Development of Mini Generator based on Wind Turbine Principle

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Abstract – *Shortage of resources to generate electricity is one of the big issues nowadays. Recently, in Malaysia, electricity is generated from fossil fuels and water flow pressure. However, fossil fuels are facing extinction problem due to the limited production of these sources while flow pressure water also has limitation to supply electrical energy to the residents. Besides, the usage of fossil as energy resources affect the environment. Thus, this research proposed a mini wind turbine as an alternative source to generate electricity for consumer daily usage. The designed generator is developed with a different number of blades and the operation is implemented by using Arduino. The analysis of the effectiveness of the designed system is measured through different evaluation of produced voltage based on a different number of fan blades and wind speed. The result shows that for ideal and simple wind turbine structure, the increment of rotational speed produced higher voltage and current. Thus, the system can be used as an alternative source of electrical generator for a small-scale individual user.*

Keywords: *wind turbine; Arduino; number of blade; wind speed*

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I. Introduction

Electricity is one type of energy that is produced from the conversion process of one or more sources into a form of charged particles that will act as a power supply to any applications. This energy can be produced either via solar panel, nuclear, hydroelectric, petroleum, ocean wave, geothermal source, wind turbine, natural gas, etc. The method of generating power supply is different from one country to another. It depends on the supply resources that they have.

In Malaysia, electricity is generated from fossil fuels, water flow pressure in hydroelectric station and solar panel. Though, regarding the quantity and costing of operation, these resources have their own constraint. In other countries such as France, Canada, United Kingdom, Germany, the United State of America, India, and China, wind system is used as one of the energy sources for their usage. The wind system is proved to be a clean fuel source and does not pollute the air like power plants that rely on combustion of fossil fuels which emit particulate matter that causes human health problems and economic damages. Therefore, in this research, a small scale of power supply generator is developed by using the wind turbine system.

There are a few studies on the evaluation of wind energy feasibility in Asian continents have been reported such as, wind turbine feasibility studies in Jordan [1] and in Peninsular Malaysia [2]-[4]. As such, control techniques to achieve wind turbine efficacy have been designed, for instance, a wind turbine with a fixed-pitch variable-speed [5-8] and variable-pitch variable-speed wind turbine [9]. In [10], PID controller is designed and implemented into the generator part of wind turbine system in order to attain the asymptotic trailing of the rotor speed while the speed of a rotor in two-mass wind turbine system is controlled by using variable speed control to maintain ideal tip-speed ratio and obtain the highest output power of turbine with the appearance of unknown stiffness [11]. The technologies, differences, advantages, and disadvantages of horizontal and vertical axis wind turbine structures were reported in [12].

The control strategies of a wind turbine such as fixed speed and variable speed were also discussed along with the wind turbine distribution profile for both vertical and horizontal-axis configurations. There are two types of

wind turbines; horizontal-axis wind turbines and vertical-axis wind turbine. Each of them has its advantages and disadvantages. The vertical-axis wind turbine is better than the horizontal one because it can capture the wind in any direction and easily maintained by the manpower. However, the shortcoming of this type of wind turbine is the energy produced is only 50% of the energy produced by the horizontal-axis wind turbine.

II. Wind Turbine System

A wind turbine is a device that transforms the moving energy in the wind into clean electricity. The operation of this system starts when the wind spins the turbine's blades. Then, a rotor captures the kinetic energy of the wind and converts it into rotary motion to drive the generator. The generator converts this mechanical power into electrical power so that it may be used for the benefit of mankind. Since wind is a natural occurrence, unlimited, free and renewable source, it is one of the best alternatives to harvest a clean wind power and non-polluting way to generate electricity. Unlike other types of power plants, it emits no air pollutants or greenhouse gasses. Wind energy is more ecofriendly than the burning of fossil fuels for electricity. A wind turbine is categorized into two styles; horizontal and vertical-axis. Permanent magnet generator allows the wind turbine to produce up to 10kW. The size permits it flexible to be used for general application and mounted almost everywhere.

The main components of the wind energy system are the rotor and its blades, shaft and electric generator. Wind turbines operate by changing the moving energy from the wind into rotating energy. This energy is then transformed into electrical energy. The energy transformation relies on the wind speed and the swept zone of the turbine. Fig. 1 shows the swept zone; that is the region where the turbine can capture the kinetic energy [4].

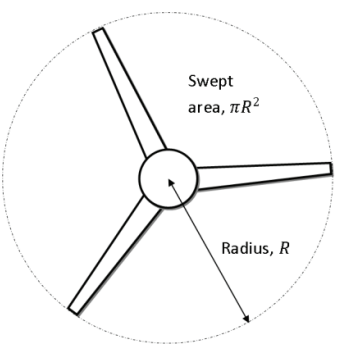

Fig. 1. Turbine swept area

The rotor blade design is one of the main parts of the wind turbine system. The design of this part has benefited from airplanes wind technology. The shape of the rotor blade and its angle of attack relative to the wind direction affects its performance. In addition, its material which is usually made of wood solid or laminated, fiberglass or metal and number of the blade also affect its action.

There are several advantages of two-blades compared to three-blades wind turbine system. One of them is the weight of two-blades is lighter than the three-blades system. One of the advantages of lower weight is easier for handling and assembly process [13]. Since work can be carried out easily and quickly, the disruption on site can be avoided [14]. Besides, [15] stated that by using less number of blades, the designers are allowed to use low-speed shaft, lighter mainframes, and tower. In addition, a small number of blades produce lower surface noise. This is proved by [16]. [17] proposed that three-blades wind turbine has an aesthetic characteristic. Thus, it has high efficiency for the loads. Similar to two-blades, the three-blades wind turbine is also less noisy since it is tending to spin slower but it produced higher power to supply electricity compared to two-blades system. In constructing a wind turbine, one of the important issues that needs to be considered is noise. Apart from that, the increasing number of blade cause the increment costing value. This research focused on producing electrical energy by using wind turbine system and the performance of the designed system will be analyzed by giving a different number and rotation speed of the blades.

