Wind Sensing Windmill

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Abstract— Energy development is a field of endeavour focused on making sufficient energy sources to meet the needs of the society. One of the most significant contributor to electricity generation is wind energy. Normally, windmills are placed at higher altitudes, wherein wind starts blowing in more than one direction due to climatic changes and seasons. This decreases the efficiency of the windmills. For this, we place pressure sensors on the nose cone of the windmill. These pressure sensors detects several speeds of wind as well as their direction and records them. This data is transferred to the control box, wherein microcontroller is placed. This microcontroller considers maximum wind speed condition. This in turn stimulates mechanical action, wherein the Ushaped clamp, placed on a roller bearing, which is connected to the nose cone aligns itself perpendicular to the direction of the wind.

Keywords: Wind Sensing Windmill

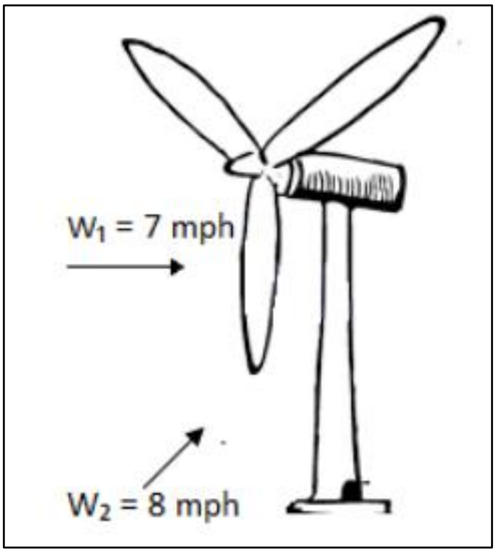
I. INTRODUCTION

Energy development is a field of endeavour focused on making sufficient energy sources to meet the needs of the society. These endeavours help in the production of conventional, alternative and renewable sources of energy. Renewable energy is generally defined as the energy that comes from resources, which are naturally replenished on a human time scale such as sunlight, wind, rain, waves, tides and geothermal heat. Renewable energy replaces conventional fuels majorly in electricity generation. One of the most significant contributor to electricity generation is wind energy. Wind energy is extracted from air flow using windmills to produce mechanical or electrical power. One of the major disadvantages of renewable sources is their irregular supply. Global wind power installations in the world is around 51,000 MW. The leading producer of wind energy is China. India ranks 5th in electricity generation by wind power, producing 22,465 MW.

Since conventional sources of energy are depleting, the world is shifting towards renewable sources of energy. To produce electricity at a better efficiency, we have to reduce one of the major disadvantage of renewable sources, that is, their irregular supply. One of the primary sources of wind energy generation is windmills. A windmill is a mill that converts the energy of the wind into rotational energy by means of vanes called sails or blades. Since, the blowing of wind is highly irrational and untimely, we need better methods of electricity generation. Normally, windmills are placed at higher altitudes. At higher altitudes, wind starts flowing in more than one direction due to climatic changes and seasons.

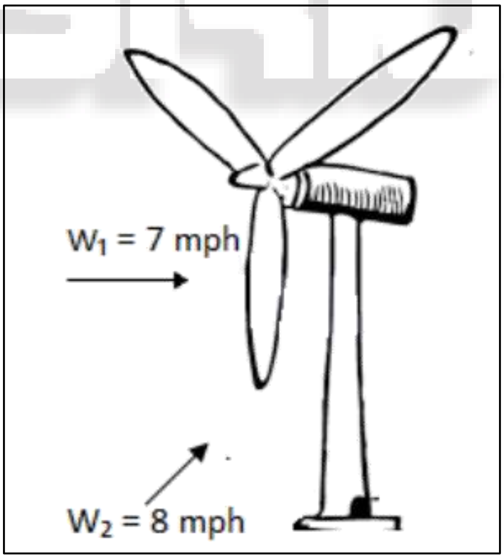
This decreases the efficiency of the windmill. So, we present an idea to increase the efficiency of the windmill.

II. THE EXISTING DESIGN OF A WINDMILL



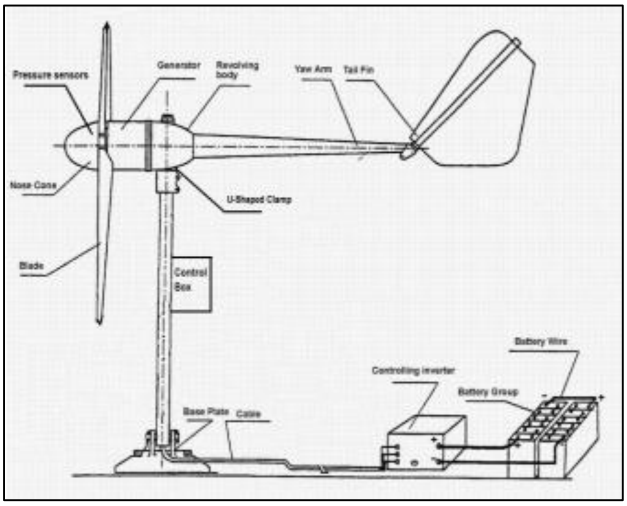
In this design, the windmill rotates with a speed of 7 mph in `α' direction. But the wind which is blowing with speed 8 mph in `β' direction is wasted. We can present a better design to eradicate this disadvantage.

