Investigation of the Catamaran Vertical Turbine Model

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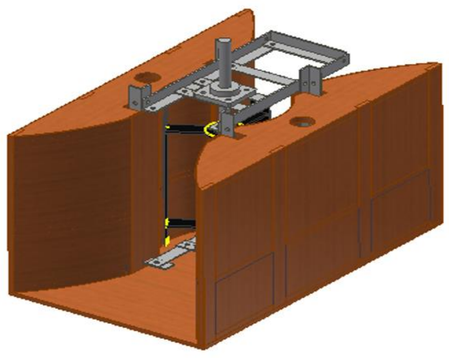
ABSTRACT

The performances of the Catamaran embedded with vertical turbine model have been investigated in the laboratory canal. The Catamaran has conduit in form of the nozzle and diffuser for concentrate the water current flowing into the vertical turbine. The Catamaran was anchored with two ropes to resist the transversal and longitudinal force movements. The numerical investigation on the catamaran vertical turbine was presented in the numerical simulation, the catamaran has a fluctuation of lateral forces due to the vortex formation behind the turbine, further the performance measurement and investigation movement analysis of the catamaran will be presented.

The vertical turbine system mounted at the catamaran as flow concentrator was tested by measuring several parameters, such as flow velocity, rotational speed, torque and anchor two ropes force. The vertical turbine has three blades of optimized NACA 0018, at chord radius ratio C/R = 0.5, and a 38 cm blade length. The vertical catamaran turbine system was tested at various flow velocities, 0.6 - 0.8 m/s. At a velocity flow rate of 0.68 m/s, has a coefficient of power C_p 0.266. At a velocity flow rate of 0.75 m/s, and the coefficient of power C_p 0.290. At a velocity of water stream of 0.79 m/s,the maximum coefficient of power C_p is 0.30 at 240 rpm. The two anchor rope system gives the force testing results shows the two ropes can stabilize the catamaran even the formation of vortex behind the catamaran still there. The measurement of left anchor rope gives a higher force than the right one. This phenomenon shown beside the vortex formation, there has the inertia force due to the wheel rotation.

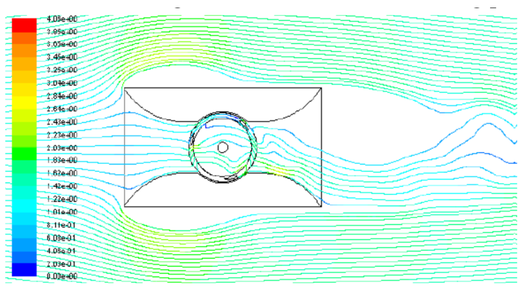
TURBINE DESIGN

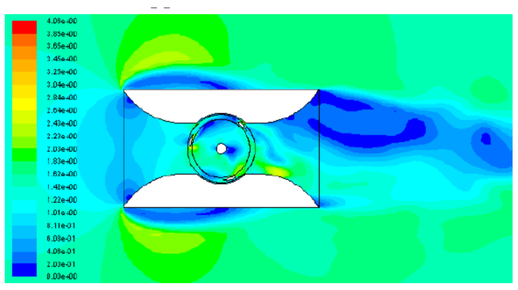


The catamaran as concentrator device and the blade profile

The turbine blade design based on optimized NACA0018 to minimize the drag and constrain the difference thickness of original geometry. The optimized blade design should have the inequality order is ≤ 0. The performance of 2-D optimized blade can be calculate using the XFOIL code where has been developed used panel vortex method couple with the viscous boundary layer.

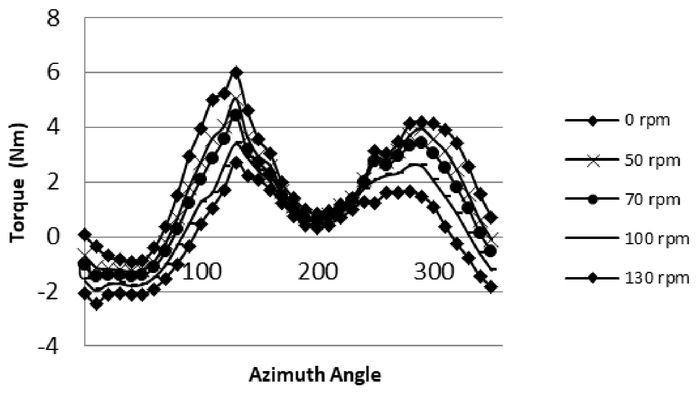
SIMULATION





water stream flows around the catamaran, rotated rotor and vortex formation

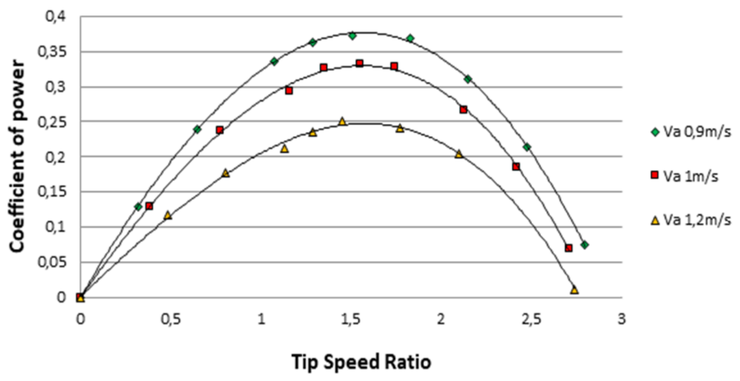
The vortex formation can occurs in the stream water behind the rotating rotor and investigates during the numerical simulation and confirmed at the experimental. The other phenomenon has to be taken into account are the flow into the concentrator device and water flow around the Catamaran. The velocity flow entering to the concentrator decreased due to the friction, the form of concentrator and turned turbine has considered as an obstacle.



