Utilizing Organic Rankine Cycle Turbine Systems to Efficiently Drive Field Injection Pumps

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ABSTRACT

Ormat initiated **f**acility expansion projects at both the Heber-1 double flash power plant and in Geo East Mesa or GEM double flash power plant which is part of the East Mesa complex. These projects were based on utilization of the spent brine, (which is sent for injection after the second flash stage of the existing steam turbines,) to generate additional electricity by means of an Ormat Energy Converter (OEC) which utilizes the organic Rankine cycle. However the injection systems were identified as one of the areas which require special attention, especially with regard to the efficiency of the injection booster pumps. In this presentation we describe a scheme to utilize the organic Rankine cycle bottoming turbine system to drive the brine booster injection pumps directly in a more efficient manner than with a direct electric motor drive.

Pump Sizing

The injection system of a geothermal power plant is a complicated system, which includes booster pumps and high pressure pumps with their control systems. The exact brine flow and injection pressure variables are hard to accurately predict. The brine flow is changing over time based on the field productivity (assuming that operational target is to maximize power plant output up to the equipment limitation). In addition, resource enthalpy tends to decline over time and any decline in enthalpy causes an increase in brine flow per given steam consumption rate. The injection pressure varies over time due to well scaling, plugging, changes in the well field and changes in the brine temperature.

The traditional solution is to size the injection pumps system to maximum anticipated conditions (maximum flow and maximum pressure). Adjusting the flow and pressure by using valves at the pump's discharge line is a simple and straight forward solution but it is a waste of energy .

Another more efficient solution is to control the pump(s) speed thus moving the pump's performance curve to the required flow and head point. This can be achieved by using an electrical variable frequency drive (VFD) to feed the pump motor. The VFD solution is practical for relatively small pumps operating with low voltage motors (480 VAC). VFD for high

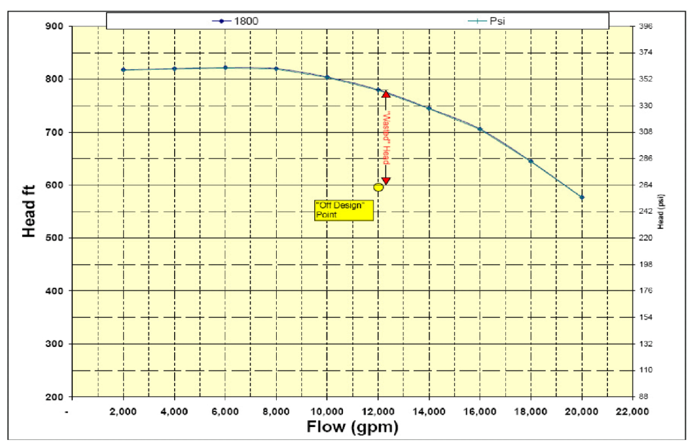

Figure 1. Constant speed pump at "off design point."

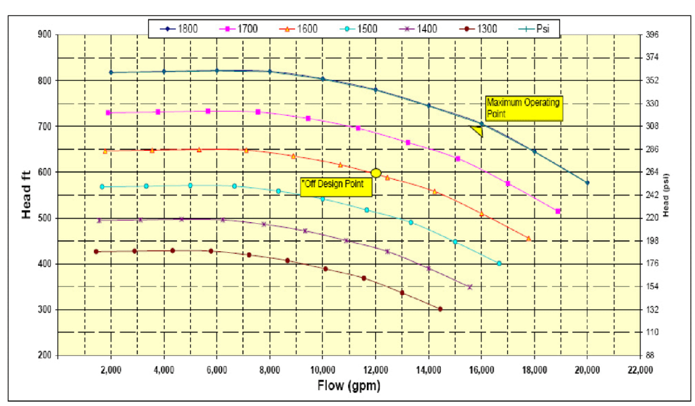

Figure 2. Variable speed pump at "off design point."

power/high voltage motors is very expensive and requires a protected and air conditioned environment. A disadvantage of VFD is the electrical loss which is some of 2% of rated output.

An alternative solution is to equip the injection booster pump with a variable speed mechanical drive such as a steam turbine. This solution is used in many conventional power stations (feed water pumps) and was implemented in the original GEM injection system were two Steam Turbine Driven Pumps (STDP) were installed.

The use of relatively small steam turbine to drive the injection pumps is not efficient due to the relatively low efficiency of the turbine, in the GEM case the efficiency of the STDP was almost 12% lower than the main turbine efficiency at design point conditions. Thus making for an inefficient use of the steam where the primary purpose is to use the steam to generate electricity in the Steam Turbine Generator (STG). At off-design conditions (lower field enthalpy and steam flow) the impact was even worse since the STDP steam consumption reduced the high pressure steam flow to the main STG shifting its operating point farther away from its design point.

