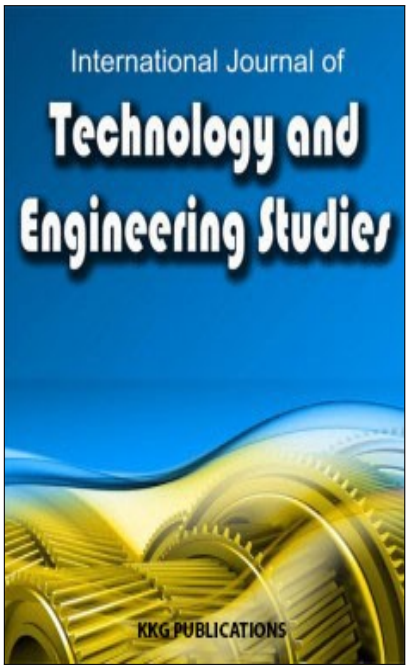

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ELECTRICITY-GENERATING WIND TURBINE FROM ELECTRIC BICYCLE MOTOR

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Abstract. The study was conducted to investigate the possibility of using an electric bicycle motor as an electricity generator combined with a small wind turbine. Wind energy is one type of renewable energy that does not cause pollution. In Thailand, the studies of wind energy application to generate electricity have been promoted. Nowadays, there are many small and medium wind turbines used for electricity generation in buildings, houses, and small communities. This project took 48 volts, 1,000-watt electric bicycle motor to apply to make a saline county wind turbine to generate electricity. The turbine consisted of 6 rotor blades. Each blade was 1.5 meters long and was made from 150 x 130-centimeter synthetic fabrics. A rotor of the turbine was connected with a rotor of the electric bicycle motor through a 1:7.5 gearbox to increase the rotational speed of the electric bicycle motor. The experiment found that the invented saline county wind turbine started rotating at the wind speed of 1.5 m/s and generated 3 phases of AC voltage. The average voltage in each phase was 6 volts at the rotational speed of 60-80 rpm. As seen from the test, at the maximum wind speed of 4.7 m/s, 11-12 volts of AC voltage in a single phase was produced with the approximate 130-140 rpm rotational speed of the motor. When connecting the generated AC voltage to rectifier and filter circuits to convert it into DC voltage for battery charging purposes, the maximum wind speed at 4.7 m/s generated approximately 15-16 volts of DC voltage. This capacity was sufficient for 12-volt battery charging in real use.

INTRODUCTION

There were various studies on electricity-generating wind turbines in a hope to use them to develop better electricity-generating wind turbines, electricity generating systems and so forth. The ultimate goal was to utilize wind energy as a clean way to generate electricity for everyday use. Most areas in Thailand were with low wind speed, hence, wind turbines were not widely used. All those wind turbines on the markets were mainly for high-speed wind areas. The development of wind turbines that could be used in low-speed wind areas was crucial. According to an initial study, saline county wind turbines had been in use to pull water balers at the coastlines from the past till now. Idea in designing saline county wind turbines to generate electricity was initiated. Various materials and equipment were adapted and applied aptly. The study on the possibility to use an electric bicycle motor as an electricity generator combined with a small wind turbine was conducted. The sources of information as follows played a significant role in this study:

Electric Bicycle Motor

Electric bicycle motor is a DC motor that changed electricity power to mechanical strength by rotating bicycle wheels. 2 types of motors were used in an electric bicycle. Each type came with its individual advantages and disadvantages as explained below:

A brushed DC motor was rotated by armature coil which later created a magnetic field that pushed against with a magnetic field from an internal permanent magnet within a motor. Electricity power was passed on to the brush and then to a commuter contact which supplied electricity into armature coil on a slot motor shaft. A brushed DC electric motor was relatively cheap and pretty inefficient. The greatest advantage of DC motors may be speed control. Since speed is directly proportional to armature voltage and inversely proportional to the magnetic flux produced by the poles, adjusting the armature voltage and/or the field current will change the rotor speed [1].

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Fig. 1 . Brushed DC electric motor

A brushless DC motor or hub motor comprised of 3 phase coil series. Each phase contained many coils and there were feedback signals from hall sensors. Each hall sensor was situated 120 degree in distance to one another. The work performance was complicated while the performance efficiency was 90% better than that of a brushed DC electric motor.

Furthermore, maintenance of this brushless motor was uncomplicated. There are also many uses for brushless DC that don't involve the need for total user control. Brushless DC motors are more reliable than brushed motors, since it has no commutators that can break and wear out [2].

