

## THE EFFECTS OF WATER DEBIT AND NUMBER OF BLADES ON THE POWER GENERATED OF PROTOTYPE TURBINES PROPELLER AS RENEWABLE ELECTRICITY

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*This research is a prototype design of a Pico hydropower plant. The Pico hydro laboratory scale is planned to be installed at the water outlet at the steam gas power plant (PLTGU) in Cilegon, whose water discharge has not been utilized. Pico hydro will produce green energy, which in turn can partially replace fossil energy needs. The purpose of this study was to determine the effect of water discharge and the number of blades on the power generated by Pico hydro. The method used in this research is an experimental method carried out in the laboratory, by designing and making Pico hydro prototypes, with several variations in the number of blades. The results of the manual calculation analysis show that the mass flow rate, circumferential speed, and the highest rotational speed are found in blade 6. Furthermore, the design process uses the CFD method, which produces the best energy when using 6 or 7 blades. The stronger the water discharge, the higher the Rpm, and the stronger the electric current and the resulting voltage. The water discharge of 0.04 m<sup>3</sup>/s produces 215 Rpm, a current of 0.30 ampere, and a voltage of 2.00 volts. While the airflow rate of 0.08 m<sup>3</sup>/s produces 695 Rpm, a current of 0.70 ampere, and a voltage of 4.30 volts. Statistical analysis also shows that the higher the Rpm value of the 6 blade turbine, the higher the power and current it produces.*

**Keywords :** Pico Hydro, CFD, Blade, Propeller Turbine

## 1. INTRODUCTION

Energy both unrenewable (fossil) and renewable energy (EBT) has a very important role in human life. Many community businesses are powered by energy, especially electricity. This is the main task of the government to provide the electrical energy which increases from time to time. The amount of electricity installed in 2017 was around 60,789.98 Mega Watt (MW), which means that it increased by 1.9% from 2016, which was 59,656.30 MW [1].

Although the fossil energy is still dominantly used by all society levels in Indonesia, the government continuously encourages the use of renewable energy. It aims to reduce the use of energy from fuel produced from fossil. Indonesia targets the use of renewable energy for power plants about 23 percent by 2025. It means, we still need 10,6 percent more to achieve the goal [2].

Particularly in Province Banten, several power plant companies are operating there including PT DL, Banten. This power plant company is a subsidiary of PT LT, Banten. The company owns five Steam Power Plant (PLTGU) units, each with a capacity of 80 Megawatts (MW) or a total of 400 Megawatts (MW). It was

established in 1998 in Cilegon. This company supplies around 6.3% of the total electrical power needs in the area of Banten Province, especially in the PTLT industrial area and surrounding estates [3].

$$Q_{opt} = \frac{3}{2} A_{pipe} \sqrt{g \frac{7 H_g}{10 CL}} \quad (1)$$

Where :

$Q_{opt}$  = Maximum discharge (m<sup>3</sup>/s)

$H_g$  = Overall turbine head (m)

$A_{pipe}$  = Surface area pipe (m<sup>2</sup>)

$CL$  = Flow loss factor

$$Nominal\ Turbin\ Power = Nn = \frac{g Q_n H_e}{75} n \quad (2)$$

$$Specific\ rotation = ns = nn \times \frac{Nn^{0.5}}{H^{5/4}} n \quad (3)$$

$$Rotation\ unit = N1 = \frac{n_n}{\sqrt{H_e}} \quad (4)$$

$$Discharge\ Unit = Q1 = \frac{Q_n}{\sqrt{H_e}} \quad (5)$$

Where :

$N_n$  = Nominal turbine power (Hp)

$nn$  = Nomilan rotation (Rpm)

$ns$  = Specific rotation (Rpm)

$H$  = Head (m)

$Q_n$  = Nominal discharge (m<sup>3</sup>/s)

$n$  = Rotation speed (Rpm)

$g$  = Gravity (m/s<sup>2</sup>)

$H_e$  = Effective falling height (m)

$n$  = Turbine rotation speed (Rpm)

$N1$  = Rotation unit (Rpm)

$Q1$  = Discharge unit (m<sup>3</sup>/s)

This Steam Power Plant (PLTGU) company has suction channels to absorb seawater into the plant to be condensed and sent back to the sea. The observation that has been done at this plant shows that this outlet channel has hidden new energy resource, which is eco-friendly and can be utilized anytime. Power plants in West Java and Banten have a total capacity of 10.399 MW. If in every 400 MW, the outlet pipeline emits energy of 22, 91 KW, the potential renewable energy that can be produced by both provinces reaches 595, 60 KW or 0.595 MW. According Multi [4], the appropriate utilization of wastewater (waste energy) is the conversion of the water-energy into electricity or power plant. As a consequence, the shortage of electricity can be overcome. Besides that, the renewable power plant in Indonesia can be more optimally utilized [5].

