side, and the lower shell on the pressure side to make the blade sufficiently strong as we can see in figure (4.12). From a structural point of view, this web will act like a beam, and simple beam theory can be applied to model the blade for structural analysis in order to determine the overall strength of the blade [6].

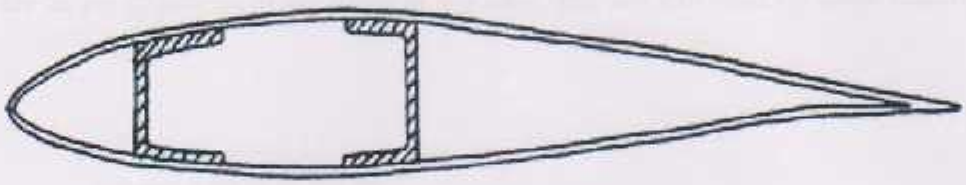

Figure 4.12- airfoil upper and lower shells

The blade sections near the hub are able to resist forces and stresses from the rest of the blade. Therefore, the blade profile near the root is both thick and wide. Further, along the blade, the blade profile becomes thinner so as to obtain acceptable aerodynamic properties. As the blade speed increases towards the tip, also the lift force will increase towards the tip. Decreasing the chord width towards the tip will contribute to counteract this effect. In other words, the blade tapers from a point somewhere near the root towards the tip as seen in figure (4.13). In general, the blade profile constitutes a compromise between the desire for strength and the desire for good aerodynamic properties. At the root, the blade profile is usually narrower and tubular to fit the hub.

Figure 4.13- Side view of Blade

The modern blade can be divided into three main areas classified by aerodynamic and structural function:

The blade root: The transition between the circular mount and the first airfoil profile this section carries the highest loads. Its low relative wind velocity is due to the relatively small rotor radius. The low wind velocity leads to reduced aerodynamic lift leading to large chord lengths. Therefore the blade profile becomes excessively large at the rotor hub. The problem of low lift is compounded by the need to use excessively thick airfoil sections to improve structural integrity at this load intensive region. Therefore the root region of the blade will typically consist of thick airfoil profiles with low aerodynamic efficiency figure (4.14) show the regions.

The mid span: Aerodynamically significant the lift to drag ratio will be maximized therefore utilizing the thinnest possible airfoil section that structural considerations will allow.

The tip: Aerodynamically critical the lift to drag ratio will be maximized; Therefore using slender airfoils and specially designed tip geometries to reduce noise and losses. Such tip geometrics are as yet unproven in the field; in any case they are still used by some manufacturers [4].

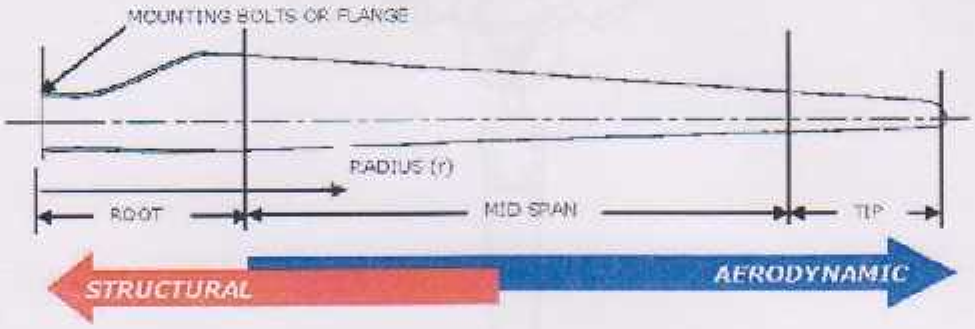

Figure 4.14- Blade region

4.6 structure dynamic:

Support structure dynamics, it is desirable to be able to replace the rotor in the numerical model by a simplified, computationally more efficient representation. Ideally, this would only be a force/momentum time series acting on the tower top and a single damper element to represent the aerodynamic damping.

4.7 Blades design:

Wind turbine rotor blades look a lot like the wings of an aircraft In fact; rotor blade designers often use classical aircraft wing profiles as cross sections in the outermost part of the blade figure (4.15) show a blade.

The thick profiles in the innermost part of the blade, however, are usually designed specifically for wind turbines. Choosing profiles for rotor blades involves a number of compromises including reliable lift and stall characteristics, and the profile's ability to perform well even if there is some dirt on the surface (which may be a problem in areas where there is little rain

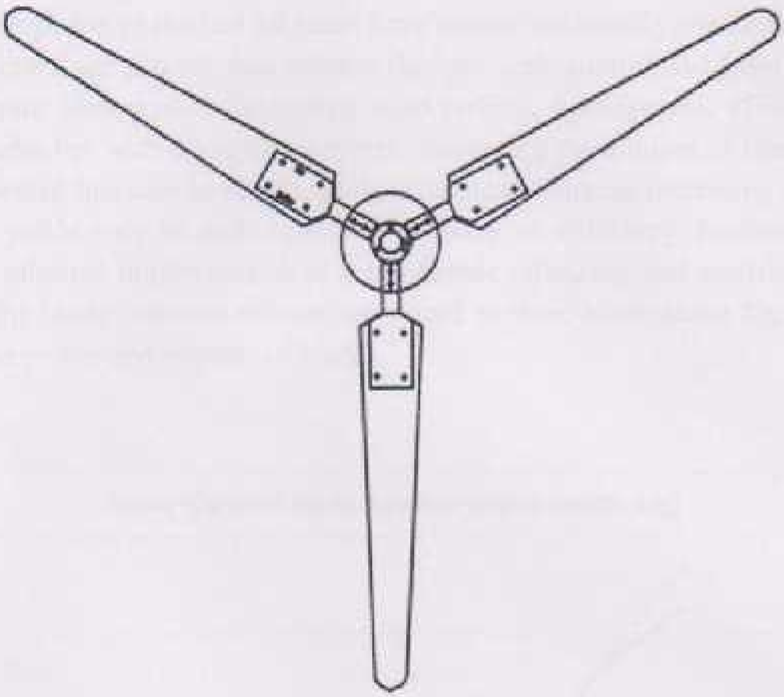

Figure 4.15- 3 Rotor blade

Most modern rotor blades on large wind turbines are made of glass fiber reinforced plastics, (GRP), i.e. glass fiber reinforced polyester or epoxy.

Using carbon fiber or aramid (Kevlar) as reinforcing material is another possibility, but usually such blades are uneconomic for large turbines.

Wood, wood-epoxy, or wood-fiber-epoxy composites have not penetrated the market for rotor blades, although there is still development going on in this area. Steel and aluminum alloys have problems of weight and metal fatigue respectively. They are currently only used for very small wind turbines.

