Savonius Turbine Performance Type – S Variation of Rotor Sweep Diameter and Air Gap

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Abstract— The savonius wind turbine with variations in the diameter of the sweep and the air gap is a technological innovation with treatment using changes in the diameter of the sweep and the distance of the air gap between the blades. And it has low self-starting and relatively high torque. The purpose of the study was to create five models and test the performance of the Savonius wind turbine with variations in sweep diameters of 500 mm, 480 mm, 460 mm, 440 mm and 420 mm with air gaps of 30 mm, 50 mm, 70 mm, 90 mm, and 110 mm. . And analyze the turbine performance to get the best Coefficient of Power (CP) from the five turbine gaps. The stages of the research method include the preparation of a literature search, turbine design planning, tool making, tool testing, data collection, data analysis, and the final stage. The results of the tests carried out showed that the Savonius turbine with an air gap of 70 mm with a CP value of 0.232 had maximum work at low wind speeds (4 m/s) and at high wind speeds (10 m/s). obtained a CP value of 0.0695.

Keywords— Savonius wind turbine, air gap, power coefficient

I. INTRODUCTION

Indonesia's commitment as stated in Government Regulation no. 79 of 2014 concerning the National Energy Policy, the target for the new and renewable energy mix in 2025 is at least 23% and in 2050 it is 31%. However, until 2020, only 135 MW of wind power plants have been installed, with details of 75 MW. in the Sidrap area. and Sidrap. of 60 MW in the Janeponto area. Meanwhile, in 2025 it has a target capacity of 255 MW Wind Power Plant (**p3tkebt.esdm.go.id/,2008**). This target was also born considering that fossil energy sources are classified as non-renewable, it is necessary to use alternative energy sources, one of which is wind energy. For this reason, research on wind energy in Indonesia must be developed by researchers so that they are able and suitable to be applied in various areas that have the potential to achieve the PLTB capacity target by 2025 (**Habibie, M. Najib, et al, 2011**).

One type of wind turbine is a vertical axis wind turbine. The advantage of vertical axis windmills is that in conditions of low wind speed, such as in Indonesia, they are easy to work. The Savonius wind turbine is a VAWT (Vertical Axis Wind Turbine) wind turbine which has low self-starting and relatively high torque. This turbine has a simple shape and construction resembling the letter S (Alit, et al., 2016). Research (Taher, G., et al., 2014) related to the use of the Savonius turbine with the CFD (Computational Fluid Dynamics) and PIV (Particle Image Velocimetry) methods at wind directions that are not constant and wind speeds are low. which is more optimal than HAWT (Horizontal Axis Wind Turbine) wind turbines.

One of the ways to increase the type of Savonius turbine is by varying the diameter of the air sweep and air owned by the turbine. Referring to the research journal belonging to Dedy Nataniel Ully and Agus Laka entitled "The Effect of Variation of Blade Gap Distance on the Performance of the Semicircular Savonius Wind Turbine" who has conducted research on the Savonius turbine with air gap variations of 10 mm, 20 mm and 30 mm (with a gap of 10 mm, 20 mm and 30 mm). 30 mm) as a basic reference for this study to further investigate the variation of air gaps. This study uses a variation of the slit width above the air gap value of 30 mm. Therefore, the idea of a research and development of a Savonius wind turbine emerged, entitled "Making a Savonius Type-S Turbine with Variations in Rotor Sweep Diameter and Air Gap". Savonius vertical axis wind turbine.

II. METHODS

A. Literature and Literary Study Methods

The library study method is a way of collecting supporting materials for making aids for the final project by browsing from books or looking for references from the internet in the form of journals or scientific articles as well as data that has been done previously. Literature study aims to increase understanding of the research topic taken. The references studied are related to the type of hydrokinetic turbine, the turbine concept to be used, the basic equation of turbine flow, how to manufacture and survey the test site and how to test wind turbines in the laboratory.

