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DISTRIBUTION OF WIND SPEED BEFORE AND AFTER THROUGH VANE TUBE TYPE FLOW STRAIGHTENER

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Abstract: Wind energy is one of the most potential renewable energy sources to be utilized as a source of electrical energy. Utilization of wind energy for electricity generation does not cause negative impact on the environment. Wind in the atmosphere is in turbulent conditions. Wind in turbulent conditions has a random and uniform velocity. In wind power plants wind speed is a major factor affecting the amount of wind energy input that can be converted into electrical anergy. The main part of wind power is wind turbines. This wind turbine converts wind energy into mechanical energy of shaft rotation and then converted into electrical energy by electric generator. To measure wind speed the wind speed conditions are made uniformly by using wind flow alignment. The wind flow straightening test kit consists of flow alignment, fan, pitot tube meter, and pitot tube holder arm rod. Straight stream flow used in this study is the type of vane tube. In this study, the wind speed measurement was taken before and after passing the flow straighteners. Measurements of wind velocity on the cross section of the wind turbine are performed horizontally, vertically and diagonally. The number of wind speed measurements as much as fifty-two points of gravity with the distance between the point of measurement about two centimeters. Based on the results of measurement and analysis, the average wind speed before passing the straightener is about 4.94 m / s and after passing the flow alignment is about 3.22 m / s. The wind velocity distribution after passing through the vane tube flow alignment is more uniform.
Keywords: Wind energy, renewable energy, wind speed, power generation, flow alignment, wind speed distribution.

I Introduction

Increased utilization of renewable energy sources need to be done continuously, because in addition to the fulfillment of energy needs also do not cause a negative impact on the environment. One potential source of renewable energy is wind energy. Wind energy can be utilized to drive wind turbines. Furthermore, the output energy from the wind turbine can be converted into electrical energy by using an electric generator. The performance of wind turbines in transforming wind energy into mechanical energy is greatly influenced by wind conditions. In addition to speed, wind conditions that affect the performance of wind turbines is turbulence, the lower the turbulence the wind turbine performance will be higher. In this study, wind turbulence was reduced by using a vane tube type flow straightener. This study is experimental by measuring the distribution of wind velocity before and after passing the flow straightener.The wind velocity test results can be used for many purposes, including for the development of wind turbine model. In developing a wind turbine model, wind speed is an important input to estimate the performance of a wind turbine model. The performance of a model of wind turbine for example is power and coefficient of performance.

II Literature review

1. Flow in pipe

The fluid flow regime is grouped into two types: laminar flow and turbulent flow. In laminar flow, the fluid flow conditions are regularly due to the fluid particles flowing on their respective path lanes. In turbulent flow, the fluid flow conditions are randomly generated. The fluid flow conditions are influenced by the properties of fluid, geometry, and disruption to the flow. The basic theory of fluid mechanics that is widely applied in various studies including the study of fluid turbulence reduction is the flow theory in the pipeline as shown in Figure 1 below.

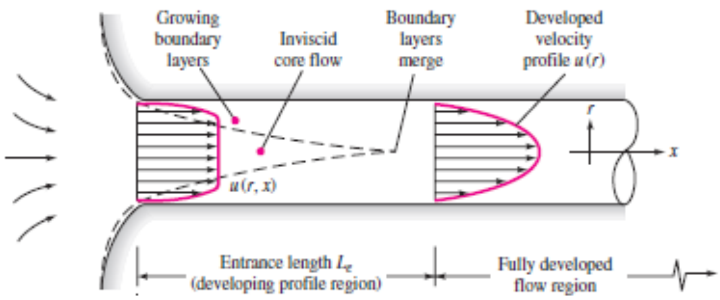

Figure 1 Flow condition in pipe con [6]

The flow conditions in the pipe can be known from the Reynolds number expressed by Equation (1) below. Generally it can be stated if the Reynolds number is less than 2300 then the laminer flow, and Reynolds number is greater than 4000 then turbulent flow [6].

$$Re_D = \frac{\rho V D}{\mu} \tag{1}$$

The Reynolds number is dimensionless, fluid density mass (ρ) in kg/m^3, average velocity flow in pipe (V) in m/s, pipe diameter (D) in m, and the dynamic viscosity (μ) in kg/m.s

2. Flow velocity measurement

The fluid flow velocity measurement is based on equation (2) below. Equation (1) known as the Bernoulli's equation is derived from the energy equation for the fluid flow with assumptions without flow losses and heat source, and steady state.