Principally, Micro-Hydro Power Plant occupies the differences of height and the amount of water discharge per second in irrigation channels, rivers or waterfalls [14]. This water flow will rotate the turbine shaft leading to the production of mechanical energy [13]. The type of turbine that was used was Kaplan. It is a reaction turbine with axial flow. In the Kaplan turbine, the runner can be adjusted, while in the propeller, it cannot. These turbines are quite popular and can operate well with high flow rates. At first glance, this turbine has similarities with the propeller used in a boat. This energy then drives generators and generators to produce electricity up to 100 kW [15].

The analysis of velocity and fluid pressure is performed using the CFD method which is through one system - fluid simulation. CFD has been widely used considering its effectiveness and efficiency compared to the experimental method [11]. Fluid mechanic analyses are generally carried out by energy conversion industries like water, wind, and gas turbines. This method is usually occupied to produce a more accurate analysis according to fluid changes in the turbine [6]. It can also predict the work of a fluid system and the

flow pattern that is difficult to be studied with manual calculation. After doing analysis using CFD, a lab scale pico hydro prototype was made as recommended from the analyses performed at CFD design.

An earlier study related to this current research is Tonglolangi stating that the Propeller turbine is better to use than a water blade or other kinds of hydro micro turbine because the space it needs is smaller or more compact [7]. The cost of making an initial drive in this turbine is up to 50% more efficient than using a waterwheel and it can produce the same power. The materials used are cheaper because they are transparent mica plastic. Research on hydroelectric energy using the system of Micro Hydro Power (MHP) was conducted by Luthfie. This study uses a variation of the angle of the siphon pipe 45° and 90°, which uses the Computational Fluid Dynamic (CFD) method. The results showed that the slope angle of the 45° siphon pipe gave better hydro coil turbine performance than the 90° siphon pipe tilt angle [16]. In other studies, the results of the Horizontal Axis Wind Turbine (HAWT) research using 3, 4 and 5 blades show that the number of blades does not increase the torque of the wind turbine. There is more power generated from turbines with a higher number of blades because torque is related to pressure [17].

This efficiency is caused by the size of the Propeller turbine which is smaller and more compact compared to other turbines. The size can be ±20 cm only so that it needs less material. The research finding shows the effect of water discharge on turbine efficiency. The higher the water discharge, the less efficient the turbine is. The maximum efficiency value (73.01 %) was found at the water discharge of 0,016 m<sup>3</sup> /s.

Astu and Djati stated that when 1 kg of water falls to a lower position (H meter) at the velocity of 0, the water work is 1 kg [12]. 1 H m – 1 H kg.m. If in 1 second, Q water flows at the height of H toward the gravitation, the water works per second or emits power in kg.m/sec [8]:

$$W_{th} = \gamma QH \tag{6}$$

Where :

$\gamma$  : the specific weight of water (liquid)

Q: the amount of water flows in a second (flow rate)

H: the height differences (head) in a meter.

Equation (6) is the theoretical power or water horsepower.

$h$  = turbine efficiency  $\approx 0.75$  until 0.9.

Thus the effective power is:

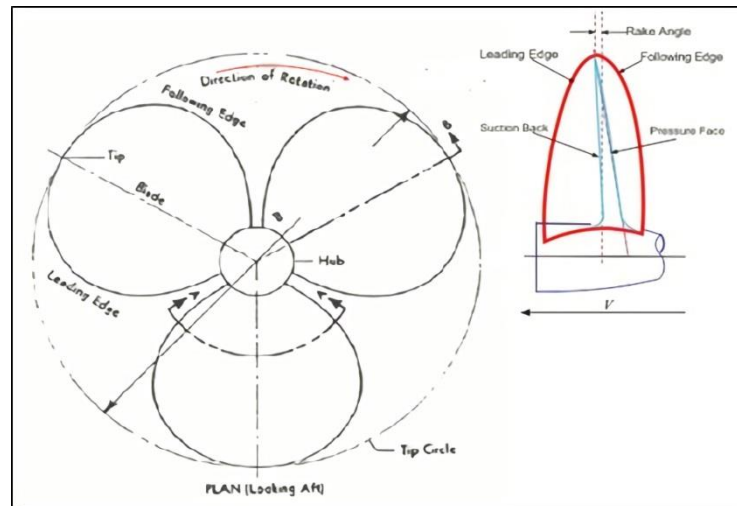
$$W_{ef} = \eta \gamma Q H \text{ kgf} \cdot \frac{m}{det} = \frac{\gamma QH}{75} \eta \text{ hp} = \frac{\gamma QH}{102} \eta \text{ kW} \tag{7}$$

The  $W_{ef}$  refers to turbine horsepower.

Discharge optimum ( $Q_{Optimum}$ ) is the fluid that can flow through a pipe in a particular duration. The optimum discharge ( $Q_{Optimum}$ ) that can be flowed by penstock can be calculated using equation 1. In the used of Kaplan propeller turbin, by identifying the discharge of  $Q_n$ , the head of  $H_e$  and the nominal rotation of  $n_n$ , the calculation of nominal power is [7] :

$$Turbin \text{ Nominal Power} = Nn = \frac{g Q_n H_e}{75} n \tag{8}$$

The Figure 1 shows the definition of a propeller diagram. According to Lomax, et al Computational Fluid Dynamics (CFD) is a method that can be used to investigate physical phenomena surrounding or inside the tested object. Those physical phenomena include dissipation, diffusion, convection, shock waves, slip surfaces, boundary layers, and turbulence. They are non-linear phenomena thus do not have an analytical solution. This bases the suggestion to solve the CFD with numerical solutions [9].



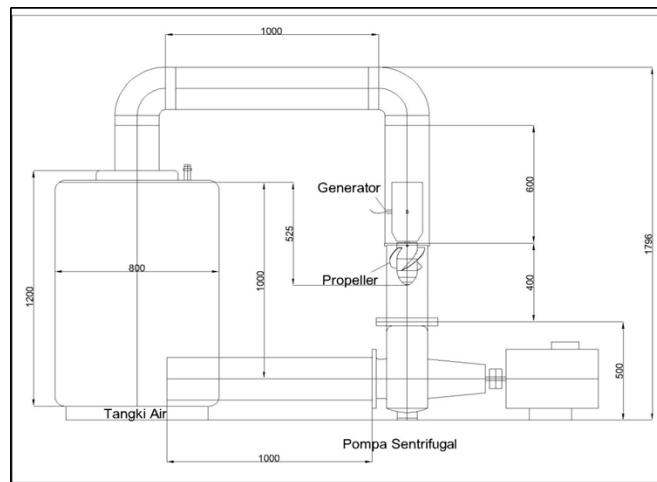
**Figure 1.** Definition of Propeller Diagram [9]

## 2. RESEARCH METHODOLOGY

The method used in this research is an experimental method carried out in the laboratory, by designing and making Pico hydro prototypes, with several variations in the number of blades.

Computational Fluid Dynamics (CFD) is a study using software to obtain quantitative assumptions related to the condition of fluid flow according to physical laws like the conservation of energy about fluid flows [10].

This study uses a program to design a centrifugal pump, motor, generator. This study also uses tools measurement like flow meter, multi meter, bolt and accessories. After that, a laboratory scale prototype was made using these materials and tools. For the prototype, we used the similarities theory with the following dimensions:



**Figure 2.** Schematic Design of Propeller Turbin

The water discharge as seen in the layout of the propeller turbine prototype is a centrifugal pump with a capacity of 360 m<sup>3</sup>/minute. It was then directed to the propeller which has the purpose to produce motion energy from potential energy water. After that, this motion energy was then converted into electrical energy with the aid of a generator.

