Integrated CFD-Surrogate Optimization to Enhance Efficiency of Turbine Designed for OTEC

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Abstract

Ocean thermal energy conversion (OTEC) power plant is one of the renewable energy sources which utilizes the thermal gradient existing between deep sea water and surface layer water. In the present research work, flow inside a radial turbine was simulated using CFD technique and optimized by Kriging (KRG) surrogate approach. Modern computational and optimization tools for design of turbine can provide significant insight to fluid flow phenomena and can be effectively utilized to improve the base design. This turbine has design speed of 34000 rpm and operating inlet & outlet temperatures are 24.5° C and 14° C respectively. The Numbers of nozzles, number of rotor blades and nozzle stagger angle variation were chosen as the design variables, and the objective was to maximize the turbine efficiency. CFD simulation was carried out for the best turbine geometry obtained based on surrogate model and this is selected for further analysis of flow.

The whole assembly of the turbine is considered for CFD simulation. ANSYS Geometry was used to make 3-D of volute and diffuser. Bladegen was used to construct rotor and nozzle blades. After creating the 3D geometry of the turbine was descritized using ANSYS Mesh & Turbogrid and initial parameters for defining the aerodynamic simulation will be set in CFX-Pre and then solved in CFX-Solver. We have considered steady state analysis with Frozen rotor technique for domain interaction. Turbulence model was $k-\omega$ SST with 10% turbulence intensity. At the inlet, mass flowrate and static pressure at the outlet is given as a boundary condition. RMS convergence criteria for solving the differential equation were 10^{-4}.

The best turbine geometry configuration is obtained through CFD coupled surrogate optimization approach. CFD simulation shows 11, 14 and 73.3 ° as the optimal number of nozzles, number of rotor blades and nozzle stagger angle respectively with the efficiency of 75.01%. The optimized turbine shows better performance characteristics as compared to reference turbine and corresponding results are presented in this paper.

References

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