$$p_1 + \frac{1}{2}\rho_1 {V_1}^2 + \rho_1 g z_1 = p_2 + \frac{1}{2}\rho_2 {V_2}^2 + \rho_2 g z_2 \tag{2}$$

The pressure difference between points 1 and 2 on a stream line for incompressible flow with the same height position can be expressed by Equation (3) below.

$$p_1 - p_2 = \frac{1}{2}\rho\left({V_2}^2 - {V_1}^2\right) \tag{3}$$

If the velocity at point 2 is zero, then the fluid flow velocity at point 1 is given by Equation (3) below. Equation (4) is used as a basis in measuring the velocity of the fluid flow by using a pitot tube meter

$$V_1 = \sqrt{\frac{2(p_1 - p_2)}{\rho}} \tag{4}$$

Fluid pressure (p) in Pa, fluid density mass (ρ) in kg/m^3, and fluid velocity (V) in m/s.

3. Flow straightener

Flow straightener is a device that serves to reduce flow turbulence and get a fully developed flow. Flow straightener is used in turbine testing facilities. Types of flow straighteners that have been known are vane tube, honeycomb screen, and rechtangular as shown in the Figure 2 below. The results of the investigation for rechtangular flow straightener, the more the number of cells obtained a more uniform profile [3]. The fluid flowing in the flow straightener has pressure drop. Under the same conditions for these three types of flow straightener, the greatest pressure drop occurs in the vane tube straightener type and the smallest pressure drop occurs in the rechtangular staightener type [4\. The resultsof the investigation for rechtangular flow straightener, the more the number of cells obtained a more uniform profile [3].

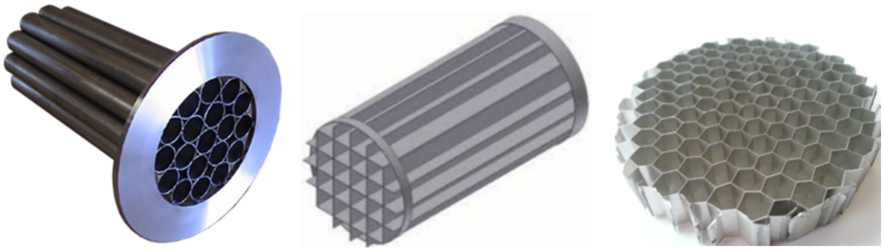

Figure 2 Type of flow straightener: (a) vane tube, (b) rechtangular, and (c) honeycomb [4]

III Method

In this study, reduction of wind turbulence was done through testing. The testing facilities used in this experiment consist of fan, flow straightener type vane tube, pitot tube meter, and measurement data processing device. The reduction of wind turbulence in the flow straightener is obtained by measuring the wind velocity in the wind flow area around the vane tube cross-section before and after the flow straightener. Analysis of wind turbulence reduction is obtained by comparing the uniformity of the wind speed distribution.

IV Testing

The experimental facilities used in this study consisted of a fan, a pitot tube meter, a vane tube flow straightener, a pitot tube probe rod, and a data processing device as shown in Figure 3 and Figure 5 below. Measurements of wind velocity at the cross-section of the flow straightener with measurement points in horizontal, vertical, and diagonal directions with spacing between measurement points of approximately 20 mm as shown in Figure 4 below. Wind speed measurements are made around the cross section of the vane tube before and after passing the flow straightener. During wind speed measurement, the pitot tube probe portion is facing and parallel to the wind direction.

