The Effect of Steering Blade Angles of Helical Turbine for Power Generation in Irigation Dam of Seluma Bengkulu

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Abstract. The Gorlov vertical axis water turbine is suitable to harness the water flow in the creation of kinetic energy for the irrigation dam. The turbine tested in this study was the Gorlov helical turbine blade with steering angles of 0º, 30º, 45º and 60º turbine diameter (d) of 0.30 m, height (h) of 0.50 m and the NACA 0020 profile. The testing was conducted on the irrigation dam of Seluma Bengkulu. The water flow showed in the velocity (Uwater) of 0.85 m/s and a round (n) of 110 rpm. The results were achieved by setting the blades in steering torque coefficient (CT) of 0.309 are turbine efficiency (ηt) of 28.5% and a power turbine (PT) of 13.699 watts.

Keywords: Gorlov helical turbine, irrigation dams

1. Introduction

The life of modern society depends largely on the availability of energy sources, especially electricity. The need for electricity is just like other basic human needs. Utilization of electrical energy have influenced and shaped human civilization in this decade, because the quality of human life has a correlation with the use of electrical energy in their daily lives. Meanwhile, demand for electricity continues to increase every year, an estimated growth of 7.1%. In 2012, the electrification ratio is 60%. However there are still many remote areas that have not received electricity. PLN (State Electricity Company) has not been able to supply electricity for reaching these remote areas.

Miftahuddin [10] explains that the primary utilization of irrigation on discharge from 2.7 to 3.1 m^3/sec and could power up to 59.823 kW. From the experimental results of this tool, a generating efficiency can work up to 79.92%.

Kurtulmus Ferhat et al [6] explain that in order to get a wind turbine economical and maximum usability in a study that was made four variations of the angle of attack of the blade printed over the relationship between lift and drag. He used a computer to calculate the lift and drag on the minimum pressure coefficient. After the evaluation of the shape of the blade and the highest yield, the safe exposure angle fell between 3º to 9º. In accordance with the relationship the lift and drag constant for a long time and in accordance with the Re number of 2000. Daisuke MATSUSHI et al [4] say that type of Darrieus water turbine, hydro power conversion with very low head has the advantage of low manufacturing costs because of its simplicity and the shape of the channel can be set to achieve higher efficiency. While the Gorlov turbine and the Darrieus one have many in common, but the helical type of the Gorlov turbine produces water excess, and it can be used among others to achieve higher efficiency.

Shawn Armstrong et al [16] argue that a vertical axis wind turbine has the advantage to be developed in the environment but the regional variation of aerodynamic thrust and radial force. The shape of the helical blade, for a vertical axis turbine can reduce load fluctuations during the operation. However, the turbine has the shape of three-dimensional complex geometries that is difficult to make and they are expensive. Straight and bent blades both have advantages to distribute fluctuations but combine aerodynamic linear axes that can be made at a cost comparable with a straight blade. The test data showed skewed blade has a power output comparable to a straight blade and aerodynamic power can be used to improve the work.

Rusman [13] explains that Gorlov helical turbine with dimensions of 300 mm high and 122 mm in diameter on the fluid flow velocity differences are: 1.85 m/s, and 1.6 m/s, can produce efficiency 31.72% and 30.95%.

Mohammed et al [12] mention that his research was to predict the phenomenon and work efficiency of a helical turbine with a rotor leaves (Gorlov helical turbine). Under his study, a change was made to the angle of the strip on the rotor blade and it has an influence on work efficiency of the turbine rotation.

Sathish et al [14] believe that a helical turbine is a device to convert the kinetic energy of a moving fluid into mechanical energy of rotation. The helical turbine is rotated by wind from the 4-way and fit when compared to other wind turbines and helical turbine is used to drive the generator.

Alexander Gorlov [2], redid his research on the back helical turbine for generating water turbine blade airfoil which focused on the security of the rotor.

Manabu Takao et al [9] explain that Vane steering geometry effects on the performance of their vertical turbine. The vertical axis wind turbines could cope with straight blade (S-VAWT) to be directed by a steering vane and the purpose of research.

Alexander N. Gorban, et al [1] explains the limits of Darrieus turbine efficiency and those of Gorlov helical turbine where plane propeller efficiency of 30 % and 60 % were given by the Betz limit resulted too much difference. While the one by Gorlov was well documented and showed that the helical turbine had an efficiency of 35 %. Therefore, it is widely used for the free flows.