### 3. RESULTS AND DISCUSSIONS

#### 3.1 Variations of Average Velocity

The potential energy of water can be obtained from the centrifugal pump which has a water discharge of 10.000 m<sup>3</sup>/hour or 2.778 m<sup>3</sup>/second. Therefore, this study employed various flows by assuming that the discharges are between 8.000 m<sup>3</sup>/hour and 12.000 m<sup>3</sup>/hour. The Table 1 below shows the Variations of Average Velocity :

**Table 1.** Variations of Average Velocity.

NO	DISCHARGE Q (M <sup>3</sup> / SEC)	SURFACE AREA A (M <sup>2</sup> )	VELOCITY V (M/ SEC)
1)	2.22	0.79	2.83
2)	2.50	0.79	3.18
3)	2.78	0.79	3.54
4)	3.06	0.79	3.89
5)	3.88	0.79	4.94

By using the equation  $P = \rho \cdot g \cdot H \cdot Q$  , we found the theoretical power of water at Q 8000 m<sup>3</sup>/ hour = 39,200 watts (39.2 kW).

#### 3.2 Mass Flow Rate (m)

In this study the potential energy of water is obtained through a centrifugal pump which has a discharge specification of 10,000 m<sup>3</sup> / hour or equal to 2,778 m<sup>3</sup> / second. Debit assumption variations ranging from 8,000 m<sup>3</sup> / hour to 12,000 m<sup>3</sup> / hour. Using the formula is  $q = V \cdot A$ , a number of average speeds are produced in the following Table 2 :

**Table 2.** Mass Flow Rate (m).

NO	DENSITY $\rho$	SURFACE AREA PIPE	VE- LOC- ITY	MASS FLOW RATE (KG/ SEC)
1)	998.00	0.79	2.83	2,215.56
2)	998.00	0.79	3.18	2,495.00
3)	998.00	0.79	3.54	2,772.44
4)	998.00	0.79	3.89	3,048.89
5)	998.00	0.79	4.94	3.872.24

#### 3.3 Total Pressure

The total value of inlet pipe pressure is required as an input parameter while the water flow rate is needed as the output parameter in CFD simulation, shown at Table 3.

**Table 3.** Total Pressure.

NO	DENSITY (KG / M <sup>3</sup> )	GRAVITY ( M / S <sup>2</sup> )	HEAD (M)	QUADRATE SPEED (MS) <sup>2</sup>	STATIC PRESSURE (PA)	DYNAMICAL PRESSURE (PA)	TOTAL P (PA)
1)	998.00	9.80	5.00	2.83	48.902	1,411.18	50,313.18
2)	998.00	9.80	5.00	3.18	48.902	1,589.17	50,491.17
3)	998.00	9.80	5.00	3.54	48.902	1,765.89	50,667.89
4)	998.00	9.80	5.00	3.89	48.902	1,941.97	50,843.97
5)	998.00	9.80	5.00	4.94	48.902	2,466.39	51,368.39

#### 3.4 Circumferential Speed (U)

Both inlet and outlet have similar circumferential speed values. We took the average circumferential speed

from analyses performed at the speed triangle (diameter = 3). Circumferential speed of Various Speeds can be shown at Table 4.

**Table 4.** Circumferential speed of Various Speeds.

NO	VELOCITY (M/DT)	CIRCUMFERENTIAL SPEED (M/S) D 0.15	CIRCUMFERENTIAL SPEED (M/S) D 0.17	CIRCUMFERENTIAL SPEED (M/S) D 0.20	AVERAGE CIRCUMFERENTIAL SPEED
1)	2.83	3.25	3.01	3.10	3.12
2)	3.18	3.66	3.39	3.49	3.51
3)	3.54	4.07	3.76	3.87	3.90
4)	3.89	4.47	4.14	4.26	4.29
5)	4.94	5.68	5.26	5.1	5.45

### 3.5 Rotational Speed (Rpm)

We calculated the rotational speed of three different diameters, and we took the average value. This can be seen in the following Table 5.

**Table 5.** Rpm of Various Discharges.

NO	VELOCITY (M/S)	DISCHARGE (M <sup>3</sup> / S)	ROTATIONAL SPEED (RPM) D 0.15	ROTATIONAL SPEED (RPM) D 0.17	ROTATIONAL SPEED (RPM) D 0.20	AVERAGE ROTATIONAL SPEED (RPM)
1)	2.83	2.22	414.09	38.25	394.37	397.24
2)	3.18	2.50	466.32	431.59	444.11	447.34
3)	3.54	2.78	518.17	479.58	493.50	497.08
4)	3.89	3.06	569.84	527.40	542.70	546.65
5)	4.94	3.88	723.72	669.83	689.26	694.27

These average Rpm would be inputted for CFD simulation and assumed as Rpm propeller when working in various discharges.

