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Performance Analysis of H-Type Darrieus Turbine Radial Projection Blades Based on NACA 0018

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***Abstract*— The H-type Darrieus turbine is a vertical wind turbine that is used to convert wind energy into mechanical energy by utilizing lift force. This research is aimed at making a modified H-type Darrieus turbine blade model from a NACA 0018 profile blade to a NACA 0018 blade with a chordline projected radially to the turbine diameter and the second result is to compare the performance of the NACA 0018-based radial projection blade to the performance of the NACA 0018 blade. This is preparation for searching literature, design making, manufacture of NACA 0018 blade test specimens and NACA 0018 based radial shadow blades, assembly and installation of test equipment, testing and data collection of wind turbine performance, data processing and analysis, final results. The variables tested were wind speeds of 7 m/s, 8 m/s, 9 m/s, 10 m/s, 11 m/s, 12 m/s. The test results show that the higher the TSR, the higher the resulting power coefficient (Cp) until the maximum Cp is reached. After that, the increasing TSR, the resulting Cp is getting smaller. The test results show that projection blades based on NACA 0018 and NACA 0018 blades produce a small maximum Cp, respectively 0.082 and 0.124 compared to the Darrieus turbine maximum Cp reference on the vertical turbine characteristic chart, which is 0.4. The NACA 0018-based radial projection produces a lower Cp than the NACA 0018 blade at speeds of 7 m/s, 8 m/s, 10 m/s, 11 m/s, 12 m/s. At a wind speed of 9 m/s the projection blade based on NACA 0018 produces a higher power coefficient than the NACA 0018 blade. Projecting the NACA 0018 blade chordline on the track causes the blade cross-sectional area and chordline length to shrink. The higher the wind speed, the smaller the resulting Cp. The solidwall phenomenon affects turbine performance. Testing without load at all wind speeds, the projection blade based on NACA 0018 produces higher rotation than the NACA 0018 blade. The parameter of the blade momentum affects the results of the turbine rotation when tested without load.**

Keywords— ***turbin darrieus tipe – H, koefisien daya turbin angin, sudu NACA 0018, sudu proyeksi radial berbasis NACA 0018, momentum.***

I. INTRODUCTION

VAWT is a wind turbine with the shaft rotating direction parallel to the wind direction. Therefore, all cardinal directions can be utilized with VWAT. The high torque causes the VWAT to operate at low wind speeds (Mahmuddin et al., 2018).

One type of VWAT turbine is the Darrieus type – H turbine. The design of the Darrieus turbine in water fluid was developed by adopting it to water fluid which is called the Cross Flow Water Turbine (CFWT).

In a study conducted by J Zanette et al (Zanette et al., 2010), a cross-flow water turbine blade was modified by changing the chord line and the shape of the NACA 0018 blade to a radial projection profile blade adjusted to the turbine diameter. The results of this study are the increased durability and performance of the Darrieus turbine. Based on this, in this study a modification of the chord line on the Darrieus turbine type H airfoil was adjusted to the diameter of the turbine circle so that the shape of the blade adjusted to the trajectory of the turbine circle.

In a study conducted by J Zanette et al (Zanette et al., 2010), a cross-flow water turbine blade was modified by changing the chord line and the shape of the NACA 0018 blade to a radial projection profile blade adjusted for diameter. There are two main types of VAWT namely drag driven VAWT (Savonius type) and lift driven VAWT (Darrieus type). The Savonius type functions similarly to a water wheel that uses a turbine. The results of this study are the increased durability and performance of the Darrieus turbine. Based on this, in this study a modification of the chord line on the Darrieus turbine type H airfoil was adjusted to the diameter of the turbine circle so that the shape of the blade adjusted to the trajectory of the turbine circle.

II. METHODS

2.1 Model and Size Determination

The height and diameter of the turbine adjusts to the turbine frame in the KE Polines Lab, namely 65 cm turbine height and 60 cm turbine diameter. The length of the chord line is determined using the dimensionless chord length equation. The optimum dimensionless chord length ($\overline{c}$) number for the h-type Darrieus turbine is 0.4 (Pramono et al., 2019) Then the chordline length (c) can be calculated using Equation (2.1) as follows :

$$\overline{c} = \frac{c}{D_R} \text{ at au } c = \overline{c} \,.\, D$$

So the value of c = 0.4 x 60 cm = 24 cm

In this study, the number of blades used for the Darrieus turbine was 3. The specifications for the type H Darrieus turbine can be seen in Table 3.1.

