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Performance Analysis of savonius hydro turbine using CFD simulation

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Abstract - *The primary goal of this study is to experimentally analyse the turbine's maximum efficiency. The goal of this research is to analyse the performance of a Savonius turbine utilised as a hydro turbine using computational fluid dynamics (CFD) simulations and experimental data. This project is primarily based on the renewable energy system.*

Key Words: Fluid dynamics, hydro turbine, modelling, performance, and simulation, along with computational fluid dynamics

1. INTRODUCTION

The current era is the era of energy. Energy can be produced by the wind, tides, sun, geothermal heat, biomass, including farm and animal waste, as well as human excrement, which is known as unconventional energy. All of these resources are renewable or limitless and don't harm the environment. Additionally, they don't demand heavy use. Currently, the world uses up to 20,000 billion Kwh of energy, of which 70% is generated by conventional sources and the remaining 30% by sources such as hydropower, geothermal, biomass, solar, wind, and atomic energy. About 16% of this 30% is created through the kinetic energy of falling or streaming water, which is then converted into power.

2. Lift Force Performance Model 3.1

Let's assume that (L) is the lifting force, which acts in the direction of the fluid flow's normal. This is explicable using the governing equation.

L=1/2 C_(L) ρAV^2.. (4.1) Where A is the area of the blade air foil, is the lift coefficient, and is the density of water. Pull Force Drag force is the name for the force that operates in the direction of flow. D represents the drag force. This force is mostly caused by the fluid's viscosity. This can be stated using the formula D=1/2 AC_d (U-V).^2..................................... (4.2) where speed is V, drag force is D, fluid velocity is U, and drag coefficient is Cd.

Where speed is V, the fluid's velocity is U, the drag force is D, and the drag coefficient is Cd.

Typically, the lift and drag coefficient values are estimated provisionally and compared to the Reynolds number. In Fig. 3.2, a region of a sharp edge at span I is indicated, together with the associated speeds, powers, and edges. The edge of the relative liquid speed to the plane of revolution is denoted by, and the relative liquid vector at span r is denoted by Vrel. L and D, which are guided opposite and parallel to the related liquid as appeared, speak to the resulting lift and drag powers.

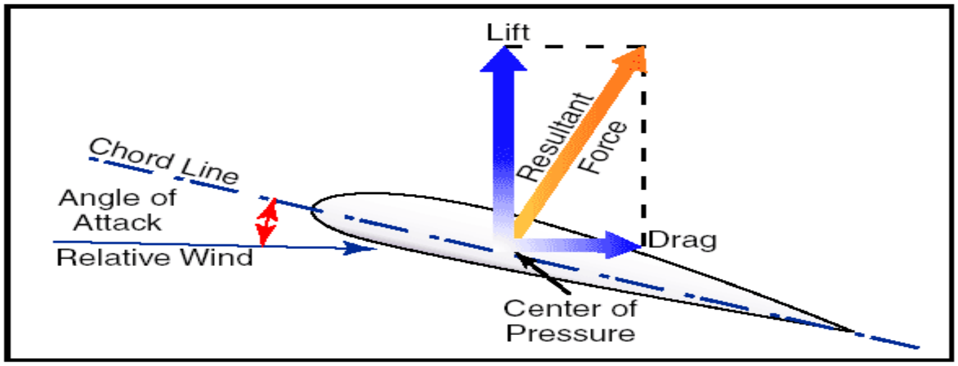

Fig 3.1 Forces Act on Blade [26]