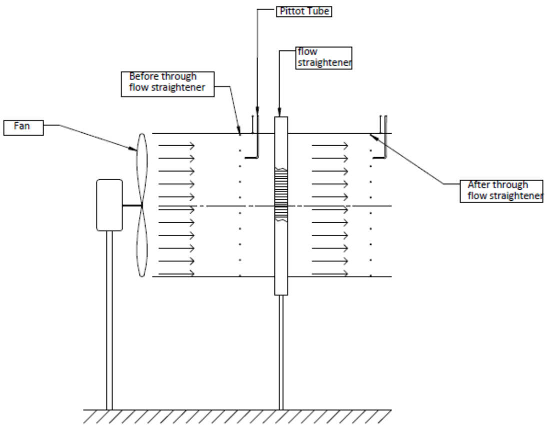

Figure 3 Test facility set up

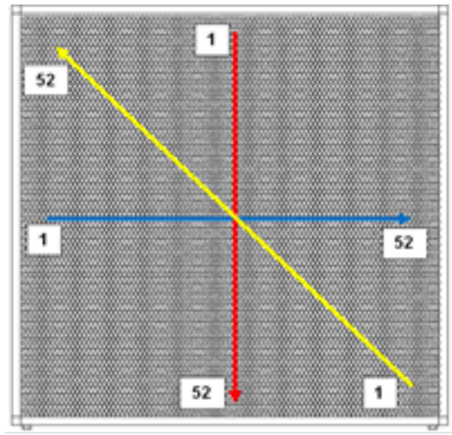

Figure 4 Measurement points direction

Figure 5 Measurement devices

V Result and Discussion

The measured wind speed data is shown in curves as shown in Figure 6 and Figure 7 below. The three curves shown in Figure 6 represent the wind velocity distribution before passing the flow straightener by the position of the measuring point in the horizontal, vertical, and diagonal directions.

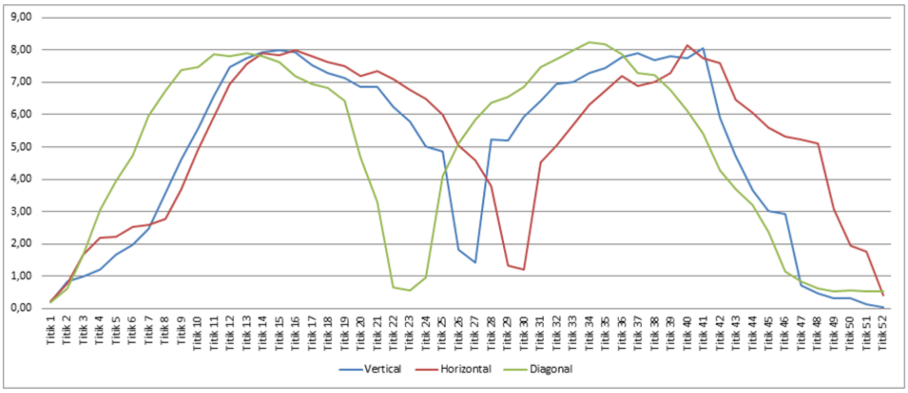

Figure 6 Wind velocity distribution curve before through flow straightener for measurement in vertical, horizontal, and diagonal position

The three curve lines shown in Figure 7 represent the distribution of wind velocity after passing the flow straightener with the position of the measurement points in the horizontal, vertical, and diagonal direction.

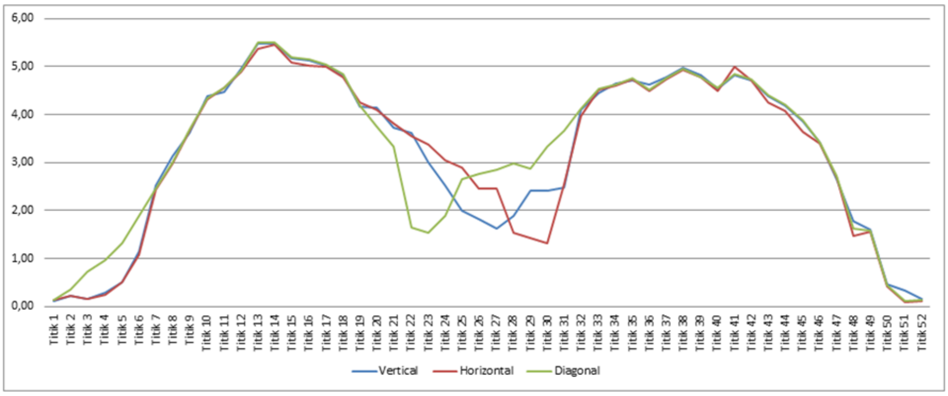

Figure 7 Wind velocity distribution curve after thruough flow straightener for measurement at vertical, horizontal, and diagonal position

The maximum wind speed on the side before passing the flow straightener is greater than the maximum wind speed on the side after passing the straighetenr flow and minimum wind speed at the start before passing the flow straightener is smaller than the minimum wind speed after passing the flow straightener. Thus it can be stated that the distribution of wind speed after passing the flow straightener is more uniform.

VI   Conclusion

Based on test data and wind speed distribution analysis for the three way point of measurement can be concluded some important things. The distribution of wind velocity after passing the flow straightener of the vane tube type is more uniform than the wind speed distribution before passing the flow straightener. The wind velocity distribution before and after the flow straightener is not influenced by the direction of the measurement point.

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