Table 3.1 Wind Turbine Specifications

No	Specification	Explanation
1	Type	Vertical Turbine
2	Diameter	60 cm

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3	High	65 cm
4	Material arm	Iron
5	Number of arm	3 buah
6	Blade profile	NACA 0018
7	Blade material	Wood
8	Chord length	24 cm

Meanwhile, the NACA 0018 profile wind turbine blade specifications can be seen in Table 3.2.

Table 3.2 Profile Wind Turbine Blade Specifications NACA 0018

No	Specification	Explanation
1	Type	Vertical Turbine
2	Diameter	60 cm
3	High	65 cm
4	Material arm	Iron
5	Number of arm	3 buah
6	Blade profile	NACA 0018 based radial projection
7	Blade material	Wood
8	Chord length	22.283 cm

2.2 Designing Turbine

a) Blade NACA 0018

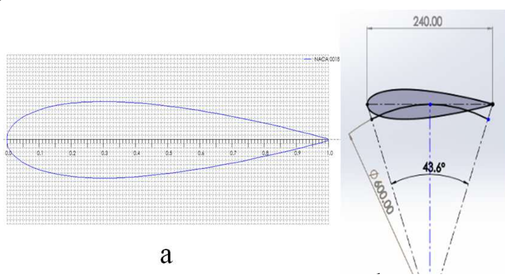

Figure 3.2 Darrieus Turbine Blades Type – H
a) NACA Profile 0018 b) Top View of NACA blade 0018

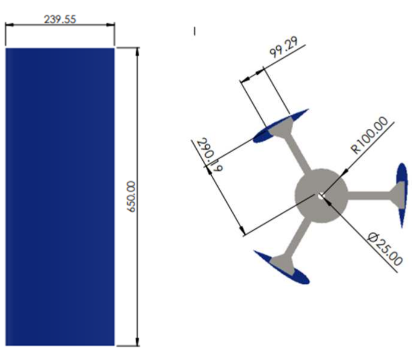

Figure 3.3 Turbine Dimensions
Darrieus Type H With NACA Blade 0018

Figure 3.4 H-Type Darrieus Turbine With NACA Blades 0018

b) Radial Projection Blade Based on NACA 0018

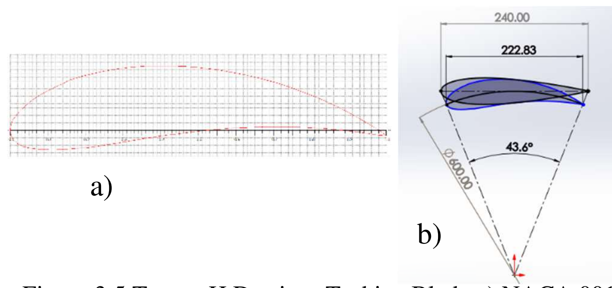

Figure 3.5 Type – H Darrieus Turbine Blade a) NACA 0018 Based Radial Projection Blade b) Top View of NACA Based Radial Projection Blade 0018

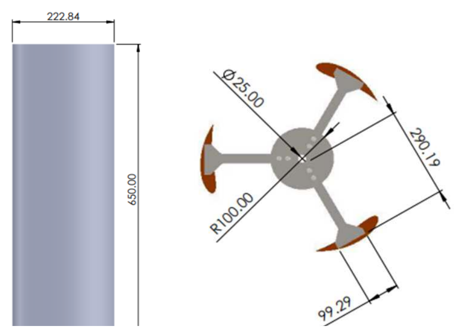

Figure 3.6 Dimensions of Darrieus H-type Turbine with NACA-Based Radial Projected Blades 0018

Figure 3.7 H-Type Darrieus Turbine With NACA Based Radial Projected Blades 0018

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2.3 Manufacture of test equipment

The design that has been planned is then made into actual goods. Turbine blades are made of wood.

