Hydrokinetic Horizontal-axis Savonius Turbine Performance Near the Free Surface

MARINE 2023

Ivo Marinić-Kragić*, Damir Vučina+

*+ University of Split, FESB
Ruđera Boškovića 32, Split, Croatia
* imarinic@fesb.hr; + vucina@fesb.hr;

ABSTRACT

Savonius-type hydrokinetic turbines (SHT) are a simple alternative to the airfoil-based turbines with relatively complex shapes (such as axial-flow turbines [1]). Accurate evaluation of the performance of the SHT performance requires a transient 3D CFD. In the case of vertical-axis Savonius-type turbine at relatively deep water, the free surface effects can be ignored, and the simulation settings are the same as for the commonly investigated Savonius-type wind turbine. The vertical-axis SHT case can also be simulated using 2D CFD [2]. However, the flow becomes more complex when considering horizontal-axis SHT near the free surface, since this requires simulation of two-phase volume of fluid CFD simulation, and an accurate free surface simulation requires 3D CFD.

In this paper, a simple SHT with semi-circular blades is analysed at different depths, rotational speeds and rotational directions. All simulations were performed with a flat free-surface boundary condition with velocity inlet v=2m/s. The turbine diameter and height were 1m. It was shown that selectin the appropriate depth is very important parameter. The optimal depth was d=1.0m from the surface to the rotational axis (blades highest point is 0.5m from the free surface), with power coefficient c_P=0.24. If the depth is decreased, the power coefficient drops significantly. At d=0.6m, it drops to c_P=0.15. It is interesting to note that at depths d>1m, the power coefficient also slightly decreases to c_P=0.22. In addition to the power coefficient estimation, a grid independency study was performed to show the recommended grid settings required to obtain the converged solution. These results can be used as an initial point for future optimization of the turbine parameters.

REFERENCES

[1] Posa A, Broglia R. Stability and transition of the wake of a hydrokinetic axial-flow turbine. 9th Conf Comput Methods Mar Eng (Marine 2021) 2022;1. https://doi.org/10.2218/marine2021.6797.

[2] Alipour R, Alipour R, Fardian F, Koloor SSR, Petrů M. Performance improvement of a new proposed Savonius hydrokinetic turbine: a numerical investigation. Energy Reports 2020;6:3051–66. https://doi.org/10.1016/j.egyr.2020.10.072.