Optimization for the inlet channel and basin of a gravitational vortex turbine through the maximization of circulation.

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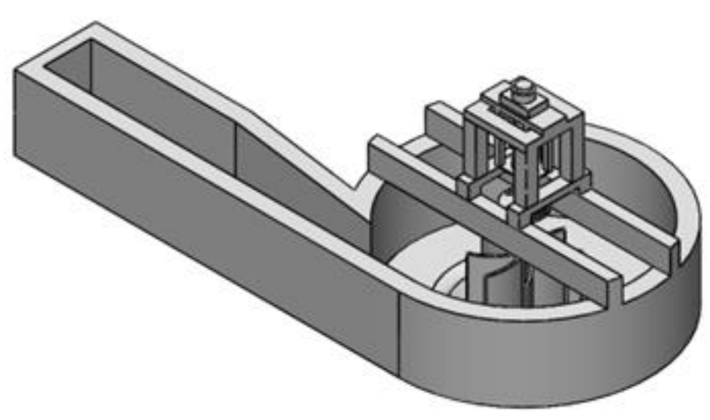
Asbtract

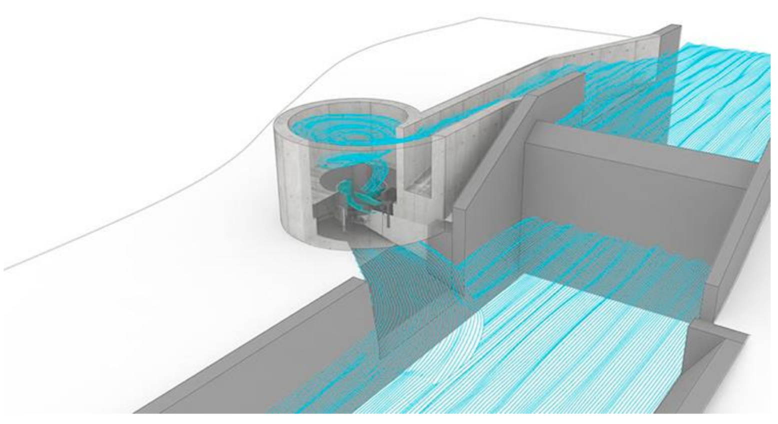
To optimize the energy generation of a gravitational vortex turbine, geometric modifications are proposed for its inlet channel and basin. These modifications include implementing a contraction in the channel, a technique commonly used in wind tunnels to accelerate the fluid and consequently improve vorticity in the basin. Three parameters were considered for optimization: the ratio between the diameter of the basin (D) and the length of the contraction (Lc), expressed as Lc/D; the size of the outlet edge (w2) relative to D, expressed as w2/D; and the height of the basin (H) relative to D, expressed as H/D. These parameters were systematically evaluated through numerical simulations to assess vortex circulation (Γ), established as the target variable. The behavior of the flow within the basin was simulated, which made it possible to identify the vorticity that was sought to be validated, obtaining positive results in what leads to the generation of the vortex thanks to the geometric changes made.

Introduction

The diversification of the energy matrix in Colombia is a crucial process aimed at reducing the country's historical dependence on oil and coal while promoting the use of cleaner and more sustainable energy sources. Gravitational vortex turbines (GVTs) propose harnessing the kinetic energy generated by the movement of fluid within a vortex formed by gravity, using a rotating rotor. This approach differs from conventional turbines, which capture the kinetic energy of wind or water flow.