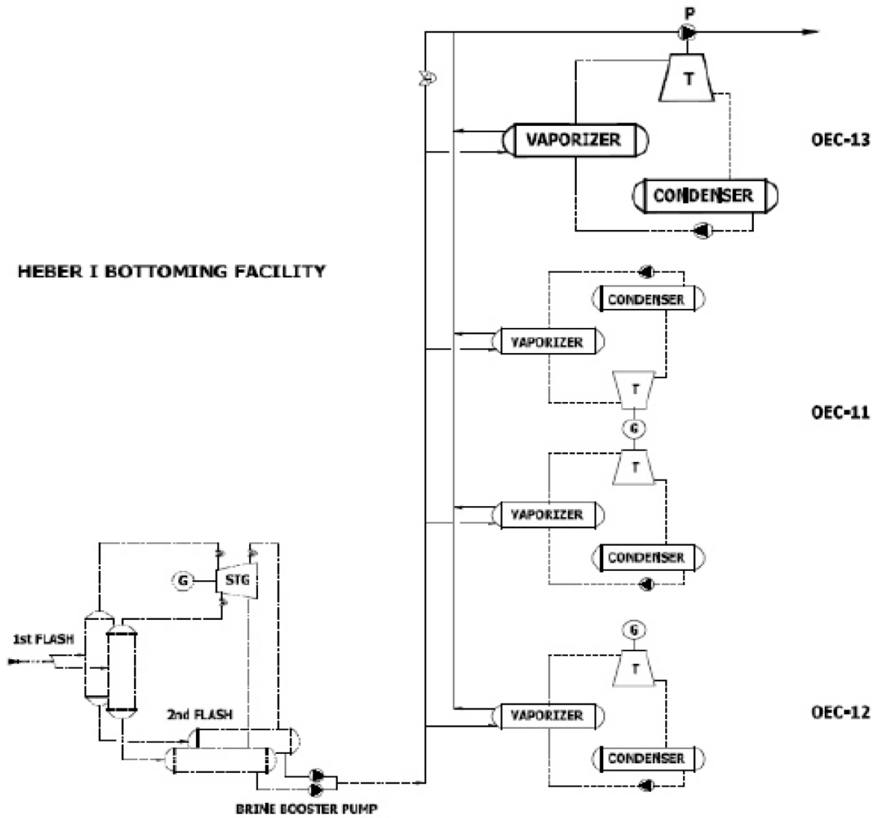

Figure 3. Simplified Heber Bottoming Cycle Facility Diagram.

Configuration Selected for Heber 1 and GEM Projects

The studies carried out as part of the bottoming OEC project design at Heber I and GEM showed that a very efficient solution will be to dedicate one of the bottoming OECs to an OEC Driven Pump. The main issues were:

1) Wide range of operation:

The pumps can be defined for maximum anticipated flow and pressure and operate at reduced speed (the lower limit is the minimum RPM allowed by the pump vendor).

2) High conversion efficiency:

The turbines used for the pumps are rated for same power output and RPM as the turbines driving the generators of the bottoming OECs used to generate electricity.

3) Less Electrical losses:

With the turbine drive instead of the VFD driven motor, and assuming 97% generator efficiency, 96% motor efficiency and 98% VFD efficiency, the overall efficiency savings are [(0.97 X 0.96 X 0.98 = 0.913] or about 8.7% of electrical losses are saved.

System Description

The case of the pump being driven by an OEC is very similar to the other cases where a generator is driven by an OEC, and the thermodynamic cycles are the same.

The vaporizer/preheater utilizes the heat from the spent brine discharged from the second flash tank of the main STG heat to heat and vaporizes the motive fluid. The motive fluid

