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Selection criteria of optimal separation pressure of liquid dominated geothermal resources

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Abstract

The purpose of this paper is to define the main selection criteria of the separation pressure for geothermal binary power plants to maximize the efficiency of the system. Separation pressure is one of the main parameters that defines temperature, flow and brine/steam ratio of the geothermal resource and thus it is a key point for its proper exploitation. Considering the specific constraints of each resource, it should be optimized to ensure the maximum power production and profitability of the investment with a proper cycle design. On a typical resource for binary plants, an analysis has been performed to evaluate the effect of different separation pressures on cycle selection. Following, an analysis of performances and costs of the ORC has been performed to understand the behavior of the overall system varying the separation pressure, in order to show methodology and results useful for the cycle assessment of geothermal projects.

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Keywords: Separation; Geothermal; Binary

1. Introduction

Binary power plants are an available and valid alternative to steam turbines for geothermal exploitation since decades. The fluid circulating in the power plant is an organic fluid (typically an hydrocarbon or refrigerant), kept separated from the geothermal source, making possible exploiting both steam and brine resources. For historical and technical description of ORC technology refer to [1]. With the improvement of the efficiency of ORC (Organic Rankine Cycle), especially for what concern turbine technology, binary is nowadays a commercial solution which is competitive and more profitable than steam turbines for low and medium enthalpy geothermal resources. In fact, for

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low enthalpy resources (wellhead temperature < 125°C [2]) or with high concentration of non-condensable gases, ORC is the only reliable and affordable solution for power production, while in the last years even for medium enthalpy resources (wellhead temperature between 125 and 225°C [2]) binary cycle has been preferred to steam turbines for the strong reduction in specific price and the lowest costs in operation.

To further increase the competitiveness of binary technology, a smart optimization in the resource exploitation is crucial. The available flow of a well is determined by regulating wellhead pressure and submersible pump consumption. For an artesian well, where there is no need of artificial pumping, wellhead pressure is the only operative parameter to regulate the well output. It has to be controlled considering the characteristic curve of each well, and closing the valve means increasing pressure of the fluid while decreasing the mass flow available. A well curve can be estimated after production test varying the wellhead pressure (see characteristics and curve for a typical resource in Figure 1). Of course, wellhead pressure is also the upper limit for the subsequent separation pressure.

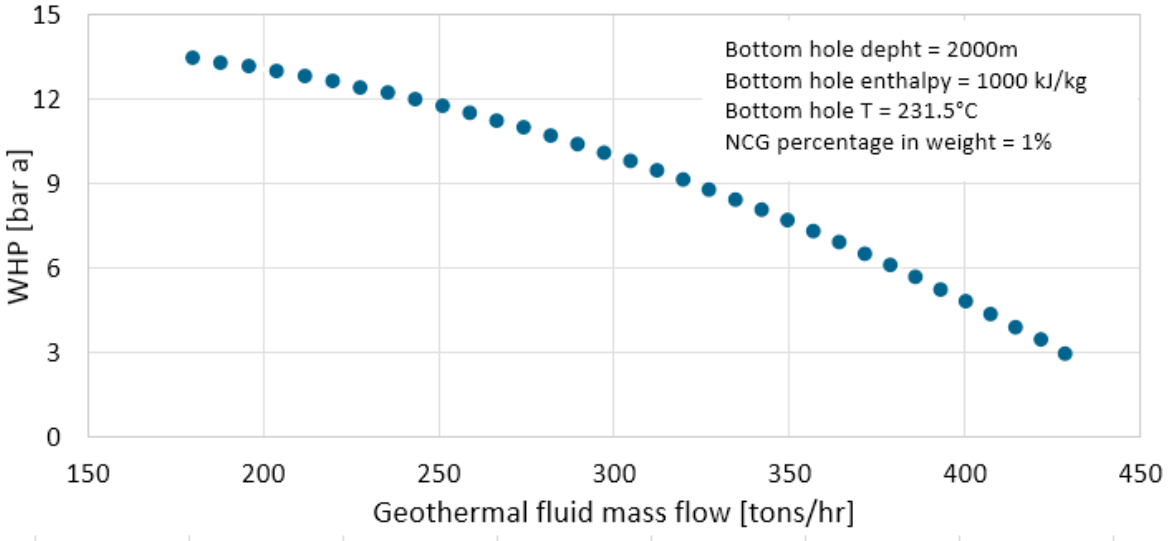

Figure 1: Characteristics and curve of a typical well

After the wellhead, the two-phase geothermal fluid is separated at a pressure depending on the pressure drops between the wellhead and the separator. If the separation station is close to the well pad, pressure drop is negligible while is relevant when the separation station is far from the geothermal wells. When different wells converge on a single separation station, the well with lower pressure defines the maximum separation pressure. For a given resource, separation pressure defines the temperature and the steam/brine ratio available at binary power plant (concentration of non-condensable gases in the resource is another parameter that influences separated flows characteristics). The optimization of the wellhead and separation pressure is a complex problem, which takes into account well curves and influences ORC configuration varying overall geothermal flow, pressure, temperature and amount of steam in the binary plant. This brings to a variation in the power output and equipment cost, that has to be studied for defining the best solution for each resource and investment conditions. The main topic of this paper is showing methods and results of this analysis for a medium enthalpy geothermal resource. Firstly, an optimization with the goal of maximizing power output varying the WHP is performed. Afterwards, a preliminary cost estimation is introduced to understand the optimal design point for increasing profitability of the geothermal investment.