2. Tools and Methods of Research

In this study, the authors set the water Gorlov helical turbine in the direction of blade diameter of 300 mm, three (3) forms of helical blade turbines with NACA 0020 and turbine height of 500 mm. blade solidity σ of 0.25, and the chord length is:

$C = \sigma \pi d / B =$

Gorlov turbine blade thickness is 26 mm.

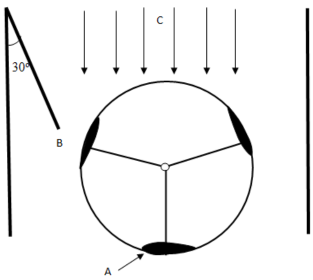

Figure 1. Schemes of the Study (Top View)

Figure 1 shows the scheme of the study without the use of a steering blade (A) helical turbine blades, (B) directional blade, (C) the flow of water.

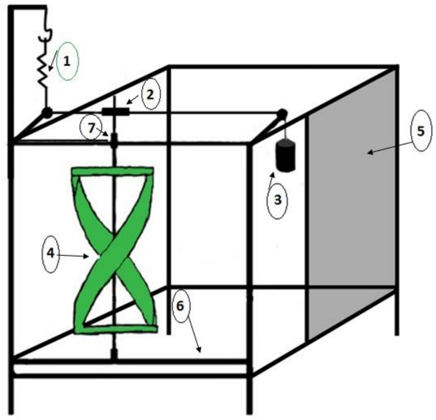

Figure 2. Construction of Helic Water Turbines

Figure 2 shows the construction of a Gorlov water turbine with frame made of steel and equipped with (1) spring balance, (2) brake drums, (3) a load, (4) helical Gorlov blade, (5) directional blade, (6) order of the turbine and (7) bearing.

The testing was conducted in the irrigation dam of Seluma Gebur Bengkulu. Selama Lubuk village has irrigated rice fields and uses the water flow for irrigation and fishery. The steering bladed was installed on the front of the turbine to regulate the sizes of the angles. The measurements were made with the braking forces on the brake drums. The brakes used a rope wrapped around a drum brake, and both ends of each strap are tied up to the loads and the springs. The tests were carried out for three turbines that use blades but without Gorlov blades and Gorlov steering. The testing for turbine blades used the steering on each angles - each point to 30°, 45° and 60°.

The data generated in this test was Uwater (water velocity) = 0.85 m/s, rotational speed (n) of 110 rpm, the spring force and load force.

3. Data from the Turbine Testings

Analyses of these calculations are taken from the results of the data from the study, with the known data is Wspring of 450 grams and 100 grams = W load with shaft speed n of 110 rpm then generated as follows:

The amount of forces on the torque on the pulley:

$$\Delta F = (W_{Spring} - W_{Load}) \text{ x } g \quad (1)$$

The amount of torque (T) Nm occurring:

$T = \Delta F\ ((D_{Pulley} + D_{Thread}) / 2$ (2)

Tangential speed of the rotor

$V_{Rotor} = \pi dn / 60$ (m/s) (3)

Turbine Angular velocity (ω)

$\omega = (2\ \pi n) / 60$ (rad/s) (4)

Gorlov turbine power (P)

$Pturbin = T\ .\omega$ (Watt) (5)

Water Power (P_{air})

$A\ P_{air} = ½(\ \rho A\ V^{3}$ (Watt) (6)

Tip speed ratio (λ)

$\lambda = V_{Rotor} / {}_{Uwater}$ (7)

The efficiency of the turbine (ηt)

$\eta_t = P_{turbine} / P_{water}$ (8)

Coefficient torque (CT)

$CT = C\_P / \lambda$ (9)

4. Results and Discussion

This experiment was to get the torque coefficient (CT) and power turbine efficiency (ηt) on the effect of the use of turbine blade angles.

