CFD STUDIES ON MODELING OF SAVONIUS HYDRO TURBINE

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Abstract - *The goal of this research is to demonstrate the key characteristics of a hydro turbine. We investigated the performance of a water turbine under various conditions in this study. The Savonius wind turbine is one of the most well-known turbines in the world of wind power production, but we have employed it as a hydraulic turbine, and there is little literature on this type of water turbine. In this study, the performance of a Savonius hydro turbine is analysed using CFD simulation and experimental data. We provided a model in Part 1 of our dissertation, and now we are investigating the experimental data. This turbine's basic structure consists of a rotor with bearing, generator, power conditioner, and load unit. The primary goal of this project is to examine the performance of a hydro turbine with various overlap ratios and aspect ratios.*

Key Words: Modeling, Performance, Simulation, Computational fluid dynamics, Fluid dynamics, Hydro turbine

1.INTRODUCTION

The current epoch is dominated by energy. Wind, tides, solar power, geothermal heat, biomass, such as agricultural and animal manure, and non-traditional energy, such as human excreta, can all be used to generate energy. Each of these sources is either infinite or sustainable, and they do not pollute the environment. Furthermore, they do not necessitate much use. Today, the world's power consumption is up to 20,000 billion kilowatt-hours, with 70 percent coming from conventional energy and the remainder coming from other common sources such as hydropower, geothermal, biomass, solar, wind, and atomic energy. About 16 percent of this 30 percent is formed by the dynamic life of falling or streaming water, which then transforms into power.

1.1 The Project's Goal

The goal of this study is to use experimental analysis to determine the turbine's maximum efficiency. This study is primarily focused on renewable energy systems, and the purpose of this paper is to investigate the performance of a Savonius turbine utilised as a hydro turbine using computational fluid dynamics (CFD) simulations and experimental data.

1.2 Finite Difference Method

The finite difference technique is a prominent method for solving PDEs numerically. It was first proposed in the 18th century by Leonhard Euler for the solution of an initial value problem. The forward and backward Euler method (FDM) is well-known. CFD development, research, and applications have all benefited from IT.

2. NUMERICAL SIMULATION

The effect of optimal obstruction is investigated in this paper using numerical simulation and fluency. The term "blockage" refers to the ability to produce or hinder the flow of water while maintaining the free stream velocity constant in a canal. The influence on performance may be seen through this work. This project focuses on improving flow blockage and investigating performance by calculating Power and Cp.

The work was done with three distinct canal parameters: the canal width was varied by modelling, and all other dimensions, such as free stream velocity and turbine model, kept constant. The three distinct canal widths span from 0.636D to 15D, and the savonius hydro turbine was used to achieve the highest feasible Cp and Power.

2.1 Modelling

The geometry modelling is done in solid work, and the boundary condition parameters stay the same. In each of these canals, the identical turbine is installed.

