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# Development of Longitudinal Water Turbine for Waterfall

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**Abstract:** The fastest-growing form of renewable energy is currently hydropower, which has seen impressive development since, due to increasing public awareness of the importance of conserving the environment, many nations have tried to turn to renewable energy sources as a better option than non-renewable. This study aims to identify how effectively the spiral water turbine double helix generates electricity in a waterfall. This study aimed to fabricate a 1-meter spiral water turbine for the waterfall. The scope of the study is to design the spiral water turbine using SolidWorks with a parameter of 1-meter length and to evaluate the power, torque and angular velocity with a theoretical method based on the Sungai Kurau velocity of the water. The results show that the power, torque, and angular velocity were increasing and produced electricity. It shows that a spiral water turbine can produce electricity based on the velocity of water flow. In future, the development of spiral water turbines can be improved by the high-quality material and the design of the turbine.

**Keywords:** Renewable Energy, Spiral Water Turbine, Hydropower

## 1. Introduction

Renewable energy is energy that is generated from natural sources that are replenished over time. Renewable energy sources include solar, wind, hydroelectric, geothermal, and biomass. Renewable energy is a clean, sustainable, and domestic energy source that can help reduce greenhouse gas emissions and improve air quality. It is a clean and efficient way to generate electricity and heat. Renewable energy is also a domestic resource that can help to reduce our reliance on imported oil. Hydropower is a renewable source of energy. The energy generated through hydropower relies on the water cycles driven by the sun, making it renewable. The flowing water can create kinetic energy with motion from the river, which can help generate electricity by turning the generator rotor from the water turbine to convert energy into electricity [1]. The previous study developed horizontal spiral turbines for generating electricity by designing spiral turbines using the Golden Ratio function to study the impact of the diameter-length ratio and the number of the turbine's blades (2 – 6 blades) on the torque of the turbine. In this study, we will study how the spiral water turbine double helix generates electricity. The parameter of the spiral water turbine was 1 meter in length and 0.28 in diameter. The objective was

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to fabricate a 1-meter spiral water turbine length and evaluate the turbine's power, torque and angular velocity. The expected outcome from this study was to expand more development in hydropower at waterfall in the future.

Savonius water turbines are a type of horizontal-axis turbine that uses the drag force of water to rotate. They are relatively simple to construct and maintain, making them popular choices for small-scale applications such as water pumping and generating electricity. Savonius water turbines can be compared to spiral water turbines to identify the power output differences between the two types of turbines. The comparison of Savonius and spiral water turbines can be used to identify the optimal type of turbine for a particular application. The diameter of the savomius is 30 cm, the length 1 meter, and twist angle is 90.

**Figure 1: Design Savonius Water Turbine**

Gunung Pulai Recreational Forest is a popular spot for locals and visitors to Kulai, Malaysia. The park offers a variety of activities, including hiking, camping, and swimming in the waterfall. The waterfall is located in the Kulai district of Johor and is easily accessible by road. The height of the waterfall ranges from 40 to 50 meters. The water in the waterfall has potential energy because it is high up in the air. As the water falls, it loses its potential energy and converts it into kinetic energy. The faster the waterfalls, the more kinetic energy it has. The water's velocity at the waterfall's base can be calculated using the formula v= √2gh, where v is the velocity of the water, g is the acceleration due to gravity, and h is the height of the waterfall.

The Betz theory expresses that no horizontal axis wind turbine can extract more than 16/27 (59.3%) of the wind's kinetic energy. The factor 16/27 (0.593) is known as the Betz limit. In 1919, Albert Betz used an analytical method to derive the Betz limit. It showed that in order to reach 59.3% of the total available power, the tip speed ratio should be infinite, which is impossible.

$$C_t : 0.593 \qquad \text{Eq. 1}$$

$C_t$: Torque Coefficient

## 2. Material and Methods

### 2.1. Spiral Water Design

The spiral water turbine blade was designed by SolidWorks. The spiral water turbine is difficult to fabricate manually because of the angle, so the best option was using 3D printing. The parameter of the spiral water turbine was 1 meter in length and a diameter of 0.28 meters. Figure 2 and Figure 3 show the design from the top and front drawings, respectively.

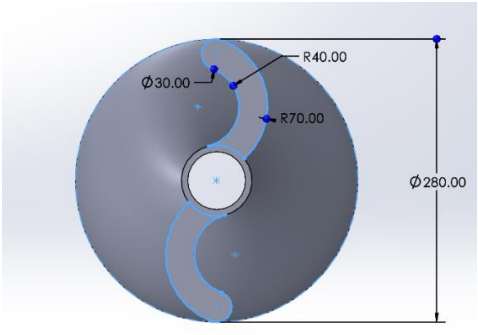


**Figure 2: Top drawing**

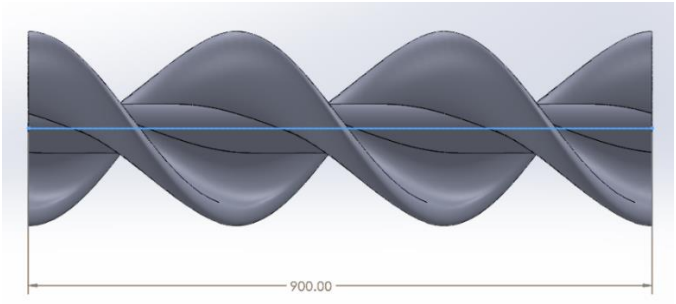


**Figure 3: Front Drawing**

### 2.2 Fabrication

The component for spiral water turbine fabrication is shown in Table 1.

