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Literature review of modification of u-type savonius wind turbine rotor for low wind speeds

Muhammad Danang Ilham Alfatih*, Priyo Heru Adiwibowo, Renaldi Prima Saptono, Rayhan Aulia Iman Fani, Dimas Ridho Pambudi, Muhammad Zardana Ciptafarizi, Kharis Setiawan
Mechanical Engineering, Univeritas Negeri Surabaya, Indonesia
Gedung E1, Jl. Ketintang, UNESA, Kec. Gayungan, Surabaya, Jawa Timur 60231
Email: muhammaddanang.22106@mhs.unesa.ac.id

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Abstract

A wind turbine is one of the tools that can be used to convert wind energy into electrical energy. The increasing need for electrical energy in Indonesia and fossil fuels are running low, so alternative to fossil fuels are needed. One of them is a wind turbine that can convert wind energy into wind mechanical energy into kinetic energy in the form of turbine blades that are used to rotate generators that can produce electricity. Indonesia is an area that has low wind speed. This study aims to analyze the effect of U-type savonius wind turbine rotor modification at low wind speeds. The research method used is a qualitative method in which we conduct library research on various literature to examine the effect of turbine rotor modification. The results obtained are the addition of a guide vane or deflector and the increase in the number of blades on the turbine rotor can improve the performance of the U-type savonius wind turbine.

1. INTRODUCTION

The increasing need for electrical energy in Indonesia is due to population growth, economic growth and patterns of energy use itself. As is known, the main energy source used for electricity generation is fossil energy. Meanwhile, fossil energy itself has limitations and can run out at any time. Therefore, alternative energy is needed to replace fossil energy to meet electrical energy needs in Indonesia and the world (Maulana et al., 2021).

Indonesia has the potential for alternative energy that can be used as a substitute for fossil energy, one of which is wind energy which has a potential of 60.6 GW (Maulana et al., 2021). According to the Danish Energy Agency, the potential for wind energy in Indonesia is 9 GW with an average wind speed of between 3 m/s to 6.3 m/s (Siregar et al., 2023). However, Indonesia has wind potential which can be used as an alternative to fossil fuels. Wind energy will be converted into electrical energy using a wind turbine which drives a generator to produce electrical energy (Anggara, 2021).

Wind turbines themselves can be divided into two, namely Horizontal Axis Wind Turbines (TASH) and Vertical Axis Wind Turbines (TASV) (Anggara, 2021). Generally, horizontal-axis wind turbines are more widely used in power plants. This is because the horizontal axis can produce large amounts of electrical energy (Salim et al., 2020) and uses the principle of lift compared to vertical axis wind turbines. But vertical axis wind turbines can be an efficient alternative for producing electrical energy. This is because the vertical axis has been developed and focused on economical manufacturing, as is known vertical axis wind turbines can also operate at low wind speeds, and can operate at altitudes close to land. (Salim et al., 2020). The Savonius type vertical axis wind turbine utilizes drag (Silla et al., 2022) on the advancing blade and returning blade (Ananto & Yuwono, 2021).

The Savonius wind turbine itself is the simplest wind turbine (Salim et al., 2020) which was created for the first time in Finland by an expert and is S-shaped when viewed from above (Anggara, 2021). The Savonius wind turbine works due to the difference in force applied to each blade (Salim et al., 2020). The Savonius wind turbine is a wind turbine that is suitable for use at low wind speeds, this is because this turbine has the ability to capture wind from all directions, apart from being able to capture wind from all directions (Lestari et al., 2023). Savonius wind turbines also have good self-starting, therefore Savonius wind turbines can be placed in areas that have low wind speeds (Manurung & Yuwono, 2021).

Type U is one type of Savonius wind turbine. This turbine has larger straight blade sides so it can receive a larger amount of wind than other types (Maulana et al., 2021). U-type has equal flow on each side (Silla et al., 2022).