Fig. 2 . Brushless DC motor

Saline County Wind Turbine

In Thailand, wind turbines for agricultural purpose had been utilized for such a long time period. Even though there was state-of-the-art technology, farmers still employed wind turbine energy to pull water from a low level to a higher land. Particularly in the upper Thai gulf areas in Samut songkram province and Samut sakorn province, wind turbines were invented by the Thai ancient local wisdom and were used. Cheap and functional local materials for the geographical areas were brought into use to make the turbines. They helped to pull a huge amount of sea water baler to saline fields for salt productions. The characteristics of the saline county wind turbines were as follows:

- Blade was made of wood adhered to a rotor. Wind contact surface was made from either bamboo mattress or canvas. At present, there were 6 plastic sheets being used and installed on a rotor on a wooden pole. Such wind turbine

required wind speed from 2.5 meters per second (m/s) and upwards in order to allow the turbine to rotate. If there was strong wind, 3 blades were folded and the other 3 were left to face the wind. All of the 6 blades were folded when they were not in use.

- Wind turbine poles were made from 2 hardwood trees sticking in pair to support a rotor.
- Shaft belts were made from sticky and durable ropes. They passed on rotation force from a rotor to a shaft axis to pull water baler.
- Shaft axis was made from either steel or round wood located on the paired wooden poles. There were wooden prongs similar to an anchor gear installed in the middle to drive and pull the baler.
- Waterspout and baler were made from wood. The waterspout was in a U shape facing up across water and saline fields. Wooden sheets in the same size to a sectional area of the waterspout made balers in tiles. Each baler was adequately connected with one another by ropes or chain drive in order to store and pull water from a low level to a high level.

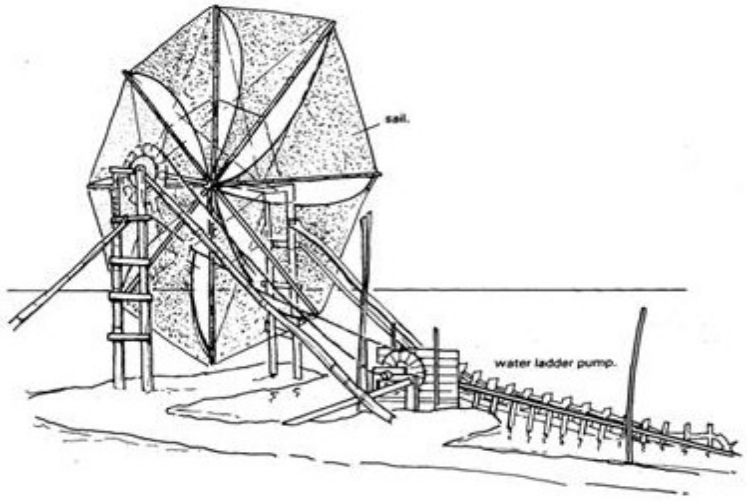

Fig. 3 . Wind turbine for pulling water baler [11]

Fig. 4 . Saline wind turbine at Thai gulf coastline [11]

In 1981, there was an assessment of 2000 sets of wind turbines used for pulling water balers. The blades of those turbines were made from wood. Also the same assessment was conducted on 3000 sets of wind turbines used in saline fields and shrimp fields. The blades of those turbines, on the other hand, were made from bamboo mattress/canvas. In 1989, survey on the wind turbines located within 20 kilometers of Samut sakorn province and Samut songkram province was executed.

It was discovered that 667 sets of the wind turbines remained. Yet presently, there are fewer wind turbines left on the saline fields. The quantity had become fewer and fewer due to the change from an agricultural area to an industrial area as well as an emergence of a motor pump water [3]. Although wind turbines for pulling water balers had remained minimal, there was a constant design development on materials to be used to make saline county wind turbine productions to generate wind energy, clean alternative energy to the environment. [4] developed and improved designs and materials for saline county wind turbines to be more functional for actual use. Bearings were the linkers to pass on emerging forces stemming from shafts down to the other components as well as reduced friction among the contact surfaces. This augmented working capability among the moving components, reduced abrasion loss, and prolonged wheels that shifted shaft forces to a mechanical suction power water pump. This pump was deployed in place of a conventional rail baler. The newly improved turbine was 2 times better in pumping water and offered half of the cost compared to a traditional saline wind turbine. In addition, [5] developed wind turbine for pumping water. A saline county wind turbine was used as a prototype and a helm was installed so as to obtain wind from all directions. Canvas was taken to make blades which reduced the overall cost. The turbine was situated on a 10-meter tower, it worked suitably with 2-3 m/s wind speed.

