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Tidal Speed Simulation of Seawater against Torque (τ) and Power (P) Produced by the Darrieus Turbine Type H

Titik Nurhayati[1], Agus Margiantono[2]

[1]Department of Electrical Enginering university of Semarang
Email: *titiknur@usm.ac.id*
[2]Department of Electrical Enginering university of Semarang
Email: *agus_margiantono_mt@yahoo.com*

***Abstract*—*The depletion of fossil energy reserves and environmental issues currently play an important role in developing the concept of renewable energy, so that the search for new renewable energy is carried out very intensively. One type of renewable new energy that has the potential to be developed in Indonesia is the energy of river estuary flows, considering that Indonesia is an archipelagic country.This study, discusses renewable energy derived from the river mouth of the Bedono village of Demak Regency. The results of the observations that have been made, the tidal currents of the river which occur 2 times in 24 hours with an average current velocity at 0.953m/s. The biggest current velocity at 14.00-16.00 is 2.5 m/s and the lowest is 0.5 m/s at 06.00-08.00. Using the Computating Fluid Dynamic (CFD) model simulation and the Darrieus Type H turbine, with specifications; Diameter 1m, chord length 0.1m, turbine length 1 m, number of blade 3 and type of blade Hydrofill: NACA 0018 obtained the greatest power occurs at 14.00-16.00 at 8007.813Watt with a torque of 3540.470Nm and the lowest power of 83.726Watt with torque amounting to 14,663Nm at 04.00-06.00.*
Keywords*— *Energy, Computating Fluid Dynamic (CFD), Darrieus Turbine Type H, Tidal, Model Simulation.

I. INTRODUCTION

The depletion of fossil energy reserves and environmental issues currently play an important role in developing the concept of renewable energy, so that the search for new renewable energy is carried out very intensively. One type of renewable new energy that has the potential to be developed in Indonesia is the energy of river estuary flows, considering that Indonesia is an archipelagic country. From the observation, the flow of the river mouth in the Bedono village of Demak Regency occurred 2 times in 24 hours with an average current speed of 0.953m / s potentially used as a power plant.

II. LITERATURE REVIEW

Darrieus Turbine

Darrieus turbine is a type of turbine that was developed by a French aeronautical engineer named Georges Jean Marie Darrieus in 1931. This darrieus turbine has advantages such as not taking too much into the flow direction because of its symmetrical shape, gravity pressure is not able to return to the blade shape, able to operate at low head and speed, while its weakness is the inability to self-starting, and high vibration. The working principle of the Darrieus turbine is due to the speed of the water flow which causes the blade to rotate with a certain rotational speed, so the resultant of the velocity will produce a hydrodynamic force [4].

Darrieus turbine is generally used as a wind power plant, but in research and trials in several places Darrieus turbines are very potential to be developed as marine currents. This turbine has various advantages including ease of manufacture, installation and maintenance. This modular and reliable turbine design can withstand high-speed currents. The darrieus turbine used in ocean currents is type H which consists of 3 blade blades, this type is divided into two types, namely straight blade type and helix blade (gorlov).

In theory, the amount of efficiency produced by wind turbines is 0.59 according to the Betz limit (Betz limit), taken from the German scientist (Albert Betz). This figure theoretically shows the maximum efficiency that can be achieved, from the curve in Figure 1, it can be seen that the efficiency of Darrieus turbine reaches 0.45%. Momentary theory in stream tube by Froude provides a simple understanding of the problem of idealized rotor modeling by assuming that:

- The acceleration of the propeller is uniform on all fluids passed.
- Flow is without friction.
- Style is distributed evenly across all profiles from stream tube.
- Inrush and outflow only have the same path

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The power of the frictionless propeller was predicted by A.Betz in 1920. In accordance with Bernoulli's theory that the incoming pressure and volume equal the pressure and volume out ($P_1 = P_2$ and $V_1 = V_2$) and so that pressure is obtained [3].

$$E = p + \gamma h + \frac{\rho v^2}{2g} = constant \qquad (1)$$

for horizontal flow

$$P_2 = P_1 - \frac{\rho(v_2^2 - v_1^2)}{2g} \qquad (2)$$

In the momentum Froude theory, propellers are assumed to be actuator discs arising from cutting the discontinuity of the propeller field pressure. Physically the pressure in the P_1 region enters larger and when passing through the propeller the pressure will drop [3].