4.7.1 Number of rotor blade:

The number of blades is selected for aerodynamic efficiency, component costs, and system reliability. Noise emissions are affected by the location of the blades upwind or downwind of the tower and the speed of the rotor. Given that the noise emissions from the blades' trailing edges and tips vary by the power of blade speed, a small increase in tip speed can make a large difference [7].

Wind turbines developed over the last 50 years have almost universally used either two or three blades. However, there are patents that present designs with additional blades, such as Chan Shin's Multi-unit rotor blade system integrated wind turbine. Aerodynamic efficiency increases with number of blades but with diminishing return. Increasing the number of blades from one to two yields a six percent increase in aerodynamic efficiency, whereas increasing the blade count from two to three yields only an additional three percent in efficiency. Further increasing the blade count yields minimal improvements in aerodynamic efficiency and sacrifices too much in blade stiffness as the blades become thinner but i need to three blade curve figure (4.16) show the relation between power and number of blades.

Figure 4.16- Power curve vs blade number

4.7.2 Blade angle:

the angle between the chord of a propeller or rotor blade and a plane normal to the axis of rotation, its value varying along the span and decreasing from root to tip because of blade twist .

Blade angle (β) = atan (2R/3rλ) – α .... (13)

Where:

R: Blade radius

r: Radius at calculation

λ: Tip speed ratio

α: Angle of attack

From the equation we found out the blade angle for each section is:

Table 4.1- Blade angle

Station	Blade angle
1	18.17 ⁰
2	9.88 ⁰
3	5.91 ⁰
4	3.6 ⁰
5	2.1 ⁰
6	1.04 ⁰

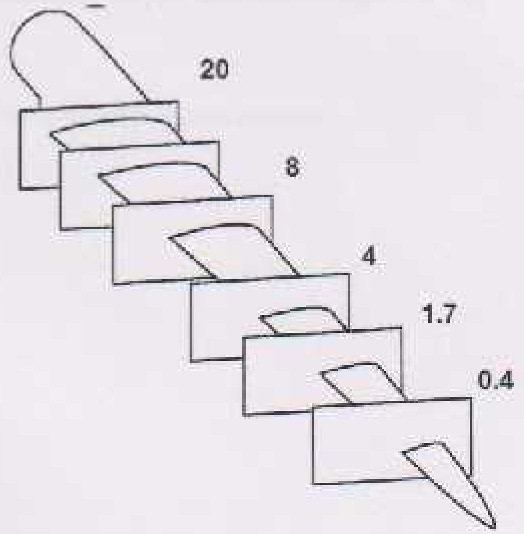

Figure 4.175- Blade angle at each section

4.7.3 Chord width :

The Chord of the blade is the width (the distance between the leading edge and the trailing edge) and it gets less (the blade gets narrower) as the diameter gets larger, With certain simplifications, mainly by neglecting airfoil drag and tip vortex losses, a mathematical formula which can be analytically resolved can be derived for the aerodynamically optimum chord distribution over the blade length :

$$\text{Chord} = \frac{16\,\pi\,R2}{9\,r\,\beta\,tsr2\,Cl} \quad \dots\dots (14)$$

Where:

R: blade radius

r: radius of calculation

B: number of blade

Tsr: tip speed ratio

C_L coefficient of lift

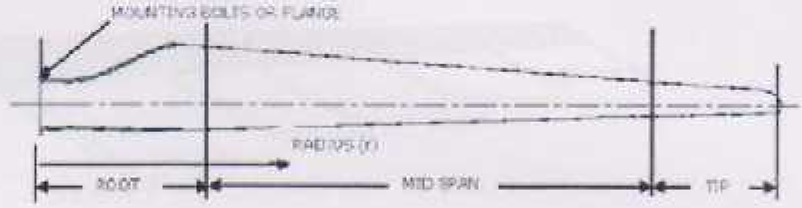

Figure 4.18- chord length parameter

Table 4.2- Chord width

Station	Chord (m)
1	0.227
2	0.142
3	0.103
4	0.081
5	0.0669
6	0.0569

This formula provides useful results for an approximated calculation of the blade contour, it's The optimum chord length distribution of the blade length and the figure(4.18) show the parameter of equation[6].

4.7.4 Blade thickness :

The blade as a structural beam The lift force on the blade, which drives the turbine round, is distributed along the blade approximately in proportion to the local radius, i.e. there is more lift force close to the tip than there is near the hub.

The lift force tends to make the blade bend. If we look at a section of the blade at some point along its length, all the lift forces outboard of that point will have a cumulative effect on the tendency to bend, with those furthest away having the greatest effect as they have the greatest leverage. The effect is called bending moment. The bending moment is greatest at the root of the blade; at this point there is more blade outboard (contributing to bending moment) than at any other point along the blade. At the tip the bending moment drops to zero.

So it is intuitive that the blade must be thickest, i.e. strongest, at the root and can taper in thickness towards the tip where the bending moment is less. As it happens, that suits the aerodynamics too: the blade needs a thinner section at the tip where drag is most critical and the local chord (width) of the blade is small.

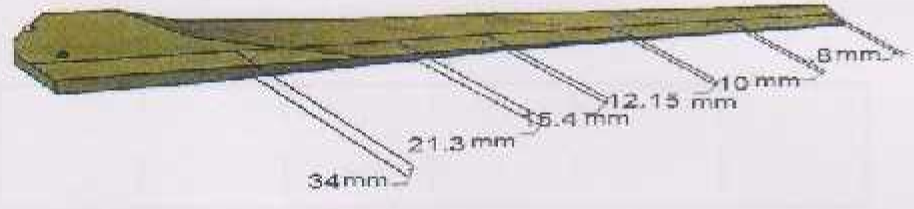

Figure 4.19- Blade thickness

Also for turbines that rely on stall for power regulation in strong winds, a thin section stalls more easily so is beneficial at the tip. Closer to the root the chord is wider, but to avoid making it very wide (hence expensive) the blade needs to be thicker to generate enough lift given the lower wind speed close to the hub (thicker airfoils can generate a greater maximum lift before they stall). Unfortunately the thickness needed to make the blade stiff and strong enough is greater than that required for aerodynamic efficiency as we can see in figure (4.19).

The existing thickness-to-chord ratios of the airfoils used must, therefore, be chosen with consideration of stiffness and strength aspects. In the outboard section of the rotor blades, which is of special interest from the aerodynamic point of view, a thickness ratio of between 15 and 12% is usual. In the inner section, near the blade root, blade thickness , The blade plan form in most cases is chamfered at the root so that the airfoil section can converge into the circular cross-section of the hub flange is increased.