B. Tool Planning Method

The methods for planning are:

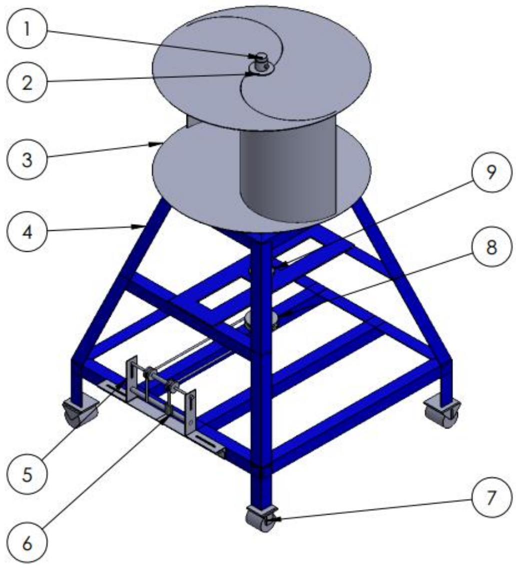
1. The design of this wind turbine consists of a Savonius wind turbine blade using stainless steel material with dimensions of length 300 mm, rotor sweep diameter of 500 mm, 480 mm, 460 mm, 440 mm, and 420 mm. This wind turbine is designed using a Savonius type S wind turbine. This wind turbine model is based on the dimensions and capacity of the blower at the Semarang State Polytechnic Energy Conversion Engineering Laboratory. All sections on the Savonius wind turbine design for this study are located in

2. Selection of the right type of material, variations of the Savonius windmill on the diameter of the rotor sweep and the blade air gap are designed using stainless steel. The choice of this material is because stainless steel has advantages over other materials, making it suitable for use as a turbine blade material. Stainless steel or stainless steel is an iron compound containing 10.5% chromium which is useful for preventing the corrosion process (metal rusting). Stainless steel is made from components of Iron, Chrome, Carbon, Nickel, Molybdenum and small amounts of other metals.

3. The turbine shaft actually uses a size of 25.4 mm with the ST 37 type because it is easy to obtain.

C. Tool Making Method

The process of activities in the manufacture of the Savonius turbine is based on design drawings and pre-determined size plans. In the manufacture of the Savonius turbine blade, the type of material to be used is determined, namely SS 304 plate with a thickness of 1mm. For its manufacture, tools and materials are needed to support the process, such as cutting scissors to cut to form the turbine blades, drill bits to make bolt holes, bevel protactors and rulers for measuring turbine blade angles, electrodes and welding machines to glue each part.

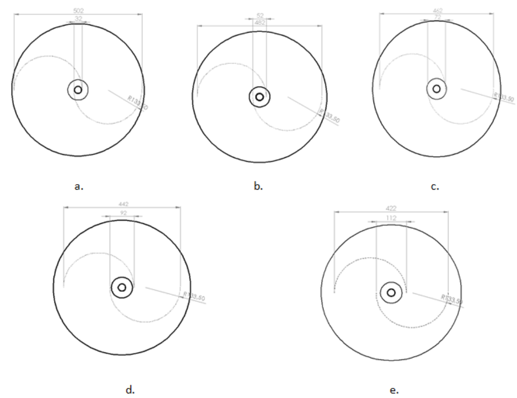


Picture 3.1 Turbine Test Framework

Description:

1. Solid Shaft
2. Flanges
3. Savonius Test Turbine Blade Type - S
4. Main Framework
5. Torque Testing Auxiliary Framework
6. Mass Balance
7. Wheel
8. Pulley
9. Bearing

The turbine made has 5 (five) variations in the shape of the blade type.



Picture 3.2 Test Turbine

Description :

a. Savonius Variation Rotor Sweep Diameter 500 mm with gap 30 mm .

b. Savonius Variation of Rotor Sweep Diameter 480 mm with gap 50 mm
c. Savonius Variation Rotor Sweep Diameter 460 mm with gap 70 mm
d. Savonius Variation of Rotor Sweep Diameter 440 mm with gap 90 mm .

Savonius Variation Broom Rotor Diameter 420 mm with Gap 110 mm

D. Working Test Method

The work test method is a Savonius turbine testing process with predetermined parameters. The wind turbine test uses seven variations of speed 4 m/s – 10 m/s and is tested at the Semarang State Polytechnic Fluid Machinery Laboratory using a blower. In collecting this data, the parameters measured are mass (kg) resulting from loading using a digital spring balance, turbine rotation (rpm) using a tachometer. After all the tests are complete, the turbine performance data can be obtained and then a graph of the turbine performance characteristics can be made. From the results of this test, it is expected to determine the most optimum efficiency value of various types of turbine blades.

The test procedures that must be carried out in collecting this data are as follows:

1. Prepare the tools and materials that will be used in conducting the test.

2. Setting up the Savonius Wind Turbine, varying the diameter of the rotor sweep and the 1st airflow up to the variation of the diameter of the rotor sweep and the 5th air gap.