III. Methodology

The development of the system began with the design of the prototype of the horizontal-axis wind turbine system by using Arduino. The suitable number of blades and its material are chosen carefully such that the effectiveness and performance of the designed system in producing electricity can be evaluated. The body of the prototype model is developed by using PVC trunk as shown in Fig. 2 while Arduino circuit and LCD display are attached to the system in order to monitor the wind speed and the output voltage produced by the system. In this model, IR sensor is used as a connector between the wind system and LCD display. The sensor will sense the rpm reading of the blade and display the value on LCD.

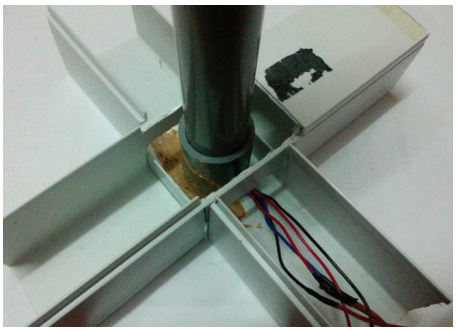

Fig. 2. PVC trunking

The analysis of this project is evaluated based on the performance of different number and rotation speed of blades. Fig. 3 shows the complete prototype of the project with three different number of blades which are two, three and four blades.

Fig. 3. The complete prototype of the project

IV. Results & Analysis

The results obtained are analyzed by measuring the value of voltage and current produced with a different number of blades and rotation speed. Table I list down the voltage and current produced with 2-blades and different rotation speed. The values in this table are also illustrated in Fig. 4.

TABLE I
BLADE SPEED VERSUS PARAMETERS WITH 2-BLADES

Speed (rpm)	Voltage (V)	Spped of Wind (km/h)	Current (mA)
1680	2.93	8	11.4
2520	3.76	11	15.9
2820	4.71	14	16.3
3180	5.61	17	17
3960	6.76	20	19.7

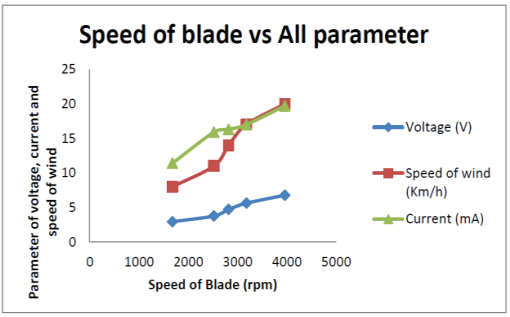

Fig. 4. Blade speed versus all parameters with 2-blades

The voltage and current generated with 3-blades and 4 blades are shown in Table II and Table III respectively while the graph for each table can be seen in Fig. 5 and Fig. 6.

TABLE II
BLADE SPEED VERSUS PARAMETERS WITH 3-BLADES

Speed (rpm)	Voltage (V)	Spped of Wind (km/h)	Current (mA)
3060	3.18	8	10.3
3840	3.6	11	15.1
4320	4.66	14	16.1
5460	5.71	17	16.9
5580	5.99	20	18.7

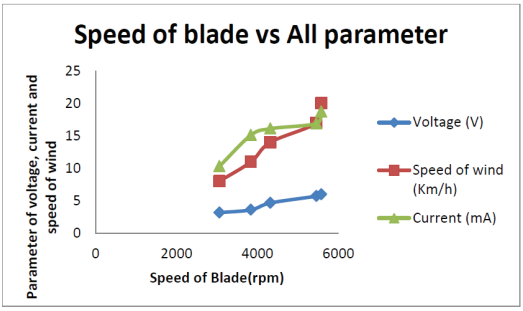

Fig. 5. Blade speed versus all parameters with 3-blades

TABLE III
BLADE SPEED VERSUS PARAMETERS WITH 4-BLADES

Speed (rpm)	Voltage (V)	Spped of Wind (km/h)	Current (mA)
3420	2.97	8	9.7
4140	3.33	11	11.8
4980	3.73	14	15.9
6000	4.32	17	16.5
6240	5.28	20	17.6

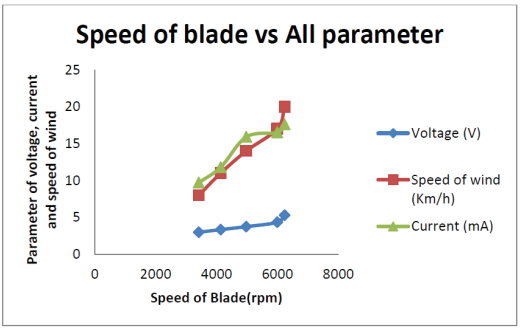

Fig. 6. Blade speed versus all parameters with 4-blades

Based on the results obtained in each Table I, II and III, the generation of voltage and current is higher when the rotation speed of blades is increased. This is because higher speed produced faster rotation of the blade. Therefore, the generation of voltage and current is also faster. This situation also can be seen in each graph in Fig. 4, 5 and 6 which proves this fact. Besides, within a certain range of rotation speed, the generation of voltage and current with the 2-blades is higher than 3-blades or 4-blades. This result supports the previous work which mentioned that the lower the number of blades yields a lighter wind turbine system. Hence, a higher rotation can be obtained.

V. Conclusion

A prototype of the horizontal-axis wind turbine system is developed in this research as a simple benchmark for higher design of this system later. Based on the operation of this prototype, the higher rotation speed of blades and the lower number of blades produced higher electrical energy.

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