Electricity-Generating Wind Turbine

A wind turbine invented to shift kinetic energy from wind to mechanical energy. When wind blew to blades, a rotor of the turbine started moving. A typical electricity-generating wind turbine was designed by attaching blades to a rotor of an electricity generator. When a turbine rotated, energy was passed on to the main shaft, to a gearbox transmission adhered to the main shaft as well as connected to a rotor of the electricity generator [6]. This was how electricity was generated.

Many factors affecting electricity generation produced from wind turbines included wind speed, blade size, blade quantity, wind turbine height, etc [7,8]. A blade was categorized into 2 types based on its rotation angles on a rotor. Vertical Axis Wind Turbine (VAWT), its rotor and its blades were in vertical angle with the wind motions. This type of turbine obtained wind at all vertical directions as seen in the Figure 5. On the other hand, Horizontal Axis Wind Turbine (HAWT), its rotor located in parallel with the wind directions .The blades were in horizontal angle with wind motions; therefore, it was necessary to have a helm to control the blades to move in accordance with the wind directions as shown in the Figure 6.

Fig. 5 . Vertical axis wind turbine

Fig. 6 . Horizontal axis wind turbine

In addition to the electricity-generating wind turbine being sold everywhere, there were some individuals who were interested in studying and creating a wind turbine for different forms of electricity generation such as [9] conducted a research by focusing on electricity generation by bringing a ventilator into connection with a gearbox to speed up the rotation of the DC motor. From the experiment, at the 2 m/s wind speed, 3.5 volts voltage was generated; moreover, a DC step-up converter was put to use to increase the voltage to 12 volts in order to use with a LED lamp. [10] developed a Horizontal Axis Wind

Turbine that produced 1 kW of electricity. He designed and made a 2 x 6 meters ESCO wind turbine which was fitting to the wind condition in Thailand where wind was of low speed and fluctuating. Such turbine obtained wind from all directions, and it was at the maximum efficiency when facing the wind from the front surface and the back surface. Besides, [11] promoted a saline county wind turbine for electricity generation by using a monopole 22-80 meters in height depending on the diameter of the blade varying from 12, 30, 50, and 70 meters. Due to the stated size, the wind turbine had a capability to produce electricity at different levels from 5, 50, 500 kW and 1 MW. There was a stretch control system as well as a fold system performed based on wind speed. Such systems were manipulated by a micro controller system and there was a system that allowed adjustment on a blade height from the beginning to the end of the pole. This system was beneficial when a repair or maintenance was in need. [12] designed small wind turbine that generated electricity for lamp outside the building and LED street lamp.

Project Objective

To design and build a horizontal axis saline wind turbine for an electricity-generation from an electric bicycle motor.

METHOD AND MATERIALS

The purpose in designing and creating a saline county wind turbine was to generate electricity from an electric bicycle motor, the research was to study and obtain feasible approaches that could be implemented by using an electric bicycle motor as an electric generator. The motor took mechanical energy from rotations of a saline county wind turbine as a starting energy source. The design steps, the production process, together with the test of such wind turbine were shown in the Figure 7.

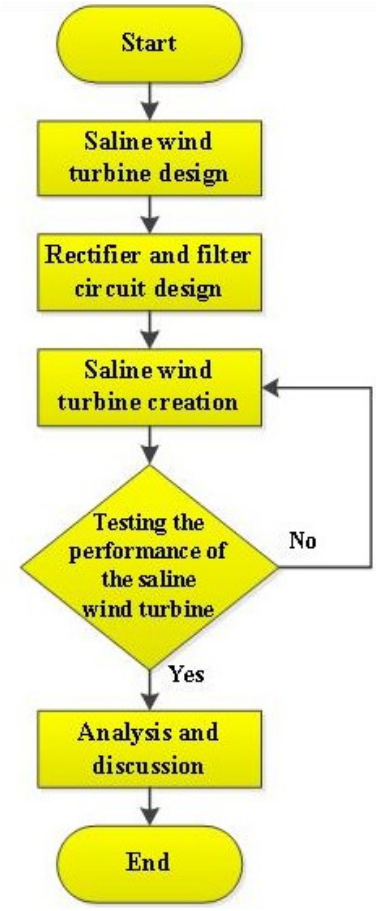

Fig. 7 . Diagram of research process

Design of a Saline Wind Turbine

From researches on various types of saline county wind turbines made for different usage purposes in Thailand, the designed wind turbine base and blades comprised of tower base and wind turbine structure. The tower base was made from 1x1 inch steel square that was assembled to a trapezoid lookalike,

