A Technical and Economic Assessment of Geothermal Aided Power Generation

Masters by Research Thesis

Jiyun Qin

THE UNIVERSITY of ADELAIDE

The University of Adelaide

The School of Mechanical Engineering

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Abstract

With the increase in demand for energy and the need for environmental protection, geothermal energy, as a renewable resource, is receiving growing attention. Stand alone geothermal power stations have been established all over the world. However these systems predominantly harvest volcanic resources, which have limited availability, while the more widespread deep resources are still expensive to access. Integrating the geothermal resources into a conventional fuel fired Rankine cycle power plant, through the so called “geothermal aided power generation” (GAPG) concept. In so called GAPG technology, geothermal fluid is used to replace parts of extraction steam in regenerative Rankine cycle power plant to preheat feedwater of power plant. The GAPG technology can significantly increase the efficiencies and reduce the costs of geothermal energy for power generation purposes.

The general aim of this research is to comprehensively study the advantages and disadvantages of geothermal aided power generation by developing and validating a simulation model that can be used as a tool for the technical and economic analysis of a GAPG system. The developed modelling simulates the steam Rankine power plant so as to assess the technology and to provide an economic analysis of GAPG technology for a variety of structural types of power plant. Two case studies are carried out with modelling. A 500 MW subcritical power plant is used as case study to study the technical performance of GAPG technology for both power boosting mode and fuel

saving mode. Two coal fired power plants, a 580 MW subcritical coal fired power plant and a 580 MW supercritical coal fired power plant, are selected as study cases to demonstrate the economic advantages of the GAPG technology with medium to low temperature geothermal resources. Cost of electricity (COE) of GAPG technology in two cases is used to compare with that in a flash cycle geothermal power plant and a binary cycle geothermal power plant.

The results indicate that the GAPG technology has higher thermodynamic first law efficiency than the geothermal alone power plant and the efficiency of the GAPG technology is no longer limited by the temperature of geothermal fluid, but rather by the maximum temperature of the Rankine cycle power plant. It is also found that utilization of the existing infrastructure of conventional fossil fired power plants can demonstrate the economic advantages of the GAPG technology as the lower COE than the geothermal alone power plant.

Chapter one of this thesis defines the concept, aims and scope of this study. Chapter two details the previous research in the field of this study. The functions and structure of modelling for GAPG technology are described in chapter three. Chapter four presents the operational method and the modelling validation. Two case studies are carried out by modelling, with the technical and economic performance of GAPG technology presented in chapters five and six.

Declarations

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the university Library, being made available for load and photocopying, subject to the provisions of the Copyright Act 1968.

Jiyun Qin

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List of Symbols and Abbreviations

Abbreviation

COE	Cost of Electricity
DEA	Deaerator
FWH	Feed Water Heater
GAPG	Geothermal Aided Power Generation
GAPGEM	Geothermal Aided Power Generation Evaluation Model
HPH	High Pressure Feedwater Heater
IPH	Intermediate Pressure Feedwater Heater
LPH	Low Pressure Feedwater Heater

Symbol

		Unit
H	Specific enthalpy	kJ/kg
M	Mass flow rate	Kg/s
Q	Heat flow	J/s
S	Specific entropy	kJ/kg.K
T	Temperature	℃
W	Work	J/s
X	Specific exergy	kJ/kg