**Table 1: Component for fabrication**

| No | Components | Quantity |
|---|---|---|
| 1 | Blade | 1 |
| 2 | Shaft | 1 |
| 3 | Frame | 7m |
| 4 | Bearing | 2 |
| 5 | Housing Bearing | 2 |
| 6 | Motor | 1 |

### 2.1. Equations

There is a formula to determine the power to calculate the power generated by the spiral water turbine. The power inlet was calculated to evaluate the spiral water turbine.

$$P_{in} = T\omega \qquad \text{Eq. 2}$$

Where $P_{in}$: Power inlet ω: Angular Velocity

For the power outlet, can be gain with using Betz Law with efficiency of 53.9% on the turbine. The power output can use equation using:

$$P_{out} = \%_{efficiency}\ P_{in} \qquad \text{Eq. 3}$$

$P_{out}$: Power outlet $P_{in}$: Power inlet

## 3. Results and Discussions

### 3.1. Results

The results (Table 2) and discussion from the study on the spiral water turbine using the data height Gunung Pulai waterfall also using the Betz Law.

**Table 2: Results**

| Height(m) | Velocity (m/s) | Rotational speed (rpm) | Torque (kNm) | Angular Velocity ($rads^{-1}$) | $P_{In}$(MW) | $P_{OUT}$ (MW) |
|---|---|---|---|---|---|---|
| 40 | 28.0 | 4509.4 | 10.78 | 472.2 | 5.0 | 2.97 |
| 41 | 28.4 | 4573.8 | 11.0 | 478.9 | 5.26 | 3.11 |
| 42 | 28.7 | 4622.1 | 11.3 | 484.0 | 5.46 | 3.23 |
| 43 | 29.1 | 4686.5 | 11.6 | 490.8 | 5.69 | 3.37 |
| 44 | 29.4 | 4734.9 | 11.9 | 495.8 | 5.9 | 3.5 |
| 45 | 29.7 | 4783.1 | 12.1 | 500.8 | 6.05 | 3.58 |
| 46 | 30.0 | 4831.4 | 12.4 | 505.9 | 6.27 | 3.71 |
| 47 | 30.4 | 4895.9 | 12.7 | 512.6 | 6.51 | 3.86 |
| 48 | 30.7 | 4944.2 | 12.9 | 517.7 | 6.67 | 3.95 |
| 49 | 31.0 | 4992.5 | 13.2 | 522.8 | 6.9 | 4.09 |
| 50 | 31.3 | 5040.9 | 13.5 | 527.8 | 7.12 | 4.22 |

### 3.2. Graph

The results and discussion from the study on the spiral water turbine using the height of Gunung Pulai waterfall and also using the Betz Laws.