The table below show the thickness at each station :

Station	Blade thickness (mm)
1	34
2	21.3
3	15.4
4	12.15
5	10
6	0.85

Table 4.3- Blade thickness

4.8 Carving the wood:

After we calculate the dimensions and angle of the blades we want to crave each blades as the following steps:

The first step:

We specify the shape at a series of stations along the length of the blade each station has 250mm length and at each station the blade has chord width, blade angle and thicknesses. When carving a blade from a piece of wood (a work piece) we can instead specify the width of the work piece and also what call the drop. These measurements will then produce the correct chord width and blade angle. The drop is a measurement from the face of the work piece to the trailing edge of the blade as we can see in figure (4.20).

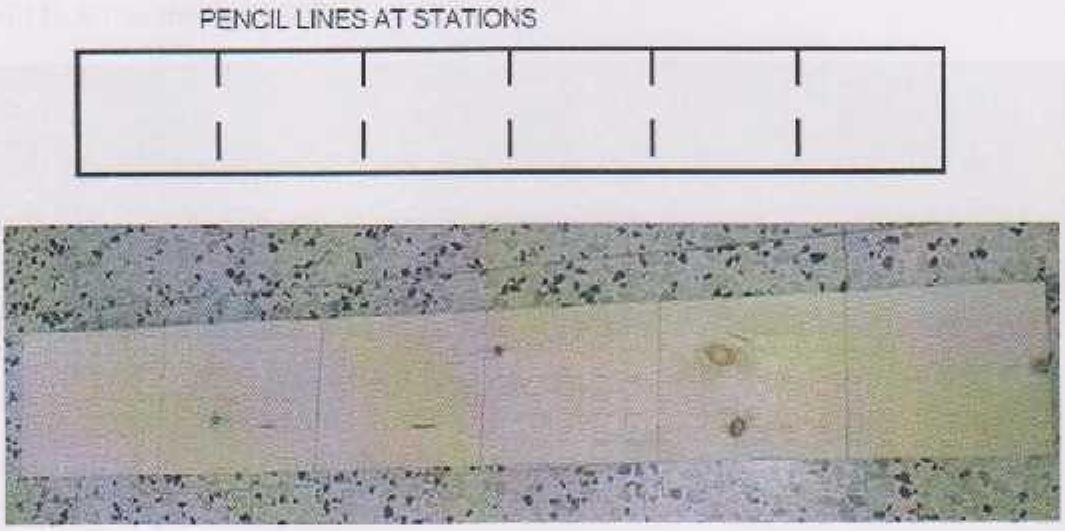

Figure 4.20- wood blade line into 6 stations

The second step:

After we specify the shape into a series of stations, mark the correct width at each station, measuring from the leading edge start from 227mm and end at 56mm as show in table(5) , and then we join the marks up with lines as illustrate in figure(4.21), then we cut and remove as the width line .

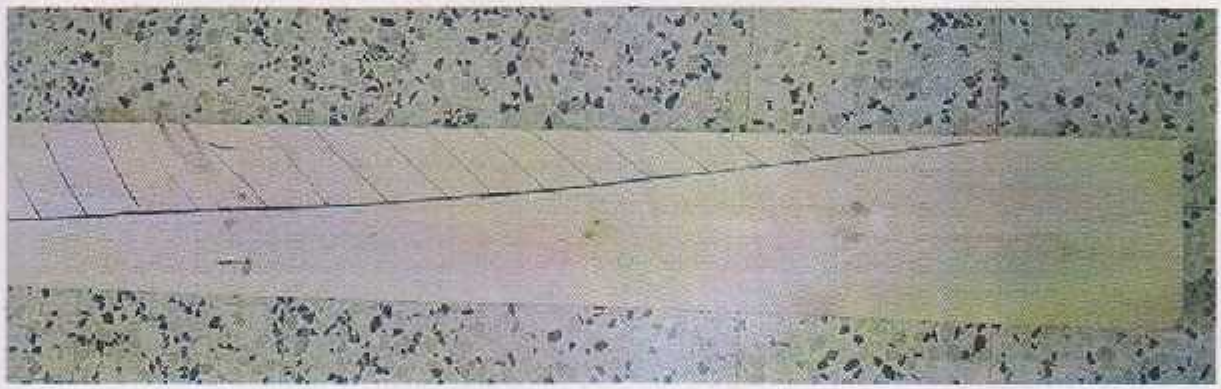

Figure 4.21- hatching the chord at each station

And then we cut the hatching area which shown in the figure (4.21) and the shape of the wood pice will look like the figure(4.22).

Figure 4.22- the shape after removing the hatching area

The third step :

In this step we want to carve the angle of the blade which leads to make drop in the blade Start by marking the stations (with a square) on the face you cut in Step One. Then mark the angle 'drop' on each of these new lines, measuring from the face of the wood and marking the position of the trailing edge at each station. ,as we can see in figure(4.23),the windward face of the blade will be angled, but somewhat flat, like the underside of an aircraft wing. The angle will be steeper (removing more wood) at the root than it is at the tip. The reason why blade-angle should change is because the blade-speed becomes slower as we approach the center. This affects the angle of the apparent air velocity striking the blade at each the angle start from (18 and end at 0.85) degree as show in table(4).

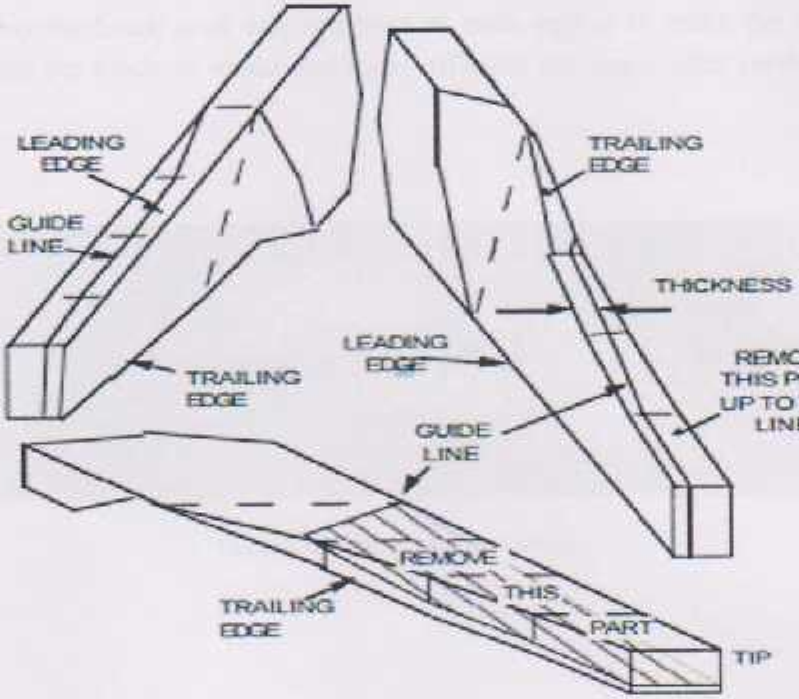

Figure 4.23- Carving the blade angle

The fourth step :