### 3.6 Rotational Speed (Rpm)

The three different numbers of turbin blades have a similar inlet ( $\beta_1$ ) and outlet ( $\beta_2$ ). Their design is determined by the three different diameters which were: D 0.15 m ; D 0.17 m; and D 0.20 m (Table 6 and Figure 3).

**Table 6.** Inlet ( $\beta_1$ ) and Outlet ( $\beta_2$ ) Blades Angle.

DE		0,15	0,17	0,2
$\beta$	$\beta_1$	41,28	43,4	46,42
	$\beta_2$	37,65	42,52	47,51

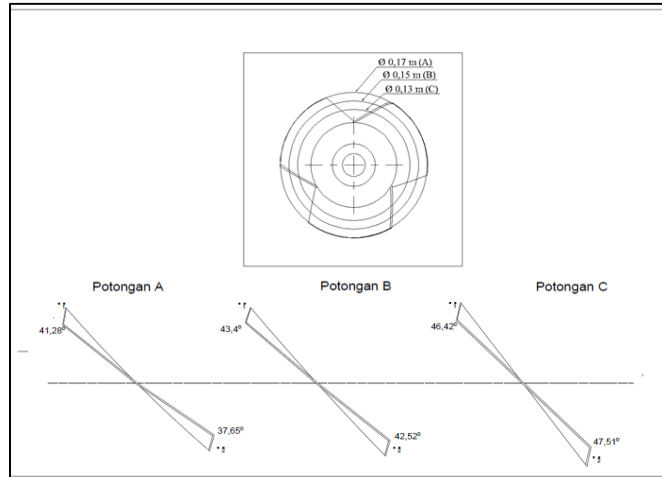


Figure 3. Blades of Turbin

### 3.7 Results of Propeller Turbin Prototype Simulation Speed Contour of Three Various Turbines

In Figure 4 and Figure 5 shows the contour speed of the simulation results of Propeller Turbines variations 1 and 2. It is seen that the fluid velocity has increased during passing the rotor and has decreased again after passing the rotor and has increased again when passing through the generator because it passes through a smaller cross section.

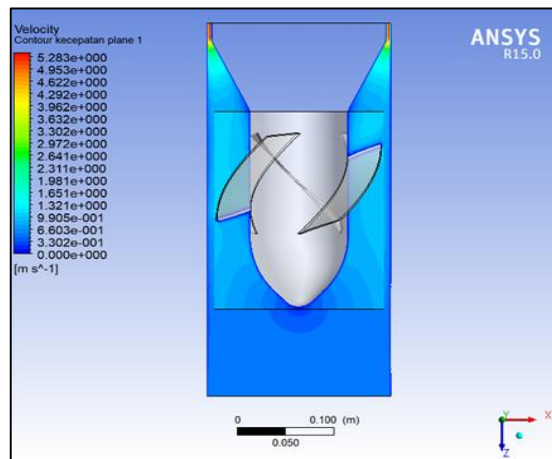


Figure 4. Water Speed Contour at three blades with the Rpm of 100

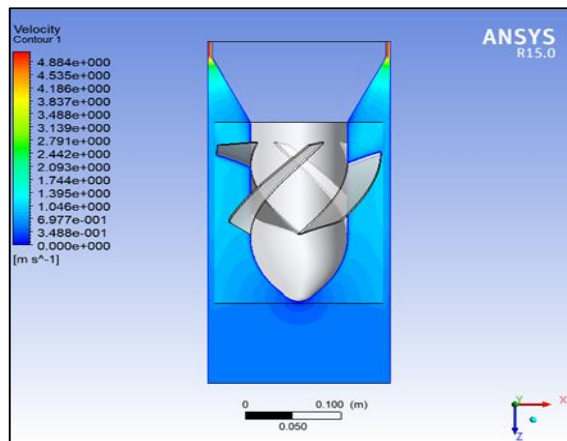


Figure 5. Water Speed Contour at four blades with the Rpm of 100

### 3.8 Streamline of the three different turbines

Streamline is the path that particles with zero mass will take through the fluid domain. In Figure 6, and Figure 7 shows the Streamline simulation results of the third Propeller Turbine variation at rpm 500. The red line shows the highest streamline velocity value, while the blue line shows the lowest streamline velocity value. Blue line velocity velocity is lower than the green and yellow lines.