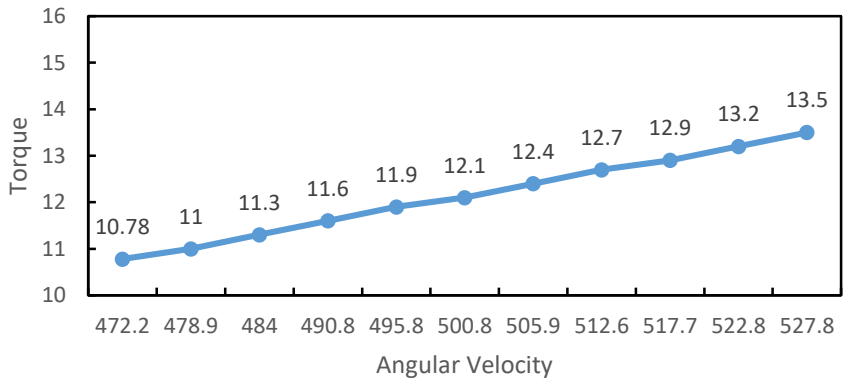


**Figure 4: Torque vs. Angular velocity**

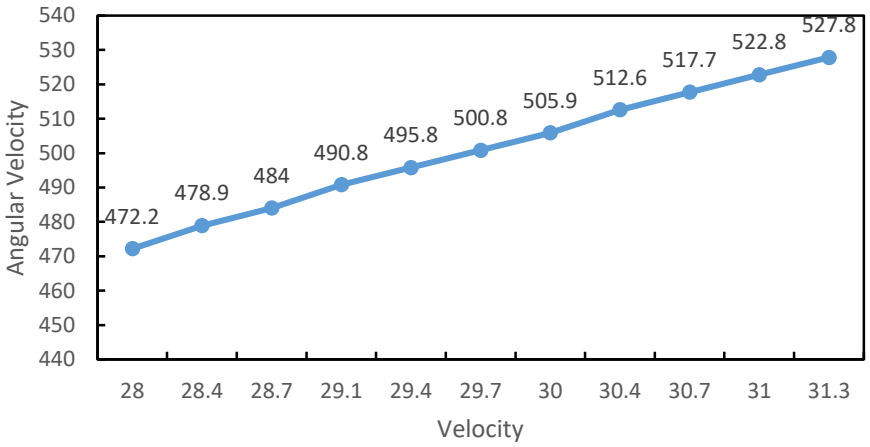


**Figure 5: Angular velocity vs. Velocity**

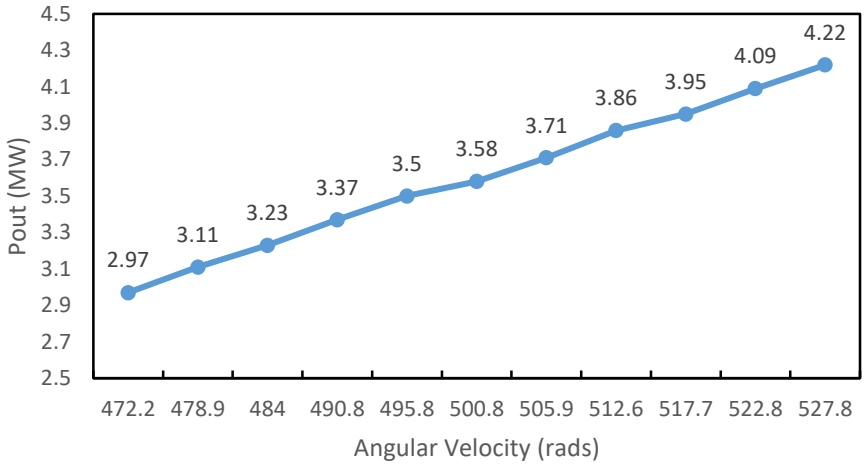


**Figure 6: Power Output vs Angular Velocity**

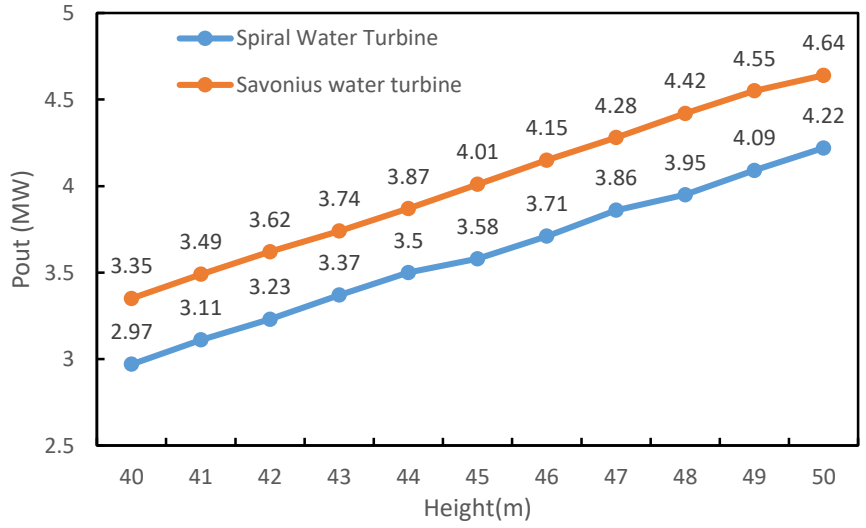


**Figure 7: Spiral Water Turbine vs. Savanius Water Turbine**

### 3.3. Discussion

#### 3.3.1. Angle of Blades

As the angular velocity increases, the torque also increases. It is because the moment of inertia of the object remains constant, so the only way for the torque to increase is for the angular velocity to increase.

#### 3.3.2. Area of Blades

As the angular velocity increases, the torque also increases. s is because the moment of inertia of the object remains constant, so the only way for the torque to increase is for the angular velocity to increase.

#### 3.3.2. Power vs Angular Velocity

As the angular velocity increases, the torque also increases. s is because the moment of inertia of the object remains constant, so the only way for the torque to increase is for the angular velocity to increase.

## 4. Conclusion

The development of the spiral water turbine has been increasing lately because of the efficiently intercept kinetic energy and well-connected blade were suitable for low velocity. This study to fabricate the horizontal water turbine which had the feature spiral water turbine. The spiral water design was designed with 65 angles, diameter with 28 cm and 0.9 m length. Then, other objective to evaluate the power, torque and rotational speed from the spiral water turbine with numerically method. The results have been analysis with different velocity based on the height of Gunung Pulai waterfall. the results, we can conclude that the power, torque and velocity were increase exponentially with the increase of water flow rate. From the data, we can conclude that angle of blade and the area of the blade contribute in generate more electricity for water turbine.

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