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Innovative Design of Electricity Power Plant Using Double Shaft Vertical Wind Turbine

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Abstract

The availability of wind power in beach area, especially in Indonesia has not been utilized yet. The strong wind can be used to rotate the turbine's rotor. Instead of fuel, we have successfully designed a new vertical wind turbine using wind power. Conventionally, horizontal wind turbine type has been commercially used in many power plants because it can transform wind energy to electricity, efficiently. However, it requires more space and thus, it cannot be employed in limited area. Vertical wind turbine offers smaller area compared to the horizontal one, but its efficiency is much lower. One reason to explain this is because the availability of blade area to convert the wind energy to electricity is relatively small. The energy conversion efficiency can be improved by modify the turbine design. We focus on modification the vertical wind turbine by adding a shaft, which additional blades have been incorporated to that new shaft. Specifically, we designed a two shaft-savonius wind turbine, used both shafts to clamp 6 pairs of blades, which 3 pairs of blades have been attached in each shaft. This design (double shaft with pairs of blades) can obtain more wind power. As a result, more electricity has been generated by using this new turbine. Moreover, the employment of lighter material in this new turbine has increased the energy conversion. The average of wind speed measured by anemometer is about 8 meter per second. This condition results shaft speed approximately 450 rpm and 14.4 Nm of torque. In summary, the electricity generated is about 780 watt hours AC.

Keywords: Wind, turbine, vertical, double, shaft, electricity, efficient.

Introduction

Electricity is a form of energy that is very important, used in all facets of life.

Electrical energy used in households, public facilities and industries, both small and large industries. During this time, electrical energy is produced from generators driven by turbines. Turbine blades can be driven by various power sources, both renewable and non-renewable energy. Non-renewable energy sources that are widely used are oil, coal and natural gas. The Ministry of Energy and Mineral Resources of the Republic of Indonesia stated that national energy consumption in 2009 amounted to 948.112 thousand barrels of oil equivalent, an increase of 21.87% compared to the national energy consumption in 2000, amounting to 777.925 thousand barrels of oil equivalent [1]. The use of non-renewable energy sources need to be aware, due to the limited remaining reserves. Utilization of renewable energy sources need to be optimized. One effort that has been done is the use of wind energy to drive a turbine to generate electricity. This research aims to design a vertical axis wind turbine as a power plant with a propeller design savonius double shaft models. The design is developed to optimize the wind turbine variables, namely: the extent, the model of curvature and position between the propellers. Propeller models aims to maximize the capture of energy from the wind in such a way so as to produce a high rotational speed with large torque. Wind turbine performance is depend on different wind velocity, tip-speed ratio and solidity as well as rotor blade surface finish [2].

Research Methods

The design of wind turbines as a power plant has been developed. Wind power plants are preferred over hydroelectricity. One of the constraints faced is the availability of water sources (rivers or waterfalls) with a minimum flow rate as required. Kayo et al. stated that the water mill performance is also influenced by the mass of material used, which is inversely proportional to the rotational speed produced[3]. The development of wind turbine design has been done, both for the horizontal axis and vertical axis. Alistated that the vertical axis can operate in flows coming from any direction, and take up much less space than a horizontal axis[4]. The preliminary research that has been done is the design of a vertical axis wind turbine with single axis - 2 blades to activate the aerator in the pond fish. The wind turbine is working properly, but it still produces a low rotation speed. It means that the energy that can be used is also relatively small. Dalom et al. stated that the energy can be captured from the wind power[5]:

$$E = ½ . \rho . A . V^3$$

Where

ρ = the air density (mol/meter^3).
A = total area of blades (meter^2).
V = the wind speed (meter/second).

Considering the formula, energy can be maximized by enlarging the blades area. Wind turbine shaft diameter is obtained through the following formula:

$$D = (P . (47\lambda . RPM)^3)^{0.2}$$

Where

λ = the comparison of the rotor speed to the wind speed.
P = equivalent to the kinetic energy of wind.

$= \frac{1}{2} m . V^2$

RPM = the target rpm of the generator.