III. DESIGN



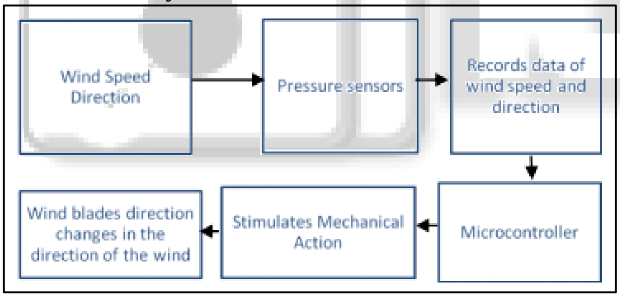
In this design, consider wind to blow at 7 mph in `α' direction. Due to climatic changes and seasons, consider the wind to blow at 8 mph in `β' direction. In this design of the windmill, it senses the maximum speed of the wind and records the data. This data is processed and the blades of the windmill aligns itself perpendicular to the direction of the wind (that is, windmill's blades rotates due to wind speed 8 mph).

IV. CONSTRUCTION AND WORKING



The wind energy turbine consists of the following crucial parts: ROTOR BLADES: They act as barriers to the wind.¬ When the wind forces the blades to move, it transfers energy to the rotor. SHAFT: When the rotor spins, the shaft spins as well.¬ The rotor transfers its rotational energy into shaft, which enters an electric generator.

ELECTRIC GENERATOR: It uses properties of¬ electromagnetic induction to produce electric voltage. So, generating voltage is in effect, generating current. The nose cone of the windmill is made up of pressure¬ sensors, which are connected to the control box. Control box is mounted on the body of the windmill. U-shaped clamp connects nose cone and the body of¬ the windmill.



Basically, the nose cone of the windmill consists of pressure sensors. These pressure sensors detects several speeds of wind as well as their direction and records them. This data is transferred to the control box, wherein microcontrollers are placed. These microcontrollers considers maximum wind speed condition. This in turn, stimulates mechanical action, wherein the U-shaped clamp placed on the roller bearing, which is connected to the nose cone aligns itself perpendicular to the direction of the wind. Thus, the windmill rotates with the maximum wind speed irrespective of climatic changes or seasons. Wind power is extracted from air flow using wind turbines or sails to produce mechanical or electrical power. Windmills are used for their mechanical power, wind pumps for water pumping, and sails to propel ships.

We can calculate the power converted from the wind into rotational energy in the turbine using equation

$$P_{avail} = \rho A v^3 C_p.$$

Where,

Pavail = Power Generated (Watts)

ρ = Air density(kg/m³)

A=Area swept by the rotor blades (m³)

Cp = Power coefficient

There are lots of factors that can make an impact on the amount of energy you can generate out of wind.

1) Wind it being a wind turbine, its output first most depends on the wind. Both the speed and force of the wind can be deciding factors. The more wind speed and force you have got, the greater is the amount of power your wind turbine generates. Different regions have different wind speeds. You can gather the available wind dynamics data and using a model like Webull Distribution you can calculate how effective the wind of a particular region is going to be.
2) Height Places of higher altitudes have more wind due to various atmospheric factors. Besides, at higher places there is less obstruction from the surrounding hills, trees and building. In fact the height is so important that alternative energy scientists and engineers are trying to use kites (due to the heights they can easily reach) to tap the wind power.
3) Rotor The amount of energy produced by your wind turbine is proportional to the size of the rotor used, when all other factors have been taken into consideration. A bigger rotor certainly generates more power. Although it may cost more, in the long run, whenever you are getting a wind turbine erected, go for a big a rotor as possible.
4) Geographic Location of Wind Turbines Average wind speed varies with geographic location, wind turbines generate more electricity as wind speed increases, and less as wind speed decreases. Wind consistency also varies with geographic location, the longer the wind blows at a given speed, the more a wind turbine in that area will generate.
5) Effect of winter on Wind Power Generation During the winter, in some locations, wind speed increases which affects wind power production.

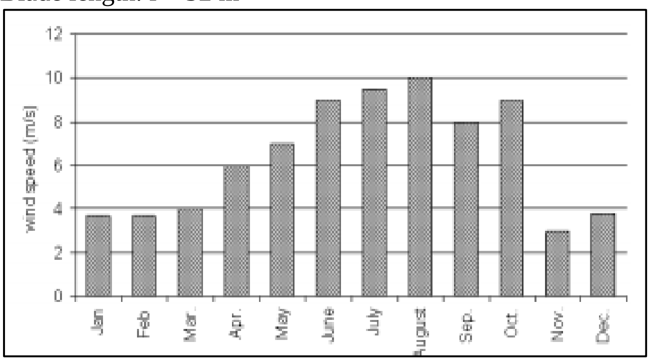
As you can see, the winter months are when wind speeds are the highest and the hottest months which are the summer months are those with the lowest wind speeds. Especially July and August.

