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 ijirset@gmail.com

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Wind Turbine Blades of Locally Wood Analysis Based on Local Wind Characteristics

Bagus Rizky Dewantoro

Human Resources Development Center of Electricity, New Energy, Renewable and Energy Conservation

MEMR, Jakarta, Indonesia

ABSTRACT: Wind energy as a renewable energy source must be properly managed, especially for areas that have not been reached by the national electricity grid. Then in an effort to increase knowledge of competent human resources for both the general public and state civil servants on wind energy as renewable energy, a study on the development of wind turbine blades that is suitable for local wind characteristics is needed. Use horizontal axis wind turbine with local wind characteristics and material characteristics of turbine blades using Jabon wood and using NACA 4415 airfoil, lift coefficient values are obtained for variations in angle of attack and power coefficient values C_p 0.4 with tip speed ratio 4. Then the design power that can be generated is 80 Watts at a turbine speed of 420 rpm, the QFem simulation results show a fairly even stress distribution from the hub to the tip of the wind turbine blades with the maximum value being at the hub with a value of 0.70 MPa at a rotating speed of 420 rpm. The simulation results through the Q-Blade can be used as a preliminary study in planning the manufacture of wind power plants, especially in renewable energy trainings.

KEYWORDS: Wind energy, wind turbine, training, local wind characteristics

I. INTRODUCTION

Electricity needs today are a primary need for humans where we are very dependent on the availability of sufficient electrical energy, with the increasing consumption of electrical energy, the need for electricity supply in Indonesia will continue to increase. Based on the assumption of average economic growth of about 6.7% per year (in accordance with the 2015-2019 RPJMN), Indonesia needs an additional average generating capacity of 7 GW per year and additional transmission network of an average of 9,000 kms per year[1]. In an effort to increase knowledge, competent human resource expertise for both the general public and the state civil apparatus in the field of renewable energy, especially in wind energy, it is necessary to develop a type of wind turbine blade in accordance with local wind characteristics, in this case Jakarta as the location of PPSDM KEBTKE.

A wind power plant is basically a windmill or wind turbine that utilizes wind energy to generate electricity. Center for The Development of Electricity, New Energy, Renewable Energy, and Energy Conservation (PPSDM KEBTKE) is a government agency under the ministry of energy and mineral resources of the Republic of Indonesia that carries out the development of human resources in the field of electricity, new energy, renewable energy, and energy conservation[2]. JaoP.Monteiro et al utilize wind flow from wind tunnels to test horizontal wind turbines [3], to perform actual demonstrations required testing in a wind simulation using wind tunnels. In this study, the development of blade type in accordance with local wind characteristics was done by adjusting the optimal airfoil shape for wind characteristics in Jakarta by using software such as Q-Blade[4]to perform various computational simulations to see the performance of the wind turbine prototype to be developed.

Adi Surjosatyo et al tested local wood wind turbines using local wind characteristics (Kampung Bungin, Bekasi) using Q-Blade software[5]and research using wind characteristics on the coast of Bekasi, Kampung Bungin[6]with the type of wood compared that is, Sengon Wood, Jabon, and Balsa, jabon wood obtained has the best elasticity modulus value between balsa and sengon wood. In addition to the value of elasticity modulus, Jabon wood also has the highest density value between Balsa wood and Sengon wood.

From all that has been explained before, the purpose of this writing is to know the performance of wind turbine prototypes with local wood material characteristics that are adapted to local wind characteristics, in this case Jakarta to produce electrical energy and later used as a learning media in PPSDM KEBTKE.

II. METHODOLOGY

The research method used in this research is computational research methods and quasi-experimental research methods. This method is done by using the design used in previous research[5] which modifies the type and length of the blade and uses the characteristic value of Jabon wood material, as well as using Jakarta wind conditions and is simulated using Q-Blade software. Q-Blade is free software developed by Berlin Technical University Department of Experimental Fluid Dynamics[4].

there are three variables used in this research:

1. Control Variable

variables specified by the author before conducting the research, the control variables used in this study are::

- characteristics of wood used are Jabon Wood
- The type of turbine used is horizontal axis wind turbine
- Type of airfoil used NACA 4415[7]
- Wind Turbine diameter 1000mm
- Wind speed is 0 m/s sampai 8 m/s

2. Dependent Variable

variables whose value is not specified by the author, but depends on the free variable. This study has dependent variables:

- turbine rotation (rpm)
- airflow form
- *Cut in speed* (m/s)
- Theoretical Power generated (Watt)

Wind Speed

Wind data is collected using an anemometer which is connected to a data logger[8] to record wind speed at a height adjusted to the wind turbine installation plan over a period of six to twelve months[9]. Meanwhile, the wind data used in this paper uses the probability of wind speed located in East Jakarta from January to December of 2018 recorded by BMKG's weather station which can be downloaded online[10]. With wind speeds recorded during January – December 2018, then obtained the probability of wind speed as shown figure 1.