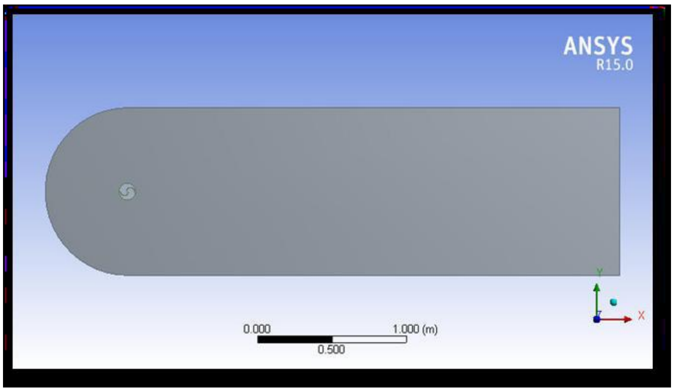

Fig.1 Savonius Hydro turbine with 5D upstream and downstream Canal width

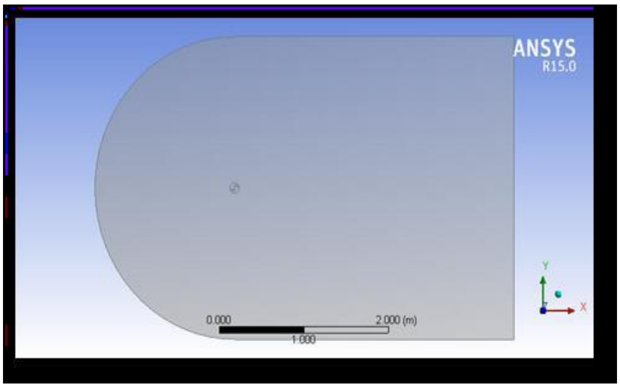

Fig 2 Savonius Hydro turbine with 10D upstream and downstream Canal width

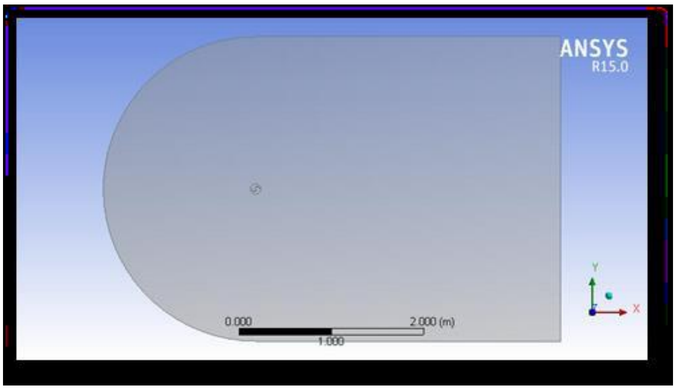

Fig 3 Savonius Hydro turbine with 15D upstream and downstream Canal width

2.3 Mesh

Ansys 15 is used to complete the geometry by importing it through Solid Works. To maximise the result, the grid size and procedure are kept the same, just the canal width is changed.

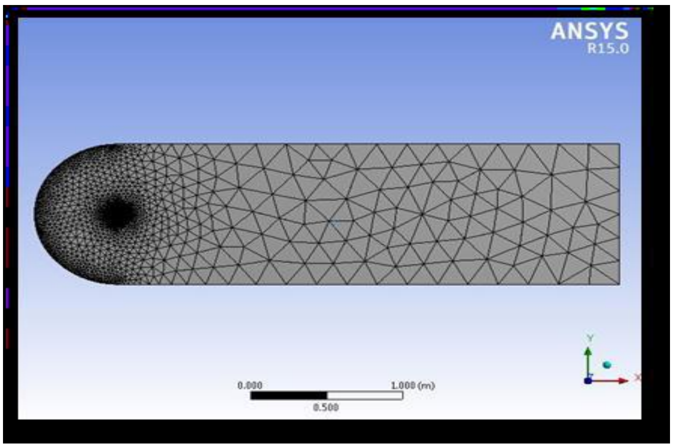

Fig 4 Meshing of Savonius Hydro turbine with 5D upstream and downstream Canal width

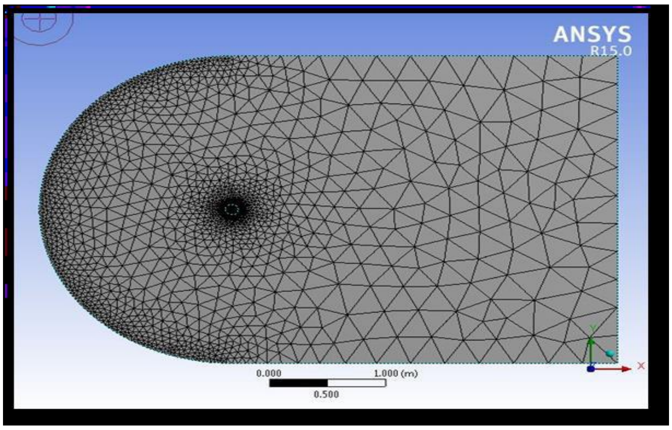

Figure 5 Savonius Hydro turbine meshing with 15D upstream and downstream canal widths

