JURNAL TEKNIK MESIN
(JOURNAL OF MECHANICAL ENGINEERING)

VOL. 15, NO. 01 , February 2026
https://publikasi.mercubuana.ac.id/index.php/jtm/index
DOI :10.22441/jtm.v15i1.18700

Experimental Study on the Performance of Spiral-Type Horizontal Axis Wind Turbines as A Result of Diameter Expansion in the Turbine

Dhimaz Rifqy Wianda[1], Abdul Hamid[1]
[1]Mechanical Engineering Department, Faculty of Engineering, Mercu Buana University, Jakarta, 11650, Indonesia

E-mail: 41318120047@student.mercubuana.ac.id

Abstract--*The significant increase in electricity consumption from fossil fuels has spurred the search for renewable energy sources, and wind is one such source that can be utilized with a horizontal-axis wind turbine (HAWT). In this case, a drag-and-lift spiral-type model was chosen and adjusted for Indonesia's low wind speeds using the wind-tunnel testing method. The purpose of this study was to verify the performance of the two nine-blade TASH-type spiral models due to the Influence of the expansion of the inner diameter of the turbine, namely the normal diameter of 50mm and the expanded diameter of 65mm. The turbine has a rotor length of 120 mm and an outer diameter of 272 mm. Turbine performance is assessed using measured parameters such as actual power, torque, rotor speed, power coefficient, torque coefficient, and tip speed ratio (TSR). The Research was carried out in a series of laboratory tests through a wind tunnel with various wind speeds from 1 m/s to 10 m/s. The test results are then used to calculate the Coefficient Power and Coefficient Torque as a function of the Tip Speed Ratio (TSR). From the calculation results, a practical value with an air gap of 65mm, Cp and efficient TSR values at a wind speed of 5 m/s, a rotational speed of 165 rpm, and a Ct of 0.31. The value of Cp and TSR at a wind speed of 5 m/s is 0.072 and 0.23, respectively.*

Article History:
Received: January 09, 2023
Revised: October 03, 2025
Accepted: January 14, 2026
Published: January 27, 2026
Keywords: *Horizontal Axis Wind Turbine (TASH), Nine Blade Spiral Type, Coefficient Power, Coefficient Torque, Tip Speed Ratio (TSR).*

1. INTRODUCTION

Electrical energy is a primary need in human life and is increasing as the population grows. Indonesia, as a developing country, urgently needs an ample and increasing supply of electrical energy annually, while this supply still relies on conventional sources (oil, natural gas, and coal) [1].

Indonesia has a variety of alternative energy sources that can replace fossil fuels, including wind energy. According to [2], wind speeds in Java range from 3 m/s to 8 m/s, indicating substantial wind energy potential. With technological advancements, wind energy can be utilized in various ways, including through wind turbines. The development of horizontal-axis wind turbines (HWTs) has been extensively pursued to achieve optimal performance. From the Research that has been carried out by [3] who designed a TASH with a three-blade spiral shaft without an air gap, the wind speed variation of 2-10 m/s resulted in the highest TSR and Coefficient of Power (Cp) value of 0.38 when tested at a wind speed of 7 m/s with a rotational speed of 357 RPM with a Torque Coefficient (Ct) of 0.55.

Previous Research encouraged researchers to update and add variables using the spiral type commonly used in water turbines and applied to lift-type wind turbines, and to calculate the solidity number effect. In the Archimedes spiral wind turbine Research with three blades, the highest efficiency was achieved at a speed of 7.05 m/s with 140.3 rpm, 15V & 1A [4]. This Research uses an air gap for wind turbines at low wind speeds, adjusted to wind conditions in the wind tunnel and to geographical conditions in Indonesia.

1.1 Wind Energy

Wind is air that moves from high pressure to low pressure or vice versa, i.e., from low air temperature to higher air temperature. The Earth is not homogeneous, resulting in differences in temperature and air pressure between areas that receive more heat energy and those that receive less, causing air flow in these regions [5].
The wind energy available in Indonesia has not been fully utilized as an alternative source of electricity.

Wind has long been viewed as a natural process with little economic value for productive community activities. This is undoubtedly driven by awareness of the emerging energy crisis and the fact that energy demand continues to increase significantly [6].

