FINAL REPORT

Utilization of Supercritical Geothermal Fluid

Project ID:	09-02-010
Coordinator:	Dr. Guðrún Sævarsdóttir, Reykjavik University
Start date:	01.01.11
Duration:	01.01.12
Partners:	*Kristinn Ingason, Mannvit, Dr. William Harvey, RU, Dr. Halldór Pálsson, HÍ and Dr. Bjarni Pálsson, Landsvirkun.*

1 Project summary

Volatile chloride (HCl) is found in geothermal fluids all over the world. When dry steam containing HCl cools to acid dew point, the compound dissolves in the condensate and forms hydrochloric acid. This can have tremendous consequences for piping and equipment as hydrochloricacid aggressively attacks steel and other metals. Severe pitting corrosion can occur and, if this happens in the turbine, cracks can form at the bottom of the pits, which will grow larger with fatigue corrosion and lead to a stress corrosion cracking. The Icelandic Deep Drilling Project (IDDP) is dealing with extreme circumstances with high enthalpy, superheated geothermal steam containing HCl. Successful corrosion mitigation is essential for the feasibility of the development of this promising recource. There are several possible methods forremoving HCl from geothermal steam. In this the applicability of each option for steam scrubbing technology was mapped, taking into account exergy conservation and cost.

By modelling powercycles with regards to the different mitigation technological options, It was shown that the destruction of superheat, caused by wet scrubbing at high enthalpies, may result in loss of considerate power. At low enthalpies and high wellhead pressures, wet scrubbing with an additional turbine does not seem to be a feasible option because of the low degree of superheat in the steam. On the other hand, at higher enthalpies, where the decree of superheat is very high, it may be uneconomic to have wet scrubbing and a second turbine step in the power cycle; the dry turbine expansion extracts most of the power anyway. A binary cycle seems to be more expensive than the other methods, regardless of enthalpy of the geofluid. It has been shown that dry steam scrubbing gives the highest power output for all enthalpies and wellhead pressures, and at the same time keeps the best $=kW ratio. It is the destruction of superheat, rather than exergy, that causes wet scrubbing to produce less power with increasing enthalpy, with respect to the other methods examined. The increase in mass flow rate in the wet scrubbing minimizes the loss total of exergy in the stream, while the destruction of superheat decreases the efficiency in the turbine. It is clear that the IDDP possesses tremendous potential for the geothermal industry. It has been shown that the first well, IDDP-1, is expected to produce around 8 times more power than a traditional borehole. Given the fact that the well is not nearly as deep as it was intended to be, the production of future IDDP wells can be expected to get even higher. The detailed results of this work are disseminated in the thesis and two papers attached to this report.

2 Project Management

PI: Guðrún Sævarsdóttir, Associate Professor at Reykjavik University.

Collaborators: Kristinn Ingason, Mannvit, Dr. William Harvey, RU, Dr. Halldór Pálsson, HÍ and Dr. Bjarni Pálsson, Landsvirkun.

The day to day supervision for the MSc student was done by Guðrún Sævarsdóttir, but regular meetings were held where the collaborators met and had valuable information exchange and insights. William Harvey supplied us with useful references and participated in meetings when he was in Iceland.

3 Student involvement

Steindór Hjartarson, MSc student at Reyst (Reykjavik University and University of Iceland)

Graduated in January 2012 with excellent results.

4 Publications and disseminations

Masters Thesis in Sustainable Energy Engineering:

"Utilization of Supercritical Geothermal Fluid", Steindór HjartarsonMaster of Science in Sustainable Energy Engineering December 2011

Papers:

Steindór Hjartarsona, Guðrún Sævarsdóttirb, Kristinn Ingasonc, Bjarni Pálssond, William S. Harveyb "Utilization of the Chloride Bearing, Superheated Steam from IDDP-1", Geothermics Special Issue for the IDDP project, 2013

http://www.sciencedirect.com/science/article/pii/S0375650513000709

Steindor Hjartarson, Gudrun Saevarsdottir, Halldor Palsson, Kristinn Ingason, Bjarni Palsson "Utilization of acid high enthalpy Geothermal Fluid from IDDP1"PROCEEDINGS, Thirty-Seventh Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 30 - February 1, 2012 SGP-TR-194

https://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2012/Hjartarson.pdf

5 Cost statement

All funding from GeoRG was used to fund the MSc students work, as well as travelling to the Stanford Geothermal Workshop and a visit to the IDDP-1 at Krafla.

	Cost item	Requested funding		Other financing		Total
2010/2011	Salaries					4.890
	Operational expenses					0
	Travel expenses					0
	Total 2010/2011:	1.890	39%	3.000	61%	4.890
2011/2012	Salaries					2.430
	Operational expenses					0
	Travel expenses					500
	Total 2011/2012:	1.130	39%	1.800	61%	2.930
2012/2013	Salaries					0
	Operational expenses					0
	Travel expenses					0
	Total 2012/2013:	0	N/A	0	N/A	0

Grand Total	**3.020**	**39%**	**4.800**	**61%**	**7.820**