3. Results and Discussions

Velocity contour of savonius hydro-turbine at Aspect Ratio e=25 and canal width 0.636D, 2.5D, 5D, and 15D

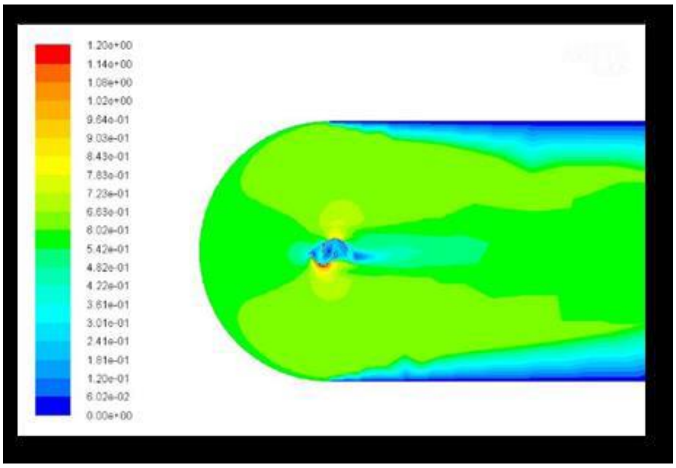

Fig 3.1 Velocity Contour at 2.5D Canal

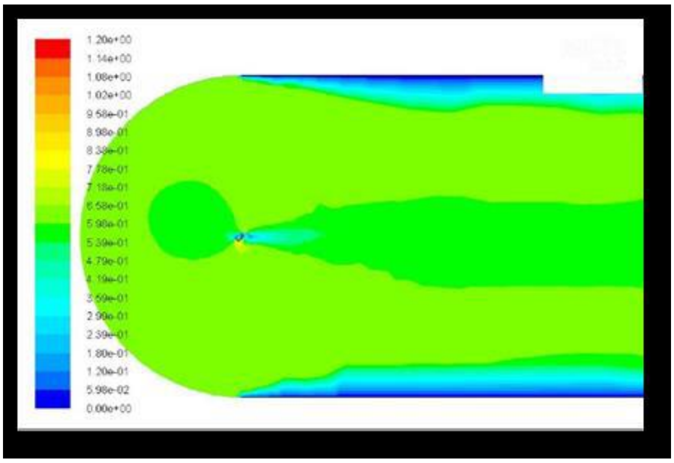

Fig 3.2 Velocity Contour at 5D Canal Width

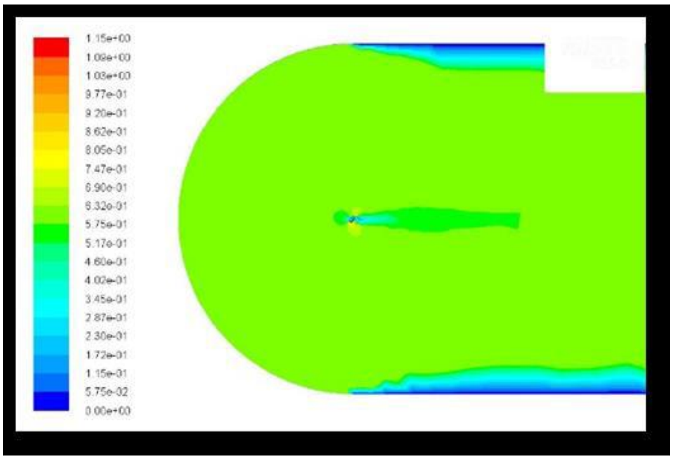

Fig 3.3 Velocity Contour at 15D Canal Width

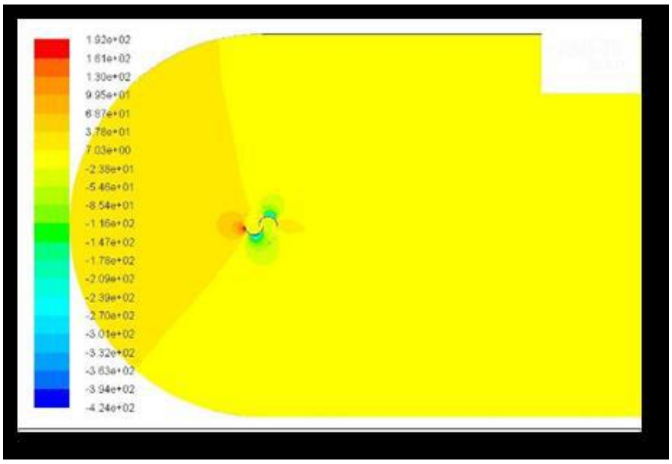

Fig 3.4 Pressure contour at 15D canal width

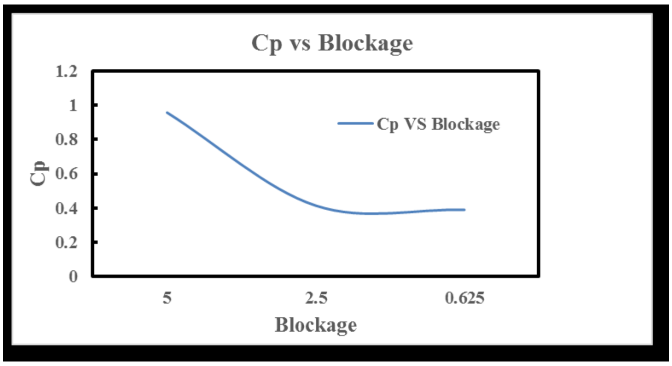

Fig 3.5 Cp Vs Blockage comparison

Closure

Figure 3.5 shows how the Cp varies with canal width. It is obvious that if the canal width is too small, the total force of water coming at a free stream velocity is dropped on the rotor. As the width of the inlet area is increased, the fluctuation continues, and at a middle position, the optimum Cp can be obtained. In this case, the feasible solution can be obtained at 5D. The width is minimized at the last location when it is unable to rotor from above. It is apparent that as the canal width is reduced, the Cp steadily decreases.

A performance investigation is carried out experimentally, with several aspect ratios being evaluated and a viable answer being found. Now, three sets of blades with varied aspect ratios were tested with a constant overlap ratio of 15, and it was discovered that the blade with the most area worked better than the others. The blade with a height of 250 mm had a Cp of 0.471508 in this study, while the rest of the blade had a lower Cp. As a result of the experiment, it is evident that the Cp can be maximized by altering the blade's aspect ratio.