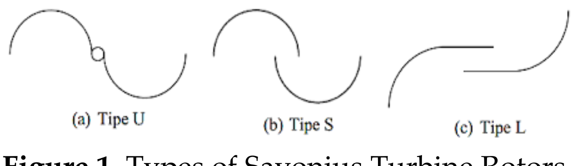

Figure 1. Types of Savonius Turbine Rotors

Wind potential in Indonesia is included in low speed winds. So modifications are needed to the U-type Savonius wind turbine so that it is more optimal in low wind conditions. Until now, many experts have carried out experiments so that the performance of Savonius wind turbines can be more optimal. One of them is by modifying the turbine rotor.

In this article we review various journals that have conducted research to optimize the performance of Savonius wind turbines at low wind speeds, by modifying the rotor. This modification is carried out by adding a guide vane or deflector and increasing the number of blades on the U-type Savonius wind turbine.

2. METHOD

Method used is library analysis method namely analyzing the tubing rotor based on literature study. This method is a qualitative method where this method uses a research approach that focuses on data analysis.

This library research was carried out in the mechanical engineering library at Surabaya State University, in March-May 2024. In this case, we have carried out research to study the effect of modifications to the U-type Savonius wind turbine rotor on low wind speeds. The research subject is the U-type Savonius wind turbine rotor.

3. RESULTS AND DISCUSSION

The Savonius wind turbine is a type of turbine that is suitable for development in areas that have low wind speeds. As is known, Indonesia has a wind speed of 3 m/s to 6.3 m/s. Therefore, areas in Indonesia can be used as a place to develop U-type Savonius wind turbines. The advantages of the Savonius wind turbine are that it can catch wind from all directions and also has good self-starting. Therefore, Savonius wind turbines can work at low wind speeds. Savonius wind turbines have several types, one of which is the U-type, this type of turbine has larger straight blade sides so it can receive a larger amount of wind than other types. However, the Savonius wind turbine still needs to be developed so that its performance is more optimal and can produce greater output power.

After conducting research on the U-type Savonius wind turbine, we got several results to optimize the performance of the U-type Savonius wind turbine, namely by modifying the turbine rotor by adding a guide vane or deflector and also increasing the number of blades on the U-type Savonius wind turbine.

3.1. Addition of guide vane or deflector

Guide Vane is a guide vane that is used to direct the wind flow towards the turbine blade. The application of the deflector concept is useful for increasing the lifting force on vertical axis wind turbines, because the Returning Blade lifting force on vertical axis wind turbines is parallel to the wind direction. (Irani et al., 2023). The purpose of adding a guide vane is to direct the wind flow toward the turbine and reduce negative torque on the return blade (Sugiharto et al., 2020).

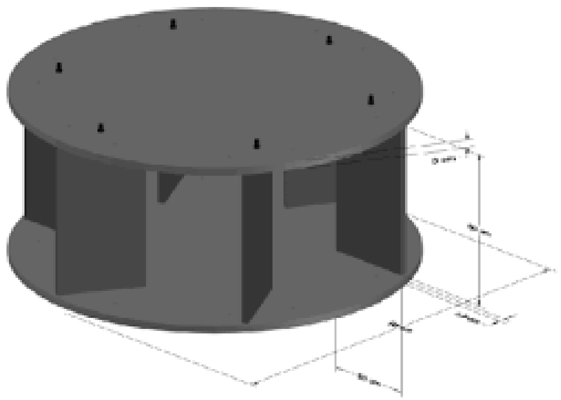

Figure 2. Guide Vane on a U-type Savonius Wind Turbine

There are several variations in the number of Guide Vane additions, namely 4, 8, 16 blades (Sugiharto et al., 2020). The pitch angle variations are 30°, 45°, and 60° (Irani et al., 2023). Pada pengujian yang dilakukan oleh

In research conducted by Irani et al. (2023), the maximum coefficient obtained was 45.4% at a pitch angle of 40° with a wind speed of 7.56 m/s. with 6 blades, at a distance of 150 cm, turbine rotation of 218.1 rpm, power produced is 61.70 Watts with a Cp of 0.88%, and torque of 3.46 Nm using a 12-watt LED light load. Research conducted by Sugiharto et al. (2020), produced static torque of 84%, dynamic torque of 57%, and power coefficient of 58% at a wind speed of 4 m/s, this test was carried out in a wind tunnel with a wind speed of 4 m/s, 5 m/s, 6 m/s. with a number of guides of 16 blades, and an angle of 45°.