Source: Oscar Andrés Jurado Chávez



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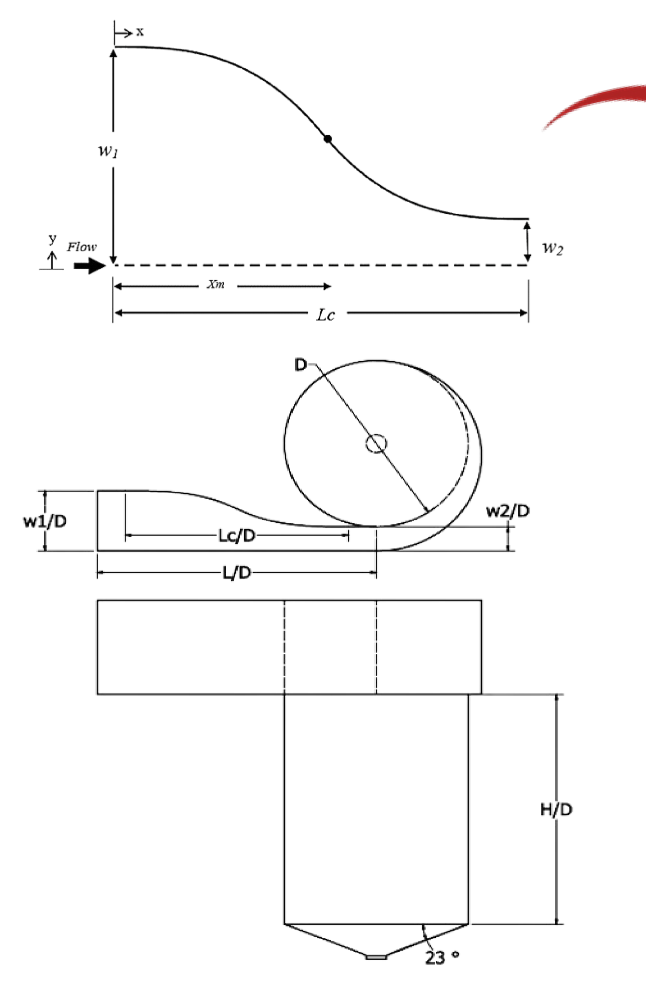
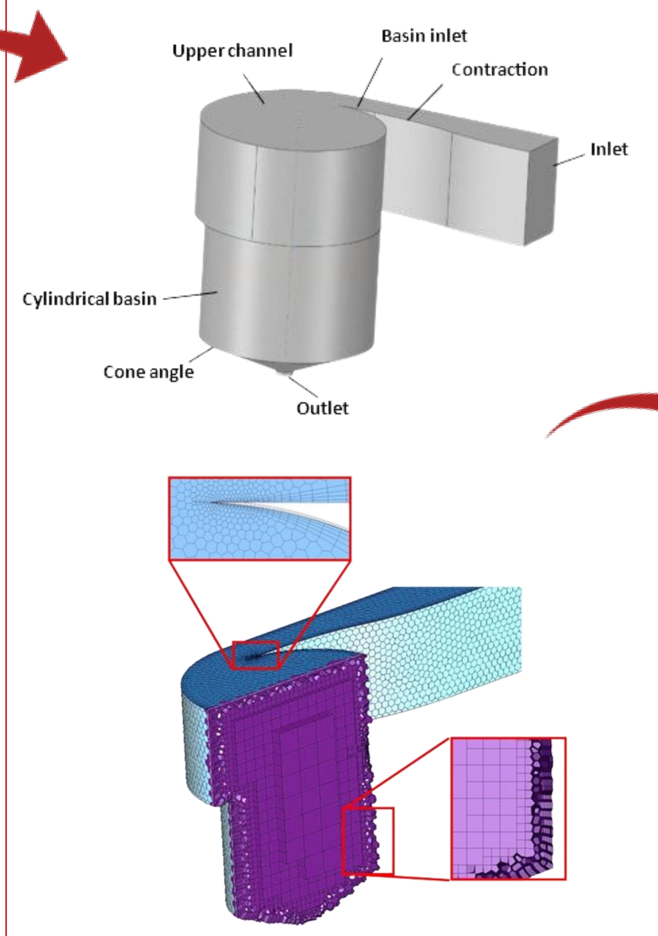
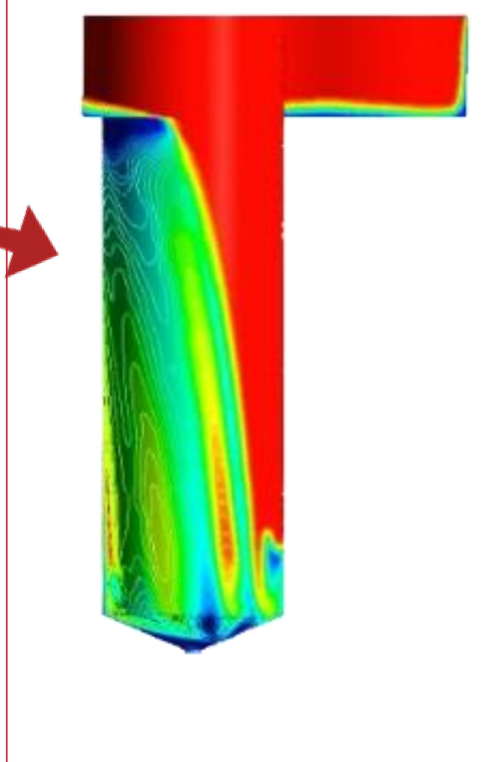
Materials and method