Sea Water Movement

• Sea current

Sea current is the movement of the mass of sea water from one place to another both vertically (upward) and horizontally (sideways movement). Examples of such movements are like the coriolis force, which is the force that turns the direction of the current from the earth's rotational power. The deflection will point to the right in the northern hemisphere and lead to the left in the southern hemisphere. This force results in a clockwise (right) gyre flow in the northern hemisphere and anticlockwise in the southern hemisphere. Changes in the direction of the current from the influence of the wind to the influence of the coriolis force are known as the ekman spiral. According to the location the current is divided into two, namely the upper and lower currents. The upper current is the current that moves on the surface of the sea. While the lower current is the current that moves below the sea surface [3].

• Tidal current.

Tidal currents are currents that occur due to changes in sea level due to tides. Characteristics of tidal currents are having a fixed period, following the tidal pattern. Therefore we know diurnal, semi-diurnal and mixed tidal currents. Tidal currents are formed by an attractive attraction between the earth and the moon's attraction. This is based on Newton's law which reads: "Two objects will be attracted to each other by forces that are inversely proportional to the square of the distance". Based on this law means that the further the distance, the less the attraction, because the distance from the earth to the sun farther than the distance to the moon, the tides of the sea level are more influenced by the moon. The tidal process is associated with periodic sea level ups and downs. The sun has a mass that is much larger than the moon, but because the moon is much closer to the earth the moon's attraction is 2.2 times greater than the sun's attraction. The maximum current flow is generally achieved at the time of the tide and near tide, while the direction of the tidal current is strongly influenced by local environmental conditions or topography. In coastal areas, the largest tidal currents are generally parallel to the coastline [3].

Computational Fluid Dynamic (CFD)

CFD is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems related to fluid flow. The purpose of CFD is to accurately predict fluid flow, heat transfer, and chemical reactions in complex systems, which involve one or all of the above phenomena.

III. RESEARCH METHODS

Survey location

The location survey is intended to find out the geographical conditions of the river covering the measurement of water depth, bridge length and tidal cycle of the area.

Measurement of current velocity

Speed measurements carried out on three sides of the bridge with the most rapid current assumption are at the place. Measurement is done every 2 hours using current drougde and stopwatch. Calculation techniques using speed formula: v=l/t With v is the speed of the tidal current (m / s), l is the "current drouge" (m) mileage and t = the time taken by the current drouge (s).

Simulation of the CFD Model

In the CFD model simulation, some of the things that are done are:

- Pre Processor
- Solver
- Post Processing
- Visualization of results

IV. RESEARCH RESULTS AND DISCUSSION

Measurement of current velocity

The measurement of tidal current velocity is carried out every 2 hours with the following measurement results:

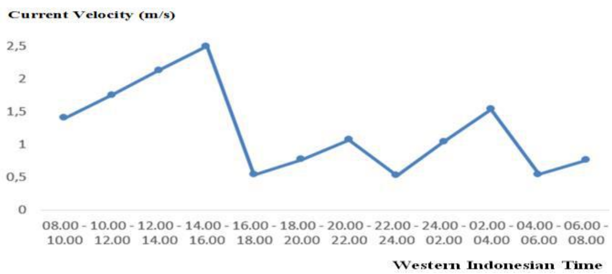

Fig. 1: Graphical Speed of Tidal Flow Against Time

Modeling of Darrius Turbine Using

Solidwork software Making a Darrius Type H turbine model Using Solidwork software where the results of 2D coordinate drawing are then redrawn using this software.