The advantage of wind turbine power plants is the capability of generating electricity, even though the wind speed is rather low. Dalom et al. have conducted an experiment on the role of wind speed for generating electricity, obtained the following result[5]. Using 1 meter square of blades and wind speed of 1.01 meter per second, can be produced of 1.16 volts dc – 0.011 ampere. Kayo et al. stated that one of the advantages of wind turbine compared to the waterwheel is the ability to generate more electricity[3].

In general, the design of turbines can be divided into two, namely horizontal axis wind turbine and vertical axis wind turbine. Figure 1 shows the horizontal axis wind turbines. The propeller will rotates with maximum speed, if the wind direction coming from the front. If the wind comes from the other direction, then the wind turbine will rotate according to the origin of the wind direction. Accommodating the mechanism, horizontal axis wind turbine needs more large area.

Figure 1. Horizontal axis wind turbine and its parts (www.wilsonms.pbworks.com)

Vertical axis wind turbines are not affected by wind direction. The design of the axis allows the rotational speed is fixed, are not affected by wind direction. It is an advantage of vertical axis wind turbine than the horizontal axis one. The development of vertical axis wind turbine has been widely applied for various purposes. In Indonesia, Lutfi et al. have developed a savonius wind turbine, to activate the fish ponds aerator[6]. Rotation of the wind turbine shaft used to activate the blade of the aerator. The blades of the aerator tapped the water, to enter the air into the water. Although, the aerator has operated in low speed, the amount of incoming air already meets the requirement. This research attempt to develop the design of the blades and shaft into a double wheel shafts, so that wind power can be optimally captured.

Figure 2. Savonius vertical axis wind turbine [7]

Ali, et al. stated that the performance of any kind of wind turbine can be expressed in the form of torque coefficient (Ct) and the coefficient of power (Cp) versus the tip speed ratio (TSR)[4]. The torque coefficient (Ct) is given by: the rotor torque divided by the wind torque. And Cp is comparison of the extracted power from the wind and the available power of the wind. TSR is given by: w * d / V; where w is the angular velocity of the rotor, d is the diameter of the savonius rotor and V is the peripheral velocity of the savonius rotor.

Vertical-axis wind turbines present a unique aerodynamic obstruction in wind tunnel testing, whose blockage effects have not yet extensively investigated. The flowfield surrounding these wind turbines is asymmetric, periodic, unsteady, separated and highly turbulent [8].

Wind Turbine Design

The design is started by making 6 pairs of blades, which will be attached to both of shafts. The blade made of aluminium. Each blade has about 1 meter square area. Totally, 12 meter square area of blades.

All of 12 blades are assembled to both of shafts. There were 2 shafts, the inner and the outer shaft. The use of both of shafts is intended for attaching the blades, so as to obtain the optimal area, optimizing capturing the wind power. Both shafts are made of drawn seamless steel pipe, 2 inch of diameter for the outer shaft and 3.8 inch diameter for the inner one. Both shafts are connected by 4 unit of bearing, type of 6210. The use of rack-system for both shafts aims to synergize the speed that produced by the shafts. Figure 4 shows the design of blade and shafts.

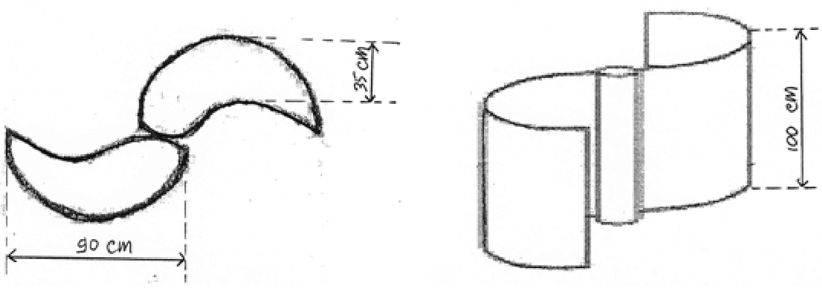

Figure 3. The design of blade.