Carving the thickness, at each station we measure the thickness so we draw the thickness in the shape and cut in at each station we start from 34mm and end at ٠.٨٥mm as in table(6), then we will have the final blade shape as we see in figure(4.24)

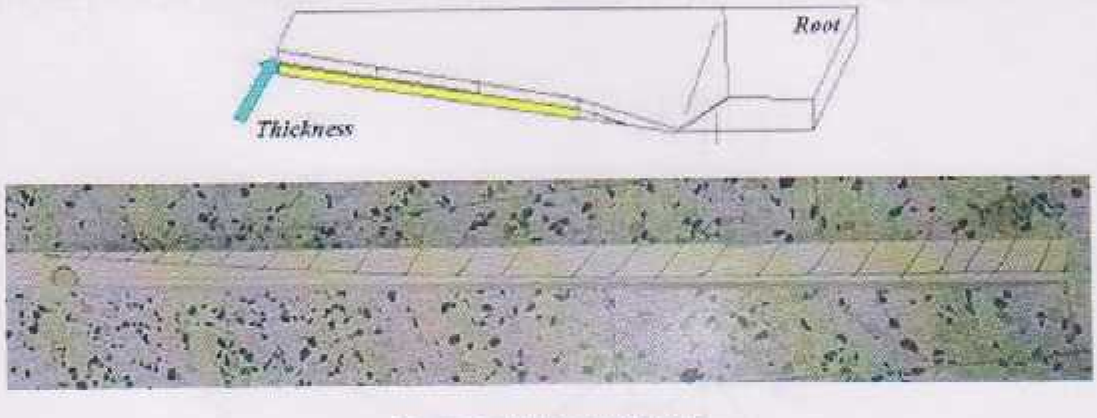

Figure 4.24- lining the thickness

As in figure(4.24) the hatch area will removed at each station to make the wood shape thin enough to allocate the blade to rotate and more efficient the shape after cutting will look like figure(4.25)

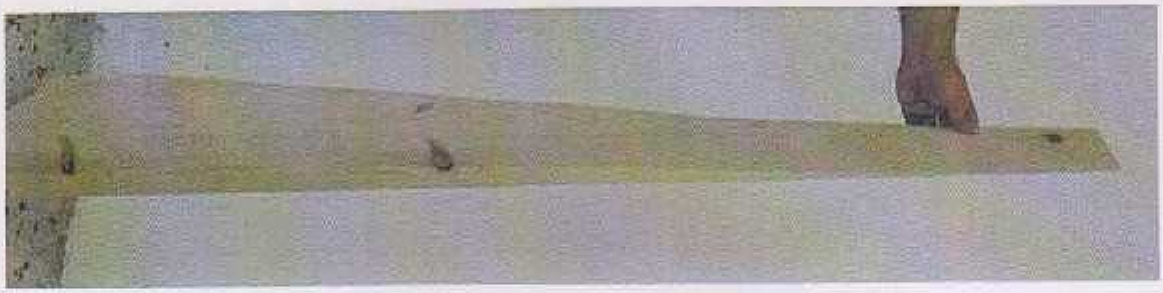

Figure 4.25- After carving the thickness

The fifth step:

In this step we want to cut the root to have a good shape for installing in the disc as we can see iv figure(4.26) we take a center line from the middle of the blade, we Cutting the roots to 120 degrees

We draw angled lines connecting the ends of this line to the point where the mid-line hits the end as shown. These two lines should turn out to be angled at 120 degrees to the edge of the wood, Saw off the triangular pieces from the corners by cutting along the angled lines, leaving a central 120-degree point on the blade root. We set the lines up vertically while we cut the work piece.

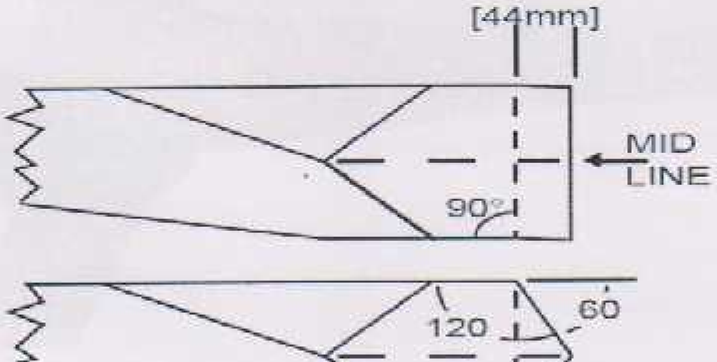

Figure 4.26- Center line root angle

Rotor Hub (the mid disc):

We have to prepare two of them in order to combine them on blade each disc on side the first on the front and the other on the other side So as to give shape and Durability to blade, the first disc will be the master and connect directly to the blades and the second is connected with the system to translate the motion as we see in figure(4.27).

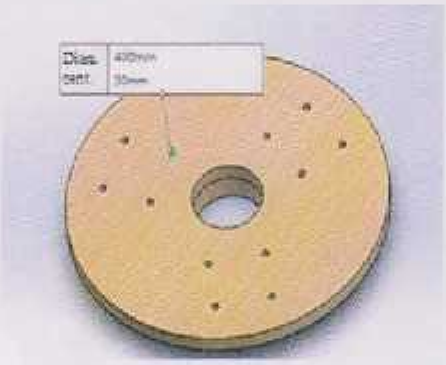

Figure 4.27- rotor hub

Then to attached the blades in 120 degree each blade attached with the other by the angle 60 degree ass see in figure(4.28).