Determination of the coordinates of the blade

Determination of blade coordinates is intended to get the edge of the blade. Making point using point command with instructions in the form of x and y coordinates, in a simulation in bedono village using a Darrieus turbine with NACA 0018 blade [5].

Blade extraction

At this stage the 2-dimensional image that has been formed in the previous stage. Will be converted into 3 dimensions, this process uses the feature-ektruder command for 1000 mm. Basically, in the turbine modeling process, several parameters are needed in the turbine, including diameter, span, chord length. In this study simulated turbine specifications are; Darrieus Type H Turbine Type, Diameter 1.0 m, Chord Length 0.1 m Turbine length 1.0 m Solidity Ratio 0.6 Number of blades 3, Type of blade Hydrofill naca 0018.

Visualization of Simulation results

CFD visualization results are presented in the figure below

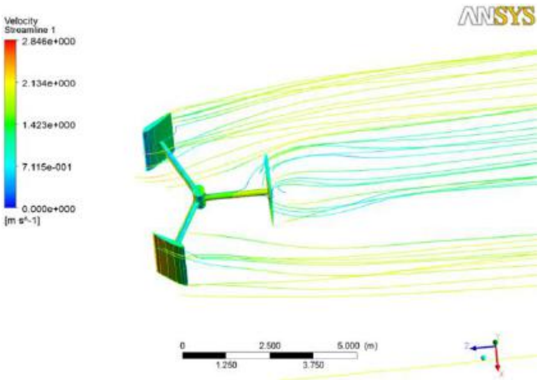

Fig. 2: Streamline Velocity in Turbines

The simulation results using CFD using tidal currents measured obtained torque (τ) and power (P) as shown below.

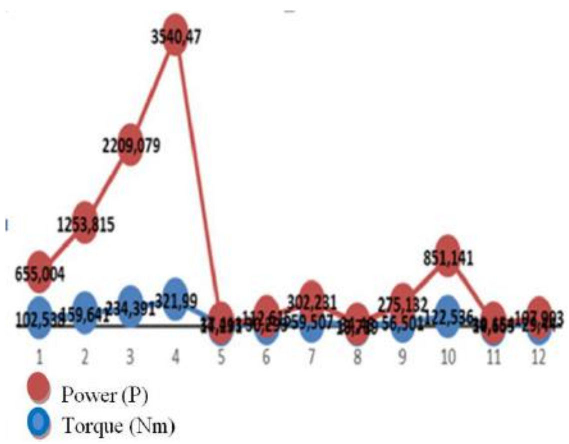

Fig.3. Torque Changes (τ) to Power (P)

It can be seen from the graph that the significant increase in power occurs when Torque (τ) reaches 321.99 Nm power (P) 3540.47W, so it can be concluded that the relationship between torque and power is not linear. The scattering result shows that the relationship is a quadratic equation with the

$$Y=0,7712 \ X^{1,4586} \qquad (3)$$

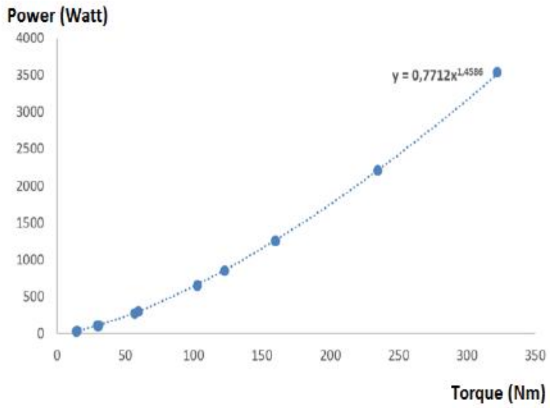

Fig.4. Torque Relationship To Power

V. CONCLUSION

From this research can be concluded several things as follows ;

- The highest speed of tidal currents occurs at 2:00 a.m - 4:00 p.m.WIB at 2.5m / s.
- The largest power of 3540.47W is generated when the torque is 321.99 Nm at 14.00-16.00.
- Torque relationship to power is a quadratic equation.

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