its base was 1.2 meter long, and its top was 0.5 meter long. 2 towers were 3 meters high and each of them was spaced 1.5 meters from one another. 1-inch bearings were installed on the tower heads to attach a shaft axis of the blades so that the rotation of the shaft axis flowed smoothly. 6 pieces of triangle blades were 1.5 meter long each. 150 x 130 centimeters synthetic fabrics were made for blades. A blade structure contained a shaft axis for bearing installation, one edge of the shaft axis came with a 30 centimeter gear dish. 70 gear teeth were used to rotate an electric bicycle motor located close to the towers. A 48 volt, 1000 watt electric bicycle motor came with a 4 centimeter diameter of the gear dish containing 12 gear teeth, to accelerate the motor rotation at the approximate ration of 1:7.5. Both gear dishes rotated following each other by a chain as seen in the Figure 8.

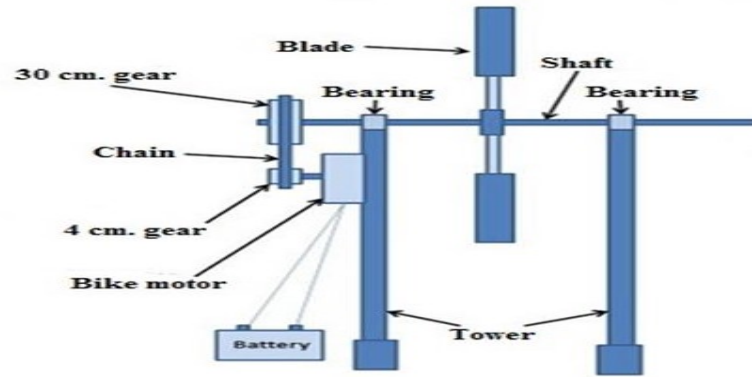

Fig. 8 . Design of saline wind turbine for electricity generation

Design of Rectifier Series and Filter Circuits

Generated electricity voltage from an electric bicycle motor was 3 phase AC voltage. When using the electricity with a LED lamp, it was important to convert AC voltage into DC voltage through a diode. Once a conversion was done, connection was made with a filter circuit by the use of a capacitor so that electricity voltage became consistent. The electricity voltage that an electric bicycle motor produced changed based on speed of the motor rotation. Then the DC voltage was connected with a battery charger to store electricity for long-term use.

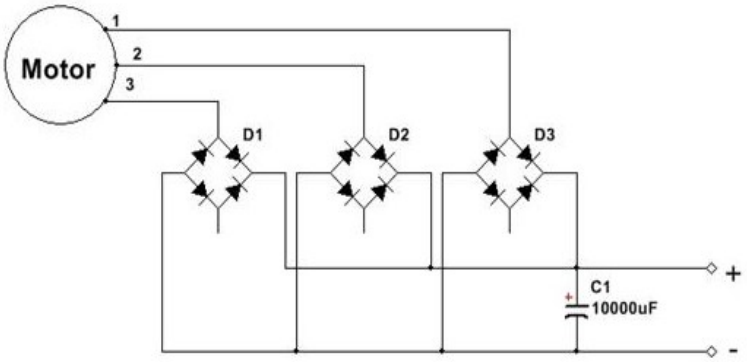

Fig. 9 . Diagram of rectifier series and filter circuit

Creation of a Saline Wind Turbine for Electricity Generation from an Electric Bicycle Motor

Once the design was completed, the next step was to build a saline county wind turbine, and then tested its performance to improve and assess the electricity generation output produced by an electric bicycle motor.

Fig. 10 . Wind turbine structure

Fig. 11 . Gear of turbine axis and gear of electric bicycle motor

Fig. 12 . Created saline wind turbine

Testing the Performance of the Saline County Wind Turbine in Terms of its Capability in Making Electricity so as to Evaluate the Study Results in Different Issues

Measuring a rotational speed of the electric bicycle motor at various wind speed levels by the use of a tachometer.

The result showed that the wind turbine started rotating at the approximate wind speed of 1.5 m/s, and the motor was rotating for about 60-80 rpm. When testing at the 4.5 m/s wind speed, the motor could rotate at the speed of 140-145 rpm as shown in the Figure 13.