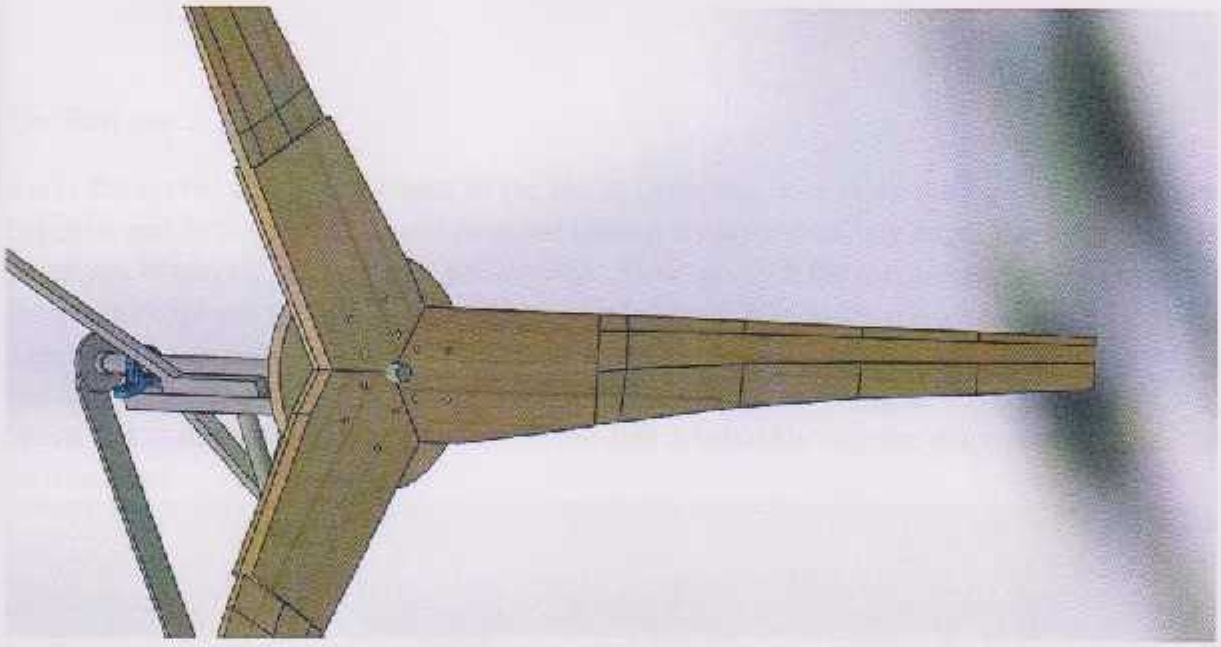

Figure 4.28- Blades attached in the disc

The blades will settled into the tow disc and drilled 12 hole and connect by bolts to the disks and drilling a mid-hole in the disc to connect the shaft which will transmit the motion as in figure(4.29)

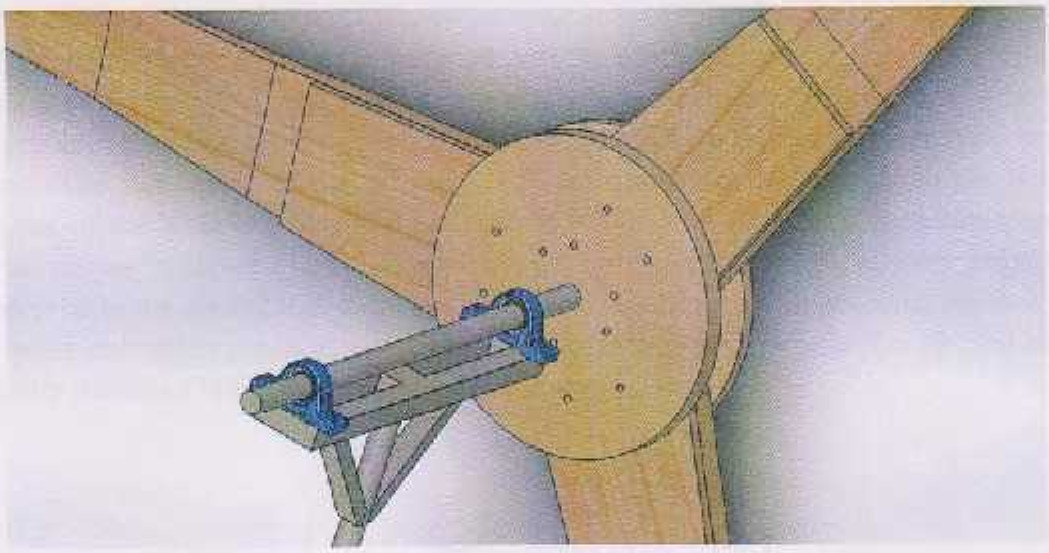

Figure 4.29- Disc holes and center rotor connect

The final step:

Carve the curved shape on the back of the blade. Draw two lines along the back of the blade, at both30% and 50% width measured from the leading toward the trailing edge. The 50% line is to guide you in carving the feathered trailing edge. Now carve off the part shown hatched, between the trailing edge and the middle of the blade width. This will form the correct angle at the trailing edge. When you have finished, it should be possible to place a straight edge between this line and the trailing edge. The trailing edge should be less than 1 mm thick as we see in figure(4.30). When this is done, the blade has to be carved into a smoothly curving shape according to the sectionshown

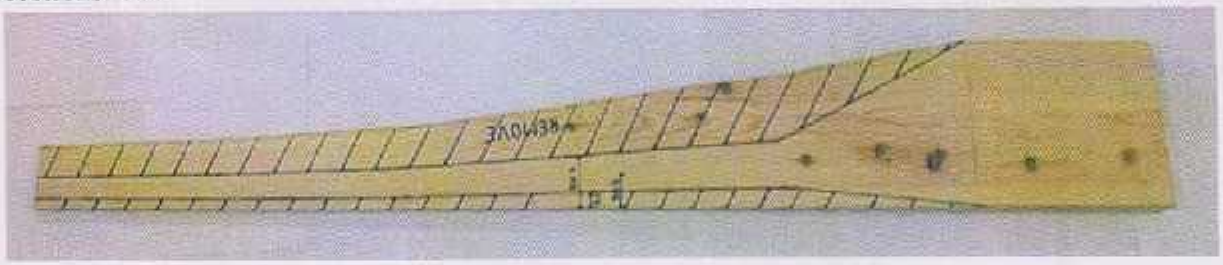

Figure 4.30- The lower side of the blade

4.9 Yaw system:

Yaw denotes the rotation of the nacelle and the rotor about the vertical tower axis. By yawing the wind turbine, the rotor can be positioned such that the wind hits the rotor plane at a right angle. The yaw system provides a mechanism to yaw the turbine and to keep the rotor axis aligned with the direction of the wind. If situations occur where this alignment is not achieved, yaw errors are produced. The yaw error, or the yaw angle, is defined as the angle between the horizontal projections of the wind direction and the rotor axis The yaw system can be either passive or active as we see in figure (4.31). A passive yaw system implies that the rotor plane is kept perpendicular to the direction of the wind by utilization of the surface pressure, which is set up by the wind and which produces a restoring moment about the yaw axis. For upwind turbines, this usually requires a tail vane in order to work properly [7].

