COMPARISON OF MAGMA POWER COMPANY'S FIRST GENERATION AND SECOND GENERATION DUAL FLASH GEOTHERMAL POWER PLANTS AT THE SALTON SEA KGRA

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ABSTRACT

In the fall of 1985, Magma Power Company started the first commercial dual-flash geothermal power plant in the United States when it brought the Vulcan Plant on-line. As this plant design was the first of its size, designers built extra reliability factors in to ensure the plant would be a commercial success. In 1988-89, Magma Power brought three additional plants into commercial production with four major design modifications developed after operating the Vulcan facility for two years and being assured of its reliability and success. These four major design changes will be discussed.

SINGLE TRAIN OPERATION vs. DUAL TRAIN OPERATION

The original Vulcan design consisted of two production trains of brine flash vessels in the plant, each capable of processing 3/4ths of full plant load. The reason for these mirrored trains was to ensure plant reliability. The designers felt if one brine train developed a piping or control valve problem, it could be shutdown, isolated, and repaired while the other train continued to generate and sell electrical power. This, in fact, has proven to be the case in actual operation since 1985. As expected, the origininal piping and design had room for improvement so ever since start-up until today, problems have occured in one train and while it was being repaired, the other train has continued to operate successfully, keeping the plant on-line selling power.

During the design of the three new plants, the two train concept was evaluated and it was decided sufficient knowledge had been gained by progressing on the learning curve of brine vessel, piping, and valve design that the new plants could be assured of minimal down-time due to production vessel failure. Again, designers have been proven correct as the new plants have operated successfully with minimal brine train down-time, saving the cost of capital equipment and maintenance on this part of the process.

SECONDARY BRINE CLARIFIER vs. MEDIA FILTERS

The original design of Vulcan consisted of two steps of brine filtration before injection back into the reservoir. The first was a reactor-clarifier, designed to bring the supersatured silica brine down to saturation and also to settle out suspended solids. The second filtration step was a set of media filters. After, numerous attempts and modifications, these media filters were abandoned because of inopertion so, since start-up, Vulcan has operated with essentially one filtration step - the Primary Clarifier. While the one Clarifier was able to bring the dissolved silica level down to saturation, the plant operates with unacceptably high levels of suspended solids in the injection brine.

As a result of the Vulcan experience, the three new plants included a Secondary Clarifier similar to the first vessel. This addition has been very successful, and the three new plants are capable of producing injection fluids with a minimal content of suspended solids. The Vulcan plant is now removing the set of media filters and installing a Secondary Clarifier.

TWO TURBINE GENERATORS SETS vs. ONE WITH DUAL ENTRY

The dual flash concept Magma utilizes in its power plants produces two sources of steam, a high pressure source from an upstream flash, and a lower pressure steam resulting from a downstream flash. Since a commercial power facility had not operated on the Salton Sea KGRA before, steam supply reliability and consistency were unknown. Wanting to ensure the commerical success of this first plant, the designers included separate turbine-generator sets for both sources of steam, or a High Pressure Turbine-Generator which has a nameplate capacity of 30 MW and a Low Pressure Turbine Generator, which has a nameplate capacity of 9 MW.

Soon after start-up, it was obvious that the steam source was very constant and reliable. This result gave the designers confidence is purchasing and operating only one turbine-generator set with high pressure steam entering the first stage and the low pressure steam entering a downstream stage. Both designs continue to operate successfully today with the new plants saving the large capital cost associated with that second turbine-generator set.

HEAT RECOVERY SYSTEM vs. INLET TO TURBINE

The Salton Sea KGRA contains small amounts of two corrosive gases --- carbon dioxide and hydrogen sulfide. The thermodynamics of this brine result in these two gases entering the plant in the vapor phase. In the Vulcan plant, these noncondensible gases are sent through the turbine and are removed through the inerts removal vacuum system at the surface condenser, then condensed for distribution.

Due to the corrosive nature of these gases, the loss of efficiency by passing them through the turbine, and the resulting electrical power costs of operating the vacuum system pumps, the designers of the new plants had a novel design concept --- the steam and gases that enter the plant from the vapor phase are not sent through the turbine and vacuum system but are instead utilized for their sensible heat content. The vapor phase off of the first separator is sent countercurrently through a network of tube-in-shell heat exchangers and condenses while fresh hotwell condensate is sent through on the other side, regenerating clean high pressure steam to be sent directly to the turbine.

SUMMARY

All four of Magma Power Company's plants at the Salton Sea KGRA have been very successful in producing electrical power and processing the geothermal fluid. The change of designs garned from the experience of the first facility were later skillfully incorporated into three new larger plants. It is expected that third generation plants will evolve further.