2.4 Testing and data collection

Following are the stages and schemes of testing the H-type Darrieus turbine with NACA 0018 blade profiles and NACA 0018 based radial projection blade profiles

1. Setting up the darrieus wind turbine test equipment.
2. Measure air density, temperature, RH using a hygrometer
3. Install the load on the generator output according to Figure 3.18.
4. Install the ammeter in series with the load according to Figure 3.18.
5. Install a Voltmeter in parallel to the load according to Figure 3.18.
6. Install NACA 0018 profile H-type Darrieus turbine blades on the turbine test bench according to Figure 3.18.
7. Adjust the distance and position of the turbine to the blower to get the wind speed according to the provisions measured using an anemometer.
8. Turn on the blower.
9. Measure the wind speed in front of the turbine.
10. Testing the turbine with zero load.
11. Measuring the rotation of the turbine with a tachometer.
12. Measuring the rotation on the generator with a tachometer.
13. Read the results of current and voltage measurements on the ammeter and voltmeter.
14. Measuring the force acting on the generator with a newton meter to get torque.
15. Record the results of measurements of wind speed, current, voltage, force on the generator, turbine rpm, generator rpm.
16. Perform steps 6 to 15 for the H-type Darrieus turbine blades with radial projection profile based on NACA 0018 and wind speed variations.
17. Tidy up equipment after completion of testing.
18. Processing data by recording the results in tabular form and then making graphs in the form of turbine characteristics.

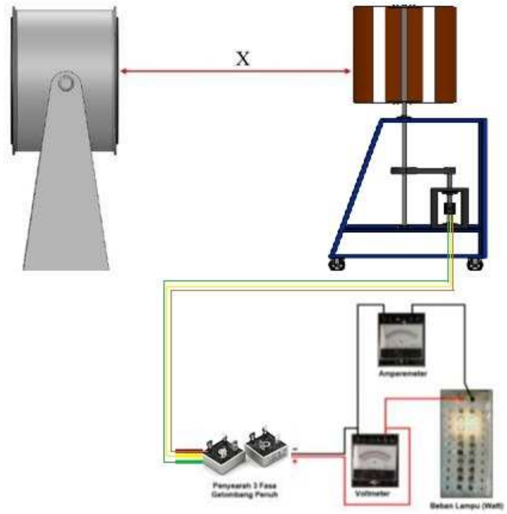

Figure 3.18 Series of Tests

2.5 Data Processing and Analysis

Data processing is performed to calculate air density, wind power, torque, mechanical power, generator output power, turbine efficiency, generator efficiency, system efficiency. Humidity and air temperature data are used to calculate the density of air. Air density data and wind speed are used to calculate wind power. Turbine rotation and torque data are used to calculate mechanical power. Current and voltage data are used to calculate the generator output power. Wind power, mechanical power, and generator output power are used to calculate turbine efficiency, generator efficiency and system efficiency.

The data that has been processed is presented in the form of a test table. The test table format can be seen in Table 3.12.

Table 3.12 Test Data Table Format

V_a	Jumlah lampu	n_T	n_G	F_g	V	I
	(buah)	(rpm)	(rpm)	(N)	(V)	(A)

After the data is presented in the form of tables and graphs, data analysis is carried out based on the test data. The analysis was carried out by looking at the performance parameters resulting from the NACA 0018 blade profile Darrieus turbine and the NACA 0018 radial projection blade profile Darrieus turbine and then explaining the differences based on various theories...

III. RESULTS AND DISCUSSION

3.1 Data Test

The data that has been collected is then entered in the table as Table 4.1.

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Table 4.1 Test Data of Darrieus Turbine Type – H Radial Projection Blades Based on NACA 0018 at 12 m/s Speed.*)

Jumlah lampu	n_t	n_g	F_g	V	I
(buah)	(RPM)	(RPM)	(N)	(V)	(A)
0	424.85	947.76	0	16.3	0
1	393.84	878.577	0.65	12.83	0.347
2	382.33	852.904	1.15	10.7	0.622
3	357.80	798.174	1.45	8.75	0.813
4	346.6	773.256	1.85	7.34	0.963
5	336.78	751.295	1.95	5.88	1.095
6	330.12	736.44	2.15	5.06	1.182
7	322.36	719.132	2.25	4.32	1.244
8	309.22	689.808	2.35	3.69	1.304
9	302.18	674.103	2.45	3.23	1.362
10	291.67	650.65	2.45	2.57	1.381
11	284.67	635.034	2.55	2.65	1.416
12	280.02	624.672	2.55	1.83	1.448
13	260.25	580.559	3.00	1.64	1.339
14	250.20	558.155	2.95	1.38	1.260
15	240.30	536.072	2.86	1.16	1.156
16	230.55	514.309	2.72	0.98	1.027

*)Tests were carried out with environmental conditions Tdb 32ºC, Twb 27ºC and P_{atm} = 1,005 bar

Mass measurements (kg) were carried out on each radial projection blade based on NACA 0018 and NACA 0018 blades. Mass data for each blade can be seen in Table 4.2.