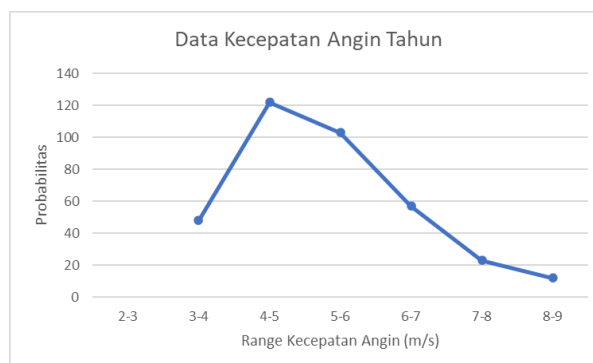


Figure 1. Wind Speed Probability



Wood Characteristics

In previous research, Adi Surjosatyo et al measured the characteristic values of three local woods, Balsa Wood, Jabon Wood, and Sengon Wood in the form of the elastic modulus and density values of the three woods, it was found that Jabon wood had the best elasticity and density values. between Sengon wood and Balsa wood[5] with a value of 4615,56 MPa and 0,34 g/cm³.

Airfoil NACA 4415

The airfoil shape used in this paper is NACA 4415, the airfoil itself is a profile shape that manipulates the flow of fluid flowing through it. The cross-sectional shape of NACA 4415 airfoil can be seen in Figure 2 below.

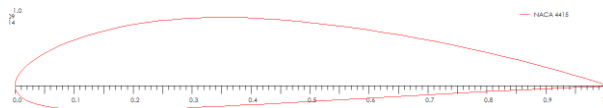


Figure 2. Airfoil NACA 4415

From the airfoil shape, a simulation can be performed to see the comparison of the value of the lift coefficient and the drag coefficient to the angle of attack (alpha).

III. EXPERIMENTAL RESULTS

Airfoil Characterization of Local Wind Speed

The Airfoil used in this paper is NACA 4415, which is then performed a simple simulation using the Q-Blade software. The parameters used in this simulation are data on actual conditions, such as wind speed and characteristic values of wind turbine wood material and can be seen in table 1.

Table 1. Parameter Input Data

Parameter	Unit
Airfoil	NACA 4415
Blade Radius	500 mm
Wind Speed	4,5 m/s
Chord	87,756 mm

By using the data in table 1 which is input on the Q-Blade to find the lift coefficient (Cl) value on NACA 4415 against the angle of attack.

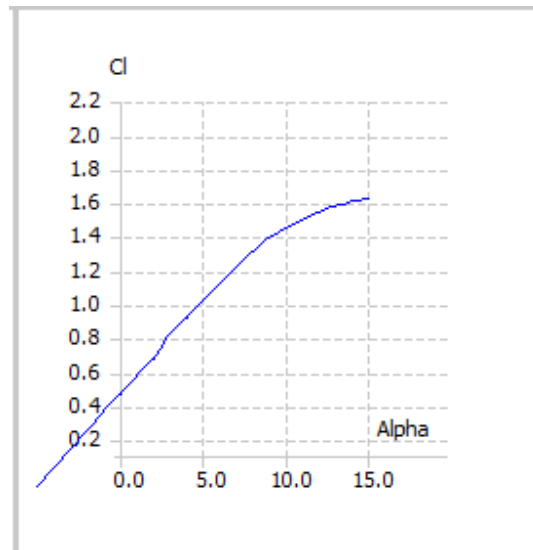


Figure 3. Cl & Alpha NACA 4415

Figure 3 shows a fairly stable increase in the lift coefficient between the range of -5° to 10° and continues to increase gradually up to an angle of 15° , this proves that the lift coefficient is more stable at various angles of attack.

Tip Speed Ratio and Coefficient Power

With several input parameters in table 1, the value of the power coefficient (CP) on the tip speed ratio is obtained as shown in Figure 4.

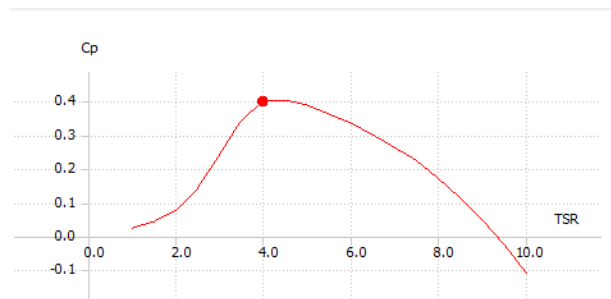


Figure 4. Coefficient Power

The tip speed ratio (TSR) is the ratio between the incoming wind speed and the wind speed at the tip of the wind turbine blade, the value of TSR obtained is TSR 4 and Cp 0.4. The power coefficient (Cp) is a Betz limit which refers to the maximum possible power that a wind turbine can produce with certain flow conditions.