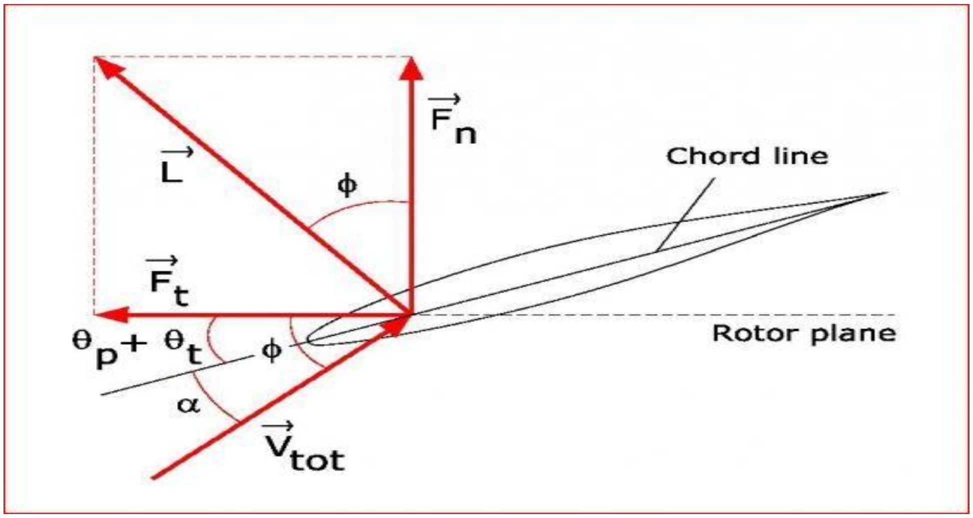

Fig 3.2 Forces on the Blade [5]

For the highest level of skill, careful consideration of the rotor edges' geometry and shape change is essential. Despite the fact that fresh airfoils are rarely made for use on rotors, turbines have frequently used airfoils that are inspired by aero plane wings. Airfoils use the concept of lift rather than drag to harness the power of the air. Cutting edges that use lift (powers against the direction of the stream) are more efficient than drag machines. In general, using lift has resulted in some bent and altered shapes.

3. ANALOGOUS SIMULATION- I

The geometry for the two-bladed Savonius turbine used in this project was developed in Solid Works and imported into the ANSYS 15 workbench, where additional operations including meshing and simulations were carried out.

Modelling and Grid Size

Table 3.1 Geometry Parameters

Parameters	Dimensions in mm
Diameter of blade (D)	50
Main domain	110
Aspect ratio (e)	5

The two basic components of the computational domain are the core domain and the outer domain. Two rotors with the right dimensions and an appropriate aspect ratio make up the main domain. Here, the motionless outer domain contrasts with the spinning primary domain. The computational domain's geometry is depicted in the following fig.

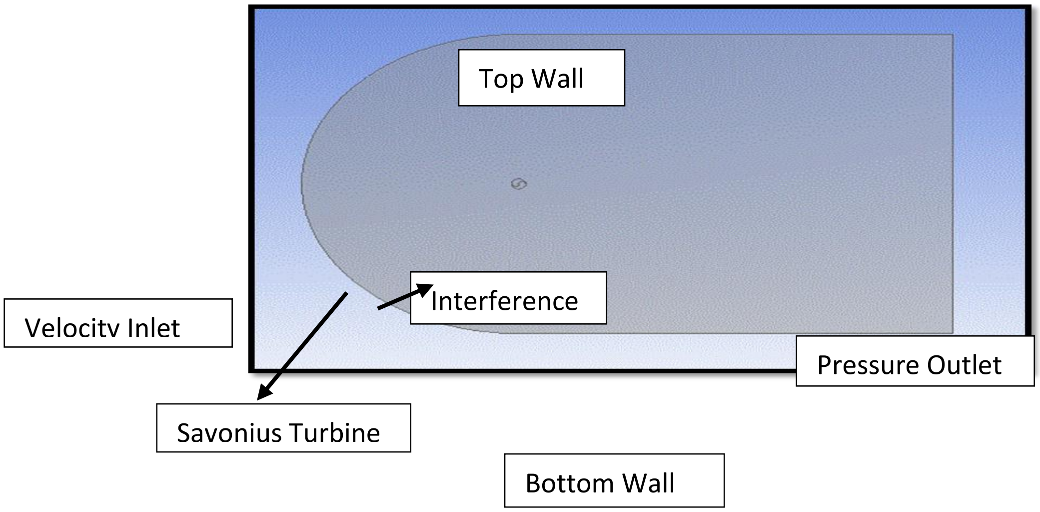

Fig 5.1Computational Domain Along With Boundary Conditions[25]

3.2 NUMERICAL SIMULATION- II

The range of the aspect ratio has been picked from 5 to 25, and a number of geometries have been optimised for this numerical simulation. After creating all of the geometry in Solid Works, it is imported into ANSYS 15 for additional numerical simulation.

