Heat Exchanger Research

Heat exchanger fouling due to scale formation is a common problem. A particularly severe application is heat transfer from brine flows. Generation of power from low temperature geothermal resources requires the transfer of heat from the brine to a binary power system. Conventional binary power systems are limited in the amount of heat that can be transferred for conversion by the boiling process. Advanced power cycles such as Energent's Variable Phase Cycle or the Kalina cycle are able to capture more heat from the geothermal resource and produce more power. The only limitation to these advanced cycles is the extent to which the brine temperature can be lowered in the heat exchanger without producing scaling. These advanced cycles have the potential of producing 20 – 30% more power than a conventional binary power system.

To determine the best method of scale reduction, a research program was carried out at a geothermal resource having a high scaling potential. The primary source of scaling was silica which was found in the brine at a level of 528 ppm.

A scaling test system with several experiments was designed and operated at Coso geothermal resource with brine having a high scaling potential. Several methods were investigated at the brine temperature of 235ºF. The experiments involved injection of four potential anti-scaling chemicals; operation of an electromagnetic device; and the circulation of abradable balls through the brine passages. The test apparatus is shown in Figure 1. Brine from a power plant separator flowed through tubes which had the scale reduction methods introduced. The tubes were immersed in a cooling water bath to reduce the temperature. The temperature of the brine was reduced to an average temperature of 125ºF.

The most promising method was found to be circulation of the abradable balls through the brine passage. Abradable balls are routinely used for the scaling of condenser tubes. The balls used for the brine descaling had a special high temperature rubber formulation with hard particles inserted in a sponge matrix. Table 1 shows the results of operation for 30 days of flowing brine. As can be seen, the abradable balls resulted in the lowest scale buildup at the tube exit. Two of the chemicals had a low scale buildup at the inlet of the tube, but resulted in a buildup of more than three times that of the abradable balls at the exit. A probable reason is the recommended injection rate was too low. Future tests will be done increasing the vendor's recommendation for the injection rate. However, chemical injection is costly and has environmental consequences. Increasing the rate can substantially increase the operating cost.

The key result is the ability to operate at the low-temperature 125ºF with only a moderate buildup of scale. For advanced low-temperature cycles, such as the Variable Phase Cycle or Kalina Cycle, the lower brine temperature will result in a 20-30% increase in power production from low temperature resources.

A preliminary design of an abradable ball system ("ABS") was done for the heat exchanger of the 1 megawatt VPC system at Coso resource. The ABS will be installed and demonstrated in Phase 2 of this project, increasing the power production above that which is possible with the present 175ºF brine outlet limit.

A hermetic turbine generator (TGH) was designed for the next phase of the project. This unit will use the working fluid (R134a) to lubricate the bearings and cool the generator. The 200 kW turbine directly drives the generator, eliminating a gearbox and lube oil system. Elimination of external seals eliminates the potential of leakage of the refrigerant or hydrocarbon working fluids resulting in environmental improvement. A similar design has been demonstrated by Energent in a binary waste heat recovery system.

Operation in Phase 2 of the TGH with and without the ABS system will demonstrate an increase in geothermal resource productivity for the Variable Phase Cycle (VPC) from 1 MW from 1 MW/million pounds of brine to 1.75 MW/million pounds of brine; a 75% increase.

For additional information, visit www.Energent.net.

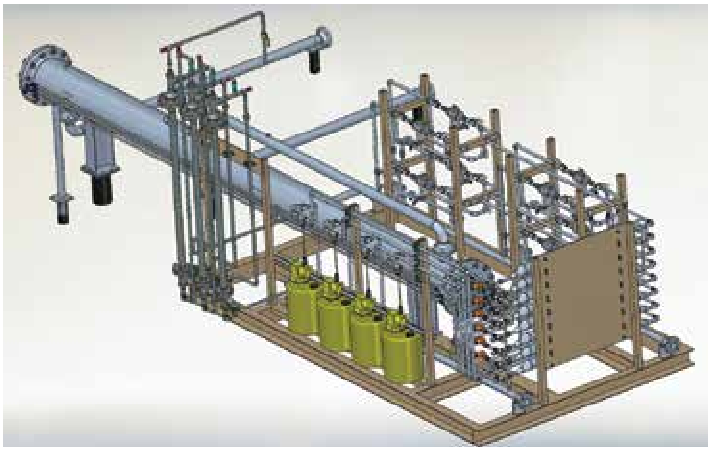

Figure 1 - Heat Exchanger Test System for De-Scaling Experiments

	INLET (mils)	OUTLET (mils)
Insulated pipe	N/A	N/A
Control heat exchanger	17.12	29.59
Chemical injection: MX 2-3628	9.79	27.38
Chemical injection: GS8464	19.35	34.22
Chemical injection: CL4700	18.40	40.23
Chemical injection: PDC9486	34.10	41.03
Electromagnetic scale device	25.90	38.57
Abradable ball heat exchanger	29.61	10.16

Table 1 - Scale Thickness Measurements for Heat Exchanger Inlets and Outlets.