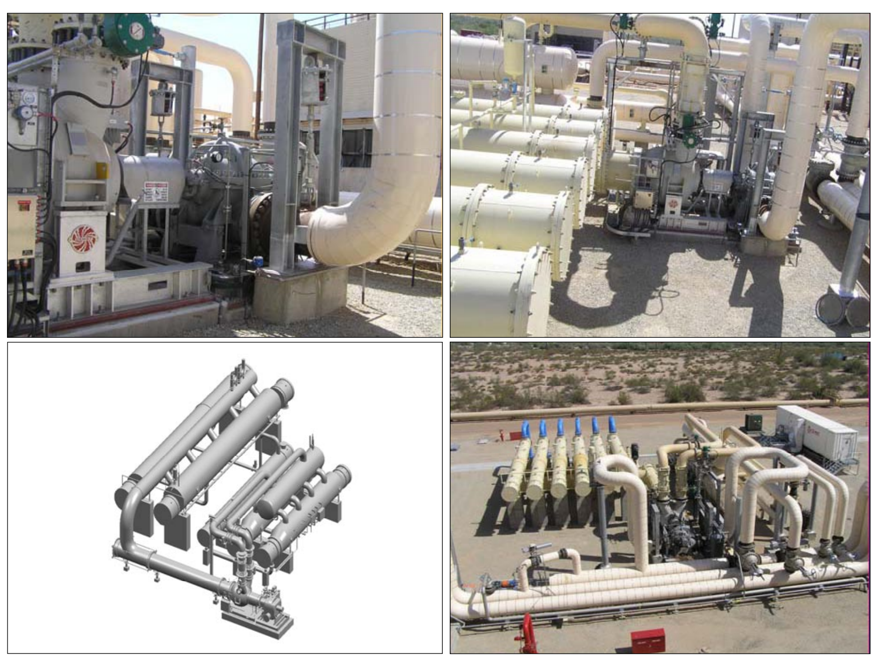

Figure 4. Photos & 3D model of Heber I and GEM OEC driven pumps.

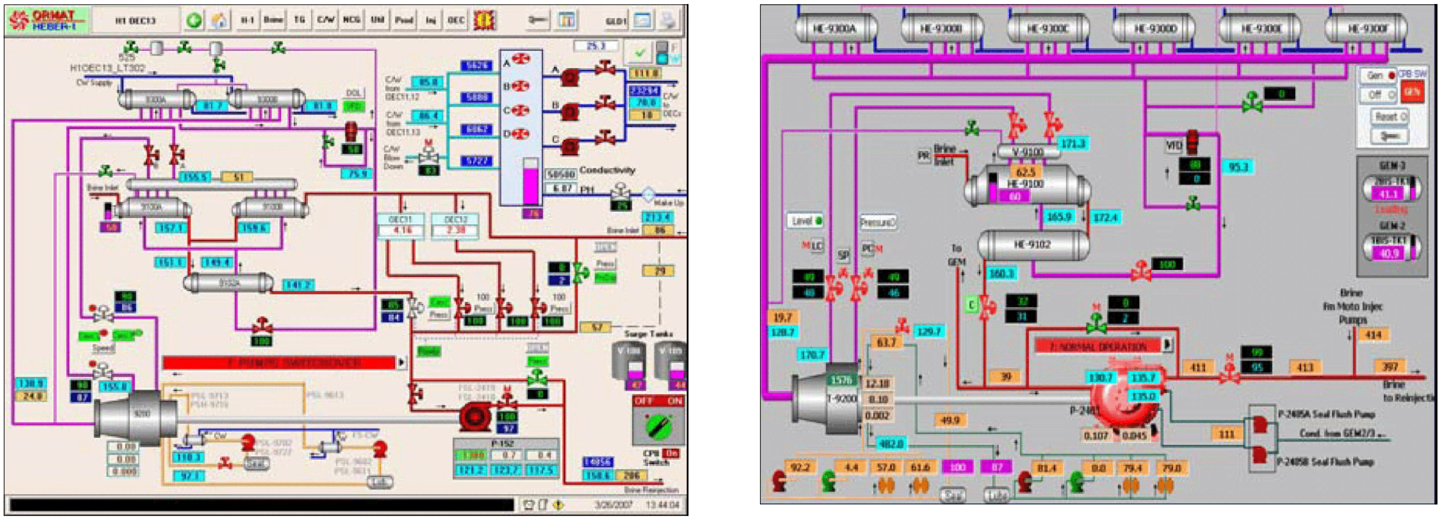

Figure 5. Photos of control screens of Heber I and GEM OEC driven pumps.

vapors drive the turbine, the exhaust motive fluid vapors from the turbine flow to the water cooled condensers. The motive fluid pumps return the condensed motive fluid to the preheater/vaporizer thus completing the cycle.

The only difference is that instead of driving a generator the turbine is connected to a horizontal vertical split brine pump. See Figure 3.

Implementation

Two OECs of the pump driving type were designed, fabricated and installed and placed in service in the Heber-1 power plant in 2006 and in GEM power plant in 2007. See Figure 4. These units are operating smoothly since commissioning and meeting all expectations. See Figure 5.