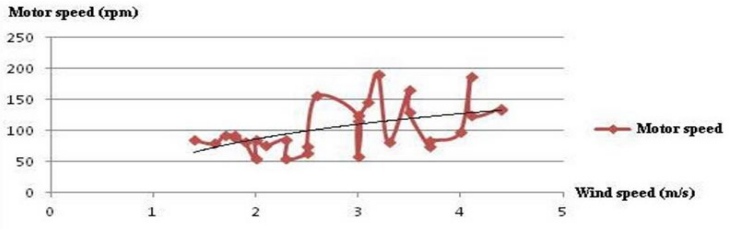

Fig. 13 . Graph showing relations between a rotational speed of an electric bicycle motor and wind speed

Measuring AC voltage that an electric bicycle motor produced at various levels of wind speed by using an AC voltmeter to measure a phase-to-phase AC voltage of the motor. A motor phase was a balance type with a phase-to-phase electricity voltage resulting in the same value in each paired phase. From the measurement, it was pointed out that a saline county wind turbine could start generating electricity at the 1.5 m/s wind speed. The phase-to-phase voltage was averagely 6 volts. It was revealed that the electricity voltage would increase more and more when the blades obtained faster wind speed. At an average 4.5 m/s wind speed, 12 volts of AC electricity were produced.

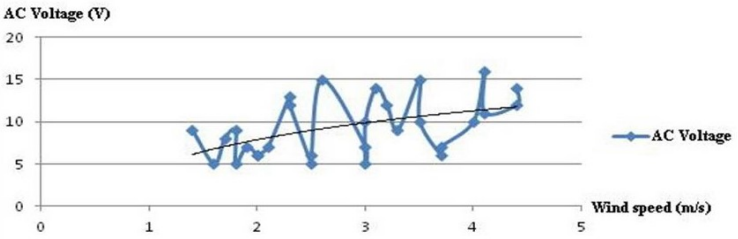

Fig. 14 . Graph showing relations between generated AC electricity voltage and wind speed.

Measuring DC voltage through a rectifier series and a filter circuit at different levels of wind speed by the use of DC voltmeter to measure the DC voltage stored in a capacitor. From the test result, the generated AC voltage from an electric bicycle motor through rectifier series and filter circuits increased DC voltage value as seen in the Figure 15. At the 2 m/s wind speed, 10 volts of DC electricity were derived. At the 4.5 m/s wind speed, 15 volts of DC electricity were obtained.

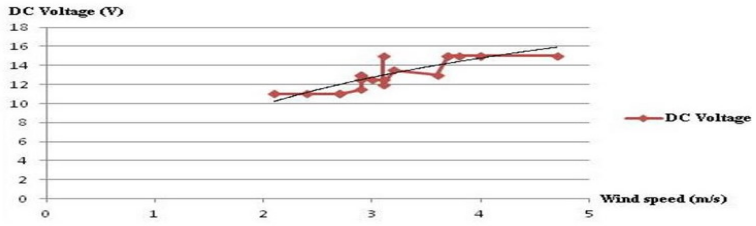

Fig. 15 . Graph showing relations between DC voltage and wind speed

DISCUSSION

The research on electricity-generating wind turbines as a result of an electric bicycle motor was aimed to bring electric bicycle motor into use as an electricity generator from wind energy. A saline county wind turbine was built to perform as an initial source in rotating a motor axis to generate electricity voltage. A saline county wind turbine did not need to have its blades installed at a high level. Materials could be purchased anywhere. Such obtained knowledge could be given to people, especially farmers who were into building a wind turbine for their agricultural usage. From the test on the wind turbine, it could be seen that a 48 volt, 1000 watt electricity bicycle motor functionally produced electricity for real use.

Generated voltage when compared to different levels of

wind speed could be summarized as seen in the Table 1. Moreover, the wind turbine must consistently face wind in order to generate electricity.

TABLE 1
HYDRO TURBINE PARAMETERS DEPENDING ON THE NUMBER OF BLADES

Wind speed(m/s)	Motor speed (rpm)	AC Voltage from motor (Volts)	DC Voltage from rectifier and filter (Volts)
1.5	60-80	6	9
2.0	80-90	7	10
2.5	90-100	9	11
3.0	110-115	10	12
3.5	120-125	11	13
4.0	130-140	12	15
4.5	140-145	12	15

CONCLUSION AND RECOMMENDATIONS

1. The wind turbine should be promoted and upgraded so as to better obtain wind at all directions. The current design can only rotate when wind blows to the front side and the back side of the turbine.
2. There should be an experiment using a low-speed generator to generate electricity. Most areas are with low-level wind speed, about 3-4 m/s. Hence, the generator should be able to help in increasing electricity voltage generation.
3. A wind charger that directly takes a 3-phase AC voltage produced from an electric bicycle motor should be deployed. It will mitigate electricity loss during the electricity generation process.

Declaration of Conflicting Interests

This study has no conflicts of interest.

Acknowledgement

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