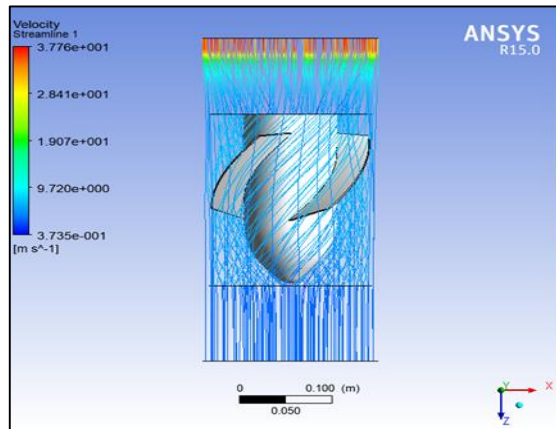


Figure 6. Streamline on blade 3, rpm 500

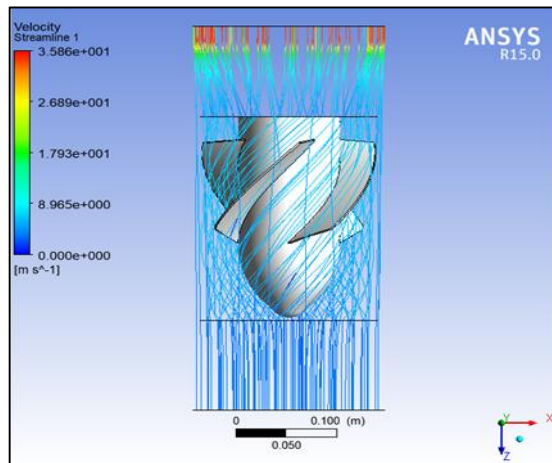


Figure 7. Streamline on blade 4, rpm 500

### 3.9 Comparative Analysis of 3 Different Number of Turbin Blades

Comparative analysis between the three turbine blades can be seen in the following Table 7 :

Table 7. Comparison Between Turbine Torque and RPM

COMPARISON OF TORQUE VALUES OF 3 DIFFERENT PROPELLER TURBINES			
RPM	TOQUE VALUE OF FIRST TURBIN – 3 BLADES (NM)	TOQUE VALUE OF SECOND TURBIN – 4 BLADES (NM)	TOQUE VALUE OF THIRD TURBIN – 6 BLADES (NM)
100	405,0350	481,7200	567,4560
300	3222,4100	3774,6700	3989,2700
600	9048,4100	8731,2200	9030,2300
900	13693,9000	15571,0000	17839,4000

It can be seen that the torque value of various propeller turbine depends on the number of blades and shows a

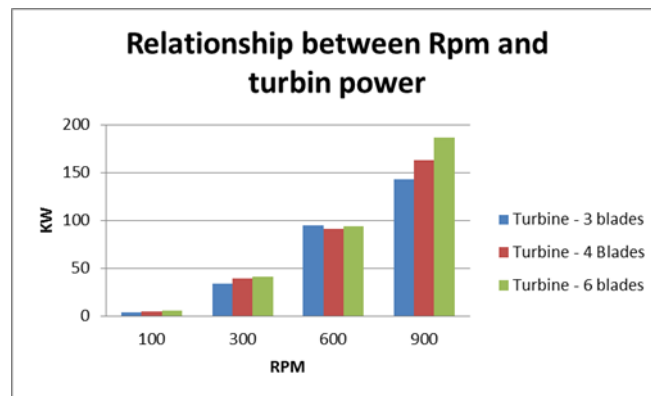


similar discharge. The more blades a propeller turbine has, the higher the water potential force it receives as it has a wider blade surface causing bigger torque. The Table 8 below shows the Comparison of Propeller Turbin Power Values According to Number of Blades :