Table 4.2 Mass of Radial Projection Blade Based on NACA 0018 and Blade NACA 0018

Sudu	Sudu proyeksi radial berbasis NACA 0018 (Kg)	Sudu NACA 0018 (kg)
Sudu A	1,360	1,475
Sudu B	1,360	1,460
Sudu C	1,360	1,495
Rata – Rata	1,360	1,476

The turbine frame weight was also measured at 3.235 kg. NACA 0018 based radial projection blades and NACA 0018 blades use the same frame.

3.2 Data Processing

The data that has been taken is then processed using the Microsoft Excel program to simplify data calculations and graphing the performance of the H-type Darrieus turbine shown in Table 4.3.

Table 4.3 Calculation Data for Darrieus Turbine Type – H Radial Projection Blades Based on NACA 0018 at Wind Speed 12 m/s

Lampu	T_g	P_a	P_m	P_g	C_P	η_g	η_s	TSR
(buah)	(Nm)	(W)	(W)	(W)		(%)	(%)	
0	0.000	411.091	0.00	0.00	0.00	0.00	0.00	1.11
1	0.085	411.091	7.77	4.45	0.019	57.29	1.08	1.03
2	0.150	411.091	13.34	6.65	0.032	49.86	1.61	1.00
3	0.189	411.091	15.74	7.11	0.038	45.17	1.73	0.93
4	0.241	411.091	19.46	7.06	0.047	36.31	1.71	0.90
5	0.254	411.091	19.93	6.43	0.048	32.29	1.56	0.88
6	0.280	411.091	21.54	5.98	0.052	27.76	1.45	0.86
7	0.293	411.091	22.01	5.37	0.054	24.41	1.30	0.84
8	0.306	411.091	22.05	4.81	0.054	21.81	1.17	0.80
9	0.319	411.091	22.47	4.39	0.055	19.57	1.07	0.79
10	0.319	411.091	21.69	3.54	0.053	16.36	0.86	0.76
11	0.332	411.091	22.03	3.75	0.054	17.03	0.91	0.74
12	0.332	411.091	21.67	2.65	0.053	12.22	0.64	0.73
13	0.328	411.091	19.9	2.20	0.048	11.06	0.53	0.68
14	0.321	411.091	18.72	1.74	0.046	9.33	0.42	0.65
15	0.309	411.091	17.31	1.35	0.042	7.81	0.32	0.62
16	0.292	411.091	15.69	1.01	0.038	6.46	0.24	0.60

Example of calculating turbine performance Table 4.3 at 5W load (2nd data) based on 2nd data (5W load) in Table 4.1 can be seen in the following calculation:

- Data Pengujian

1) Wind speed (v) = 12 m/s
2) Rotation of generator (η_G) = 878.577 rpm
3) Voltage (V) = 12.83 V
4) Current (I) = 0.0347 A
5) Generator shaft force (F_g) = 0.65 N
6) Air mass (ρ_a) = 1.21kg/m^3
7) Nominal load of the lamp = 5 W
8) Turbine Area (A)

Turbine area = (L_t)(D)
= (0,65)(0,6)
= 0,39 m^2

9) Dynamic viscosity (μ) = 1.818 x 10^{-5} kg/ms.

- Calculation of the density of air (ρ_a)
  The value of the density of air obtained is 1,2 kg/m^3.
- Calculation of Reynolds number (Re)
  Re is calculated using Eq (2.3).
  Wind speed 1 (v1) = 12 m/s

$$Re = \frac{(\rho)(v)(A)}{\mu}$$

$$Re = \frac{(1.21)\,(12)\,(0.39)}{1.818\ x\ 10^{-5}}$$

$$Re = 311485{,}148$$

- Calculation of wind power
  Wind power calculation is done by Equation (2.4) as follows:

$$P_a = (0{,}5)(\rho)(A)(v^3)$$
$$= (0{,}5)(1{,}21)(0{,}39)(12^3)$$
$$= 411.0912\ W$$