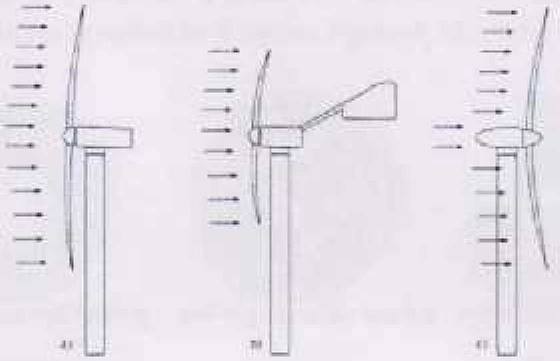

Figure 4.31-turbine rotate with yaw

In this project the design of the rotate for turbine with rotor diameter 3m the optimum dimension for yaw will be 30*50cm and the thickness is 0.1cm as the figure (4.32) illustrates [2].

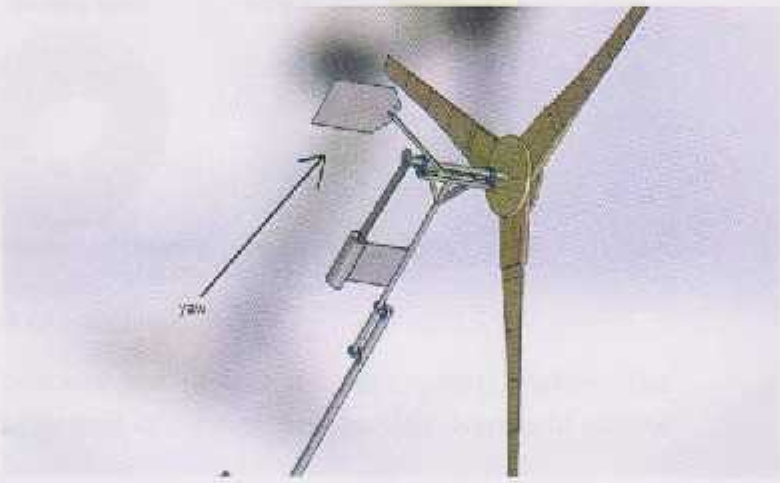

figure 4.32 Yaw system

4.10 Other connection:

The connection between wind turbine and piston pump divided into three types: hinged, rod and bearing this connection is important because a piston pump has a fixed stroke, the energy demand of this type of pump is proportional to pump speed only. On the other hand, the energy supply of a wind rotor is proportional to the cube of wind speed. Because of that, we have to transmit the power with less friction and vibration, in the next section we discuss each part and why it needed.

4.10.1 Bearing:

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Many bearings also facilitate the desired motion as much as possible, such as by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts figure(4.33) show different type of bearings.

Figure 4.33- Bearing types

Bearing being a machine element that allows one part to bear (i.e., to support) another. The simplest bearings are bearing surfaces, cut or formed into a part, with varying degrees of control over the form, size, roughness and location of the surface. Other bearings are separate devices installed into a machine or machine part. The most sophisticated bearings for the most demanding applications are very precise devices; their manufacture requires some of the highest standards of current technology.

In this project we need for three types of bearing :

- Block bearing :

A bearing block, also known as a Plummer block or bearing housing, is a pedestal used to provide support for a rotating shaft with the help of compatible bearings & various accessories. Housing material for a pillow block is typically made of cast iron or cast steel. in the project it located in tow site the first is to connect the center rotor with turbine tower and the second location is to connect the base tower and the secondary tower with each other while allowing the turbine and the secondary tower to rotate with yaw as show in figure (4.34).

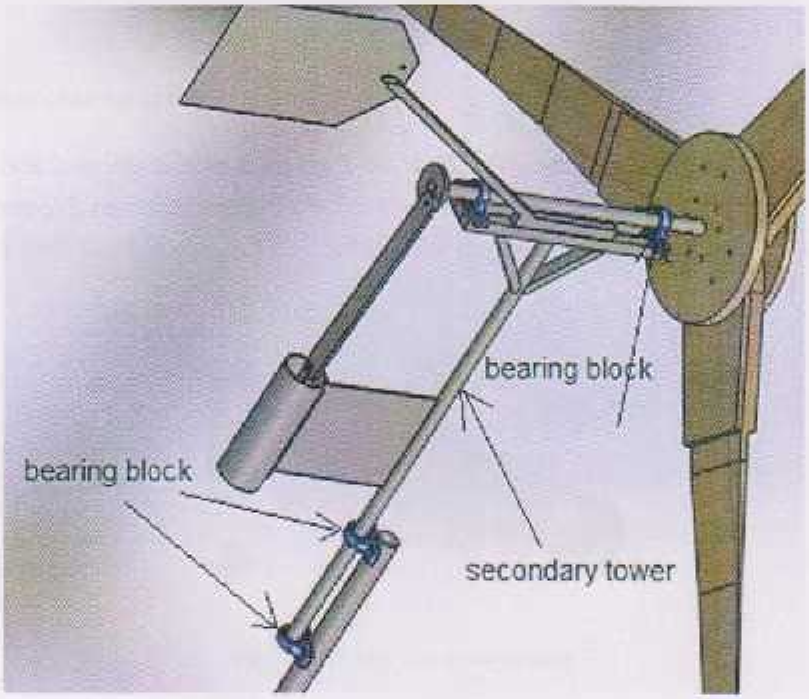

Figure 4.34- Bearing block

- Housing-rod end bearing :

rod end bearing, also known as a heim joint or rose joint, it's a mechanical articulating joint. Such joints are used on the ends of control rods, steering links, tie rods, or anywhere a precision articulating joint is required, and where a clevis end (which requires perfect 90 degree alignment between the attached shaft and the second component) is unsuitable. A ball swivel with an opening through which a bolt or other attaching hardware may pass is pressed into a circular casing with a threaded shaft attached. The threaded portion may be either male or female. The heim joint's advantage is that the ball insert permits the rod or bolt passing through it to be misaligned to a limited degree (an angle other than 90 degrees). A link terminated in two heim joints permits misalignment of their attached shafts (viz., other than 180 degrees) when used in tension. When used in compression, the through-rods are forced to the extreme ends of their ball's misalignment range, which cocks the link at an oblique angle.

Figure 4.35- Housing rod end bearing

So in the project it were used to connect the pump shaft to disc as show in figure(4.35) .

- **Fork connector bearing :**

Fork connector is a bearing which connect tow shaft with each other from both side and it allow the each shaft to move one can move in vertical axis and the other rotate in their axis as show in figure(4.36) ,this fork used in project to connect the piston pump rod to the rod which connected to center disk.

Figure 4.36- fork connector bearing

4.10.2 Connection rod :

A rod or link is a solid or hollow shaft which used for transmitting motion and force between a rotating and reciprocating part, as between a piston and a crankshaft or between tow disc, in this project rods uses in two cases one to connect the center disc with the outer disc , and the second is to connect the outer disc to the piston pump as show in figure(4.37).