**Table 8.** Comparison of Propeller Turbin Power Values According to Number of Blades

VALUES OF COMPARISON OF PROPELLER TURBIN POWER WITH THREE DIFFERENT NUMBER OF BLADES			
RPM	POWER OF THE FIRST TURBINE – 3 BLADES (KW)	POWER OF THE SECOND TURBINE – 4 BLADES (KW)	POWER OF THE THIRD TURBINE – 6 BLADES (KW)
100	4,24	5,04	5,94
300	33,74	39,53	41,78
600	94,75	91,43	94,56
900	143,40	163,06	186,81

Power was generated by a Propeller turbine that the highest had 6 blades with 900 Rpm, which was 186,81 KW (Table 8). The turbine power is highly affected by torque and Rpm. The higher the torque value, the lower the power it produces due to the angular velocity factor. It is affected by turbine spins which is equivalent to the discharge value. The relationship between Rpm and Turbin power can be show at Figure 8 below :



**Figure 8.** Graph of Correlation between Rpm and Power generated by Propeller turbine

### 3.10 Comparison of Efficiency between 3 different numbers of blades

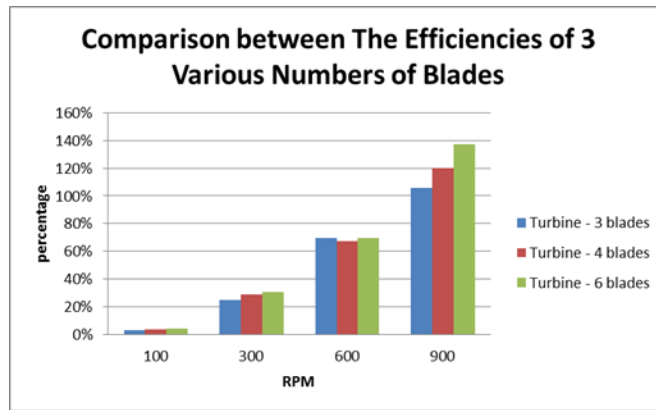
Comparison of efficiency between propeller turbines with three different numbers of blades can be seen at Table 9 follows :

**Table 9.** Comparison of Efficiency between propeller turbines

COMPARISON OF EFFICIENCY VALUES OF 3 DIFFERENT PROPELLER TURBINES			
RPM	THE EFFICIENCY OF THE FIRST TURBINE – 3 BLADES (NM)	THE EFFICIENCY OF THE SECOND TURBINE – 4 BLADES (NM)	THE EFFICIENCY OF THE THIRD TURBINE – 6 BLADES (NM)
100,000	3.1 %	3.7 %	4.4 %
300,000	24.8 %	29.1 %	30.7 %
600,000	69.7 %	67.2 %	69.5 %
900,000	105.5 %	119.9 %	137.4 %

According to Table 9 we can see the highest efficiency in turbines with 6 blades, 900 rpm with an efficiency value of 137.4%. The lowest efficiency in turbines with a total of 3 blades, 100 rpm, ie with a value of 3.1%. The higher the number of rpm and the more number of blades, the higher the efficiency, up to a certain amount.

The relationship between Rpm and Turbin power can be shown at Figure 9 below :



**Figure 9.** Graph Comparing the Efficiency of 3 various numbers of blades

### 3.11 Test on Prototype

In this study, the flow of pump was varied by adjusting the motor rotation using an inverter (20Hz, 25Hz, 30Hz, 35Hz, and 40Hz).

$$Ns = \frac{120 \times F}{P}$$

Where :

Ns = Specific rotation (Rpm)

F = Frequency (Hz)

P = Number of pole

$$Ns = \frac{120 \cdot 20}{4}$$

$$Ns = 600 \text{ Rpm}$$

According to data above, the maximum rotational speed was 1450 rpm producing discharge of 360 m<sup>3</sup>/hour, and the rotation of induction motor was 600 rpm. Therefore, we used the equation to obtain.

$$360 \text{ m}^3 / \text{hour} = 0.1 \text{ m}^3 / \text{s}$$

$$\frac{a1}{a2} = \frac{b1}{b2}$$

$$\frac{0,1 \text{ m}^3 / \text{s}}{a2} = \frac{1450 \text{ rpm}}{600 \text{ rpm}}$$

$$a2 \cdot 1450 = 0.1 \cdot 600$$

$$a2 = 60 : 1450$$

$$a2 = 0.0413 \text{ m}^3 / \text{s}$$

Complete data can be seen in the following table (Table 10) :