The geometry of the same size with the same rotor diameter but different blade positions and produce a workable solution. In this case, all of the geometry is calculated using the same procedure as in the previous chapter.

Below figures show the 5 different geometry having different aspect ratio.

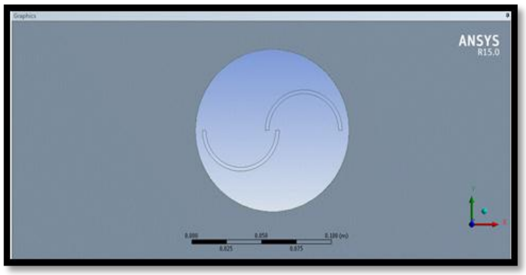

Fig 6.1 Savonius Hydro-Turbine with Position

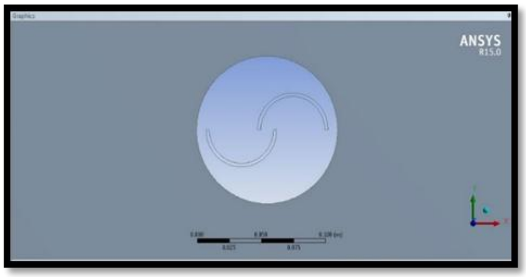

Fig 6.2 Savonius Hydro-Turbine with Position e =10

Results and Discussions

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

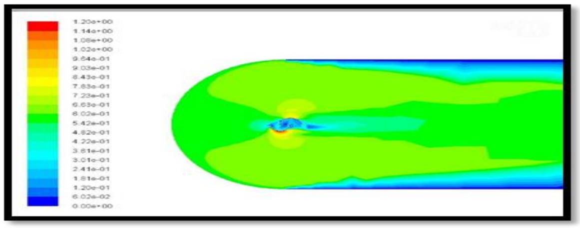

Fig 8.7 Velocity Contour at 2.5D Canal Width

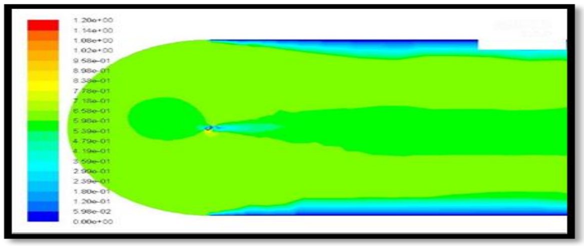

Fig 8.8 Velocity Contour at 5D Canal Width

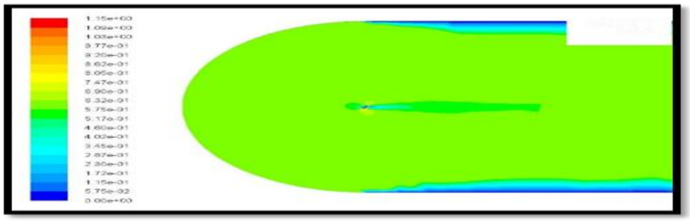

Fig 8.9 Velocity Contour at 15D Canal Width

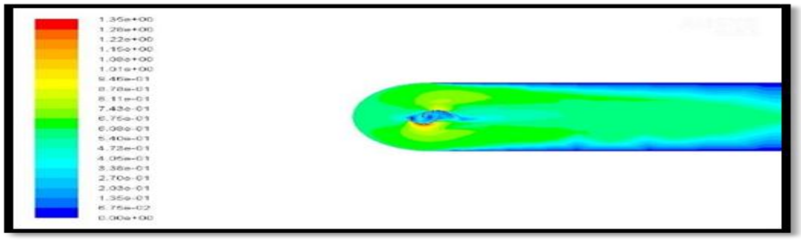

Fig 8.10 Velocity Contour at 1.25D Canal Width

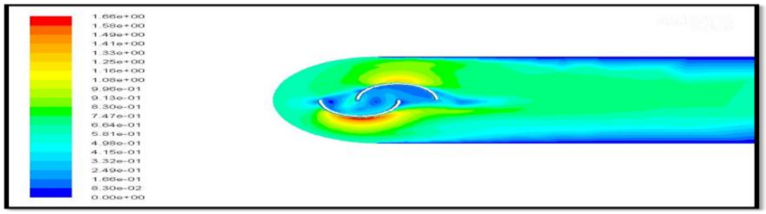

Fig 8.11 Velocity Contour at 0.636D Canal Width

8.3.2 Pressure contour of savonius hydro-turbine at Aspect Ratio e=25 at different canal width

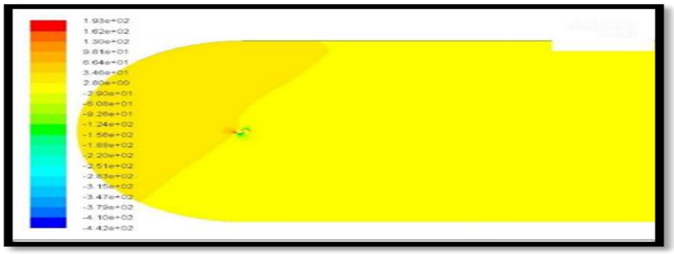

Fig 8.12 Pressure contour at 5Dcanal width

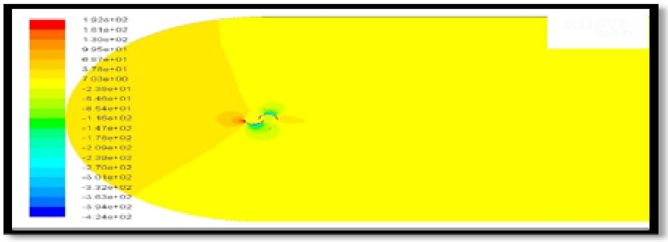

Fig 8.13 Pressure contour at 15D canal width

