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A study of Wind Energy with reference to a locally fabricated windmill.

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Abstract :

Energy is a basic requirement for economic development of a country. Every sector of economy namely, agriculture, industry, transport, commercial and domestic – needs inputs of energy in all forms have been steadily rising all over the world. Consequently the world is increasingly becoming dependent on fossil fuels such as coal and oil and gas. Rising prices of oil and gas and potential shortages in future lead to concerns about the security of energy supply needed to sustain the economic growth. Since these conventional energy sources are limited and exhaustible, there is an urgent need to focus attention on development of renewable energy sources.

Wind power is the extraction of kinetic energy from the wind for conversion into a useful form of energy - mechanical or electrical. The generation of mechanical energy by windmills has emerged as a mature, modern and cost-effective technology for large scale use in agricultural and industrial sectors. The paper discusses wind energy in general with reference to a windmill indigenously fabricated by Mr. Mehtar Hussain, Vill- Muslim Ghopa, P.O.- Sipajhar, Dist.- Darrang, State - Assam (India) to pump ground water to irrigate his cultivation field.

Key Words :

Wind energy, Wind turbine, Ground water pumping.

Introduction :

Wind is a form of renewable energy and is felt when air moves. As air has mass, it possesses energy. The power carried by a flowing mass of air depends upon the cross-sectional area of the mass of the wind taken at right angles of the velocity of wind, the density of the air and wind speed.

Wind Power may be expressed as,

$$P = \frac{1}{2} \rho A v^3 \text{ (watts)}$$

Where, ρ = air density (kg/m^3)

A = Area of cross-section of mass of wind (m^2)

v = Wind speed (m/s)

The power that can be converted to mechanical energy by the turbine depends upon the efficiency (η) of turbine. Thus power of the turbine may be expressed as,

$$P_{turbine} = P \times \eta$$

$$= \frac{1}{2} \eta \rho A v^3$$

Efficiency of a turbine is of the order of about 0.42 and its maximum theoretical value is 0.59 (Betz limit)

The wind power can be converted to electricity if the wind speed is either equal or greater than 4.5 m/s.

Wind power can be harnessed with the help of a wind turbine generator system usually consists of a tower and a turbine.

A tower is needed to get the wind turbine up into the air. The tower is at least 10 meters higher than any obstructions such as trees, buildings in the nearby surrounding area. A tower is designed to resist the full thrust produced by an operational wind turbine or a stationary wind machine in a storm. For this purpose a steel lattice tower or tubular pole tower may be constructed.

The modern wind turbine design uses either two or three bladed turbines. But the three bladed turbines are becoming popular and have a number of technical advantages. The hub of two bladed turbines is lighter and thus, the entire structure is lighter. The three bladed designs are much better understood aerodynamically and also have a lower noise level than the two – bladed turbines. Turbine blades are made of glass-reinforced plastic (GRP) which is stiff enough to prevent the blades from being pushed into the tower by strong winds. Moreover, the blades are placed at a considerable distance in front of the tower and are sometimes tilted up a small amount.

Wind turbines are of two types based on the axis about which the turbine rotates. They are – 1. Horizontal axis wind turbine (HAWT)

2. Vertical axis wind turbine (VAWT)

Horizontal axis wind turbine :

A turbine which rotates about a horizontal axis is called a horizontal axis wind turbine, which is most common.

Vertical axis wind turbine :

A turbine which rotates about a vertical axis is called a vertical axis wind turbine, which is less frequently used.

The study of the locally fabricated windmill :

Wind energy is a clean and abundant source of renewable energy which can be exploited for pumping water in remote locations and wind turbines are one of the oldest methods of harnessing the energy of the wind to pump water. This technique was successfully used by a local villager named Mr. Mehtar Hussain, Sipajhar, Dist.- Darrang, Assam, India to pump ground water to his cultivation field.

The windmill developed by Mr. Hussain is a horizontal axis wind turbine (HAWT) consists of two supporting vertical bamboo posts parallel to each other. These two posts are further supported by another two inclined bamboo posts. At the top of the supporting posts an iron shaft is mounted on the bearing. A four bladed wind turbine is mounted at the centre of the shaft. A tube well is connected to the shaft through a lever ball-bearing system. The lever is divided into two segments to secure better efficiency. As the turbine is rotated by the wind the lever pushes and pulls the handle of the water pump. As a result ground water discharges.

Mr. Hussain installed three windmills at open cultivation fields at three different places named Mahariapathar, Sipajhar and Kaniatari in the District of Darrang, Assam.

Table 1: Data of wind turbine installed at Mahariapathar.

Sl. No.	Particulers	Remarks
1.	Number of blades	4
2.	Blade dimensions	Trapezium (36-159-142-159)cm
3.	Blade material	Aluminium
4.	Blade Thickness	0.5 mm.
5.	Blade angle	7.1 degree
6.	Hub diameter of turbine	58.5 cm.
7.	Tip diameter of turbine	381 cm

8.	Crank length	20 cm
9.	Wind turbine height from ground	328 cm
10.	Materials used	Bamboo, wood, aluminium, steel
11.	Wind direction	West to east
12.	Ground water level	20 feet

Table 2: Data of wind turbine installed at Sipajhar.

Sl. No.	Particulars	Remarks
1	Number of blades	4
2	Blade dimensions	Trapezium (36-158-142-158)cm
3	Blade material	Aluminium
4	Blade Thickness	0.5 mm.
5	Blade angle	7.1 degree
6	Hub diameter of turbine	58 cm.
7	Tip diameter of turbine	380 cm
8	Crank length	20 cm
9	Wind turbine height from ground	329 cm
10	Materials used	Bamboo, wood, aluminium, steel
11	Wind direction	West to east
12	Ground water level	30 feet

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Table 3: Data of wind turbine installed at Kaniatari

Sl. No.	Particulars	Remarks
1	Number of blades	4
2	Blade dimensions	Trapezium (28-153-141-153)cm
3	Blade material	Aluminium
4	Blade Thickness	0.5 mm.
5	Blade angle	10 degree
6	Hub diameter of turbine	58 cm.

7	Tip diameter of turbine	379 cm
8	Crank length	20 cm
9	Wind turbine height from ground	340 cm
10	Materials used	Bamboo, wood, aluminium, steel
11	Wind direction	West to east
12	Ground water level	40 feet

Table 4: Data for the water discharge of the three wind turbines installed at three places of Darrang district on 15-12-2006.

Sl. No.	Place	Wind velocity (m/s)	Rotor speed (RPM)	Water discharge Liter /min	Ground water level (feet) (as reported)
1.	Maharia Pathar	2.96	35.790	42.614	20
2.	Sipajhar	2.94	45.712	13.571	30
3.	Kaniatari	3.00	15.794	8.299	40

The wind velocities measured at all the three places are fairly comparable. From the above table of data it is observed that, the amount of water discharge is significant at Mahariapathar with least ground water level. At Kaniatari the ground water level is deepest and amount of water discharge is lowest, though the wind velocity is a little bit more. The rotor speed of the wind turbine at Sipajhar is found to be highest, but the amount of water discharge is not more. It might be due to some mechanical defects of the hand pump.

Conclusion :

The wind speed in the District of Darrang, Assam, India is found to be not sufficient for electricity generation. Yet, it can be used for water pumping for irrigation purpose.

The wind pump developed by Mr. Hussain is though not advanced in design, yet, it has been observed that, the pump is suitable for water pumping at a shallow ground water level especially the south and eastern part of Darrang district. Moreover, the pump is highly cost-effective and affordable for the farmers.

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