**Table 10.** Variation of Flow Discharges

NO	INVERTER, FREQUENCY (HZ)	MOTOR ROTATION (RPM)	WATER DISCHARGE (M <sup>3</sup> /S)
1)	20	600	0,04
2)	25	750	0,05
3)	30	900	0,06
4)	35	1050	0,07
5)	40	1200	0,08

### 3.12 Effect of Discharge on Turbine Rotation

Every time we did a test on a variation of flow discharge and number of the blade, we did recording according to column data. We repeated this activity until we got 5 various flow discharges and 6 blades. Efficiency according to Simulation on 6 Blades can be seen at Table 11.

**Table 11.** Efficiency According to Simulation on 6 Blades.

NO	WATER DISCHARGE (M <sup>3</sup> / S)	RPM	CURRENT STRENGTH, AMPERE (A)	VOLTAGE, VOLT (V)
1)	0.04	215	0.30	2.00
2)	0.05	320	0.35	2.60
3)	0.06	411	0.40	3.10
4)	0.07	574	0.50	3.76
5)	0.08	695	0.70	4.30

### 3.13 Comparison of Testing Efficiency and Simulation Efficiency

Comparison of test efficiency and simulation efficiency is done to find out the differences between the two data. In this study data have been obtained in the form of output power from the generator based on the results of the test data, then the theoretical data on water power and simulation power are obtained from CFD simulations conducted by colleagues. Following Table 12 results of power generated from 6 blades simulation data as follows.

**Table 12.** Power According to Simulation Data.

NO	AVERAGE RPM	POWER (WATTS)
		6 BLADES
1)	74.3	13.4
2)	185.7	23.2
3)	297.1	47.9
4)	408.5	76.7
5)	519,9	112.4

$$\eta = \frac{\text{Turbin power}}{\text{Water power}} \times 100\%$$

$$\eta = \frac{13,4}{29,6} \times 100\%$$

$$\eta = 45.2 \%$$

Table 13 below shows the results of 6 blades simulation efficiency, which is in the form of a comparison of simulation power (watts) with theoretical power (watts). At a simulation power of 13.4 watts, the theoretical power is 29.6 watts, so the result is an efficiency of around 45.2%. Next to the simulation power of 23.2 watts, the theoretical power is 51.4 watts, so that the efficiency results are around 45.2%.

**Table 13.** Simulation Efficiency 6 Blades.

6 BLADES		
POWER SIMULATION (W)	POWER THEORETICAL (WATTS)	EFFICIENCY(%)
13.4	29.6	45.20
23.2	51.4	45.15
47.9	106.08	45.13
76.7	170.04	45.10
112.4	249.6	45.03

#### 4. CONCLUSIONS

According to the discussion above, some conclusions that can be withdrawn are as follows:

1. The analysis indicates that the torque value of various propeller turbines is higher when there are more blades and show a similar discharge. Also, it is higher when the flow discharge is bigger. The torque value of the propeller turbine with 6 blades is higher than the ones with 1 or 2 blades and result in various flow discharges. The analysis shows that the more blades a turbine has, the higher the torque score that it results.
2. The strongest power is generated by a propeller turbine with 6 blades, followed by the one with 2 blades, and the weakest power was resulted by the turbine with one blade only. The turbine power is highly determined by torques and angular velocity. The bigger the torque score, the smaller the power is which is caused by the angular velocity factor. The angular velocity factor is affected by turbine rotation which is directly proportional to the discharge. The higher the discharge, the stronger the turbine rotation which peaks at  $0.0972 \text{ m}^3/\text{s}$ .
3. The best number of blades for a power plant company that utilizes energy from an outlet channel is 6.
4. Test and measurement on hydropower prototype using 6 blades identify that the higher the water discharge is, the bigger the RPM value, currents and voltages are. The water discharge of  $0.04 \text{ m}^3/\text{s}$  will produce rpm = 215, currents = 0.30 A and voltages = 2.00 volt. While the water discharge of  $0.08 \text{ m}^3/\text{s}$  emits the rpm of 695, current of 0.70 A and voltages of 4.30 volt.
5. Statistical analysis shows that the higher the RPM value of propeller turbine with 6 blades, the stronger the power and voltages it emits.

#### 5. ACKNOWLEDGMENT

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