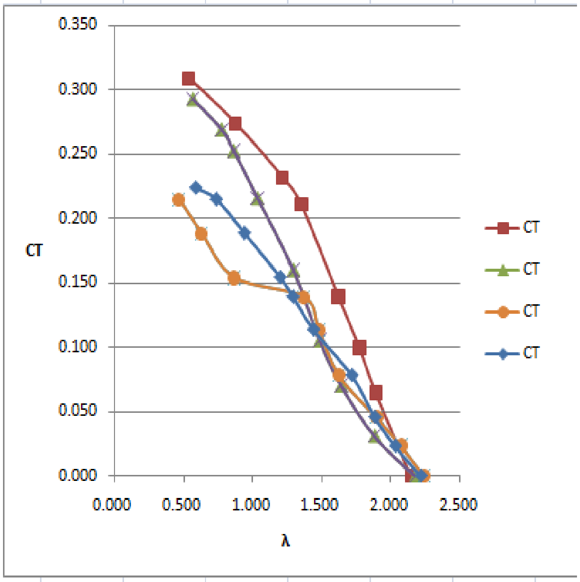

Figure 3. Graph CT with λ

The torque coefficient generated by the image of three-blade Gorlov turbines resulted in the steering blades of CTmax = 0.223 with $\lambda = 0.591$ at the line torque pointed to the location of $0.591 < \lambda < 2.216$ meaning that the turbine wheel was fast enough.

The shape of the graph CT and λ was quite good, where the value of CT can be found by a comparison between the torque (T) and $½\ \rho V^2 A$ r.

In the CT image with λ graphs generated by the turbine blades Gorlov with a steering angle of 30º can be seen that the value of CT max = 0.214 and λ = 0.469 with operational line limit is $0.469 < \lambda < 2.238$.

Figure 4 show the CT images with λ generated by the turbine Gorlov with a steering angle of 45º. It can be seen that the value of CT max = 0.292 and λ = 0.469 with dividing lines of $0.469 < \lambda < 2.238$.

Figure 4 shows the CT images with λ generated by the turbine blades Gorlov with a steering angle of 60º. It can be seen that the value of CT max of 0.309 and λ of 0.540 with dividing lines limit is $0.540 < \lambda < 2.144$.

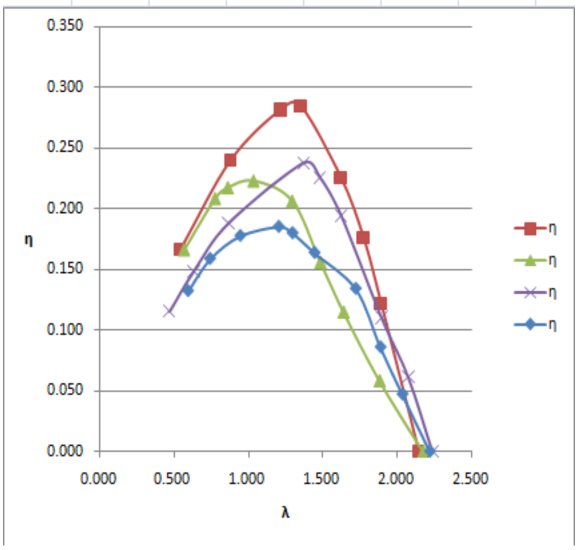

Figure 4. Graph ηt with λ

Figure 4 shows graphic images and blade tip speed ratio with steering angle of 60º, the value of η_t max of 28.5% with λ of 1.351. The second condition shows the steering angle of the blade 45º value η_t max of 23.8% and λ of 1.035. The third condition shows the steering angle of the blade 30º value η_t max of 22.3% and λ of 1.20. The fourth condition refers to the efficient turbine blades of the maximum value of η_t max of 18.5% and λ of 1.351.

In the fourth Gorlov turbine test, the biggest efficiency points to the steering angle of 60º with the value of maximum efficiency (ηt) of 28.5%.

5. Conclusions

Three conclusions are drawn in this study:

1. The kinetic energy contained in the water flow rate can be converted into mechanical energy

when the Gorlov helical vertical axis turbine was used.

2. With a steering angle of 60º at a speed rate of water of 0.93 maximum efficiency (η_t) max of 28.499 % power turbine (P_t) of 13.699 Watt, the use of the Gorlov turbine obtained sufficient efficiency like Gorlov had done.
3. Other experiments with the steering angles of 30º, 45º, and without blades, resulted in the less efficiency and lower power.

Glossary of Terms and Abbreviations

A = cross-sectional area wet Gorlov turbine (m^2)
B = Number of blades
C = Blade chord Width (m)
CT = coefficient of torque (Nm)
D = diameter of rotor (m)
F = Force (kg)
g = gravity of the earth (m/s^2)
P_{air} = of water Power (Watts)
Pt = turbine power (Watts)
R_{pulley} = The radiusof the pulley (m)
T = Torque (Nm)
U_{air} = water velocity (m/s)
V_{rotor} = turbine rotor peripheral velocity (m/s)
η_t = turbine efficiency (%)
λ = tip speed ratio
ρ = density of water (kg/m^3)
σ = Solidity Gorlov turbine
ω = Angular velocity of the rotor (rad/s)

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