- Calculation of torque
  Torque calculation is done by Equation (2.5) as follows:

$$T_g = (F_g)\ (l_g)$$
$$= (0.65)(0.13)$$
$$= 0.085\ Nm$$

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- Calculation of mechanical power
  Mechanical power is calculated by Equation (2.6) as follows:
  $P_m = \frac{(2)(\pi)(n)(T)}{60}$
  $= \frac{(2)(\pi)(878,577)(0,0845)}{60}$
  $= 7.770428$ W
- Calculation of generator power
  Generator power is calculated using Equation (2.7) as follows:
  $P_g = (V)\,(I)$
  $= (12.83)\,(0.0347)$
  $= 4.45201$ W
- Calculation of the power coefficient
  The power coefficient is calculated using Equation (2.8) as follows:
  $C_p = \frac{P_m}{P_a}$
  $= \frac{7.770428}{411.0912}$
  $= 0.018902$
- Calculation of generator efficiency
  Generator efficiency is calculated using Equation (2.10) as follows:
  $\eta_g = \frac{P_g}{P_m}$ x 100%
  $= \frac{4.45201}{7.770428}$ x 100%
  $= 57.29427$ %
  Calculation of system efficiency
  System efficiency can be calculated by Equation (2.11) as follows:
  $\eta_s = \frac{P_g}{P_a}$ x 100%
  $= \frac{4.45201}{411.0912}$ x 100%
  $= 1.082974$%
- Tip speed ratio calculation (TSR)
  $\lambda = \frac{(\pi)(D)(n)/60}{v}$
  $= \frac{(3,14)(0,6)(878,5)/60}{12}$
  $= 1.031$

3.3 Discussion

The data that has been processed is then analyzed. The analysis was carried out on the research object, namely the H-type Darrieus turbine with radial projection blades based on NACA 0018 and the performance of the H-type Darrieus turbine with NACA 0018 blade. The test variables in this study were wind speed 7 m/s, 8 m/s, 9 m/s, 10m/s, 11m/s, 12m/s. Important parameters in determining the performance of wind turbines are the Reynolds number (Re), tip speed ratio (λ), and power coefficient (Cp).
The highest system efficiency of the two is 3.11% and 3.58%, respectively. This small system efficiency is caused by the very small Cp produced. Figure 4.1 and Figure 4.2 show the Cp produced by the H-type Darrieus turbine.

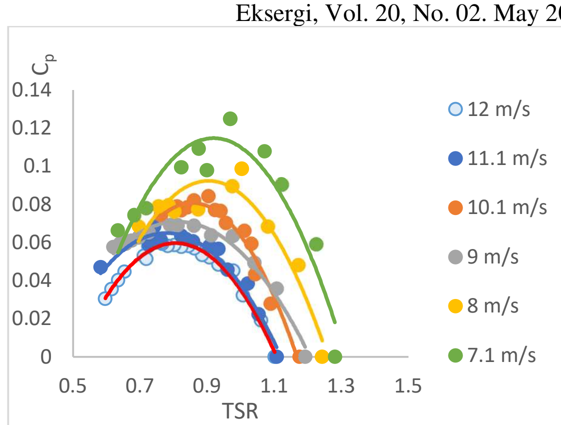

Figure 4.1 Graph of Characteristics of the Relationship between Power Coefficient (Cp) and Tip Speed Ratio (λ) Darrieus Type – H Turbine NACA 0018 Blade at Wind Speeds of 7 – 12 m/s.

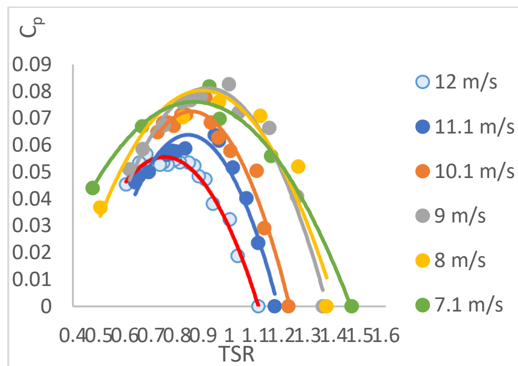

Figure 4.2 Graph of Characteristics of the Relationship Coefficient of Power (Cp) to Tip Speed Ratio (λ) Darrieus Type – H Turbine Radial Projection Blade Based on NACA 0018 at Wind Speed 7 – 12 m/s.