Power Generated

In the computational simulation, the design power that can be generated is 80Watt at 420 rpm. The graph of the design power comparison with the turbine rotational speed can be seen in Figure 5.

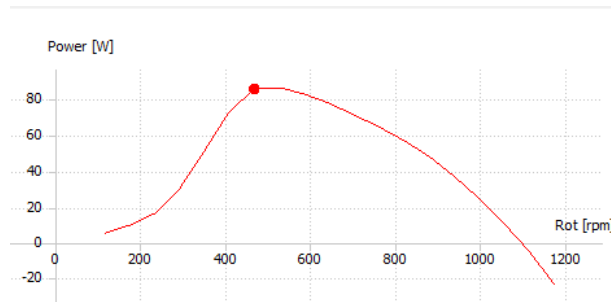
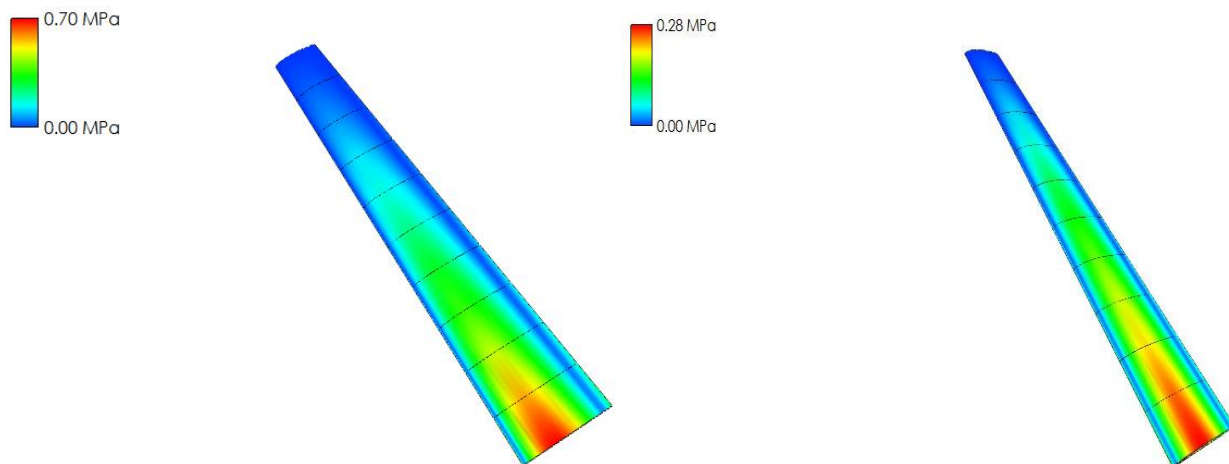


Figure 5. Turbine Rotating Speed and Power

QFem Simulation Results

The results of the QFem simulation show that the characteristic values of wood and wind used have a maximum stress of 0.70 MPa at the hub of the wind turbine blades at 420 rpm, but the maximum stress will decrease to 0.28 MPa when the turbine rotational speed drops at speed of 300 rpm with relatively the same stress distribution. The stress distribution on wood is also quite even when seen from the QFem results in Figure 6 below.



(a). Rotating Speed 420 rpm

(b). Rotating Speed 300 rpm

Figure 6. Wood Stress Distribution

IV. CONCLUSION

Based on the results of data processing and analysis, several things can be concluded:

1. The initial study of the manufacture of a wind turbine can be carried out computationally using the input data parameters measured in real conditions.
2. Using wind speed data recorded for one year.
3. Jabon wood can be used as raw material for the manufacture of wind turbine blades based on the characteristic values of the wood combined with the QFem simulation results with a fairly even pressure distribution on the wind turbine blades.
4. Airforil NACA 4415 according to the local wind characteristics used in this paper, namely East Jakarta with a TSR value of 4 and a Cp value of 0.4.
5. The theoretical power that can be generated is 80 Watt using the Q-Blade.



This research is expected to be continued in the wind tunnel to see actual performance, among others.

1. Measurement of static pressure along the wind turbine flow in the upstream and downstream wind turbines.
2. See the visualization of the wind flow before and after passing the wind turbine.
3. Wind turbine cut-in speed value.
4. The amount of vibration value generated by the wind turbine.
5. Value of noise that can be generated by wind turbines.

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