Table 1. Beaufort scale wind speed [7]

Scale	Wind Speed (m/s)	Description
0	0.447	Calm.
1	0.447 - 1.34	Light air.
2	1.78 - 3.12	Gentle breeze.
3	3.57 - 5.36	Soft wind.
4	5.88 - 8.04	Moderate breeze.
5	8.49 - 10.72	Cool breeze.
6	11.17 - 13.85	Strong breeze.
7	14.3 - 16.98	Moderate wind.
8	17.43 – 20.56	Wind.
9	21.01 – 24.14	Strong wind.
10	24.58 – 28.16	Powerful wind.
11	28.61 – 32.18	Storm.
12	32.63 <	Hurricane.

2. METHODOLOGY

2.1 Research location

The Research was conducted in the wind tunnel laboratory of the Mechanical Engineering Department at Mercu Buana University.

Figure 1. Wind tunnel

A wind tunnel is a medium in which models are placed for testing.
The wind tunnel used has a square cross-section with a height of 400 mm, a depth of 400 mm, and a length of 600 mm, and is powered by a motor that drives a fan to push air. This wind tunnel has a minimum variable speed of 1.0 m/s.

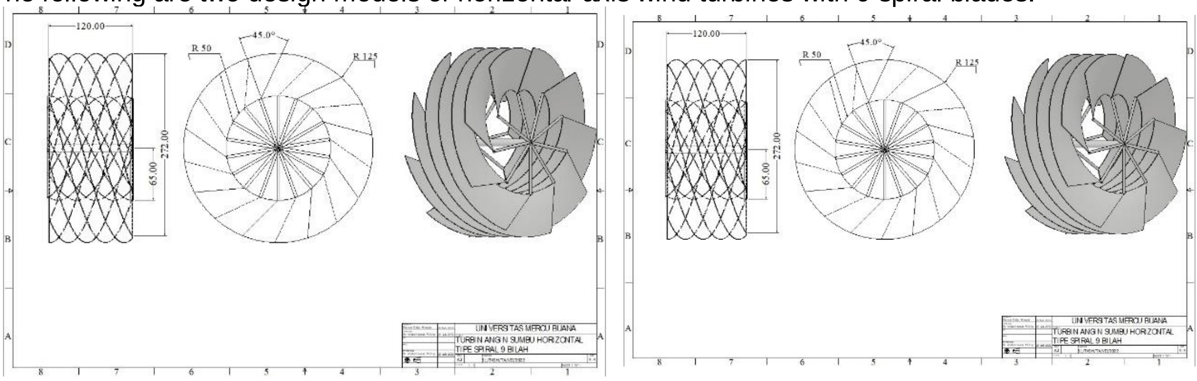
2.2 Measuring Instruments

A Lutron digital anemometer with a range of 0.8-30 m/s, model AM-4200, and a TQ-8800 digital torque model are used to monitor wind speed and turbine shaft speed. In contrast, a Sanwa analog multitester, model YX360TRF, is used to determine volts and amps. Taff STUDIO LCD Digital Laser Photo Tachometer 2.5-100,000 RPM - DT-2234C+ in black, and a 12-volt DC generator. The tools are shown in image 2.

Figure 2. The measuring instruments used for testing

2.3 Wind turbine design

The following are two design models of horizontal-axis wind turbines with 9 spiral blades.



(a) (b)

Figure 3. Figure 3 (a) TASH blade 50mm (b) TASH blade 65mm

2.4 Experimental Study

Tip Speed Ratio (TSR), λ with respect to wind speed V_w, is defined as [8]

$$\lambda = \frac{Cp}{C_t} \tag{1}$$

Where:
Cp = Power coefficient
Ct = Torque coefficient

A. Actual Power

By measuring the voltage (V) and current (I) recorded and obtained from the experiment, and based on the definition that wind power is obtained from the multiplication of voltage and current, the actual wind power (experiment) is

$$Pw\ \mathrm{exp} = V\ x\ I \tag{2}$$

The theoretical power of the turbine is derived based on [9]. Thus, the power coefficient Cp can be expressed as:

$$Cp = \frac{Pw.exp}{T} \tag{3}$$

And the theoretical power is derived from [10], namely

$$Pm, ideal = \frac{1}{2}\rho\left(\frac{16}{27}AV_{W1}^{3}\right)[W] \tag{4}$$

The torque value, T_t, is obtained from [11], namely

$$T_{th} = \tfrac{1}{2}\rho R^{2}\ HV_{w}^{2} \tag{5}$$

Moreover, the large value of c0-efficient torque is determined from:

$$C_t = \frac{T_{exp}}{T_{th}} \quad (6)$$

Solidity Numbers are defined from, which is

$$\sigma = n\frac{c}{d} \quad (7)$$

Where:
n: Number of blades
c: Blade length
d: Outer diameter of the turbine

Equations 1 through 6 are used to calculate and analyze the measurable and unmeasurable parameters of the turbine.