Oscillation of the torque of the straight blade rotor

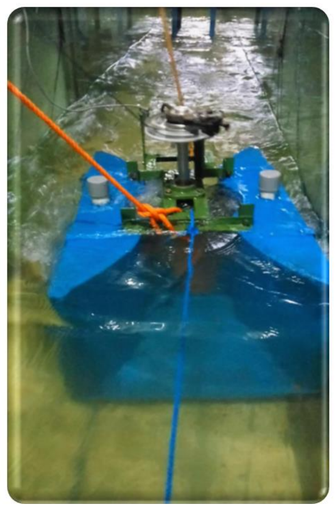
Numerical simulation predict the oscillation of torque produced, where this figure shows the power oscillation depend of azimuth of blades, the power varies between 15 Watt to 76 Watt depend on the azimuth. The oscillation happens due to the rotation of blades and the vortex shedding formation immediate at the down-stream of Catamaran outlet.

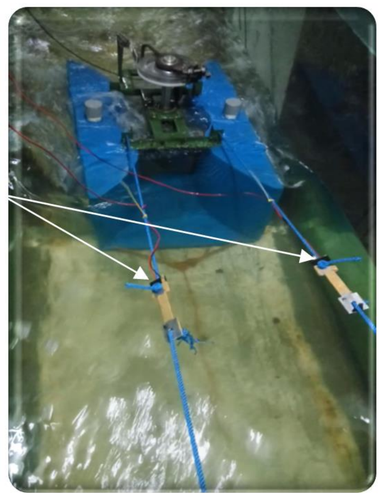
The concentrator channel device at catamaran augments the velocity and creates the positive torque to get the starting ability of the straight blade of rotor. The coefficient of power at higher stream flow velocity has smaller than at lower velocity, the TSR at maximum coefficient of power located at 1.5 to 2



Coefficient of power result from numerical simulation

EXPERIMENT

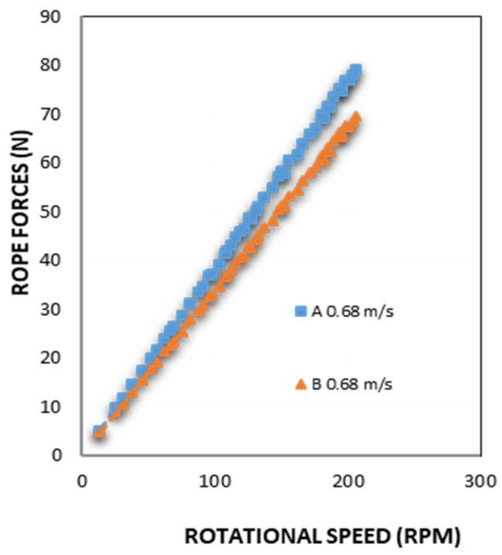




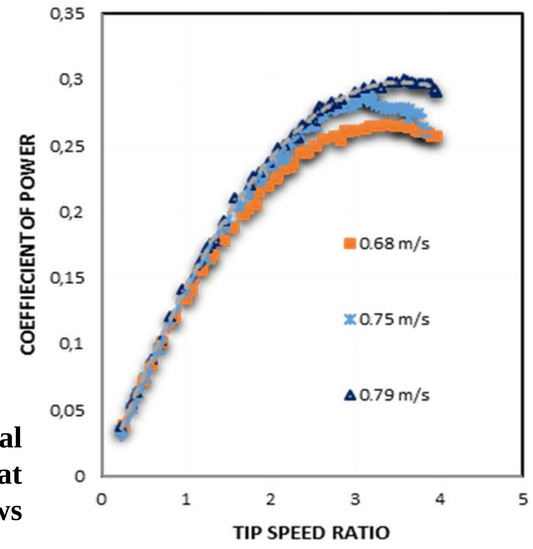
the right and left rope force at difference of the velocity and the rotational speed

The catamaran equipped with torque measurements and rpm meter and strain gage at the anchor rope to measures the rope forces. The unbalance forces increases as the rotational speed of the straight blade rotor also increase. It may show also the force of anchorage rope increase with the velocity stream increase. The two rope anchor system can maintain the orientation of catamaran and keep in the stable condition with small oscillation movement.

RESULTS



(left picture) The right rope (A) and left rope (B) force at difference of the velocity and the rotational speed



(right picture) the experimental result of the power coefficient at several velocity stream flows

CONCLUSIONS

The catamaran as concentrator of water stream with straight blade rotor has been investigated. The straight turbine is placed in the middle of concentrator has starting capability. The coefficient of power will increase to 0.40 if the water stream velocity reaches value of 1.1 m/s. The rope anchorages have to be placed in the both side right and left of the catamaran to maintain stability and should be oriented facing to the velocity of water stream. The catamaran with the passage of water is considered as submerged obstacle than the velocity of water stream will decelerate in the enter region, accelerate on the nozzle same as velocity on the free stream. The rotational of the rotor and vortex formation behind the rotor generate unbalance force on the anchorage ropes.

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