3. Turn on the blower to adjust the wind speed using an anemometer. By adjusting the distance between the Savonius wind turbine and the blower according to the required speed (4 m/s – 10 m/s).

4. Install the spotlight on the turbine shaft to get the turbine shaft rotation.

5. Install the Savonius Wind Turbine variation 1 on the turbine frame using a wrench to tighten the bolts on the top and bottom flanges.

6. Attach the load to the torsion meter test string with a load variation of 0; 0.05; 0.1; 0.15; 0.2; 0.25.

7. Record the required parameters, namely the turbine shaft rotation (rpm) on the tachometer and the digital spring balance (Kg) that is read.

8. Repeat Steps 5-7 for wind speed variations of 4 m/s, 5 m/s, 6 m/s, 7 m/s, 8 m/s, 9 m/s, 10 m/s.

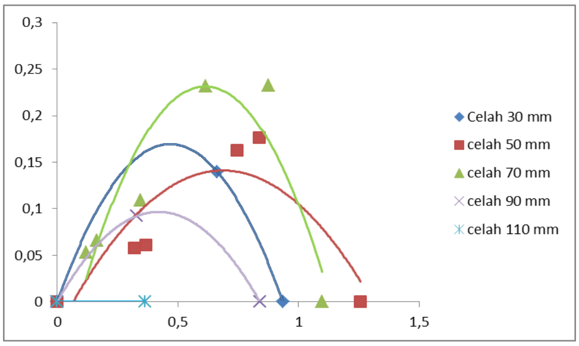
After testing on the Savonius windmill variation 1 was completed, then it was replaced with variation 2 to variation 5.

E. Method of Analysis and Discussion

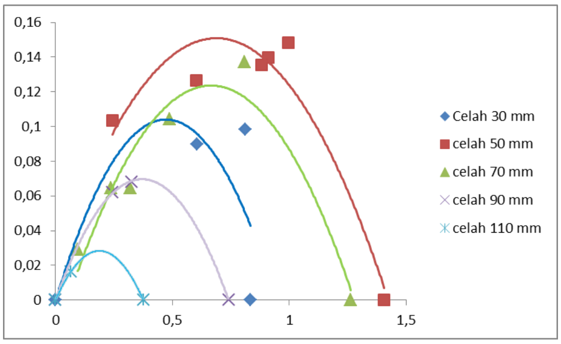
Is a method obtained after testing and data collection, the parameters measured are turbine torque, turbine rotation, flow velocity. After all the tests are complete, the turbine performance data can be obtained and then a graph of the turbine performance characteristics can be made. Analysis complete by comparing CP with TSR

III. RESULTS AND DISCUSSION

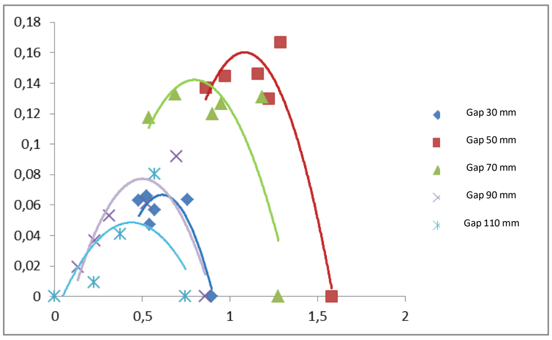
A. Characteristics of CP against TSR



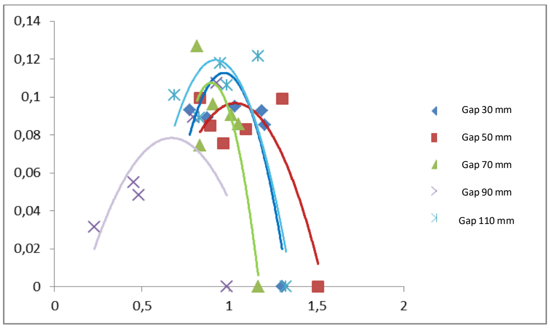
Picture 4.1 Characteristics of the Coefficient of Power (CP) against the tip speed ratio (TSR) at a Flow Velocity of 4 m/s.