2.5 TASH model material

The model in Table 1 is made of thin aluminum, 0.2 millimeters thick.

Table 2. Spiral TASH model design parameters

TASH	L_r [mm]	D_i [mm]	D_o [mm]	c [mm]	σ_r
Model 1	**120**	**50**	**257**	**73.5**	**9.28**
Model 2	**120**	**65**	**272**	**66**	**9.24**

Where:
L_r: Rotor length
D_i : Inner diameter
D_o: Outer diameter
c: Blade length
σ_r: Solidity number

2.6 Experimental Procedure

The first spiral-type TASH model was initially set on a wooden base plate and placed in the wind tunnel. The voltmeter and ammeter were then connected in series and parallel to the rotor circuit as a power source. The wind tunnel was activated to provide a working fluid to rotate the rotor. Various wind speeds ranging from 1 m/s to 10 m/s were applied to the model, with anemometer readings and corresponding instantaneous values of voltage, current, and rotor speed in revolutions per minute (RPM) measured with a tachometer for each wind speed. The wind turbine torque is also measured with a torque-measuring device that is synchronized with and related to the wind speed. These values are recorded in a manual log in tabular form. The tabulated results are then analyzed to calculate the power coefficient Cp, torque coefficient Ct, and tip speed ratio (TSR). The same is done for the second model.

3. RESULT AND DISCUSSION

3.1 Tables and Graphs

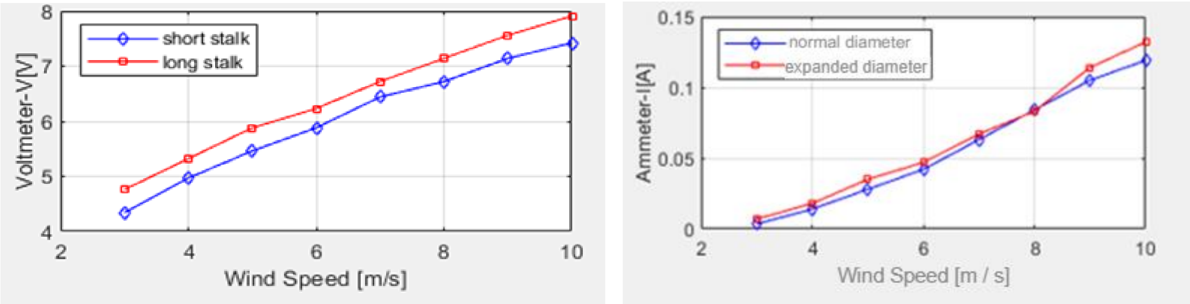
The following is a collection of data from wind turbine testing using two different blade lengths, namely 50 mm and 65 mm, with different wind speed variables. Tables 3.1 and 3.2 show the results of the data collected during testing in a wind tunnel.

Table 3. Results of normal diameter wind turbine data collection

No.	Wind speed (m/s)	Current (Amp)	Voltage (Volt)	Turbine rotation speed (rpm)	Torque (N.m)
1	3	0.0034	4.34	134	0.014
2	4	0.014	4.97	189	0.0237
3	5	0.028	5.46	221	0.035
4	6	0.042	5.88	250	0.0455
5	7	0.063	6.44	281	0.0542
6	8	0.084	6.72	320	0.0595
7	9	0.105	7.14	375	0.0665
8	10	0.119	7.42	400	0.0717

