DESIGN AND SIMULATION OF A 50KWE HYDROKINETIC TURBINE FOR THE CURRENTS OF THE COZUMEL CHANNEL

Adriel Johanam Canul Arévalo[1] and Víctor Manuel Romero Medina[2]

[1]adriel.canul.ac@gmail.com
[2]vromero@ucaribe.edu.mx

Introduction

Colina (2018) points out that hydrokinetics takes advantage of the energy that is produced in the rivers and seas flows, through generators to that have devices attached such as turbines to produce electricity. Hydrokinetic turbines have the same operating principle as wind turbines, with the advantage that they work with a denser and more viscous fluid (water), the characteristics of the fluid allow higher energy densities and lower instabilities to be achieved. Hydrokinetic turbines are classified according to Kan, Bhuyan, Iqbal and Quaicoe (2009) by their configuration as: axial, vertical, cross flow, Venturi and gravitational Vortex.

Cross-flow turbines work regardless of the flow direction as long as the rotor axis is perpendicular to the flow, that is why these turbines are omnidirectional. The Gorlov turbine has an helical shape that divides the forces evenly in each revolution, preventing any damage to the rotor. This type of turbine always has a blade with an ideal angle of attack to the flow.

Methods and materials

The cross flow turbines harnessing the kinetic energy of the sea currents however, there are main equations that govern this type of system to obtain the amount of usable power (P_w) and the useful power (P_U) (Gorlov, 2001).

$$P_w = \frac{1}{2}\rho A V^3 \quad (1)$$

$$P_{U=}\eta P_w = \frac{1}{2}\eta\rho A V^3 \quad (2)$$

where ρ us the fluid density, A is the transversal área of the turbine where the flow cross, V is the fluid's flow and η is the turbine efficiency.

The ORPC TidGen tubine's dimensions where taken as: 7.2 m for lenght and 2.8 m of diameter, hidrodinamyc profile NACA0021, angle of attack of 8.5°, twist angle of 120°, efficiency (η) of 25.5% and with 3 blades that formed the turbine, according to Bárcenas *et al* [11], this turbine is adequate for the depths of the coast of the cozumel channel of 50 m. Was calculated with ecuation 2 that the turbine culd produce 50 kWe with a fluid flow speed of 2.7 m/s registered by Alcérreca *et al* [12]. The profile chord lengt was calculated with ecuations 3 and (Yunus, 1996).

$$W = 2\pi \frac{n}{t} T \quad (3)$$

$$T = \frac{1}{2}\rho V_{fluido}^2 c B L r \quad (4)$$

where T is the arrow work, $n/t=\dot{n}$ are revolutions per minute, c is the chord length, B is the Blade nummber, L is the tubine lenght and r is the turbine radio, subsequently the equations where equated c was cleared and equation (5) was obtained and was calculated that for 10 rpm (revolutions per minute) the turbine needs a chord length profile of 0.42 m.

$$c = \frac{W}{\pi \dot{n} \rho V_{fluido}^2 B L r} \quad (5)$$

The design was made it in SpaceClaim module of Ansys 19.2 software. The geometry was discretized in the Mesh module of Ansys 19.2 generating 446,293 nodes and 2,440,628 elements in the mesh. The turbine was defined as a body in motion and with constant density, the model was established as transient and based on the pressure in Fluent of Ansys 19.2, in the boundary conditions two fluid velocities were defined keep them constant, the velocities were 2.7 m/s and 1.5 m/s. For the solution methods, those of second order were chosen and reports were generated to obtain the values of the elapsed time in seconds, the torque of the turbine and its angular velocity for each of the aforementioned fluid velocities.

Results

The turbine reached a power generation of 7.65 kW whit fluid flow speeds of 1.5 m/s with an angular velocity turbine (ω) of 2 rad/. Samly the turbine reached a power generation of 50kW whit current speeds of 2.7 m/s, with an angular velocity turbine of 3.9 rad/s (Figure 1).

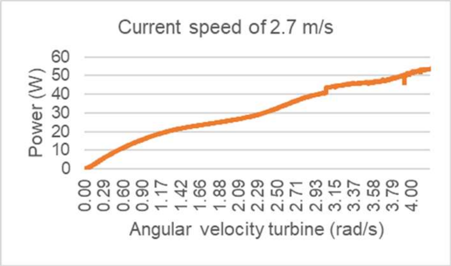

Figure 1. Power (kW) vs Angular velocity turbine (rad/s).

As is shown in Figure 2, after 1 second of animation (with fluid speed at 2.7 m/s) and 2.5 seconds of animation (with fluid speed at 1.5 m/s), it is observed that the fluid, when deflected on the surface of the blades, increases its speed, causing the desired rotation of the blades, the yellow and green contours can be observed that indicate higher fluid speeds around the aerodynamic profiles of the rotor, It is also observed that there is generation of turbulence inside the rotor and in the wake that is generated when the current crosses the turbine.

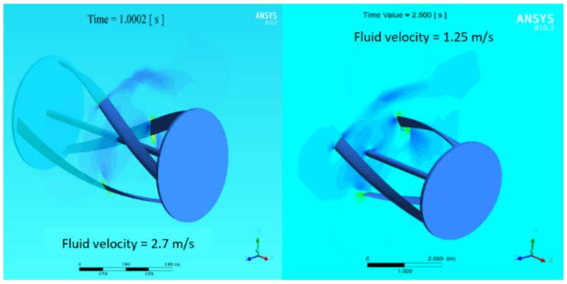

Figure 2. Velocity contours of the fluid flow when crosses the turbine.

The static pressure of the fluid on the turbine was analyzed and it was observed that the regions of the blades that are orthogonally aligned to the direction of the fluid have higher static pressure, this is due to the fact that being located due it Works like a wall which generates greater drag forces in the blade, it was also observed that the regions of the blades that are parallel aligned to the fluid have lower static pressure, creating a lift force, both behaviour are due to the size of the surface in contact and the choice of the hydrodynamic profile (Figure 3).

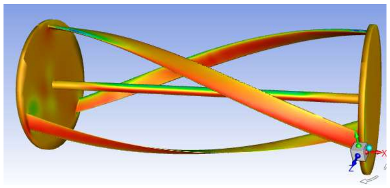

Figure 3. Static pressure on the turbine.

Conclusions

The data obtained through the simulation behave in such a way that they approximate the data obtained theoretically, however it was considered that the approximations could be more exact knowing some values of the turbine marketed by the Ocean Renewable Power Company such as: the hydrodynamic profile, the chord length of the profile and the angle of attack of the profile, in this way estimation errors would be minimized by approximating the design of the geometry much more to the real design of the turbine, in the same way it is ideal to extend the time of numerical analyzes through Ansys and thus be able to project in future research the time in which the turbine will maintain its maximum angular speed constant producing its maximum power and evaluate the operation of the turbine at various current speeds of the Cozumel channel.

References

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