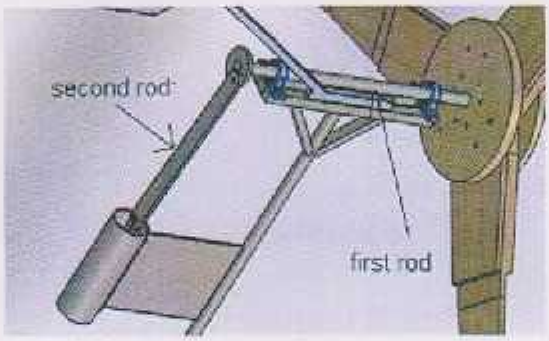

Figure 4.37- connection rod

CHAPTER FIVE

Experimental Result, Recommendation and Conclusion

5.1 Introduction

5.2 Experimental Result

5.3 Recommendation

5.4 Conclusion

5.1 Introduction

In order to determine if the project is acceptable or not, so this chapter provides experimental result we did, recommendations, and conclusion. In this chapter we are listing some goals hope to be accomplished or at least under attention.

5.2 Experimental results

We made some experiment test on this project among these tests was the wind turbine test; under different position and days we did this test, we calculate the theoretical wind power came from turbine after Betz limit then we compare it with the actual wind power came from turbine were it multiply by the power coefficient which equal 35% and the following table show these value table 5.1 :

Wind Speed (m/s)	Wind $Power_{theoretical}$ (watt)	Wind $Powera_{actual}$ (watt)	Turbine efficiency %
1	-	-	-
2	-	-	-
3	-	-	-
3.5	101.18	59.16	0.58
4	151	88.3	0.58
4.5	215	126.18	0.58
5	295	172.5	0.58
5.5	392.6	229.6	0.58
6	509.7	298	0.58

Table 5.1 wind Power

Also we can make a relation between the theoretical and actual wind power and we can conclude that the relation is directly proportional as it shows in the following figure 5.1:

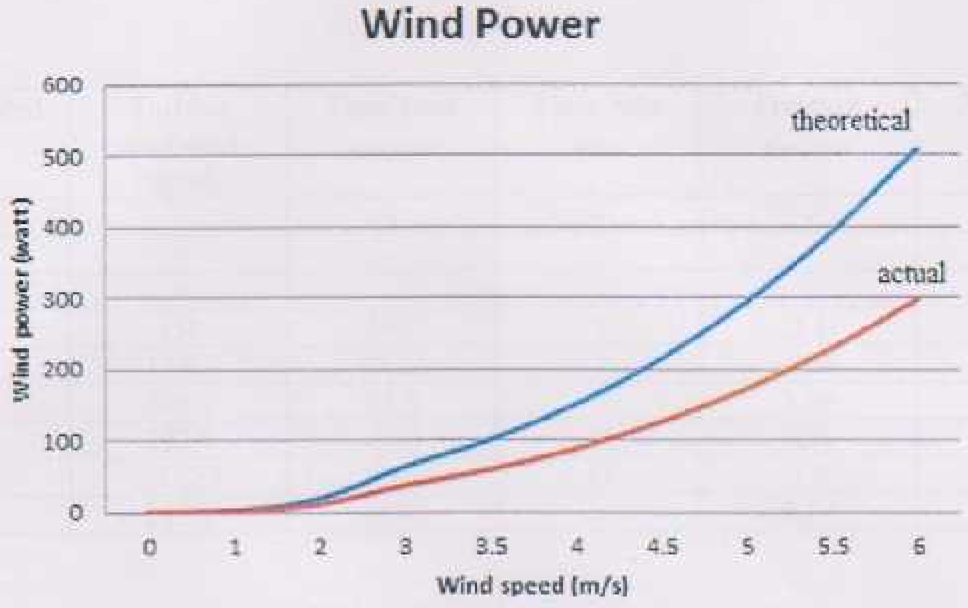

Figure 5.1 Wind Power VS Wind Speed

And the following figure5.2 show the turbine rotor while testing .

Figure 5.2 turbine rotor

The second test was for the pump , we did tow test for the piston pump ,flow rate and pressure output the test did under different days and turbine rotational speed, then it compared with the theoretical values and the following table show these value table 5.2 :

Wind Speed	Turbine rotational speed	Flow Rate theoretical	Flow Rate actual	Pressure theoretical	Pressure actual
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
3.5	156	19.5	1	3.1	0.5
4	178.3	22.28	7	4.06	2.5
4.5	200.6	25.3	9	5.09	3
5	222.9	27.8	12	6.36	4
5.5	245.22	30.6	15	7.7	5
6	267.5	33.43	-	9.14	-

Table 5.2 Pump performance

The following curve illustrate the relationship between the wind speed and rotational speed figure 5.3 :

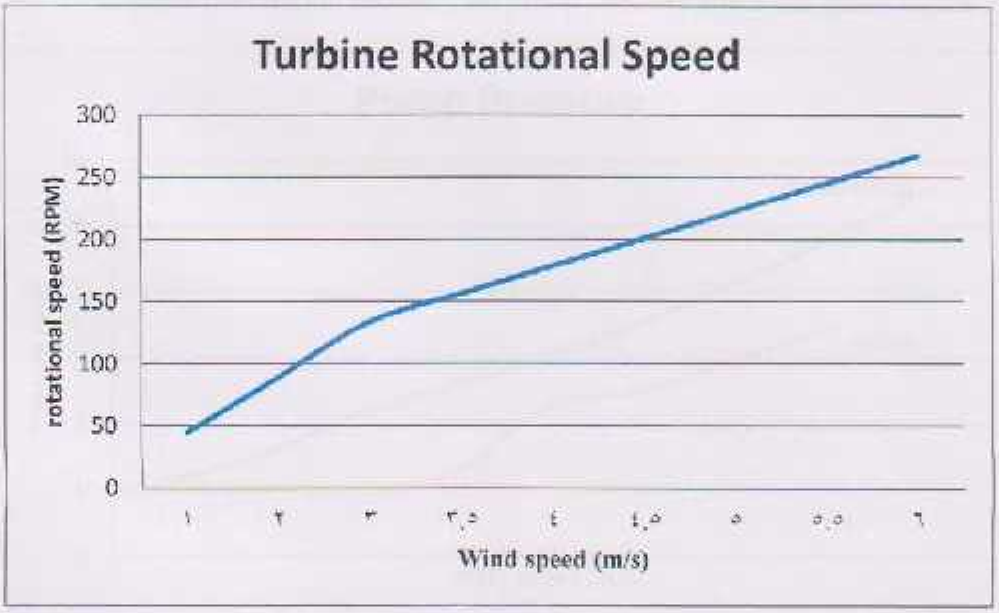

Figure 5.3 Rotational Speed VS Wind Speed

Also we draw the relation between the pump flow rate and the wind speed and it look like the following figure5.4:

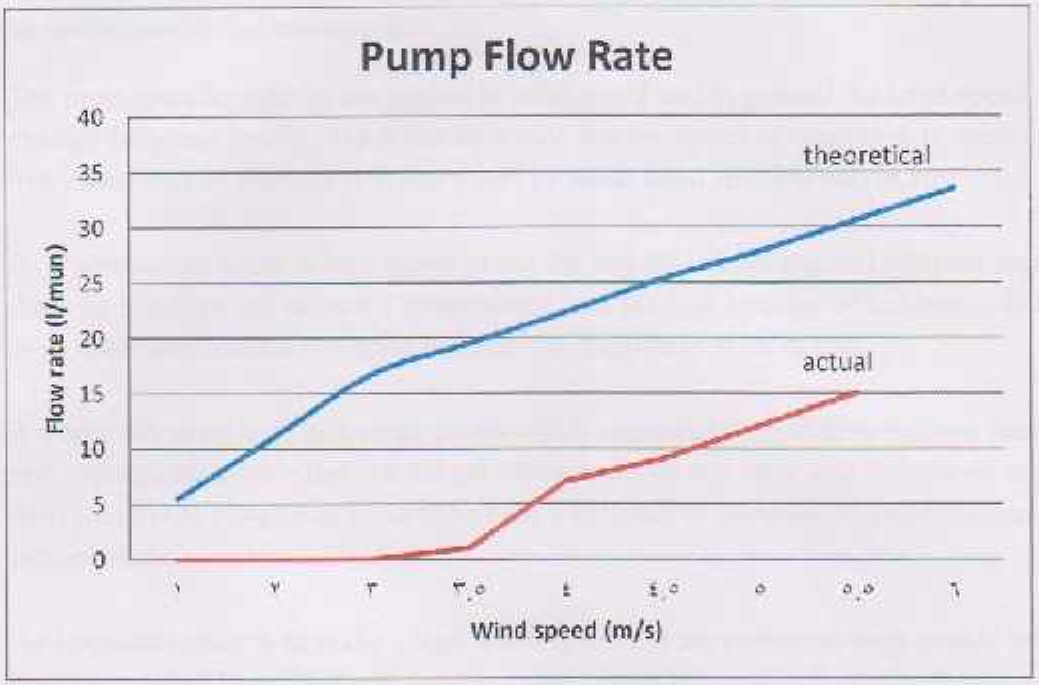

Figure 5.4 Flow Rate VS Wind Speed

And the last curve show the relation between the pump pressure and wind speed figure 5.5:

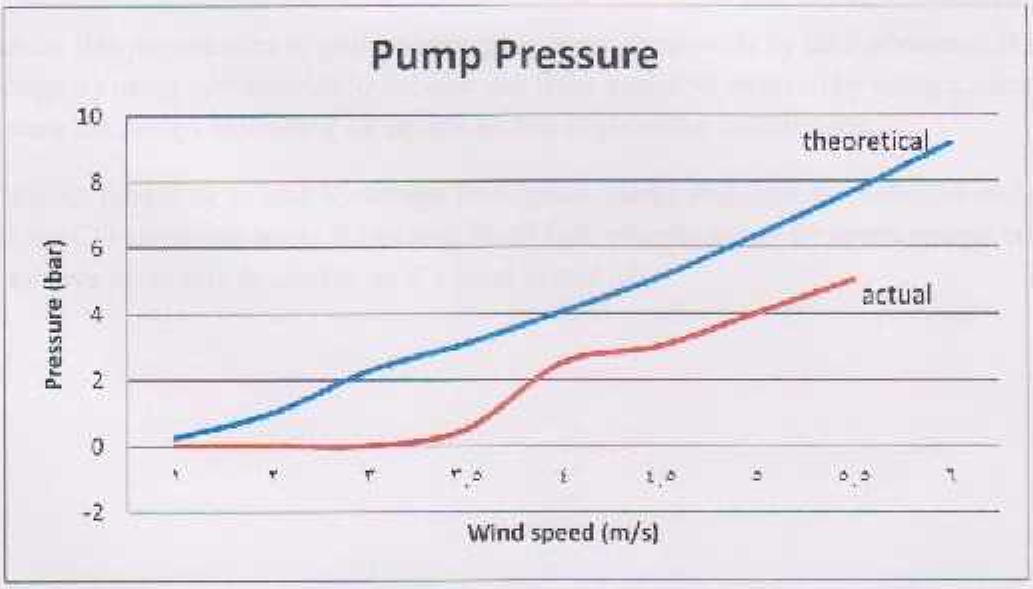

Figure 5.5 Pressure VS Wind Speed

5.3 Recommendation

Based on the experimental tests and **the behavior** of the project under different situations the following recommendations can be made:

- The most specific point in the project is wind speed and in general the wind speed were change daily and hourly , but it can be notice that the speed of wind high in winter and low in summer so the best efficiency will be when wind speed is maximum.

- It recommended to use a high tower or put the turbine in high places i.e.(tower building ,high building) or use at least 3 meter tower, and the best location of turbines is in the open area were located out cities because the roughness of air is low.

- It's better to use a high efficiency pump which manufacturing under precision situation and increase the connection rod length between pump and rotor disc to increase torque delivered to the pump also it could be used a cylinder to increase the force exerted on the piston pump.

- An important point is to make a sign warning around the turbine to keep people safe, and it recommended to make a safe zone and don't enter into unless for maintenance and professional person.

5.4 conclusion

As we know this project aims to pull and pumping water from wells by take advantage from the wind energy by using turbine with lower cost and from available material by using a mechanical system were the design depending on equations and engineering calculations.

So this project providing to take advantage from green energy and limit the pollution and decrease the CO emissions while it replaced fossil fuel, electric power by green energy, also this project achieve economic feasibility so it's good in real life.

Terms and Definitions:

Angle of attack: Angle between the direction of the resulting wind velocity on the blade and the chord line of the blade airfoil section.

Betz limit: Maximum energy conversion efficiency theoretically obtainable from a wind turbine rotor, equal to 16/27 ≈ 0.593 of the total kinetic energy contained by the wind at a given wind speed within a given capture area

Blade Angle: Angle between the plane of the rotor and the local chord line of the blade profile.

Blade root: Part of the rotor blade that is closest to the hub.

Cut-in wind speed (Vin): Lowest mean wind speed at hub height at which the wind turbine starts to produce power.

Cut-out wind speed (Vout): Highest mean wind speed at hub height at which the wind turbine is designed to produce power.

WPU: wind power unit.

WEC: wind energy converter.

VAWT: vertical axis wind turbine.

HAWT: horizontal axis wind turbine.

TSR: tip speed ratio.

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