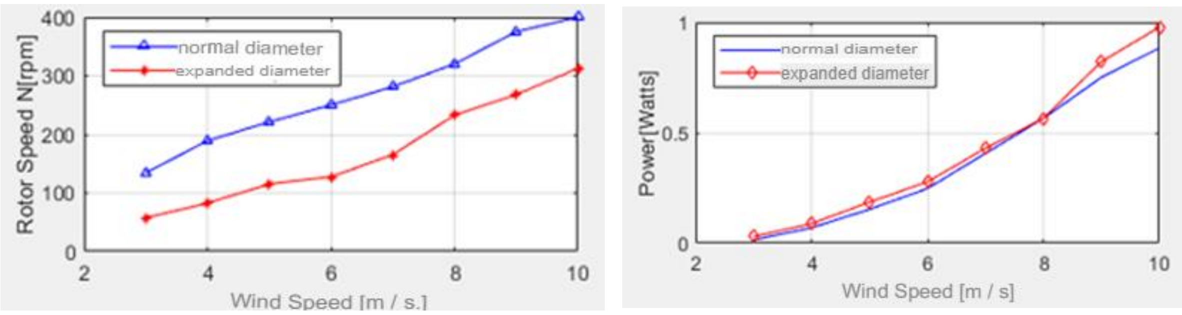
Table 4. Results of data collection on expanded diameter wind turbines

No.	Wind speed (m/s)	Current (Amp)	Voltage (Volt)	Turbine rotation speed (rpm)	Torque (N.m)
1	3	0.007	4.2	57.5	0.016
2	4	0.018	4.9	82.5	0.027
3	5	0.035	5.3	115	0.037
4	6	0.047	5.9	127.5	0.047
5	7	0.067	6.4	165	0.058
6	8	0.083	6.8	232.5	0.069
7	9	0.114	7.2	267.5	0.078
8	10	0.132	7.4	312.5	0.083



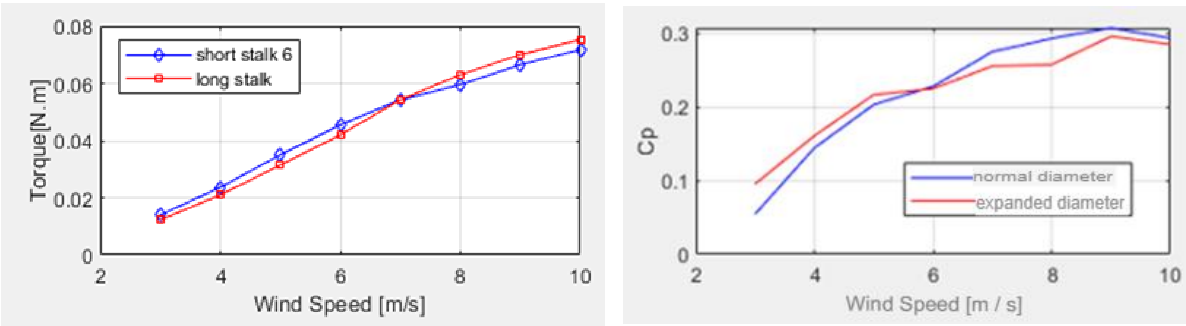
(a) (b)

Figure 4. Figure 4 (a) Experimental curve of rotor voltage versus wind speed
(b) Experimental curve of rotor current versus wind speed



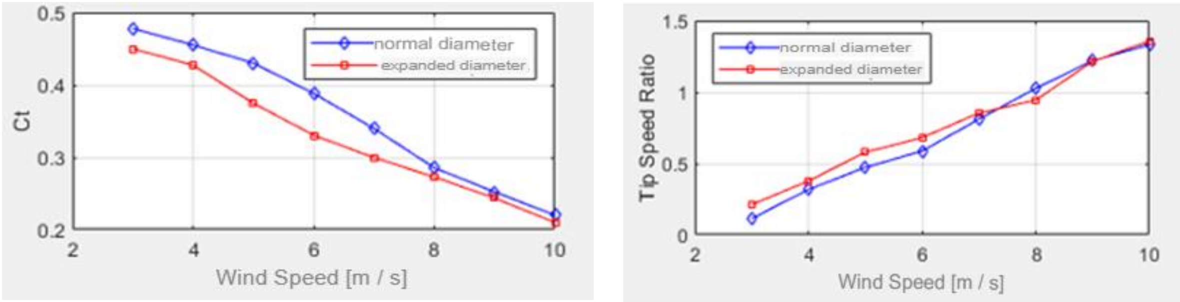
(a) (b)

Figure 5. Figure 5 (a) Experimental curve of rotor rotation versus wind speed
(b) Actual power curve versus wind speed



(a) (b)

Figure 6. Figure 6 (a) Actual torque curve versus wind speed
(b) Actual power coefficient curve versus wind speed



(a) (b)

