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Optimum Design and Simulation of a Radial-inflow Turbine for Geothermal Power Generation

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Abstract

A numerical model associated with preliminary design of a turbine for utilization of geothermal energy is developed. Considering the geothermal water flow at low/moderate temperature of the target area, Yilan (Taiwan), a radial-inflow turbine with a refrigerant, R134a, which has high density has been adopted in the study. A preliminary design method based on theoretical formulations, namely the mean-line approach, and an optimization scheme based on a genetic algorithm are used to create the optimal geometry of the turbine. This provides an input for three-dimensional (3-D) simulation of the flow field, in terms of the commercial software ANSYS-CFX. The results of various physical features are compared with that of the preliminary design in order to identify the sources of some disagreement that have not been clarified for general 1-D analyses. Specifically, by changing the specific speed, we have found that there is a minimum value of total entropy increase throughout the passages. This enables us to conclude that the model of incidence loss in the preliminary analysis underestimates the loss that causes flow separation, which can be identified in the numerical simulation, therefore leading to their disagreement. The integration of the geometrical optimization via the preliminary design and the numerical simulation for the detailed flow properties can help us attain superior analysis and design. Consequently, it resulted in an increase of turbine power about 3.6% when the specific speed and blade shape were optimized in the tested ranges.

1. Introduction

Power generation from a geothermal resource has drawn increasing attention nowadays due to its clean and sustainable nature, which can help reduce dependence on fossil fuels. This is particularly an attractive and promising way of creating clean energy in Taiwan, where energy sources are mostly imported from other countries. It is recently planned by the government to extract usable energy from the geothermal sites specifically in Yilan area. To achieve this goal, therefore, it is aimed to start with a power plant that can generate 1 MW in accordance with the geothermal conditions in Yilan, and the project is to assess the feasibility by using a preliminary analysis and numerical modelling. According to the temperature and type of a geothermal resource, different power plants such as dry steam,

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