The following work was done in CFD to better understand the effect of blockage. A numerical simulation for the fixed geometry with aspect ratio and overlap ratio is carried out to obtain the right behaviour of the Savonius hydro turbine. In the blockage analysis, a wide range of domains were used, with domain widths ranging from 0.637D to 15D, and it was discovered that the best result may be obtained at a specific place in the domain, which is at 5D.

4. CONCLUSIONS

In this study, the performance of a Savonius hydro turbine CFD simulation at low velocities in the range of 0.6 m/s inside an open canal was investigated. For the same values, the experimental and CFD results are compared to each other. The following findings are drawn from this research:

- The findings illustrate the torque and power output of the Savonius hydro turbine, indicating that at a certain point with a low free stream velocity, the maximum Cp may be achieved with less fluctuation in the turbine.
- This work's viable position is at a TSR of 0.7, where the largest power co-efficient is achievable, which is substantially greater than any other position in this work.
- Despite the fact that the Savonius turbine is primarily a wind turbine, the goal of using it as a hydro turbine is to extract maximum power output because hydro power is superior to wind power. A free stream velocity of water of 0.6 m/s would be suitable for the current work because torque and power fluctuate less.
- Because the location of the turbine in the water has an impact on performance, it was decided to conduct an experiment with the blade position. In this work, a feasible position is generated, and it is concluded that the performance of the turbine can be improved by keeping it at an angle.

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