Geometry design



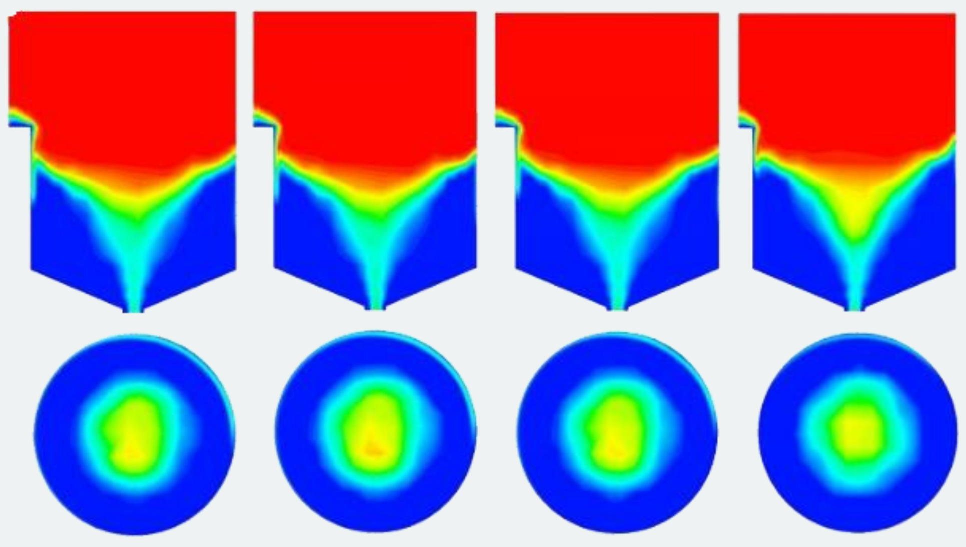
Simulation parameters



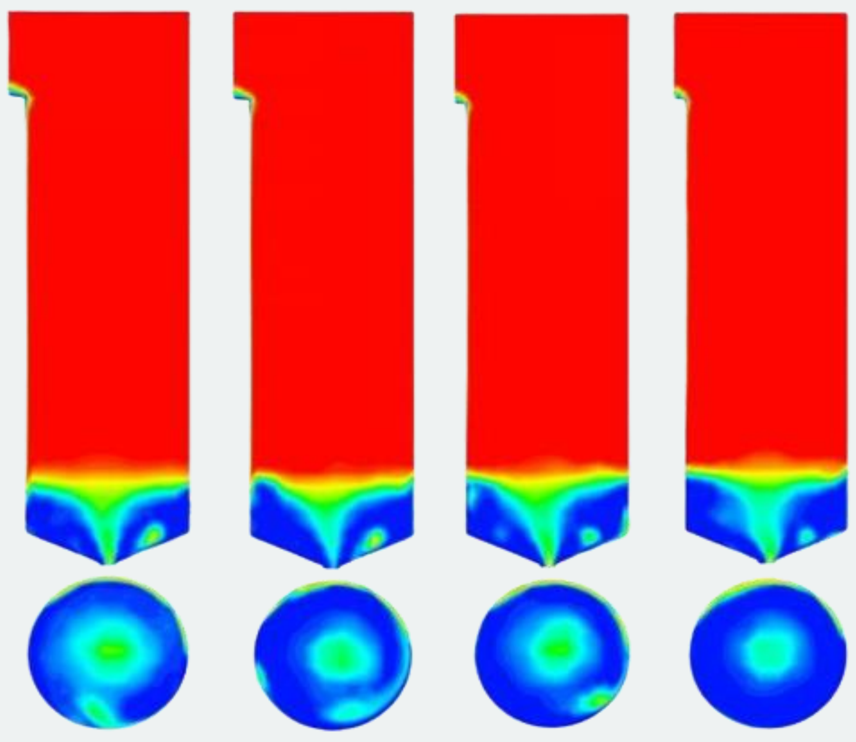
Result simulation

Results

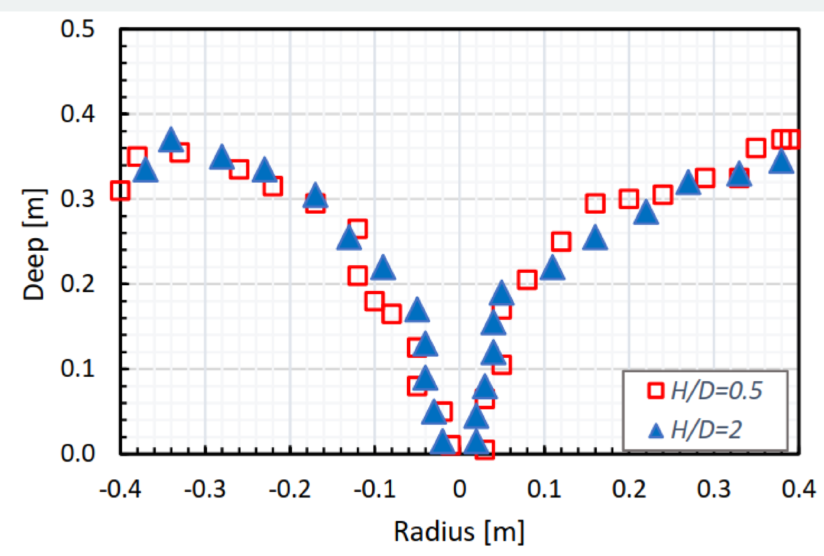
Initially, a numerical study was carried out to determine the influence of the length of the inlet channel on the behavior of the vortex in the basin.



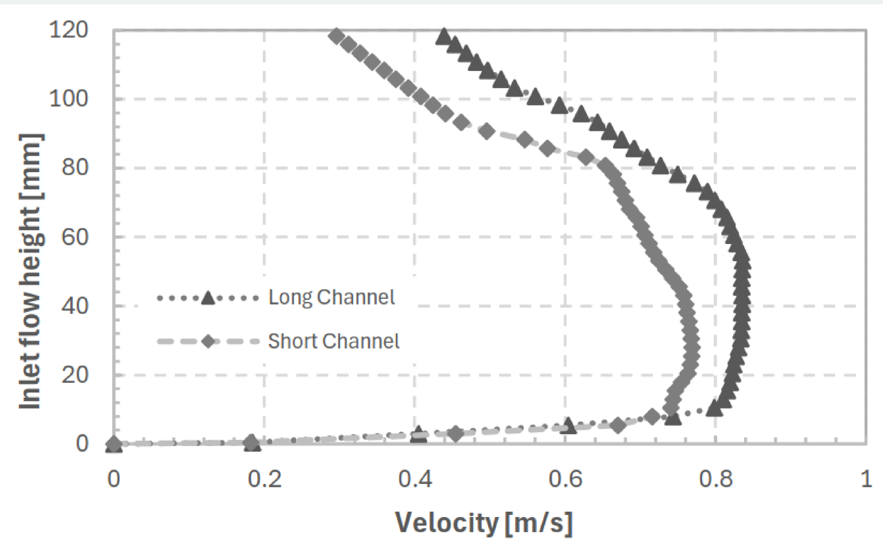
Water volume fraction for *H/D*=0.5; experiments 2, 3, 7 and 8



Water volume fraction for *H/D*=2; experiments 1, 4, 5 and 6



Vortex profile for Lc/D =0.7, w2/D=0.4



Velocity profile to the basin inlet

Conclusion

The results allowed us to validate that for the values of H/D=0.5, Lc/D =0.7 and w2/D=0.4, a more symmetrical vortex is present, which can be better used for energy.

To simulate the behavior of the flow within the basin, it must be taken into account that the inlet channel must have a minimum length, according to the literature for open channels, since this allows a better approximation to the real conditions of this kind of flows.

Reference

[1] Velásquez, L., Posada, A., & Chica, E. (2023). Surrogate modeling method for multi-objective optimization of the inlet channel and the basin of a gravitational water vortex hydraulic turbine. Applied Energy, 330, 120357.

[10] Fang, F. M., Chen, J. C., & Hong, Y. T. (2001). Experimental and analytical evaluation of flow in a square-to-square wind tunnel contraction. Journal of wind engineering and industrial aerodynamics, 89(3-4), 247- 262.

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