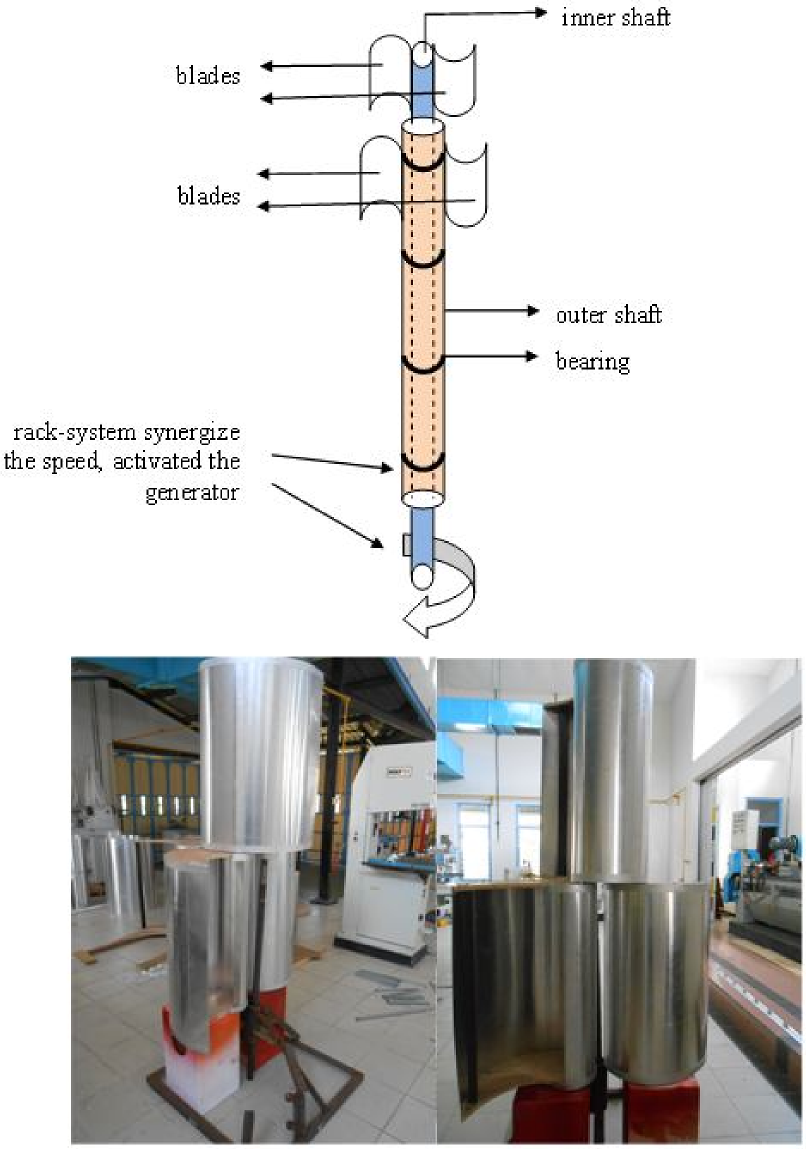

Figure 4. The design of shafts and blades for vertical axis wind turbine.

Result and Discussion

We have conducted experiment, which installing the wind turbine on the roof. The experiments have been conducted to determine the data of wind speed, shaft rotation speed and the electrical power generated. Table 1 contains results of the experiments.

Table 1. Various wind speed produced various electricity power

No.	Wind speed (km/hour)	Shaft speed (rpm)	AC output (watt hour)
1	28.8	450	780
2	25	427	628
3	27	446	701
4	20	392	571
5	17	338	N/A
6	15	225	N/A
7	10	202	N/A
8	20	388	571
9	23	416	602

Several experiments have been conducted at various times. Weakest wind speed is obtained in the early morning. The strongest wind speed was obtained at noon, produced maximum 780 watt hours of electricity. While the wind speed is below 20 km/hours, we didn't get the electricity. Using a double-step savonius rotor, Menetstated that minimum wind velocity is 10 m/s[9].

Conclusion

The designed-turbine has been work properly and resulting electricity. Need to make any experiments to optimize the result, by adjust the position between the blades.

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