Based on the research above, it can be concluded that adding a guide vane or deflector can optimize the performance of a U-type Savonius wind turbine at low wind speeds compared to a U-type Savonius wind turbine without a guide vane or deflector.

3.2. Increasing in number of blades

Generally, U-type Savonius wind turbines have 2 blades that form the letter S, but U-type Savonius wind turbines have been developed a lot, one of which is by varying the number of turbine blades. The variations that can be given to the blades vary from 2, 3, 4 blades or even more. In several studies it was found that the greater the number of blades, the greater the generator output power (Salim et al., 2020).

Research conducted by Anwar (2023) shows that the 4-blade Savonius wind turbine has the largest rotation, namely 64 rpm, the turbine power is 15.42 Watts, the coefficient of power is 0.56%, and the electrical voltage produced by the generator is 6.1 Volts. This can be interpreted as the U-type Savonius wind turbine with 4 blades having maximum performance at low wind speeds.

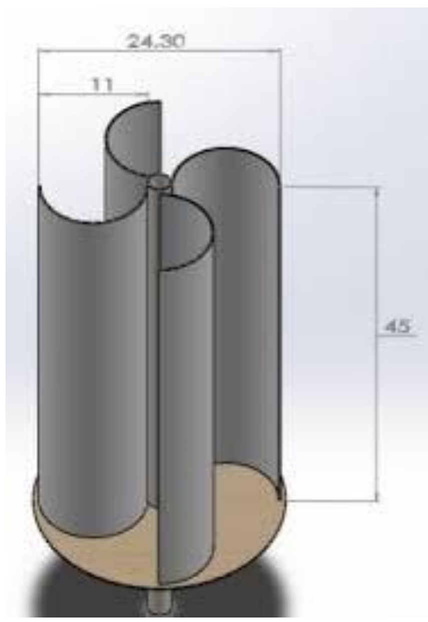

Figure 3. U-type with 4 Blades

Regarding this, it can be concluded that adding blades to the U-type Savonius wind turbine can improve the performance of the U-type Savonius wind turbine. where the average power of the U-type Savonius wind turbine generator is 4.8 Watts. Meanwhile, the Savonius U-type 4 blade wind turbine has an average generator power of 6.1 Watts (Anwar, 2023). Therefore, increasing the number of blades on a Savonius wind turbine could be one idea for modifying the rotor so that the performance of the U-type Savonius wind turbine is maximized.

By adding a guide vane or deflector and also the number of blades, you can optimize the performance of the U-type Savonius wind turbine. If we look at the journals that we have analyzed, the results show that the U-type Savonius wind turbine with the addition of a guide vane or deflector and the number of blades has more optimal turbine performance compared to a turbine without a guide vane and the addition of the number of blades.

4. CONCLUSION

Based on the literature analysis we can draw conclusions: (1) the U-type Savonius wind turbine with the addition of a guide vane or deflector on the turbine rotor produces maximum turbine performance results compared to the U-type Savonius wind turbine without a guide vane or deflector at low wind speeds. (2) increasing the number of blades also affects the performance results of the U-type Savonius wind turbine, namely increasing the average power of the generator which makes this turbine more optimal at low wind speeds, compared to wind turbines that have 2 blades.

5. DECLARATION/STATEMENT

5.1 Acknowledgment

We would like to thank all parties who have helped or provided information regarding Savonius wind turbines.

5.2 Author Contributions

Muhammad Danang Ilham Alfatih contributed to determining the research idea. Priyo Heru Adiwibowo and Renaldi Prima Saptono contributed to the preparation of the article. Rayhan Aulia Iman Fani, Dimas Ridho Pambudi, Muhammad Zardana Ciptafarizi, and Kharis Setiawan contributed to the use of the reference management tool.

5.3 Conflict of Interest

The Authors declare that there is no conflict of interest.

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