Figure 7. Figure 7 (a) Actual torque coefficient curve against wind speed
(b) Actual Tip Speed Ratio curve against wind speed

4. CONCLUSION

Referring to the results of testing and calculations that have been carried out, from these two points, it can be concluded that:
Based on the testing and data processing results, TASH with a 65 mm air gap has higher efficiency than TASH with a 50 mm air gap. This can be seen in the power coefficient and speed ratio graphs, which show the highest values at 0.072 and 0.23, respectively, at a wind speed of 5 m/s. However, the torque coefficient value of TASH with a 65mm air gap is smaller than that of TASH with a 50 mm air gap. This is due to a difference in diameter caused by the air gap between 65 mm and 50 mm. In the previous study in subchapter 2.1.1, which produced a speed ratio of 0.79, the addition of a 65 mm air gap resulted in a higher efficiency than the previous design without an air gap, as indicated by the higher speed ratio.

REFERENCES

[1]. B. Prasetiyo, “Turbin angin sumbu horizontal tipe tsd 500 pada beban konstan,” *J. Tek. Energi*, vol. 11, no. 3, pp. 75–78, 2015.

[2]. A. R. Dewi, S. Handini, N. P. Anggraeni, and R. G. Septiansyah, “Analisis Data Kecepatan Angin di Pulau Jawa Menggunakan Distribusi Weibull,” *J. Stat. dan Apl.*, vol. 6, no. 1, pp. 130–136, 2022, doi: 10.21009/jsa.06112.

[3]. D. A. Santoso and A. Hamid, “Studi Experiment Melalui Wind Tunnel Terhadap Kinerja Turbin Angin Sumbu Horizontal Poros Kerucut Type Tiga Bilah Spiral Tanpa Airgap,” *Lap. Tugas Akhir*, 2022.

[4]. B. Bono, S. Priyoatmojo, A. A. Haryono, D. K. Febriyani, M. S. Habibullah, and Z. Rahmah, “Rancang Bangun Turbin Angin Archimedes Spiral Dengan Tiga Blade Sebagai Penggerak Mula Pembangkit Listrik Tenaga Bayu,” *Eksergi*, vol. 16, no. 1, p. 20, 2020, doi: 10.32497/eksergi.v16i1.2201.

[5]. Muhammad Rizal and H. Fachri, “Analisa Potensi Energi Angin dengan Distribusi Weibull Untuk Pembangkit Listrik Tenaga Bayu (PLTB) Banda Aceh,” *CIRCUIT J. Ilm. Pendidik. Tek. Elektro*, vol. 1, no. 1, pp. 1–8, 2017, doi: 10.22373/crc.v1i1.1377.

[6]. D. Hermawan, “Pengaruh Jumlah Blade Terhadap Kinerja Turbin Angin Sumbu Horizontal,” pp. 1–9, 2016.

[7]. A. Gunadhi, R. Sitepu, Z. Bilal, P. Angka, and L. Agustine, “Perangkat Navigasi Arah Angin, Arah Kapal, Dan Kecepatan Angin Untuk Nelayan Tradisional,” *J. Ampere*, vol. 4, no. 2, p. 307, 2020, doi: 10.31851/ampere.v4i2.3449.

[8]. D. H. Didane, N. Rosly, M. F. Zulkafli, and S. S. Shamsudin, “Performance evaluation of a novel vertical axis wind turbine with coaxial contra-rotating concept,” *Renew. Energy*, vol. 115, no. 2018, pp. 353–361, 2018, doi: 10.1016/j.renene.2017.08.070.

[9]. D. De Tavernier, C. Ferreira, and G. van Bussel, “Airfoil optimisation for vertical-axis wind turbines with variable pitch,” *Wind Energy*, vol. 22, no. 4, pp. 547–562, 2019, doi: 10.1002/we.2306.

[10]. J. Krishnaraj, S. Ellappan, and M. A. Kumar, “Additive Manufacturing of a Gorlov Helical Type Vertical Axis Wind Turbine,” *Int. J. Eng. Adv. Technol.*, vol. 9, no. 2, pp. 2639–2644, 2019, doi: 10.35940/ijeat.b4116.129219.

[11]. B. Rapelli, R. T. Suryavanshi, M. L. Shelke, S. G. Patil, P. Tikar, and D. I. T, “Design and Development of Foldable and Portable Windmill,” pp. 3084–3094, 2017