Figure 4.1 and Figure 4.2 show the Cp produced by the H-type Darrieus turbine with radial projection blades based on NACA 0018 and NACA 0018 blades, respectively 0.125 at TSR 0.96 and 0.0826 at TSR 0.998.
Based on the graph of Figure 2.2, the Darrieus turbine can produce Cp of up to 0.4 at TSR 6. When compared with the graph, the highest Cp produced by the Darrieus type-H turbine in this study is very small, namely 31% of the highest Cp that can be produced by the Darrieus type-H turbine. This is because the H-type Darrieus turbine in this study works in a small TSR range of 0.47 – 1.46. The graph in Figure 2.2 shows that at TSR < 3, the Darrieus turbine can only produce Cp below 0.1.
Research conducted by Ramlee et al (2022) regarding the effect of diameter-based solidity on the performance of H-type Darrieus turbines. Increasing solidity from 0.3 to 0.7 will reduce Cp by 30%. So it shows that the greater the solidity the smaller the resulting maximum Cp. The H-type Darrieus turbine used in this study has a total of 3 blades, a turbine diameter of 0.6 m, and the chordline length of the radial projection blade based on NACA 0018 and NACA 0018

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blades is 0.24 m and 0.222 m respectively. Based on Equation (2.1) the solidity of the two blades is 1.11 and 1.2 respectively. The solidity of the two blades when compared with the results of the study of Ramlee et al (2022) with the largest solidity variation of 0.7 with the highest Cp of 0.280 has a very large solidity value of 158% and 171% respectively with a much smaller Cp of 29% and respectively 44.6% smaller. Based on these data it shows that the very small Cp results in this study were due to the large solidity in accordance with the research of Ramlee et al (2022).
The graphs in Figure 4.1 and Figure 4.2 show that the greater the wind speed, the smaller the resulting Cp. solid. So that the wind flow is not able to pass through the turbine blades properly.
However, the higher the wind speed does not mean the smaller the shaft mechanical power (Pm) produced. Figure 4.3 shows the characteristic curve of the relationship of mechanical power (Pm) to the shape of the H-type Darrieus turbine blades.

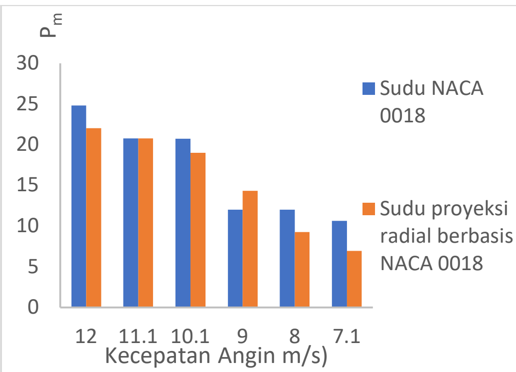

Figure 4.3 Graph of the Characteristics of the Relationship of Mechanical Power (Pm) With Wind Speed (m/s).

As the wind speed increases, the wind power generated is greater. However, the resulting increase in mechanical power is not as big as the increase in wind power. Figure 4.4 shows a graph of the relationship between power generated and wind speed.

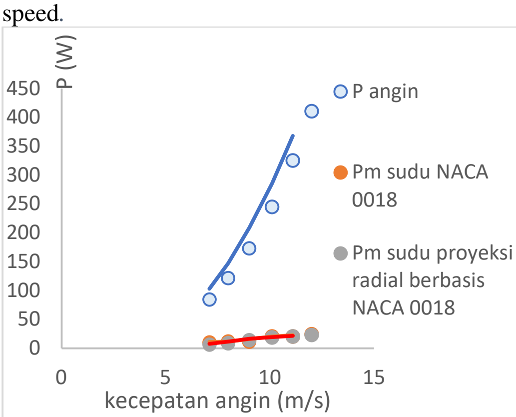

Figure 4.4 Graph of Power Generated Relationship with Wind Speed.

Cp is the ratio of shaft mechanical power to wind power so The smaller the increase in mechanical power compared to the increase in wind power, the smaller the resulting Cp.
Figure 4.5, Figure 4.6 and Figure 4.7 show a comparison of the Cp of NACA 0018 radial projection blades and NACA 0018 blades.

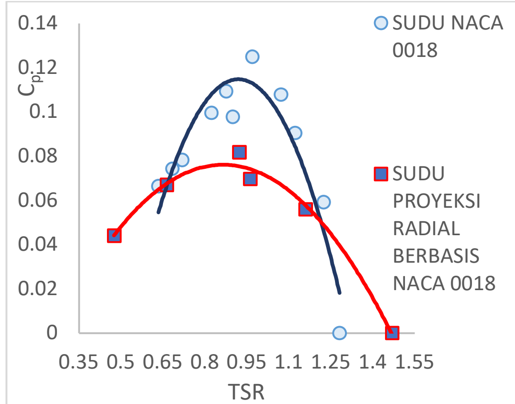

Figure 4.5 Graph of the Characteristics of the Relationship between Power Coefficient (Cp) and Tip Speed Ratio (λ) at a Wind Speed of 7 m/s