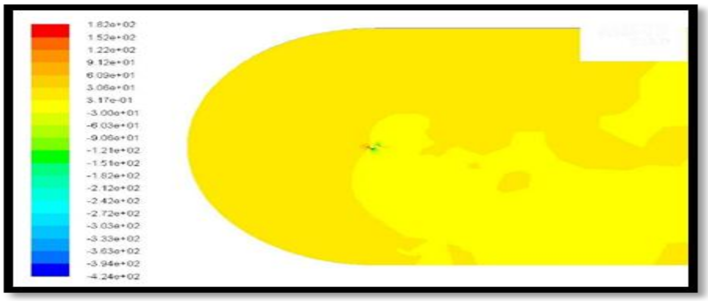

Fig 8.14 Pressure contour at 10D canal width

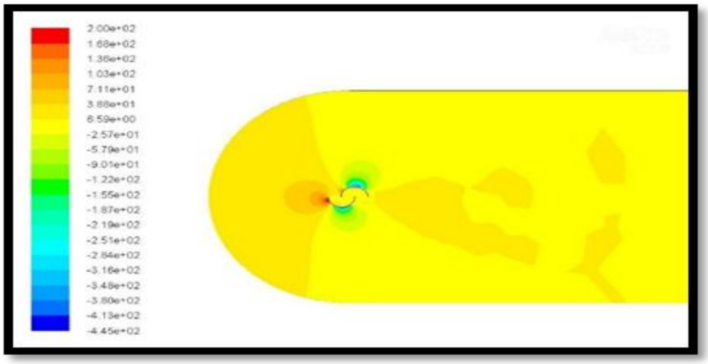

Fig 8.15 Pressure contour at 2.5D canal width

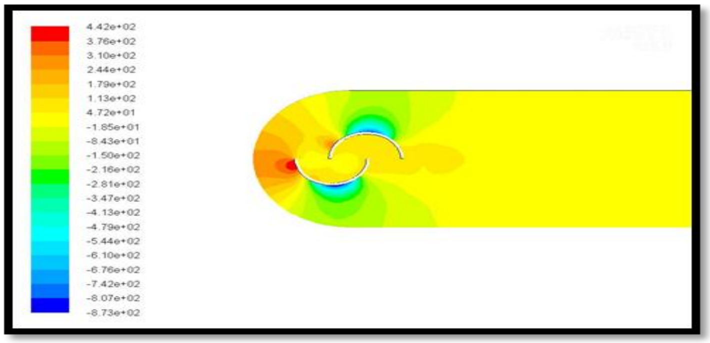

Fig 8.16 Pressure contour at 0.636D canal width

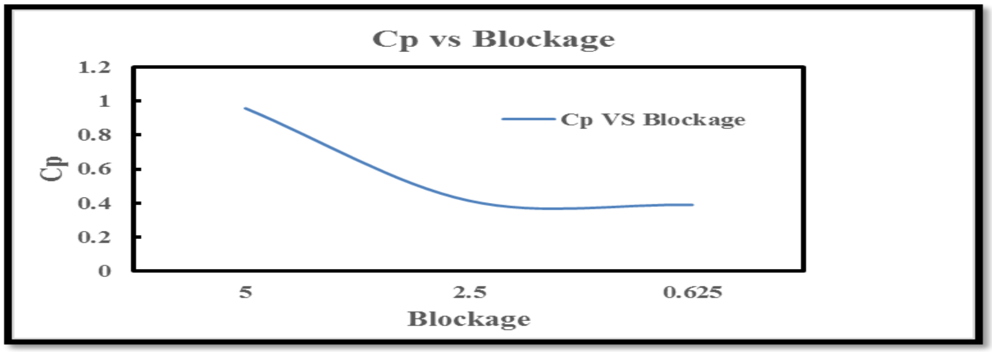

Fig 8.17 Cp Vs Blockage comparison

The above fig 8.17 shows that as the blockage is reduce the value of Cp is increased and at 5D width of the canal the optimum Cp can be achieved.

8.4 Closure

The fig 9.17 shows how the Cp is varying with respect to canal width it is an obvious observation that if the canal width is too small the total force of water which is coming with a free stream velocity is dropped on the rotor and then while increasing the width of the inlet area the fluctuation is continue and at a middle position able to get the optimum Cp in this case the feasible solution can be able to get at 5D. The width is minimize at the last position where it is unable to rotor from above it is clearly observe that while reducing the width of the canal the Cp is decreasing gradually.

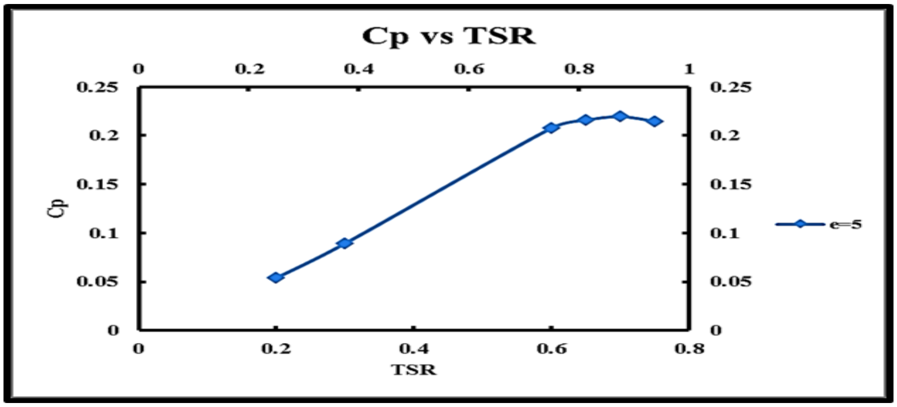

Fig 6.101 Comparison between Cp vs TSR with an aspect ratio of 5

4. CONCLUSION

The performance of a Savonius hydro turbine CFD simulation is examined in the current work at low velocities in the range of 0.6 m/s inside an open canal. For the same settings, results from both experiments and CFD work are compared. The research results are summarised in the following conclusions:

1. The findings of the torque and power performance measurements of the Savonius hydro turbine indicate that the maximum Cp can be attained at a specific location with a low free stream velocity with less fluctuation in the turbine.
2. The location determined by this work is the most practical since it allows for a maximum power co-efficient that is far higher than that of any other position.
3. Free stream water velocity of 0.6 m/s would be ideal for the current work because it can be achieved with less fluctuating torque and power.
4. As the overlap ratio increases, it is seen that the areas that cover a larger percentage produce high Cp at a specific point, which indicates that the power extracted through a Savonius hydro turbine is increasing gradually.
5. The Cp is observed to start decreasing at e=30 as the overlap ratio is further raised, indicating that e=25 is the practical point for the blade.

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