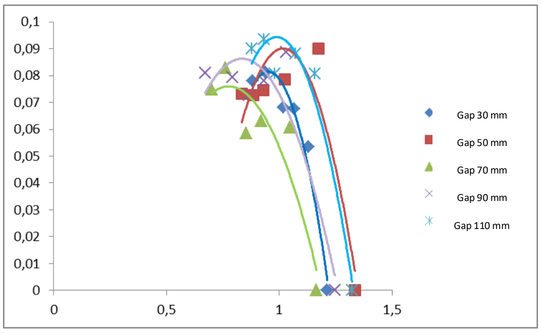
Picture 4.2 Characteristics of the Coefficient of Power (CP) against the tip speed ratio (TSR) at a Flow Velocity of 5 m/s.



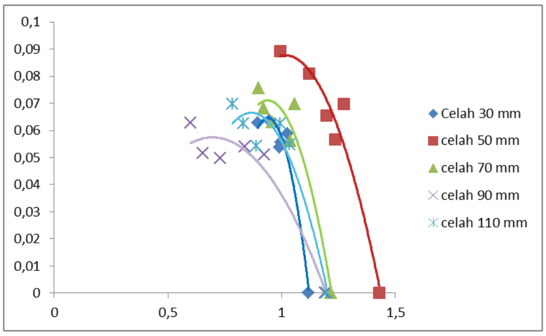
Picture 4.3 Characteristics of the Coefficient of Power (CP) against the tip speed ratio (TSR) at a Flow Velocity of 6 m/s.



Picture 4.4 Characteristics of the Coefficient of Power (CP) against the tip speed ratio (TSR) at a Flow Velocity of 7 m/s.



Picture 4.5 Characteristics of the Coefficient of Power (CP) against the tip speed ratio (TSR) at a Flow Velocity of 8 m/s.



Picture 4.6 Characteristics of the Coefficient of Power (CP) against the tip speed ratio (TSR) at a Flow Velocity of 9 m/s.

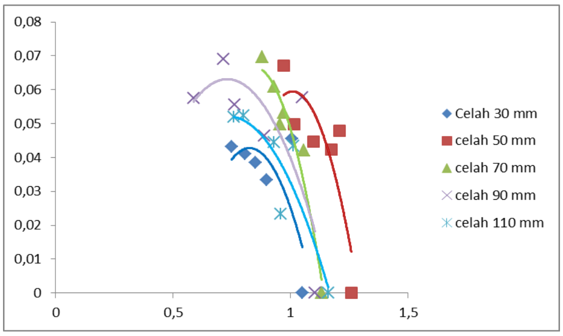


Figure 4.7 Characteristics of the Power Coefficient (CP) against the tip speed ratio (TSR) at a Flow Velocity of 10 m/s

Based on the characteristic graph that has been made, it can be seen that each type of turbine blade variation has a different peak Power Coefficient (CP). This value is influenced by the input power obtained from the kinetic power and the output power, namely mechanical power. The kinetic power (Pkin) is influenced by the wind speed and the cross-sectional area of the collision. Wind speed and cross-sectional area are directly proportional to kinetic power. Mechanical power is affected by rotation and torque. Torque is inversely proportional to rotation. The smaller the rotation, the greater the torque produced. From the test data obtained a parabolic curve shape from the graph of the characteristics of the Coefficient of Power (CP) to the tip speed ratio (TSR) which reaches the optimum point where the turbine power coefficient decreases after reaching the peak point.

IV. CONCLUSION

1. Based on the parameters of the Savonius windmill performance test, the air gap variations are:

   a. The maximum point on the graph of the relationship between CP and TSR with low wind speeds of 4 m/s, 7 m/s, and 10 m/s is the Savonius wind turbine with an air gap of 70 mm with a sweep diameter of 460mm.

b. b) The maximum point on the graph of the relationship between CP and TSR with wind speeds of 5 m/s, 6 m/s, and 9 m/s is the Savonius wind turbine with an air gap variation of 50 mm with a sweep diameter of 480mm.

c. c) The maximum point on the graph of the relationship between CP and TSR with a wind speed of 8 m/s is the Savonius wind turbine with an air gap of 110 mm with a sweep diameter of 420 mm.

2. The characteristic of the Savonius wind turbine is that it works at low wind speeds. Based on the results of the tests carried out, it shows that the Savonius wind turbine with an air gap of 70 mm with a CP value of 0.232 has a maximum work at low wind speeds (4 m/s) and at high wind speeds (10 m/s) a CP value of 0.0695 is obtained

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