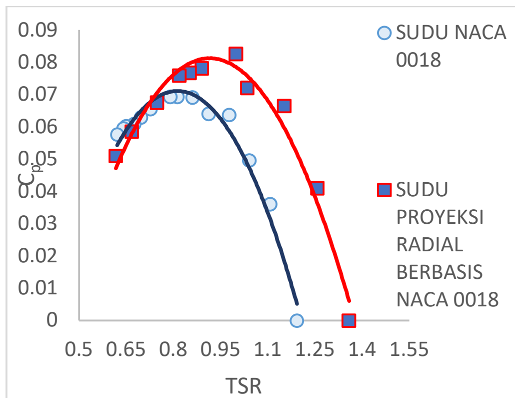

Figure 4.6 Graph of Characteristics of the Relationship between Power Coefficient (Cp) and Tip Speed Ratio (λ) at Wind Speed 9 m/s

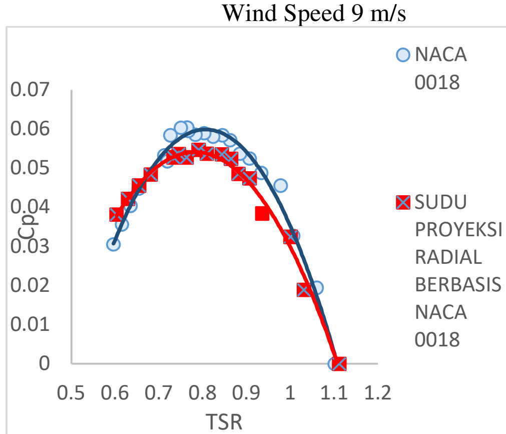

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Figure 4.7 Graph of the Characteristics of the Relationship between Power Coefficient (Cp) and Tip Speed Ratio (λ) at Wind Speed 12 m/s

The graphs in Figure 4.5, Figure 4.6 and Figure 4.7 show the performance characteristics of the H-type Darrieus turbine at wind speeds of 7 m/s, 9m/s and 12 m/s. Each chart has two trendlines which include the radial projection angles based on NACA 0018 and the NACA 0018 angles. The two trendlines form a parabolic curve. Based on Figure 4.5, Figure 4.6 and Figure 4.7 and data that has been processed, the NACA 0018 blade at wind speeds of 7 m/s, 8 m/s, 10 m/s, 11 m/s, 12 m/s produces a higher maximum Cp than the radial projection blade based on NACA 0018. At a wind speed of 9 m/s the radial projection blade based on NACA 0018 produces a higher maximum Cp than the NACA 0018 blade.

The Darrieus turbine is classified as a lift-type turbine, which uses the principle of lift to move the blades due to the method of wind force acting on the blades (Ghiasi et al., 2021).

Equation (2.14) regarding the lift force on a wind turbine shows that the cross-sectional area of the blade is directly proportional to the cross-sectional area of the blade. The smaller the cross-sectional area of the blade, the smaller the lift force generated by the wind turbine.

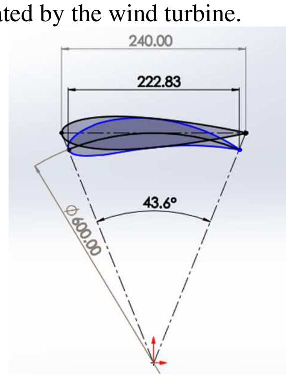

Figure 4.8 Shape of NACA 0018-Based Radial Projection Profile Blades and Profiles NACA 0018

Blades with a radial projection profile are NACA 0018 blades whose chordline is deflected according to the turbine rotation line. Figure 4.8 shows an blade with a radial projection profile that has increased in area above the chordline and shrinks below the chordline compared to the NACA 0018 profile. The blade with the NACA 0018 profile has a circumference of 52 cm and a height of 65 cm and has a cross-sectional area of the blade exposed to wind of 0.338 m2. The blade with a radial projection profile based on NACA 0018 has a circumference of 48.2 cm and a height of 65 cm and has a cross-sectional area of the blade exposed to wind of 0.312 m2. So that the resultant change in blade area with a radial projection based on NACA 0018 has decreased the cross-sectional area of the blade by 7.96%. In accordance with Equation (2.14) it shows that the lift force received by the NACA 0018 radial projection blade is smaller than the NACA 0018 blade. So that with a greater lift force the NACA 0018 blade Darrieus turbine Cp is greater than the NACA 0018 blade radial projection.