V. CALCULATION

India ranks 5th in electricity generation by wind power. One of the significant contributor is Karnataka, ranking 4th, producing 1472.75 MW.

A. Place: Bengaluru

Blade length: l = 52 m



1) CASE 1: Considering Minimum Wind speed Wind speed:
v = 3 m/sec Air density,
$\rho = 1.1614\ kg/m^3$
Power Coefficient, Cp = 0.4
The theoretical maximum power efficiency of any design of wind turbine is 0.59 (i.e. no more than 59% of the energy carried by the wind can be extracted by a wind turbine). This is called the "power coefficient" and is defined as:
$Cp_{max} = 0.59$

Also, wind turbines cannot operate at this maximum limit. The Cp value is unique to each turbine type and is a function of wind speed that the turbine is operating in. The real world limit is 0.35-0.45 even in the best designed wind turbines.

$A = \pi r^2 \Rightarrow$
$A = 3.14 \times 52 \times 52 \Rightarrow$
$A = 8495\ m^2$
$P_{avail} = (\rho A v^3 Cp)/2$
$= 3^3 \times 8495 \times 0.4$
$= 0.0532$ MW

2) CASE 2: Considering Maximum Wind speed
Wind speed:
v = 10 m/sec
Air density, $\rho = 1.1614\ kg/m^3$
Power Coefficient, Cp = 0.4
$A = \pi r^2 \Rightarrow$
$A = 3.14 \times 52 \times 52 \Rightarrow$
$A = 8495\ m^2$
$P_{avail} = (\rho A v^3 Cp)/2$
$= \frac{1}{2} \times 1.1614 \times 10^3 \times 8495 \times 0.4$
$= 1.9732$ MW

3) CASE 3: Average wind speed Average wind speed in Bengaluru is 6.41 m/s
Wind speed:
v = 6.41 m/sec
Air density,
$\rho = 1.1614\ kg/m^3$
Power Coefficient, Cp = 0.4
$A = \pi r^2 \Rightarrow$
$A = 3.14 \times 52 \times 52 \Rightarrow$
$A = 8495\ m^2$
$P_{avail} = (\rho A v^3 Cp)/2$
$= \frac{1}{2} \times 1.1614 \times 6.41^3 \times 8495 \times 0.4$
$= 0.51969$ MW

Normally, Windmills in Beijing rotates with speed 6.38 m/s. With our design, we can increase the power generated, which is equal to the difference between the power generated by maximum windspeed and power generated by average windspeed.

That is, Power generated = 6.638 MW – 0.54049 MW = 6.0971 MW.

Thus, the extra power generated by our design by a single windmill of blade length 52 m is 6.0971 MW.

VI. Application

Applications for small wind turbines can be divided into several broad categories: generating electricity at remote sites, producing electricity in parallel with the electric utility, heating, and pumping water.

Next to their reputation for mechanically pumping water and grinding grain, wind turbines are best known for their ability to generate power off- the grid at remote sites. They've distinguished themselves in this role for decades. During the 1930s, when only 10 percent of North American farms were served by electricity, literally thousands of small wind turbines were in use, primarily on the American Great Plains. These home light plants provided the only source of electricity to homesteaders in the days before the rural electrification brought electricity to all.

Strong winds in winter are balanced by long sunny days in summer, thus enabling designers to reduce the size of each component. They've found that these hybrids perform even better when coupled with small backup generators to reduce the amount of battery storage needed.

There are numerous applications for low-power, offthe-grid systems where battery storage isn't required. One classic application is the cathodic protection of pipelines where a small wind turbine provides an electric charge to the surface of the metal pipe. The charge counteracts galvanic corrosion in highly reactive soils. Storage isn't needed during calm winds because corrosion is a slow process that occurs over long periods. Eventually, the wind returns and again protects the exposed metal. All cathodic protection in rural areas was, at one time, provided by wind turbines. Today, pipelines primarily use small PV modules for cathodic protection, but wind machines are making a comeback

One-third of the world's people live without electricity. In China alone, half the population lives without access to utility power. Many Third World nations are scrambling to expand their power systems to meet the demand for rural electrification. Most are following the pattern set by the developed world: build new power plants and extend power lines from the cities to rural areas. However, with the advent of reliable hybrid power systems using wind and solar energy, this approach to rural electrification doesn't make as much sense today as in the past.

Developing nations will find it more cost-effective, says Mike Bergey, to install hybrid power systems rather than to stretch heavily loaded, and often unreliable, central-station power from the large cities. Though these hybrid systems generate little power in comparison to central power plants, Third World villages need little power. One kilowatt-hour of electricity provides 10 times more services in India than it does in the U.S. state of Indiana.

Hybrid power systems featuring small wind turbines, because of their relative low cost, enable strapped governments to get power into villages quickly. As the central power system expands to these villages, the hybrid systems can be removed and sent on to even more remote villages.

VII. Conclusion

Thus with this idea, the windmill gives greater efficiency. With greater efficiency, higher amount of electricity can be produced. Thus, these valuable energy sources can be implemented in various domestic as well as industrial applications.

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