In addition, the radial projection blade based on NACA 0018 also changes chordline length. The blade with the NACA 0018 profile has a chordline length of 24 cm while the radial projection profile based on NACA 0018 has a chordline length of 22,238 cm. So that the blade with a radial projection profile based on NACA 0018 has a shorter chordline length than the NACA 0018 profile.

Research that has been carried out by Arif and Fina Andika (2021) where the longer the chord, the blade will get a greater lift force than the drag force, resulting in greater turbine power and speed (Fachrudin & Astuti, 2021).

Figure 4.5, Figure 4.6, Figure 4.7 shows that the radial projection blade based on NACA 0018 produces higher rotation when the load is zero than the NACA 0018 blade at the same wind speed of 7 m/s and 9 m/s and 12 m/s. Figure 4.9 shows the TSR produced by the two blades at wind speeds of 7 m/s, 8 m/s, 9 m/s, 10 m/s, 11 m/s, 12 m/s with a loading of 0.

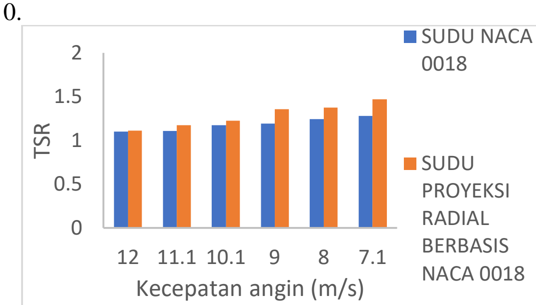

Figure 4.9 TSR Graph Generated Radial Projected Angles Based on NACA 0018 and NACA 0018 Angles at Wind Speeds of 7 m/s, 8 m/s, 9 m/s, 10 m/s, 11 m/s, 12 m/s With Loading 0.

The book on basic physics written by Nurlina and Riskawati provides an explanation of momentum, which is the product of the mass of an object and the speed of the object. The law of conservation of momentum explains that the momentum of an object before and after the collision is the same (Nurlina et al., 2019). Equation (2.15) shows the momentum calculation formula.

The two blades are tested at the same wind speed, so the wind momentum of the two blades is the same. Before the wind hits the blade, the blade is at rest so that the momentum is zero. When the wind hits a stationary blade, the blade will move and the blade's momentum will be the same as the wind's momentum. When the wind gives the same momentum to both blades, the momentum received by both blades is also the same. Based on Equation (2.15) the same momentum with different weight components results in different speeds. Table 4.2 shows that the NACA 0018 blade has a mass of 8.5% heavier than the NACA 0018-based radial projection blade. Based on these data, the NACA 0018 blade produces smaller rotation due to the greater weight than the NACA 0018-based radial projection blade so that the resulting rotation is higher. small.

When the turbine is loaded with the NACA 0018 blade, it produces a higher Cp than the NACA 0018-based radial

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projection blade, this is because the NACA 0018 blade can convert wind power into mechanical power better than the NACA 0018-based radial projection blade, so that the NACA 0018-based radial projection blade experiences the decrease in rotation and mechanical force (Fg) is greater than the NACA 0018 blade when the load is increased.

IV. CONCLUSIONS

Based on the data obtained, it can be concluded that:

1. Research that has been carried out on H-type Darrieus turbines with NACA 0018 blades and NACA 0018 based radial projection blades has resulted in the conclusion that:
2. The small system efficiency of 3.11% and 3.58% is due to the large solidity of the turbine, namely 1.11 and 1.2, causing the turbine to produce a low Cp.
3. The higher the wind speed the smaller the Cp resulting from wind speeds of 7 m/s to 12 m/s Cp decreased by 51.68% on the NACA 0018 blade and 30.6% on the radial projection blade based on NACA 0018.
4. The Cp produced by the NACA 0018 blade is 52.43% higher than the radial projection blade based on NACA 0018.
5. The application of the NACA 0018 chordline airfoil on the rotating track of the turbine causes a reduction in the length of the chordline by 7.5% and the area of the blade casing is reduced by 7.96%.
6. The test results at the same loading at each wind speed resulted in a higher radial projection based on NACA 0018 blade rotation than the NACA 0018 blade. The highest increase in rotation was obtained at a wind speed of 7 m/s, namely 14.6%..

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