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Optimum operation of a novel ejector assisted flash steam cycle for better utilization of geothermal heat

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ABSTRACT

Dual flash steam cycle (DFSC) is a proven technology to produce power from hot geothermal water. However, in a DFSC, substantial exergy destruction occurs during the two flashing processes. A good amount of thermal energy is also lost with the saturated water exiting the low-pressure vapour separator (LPVS). In the present study, saturated water exiting the high-pressure vapour separator (HPVS) of the geothermal flash steam cycle is used as the motive stream of an ejector. The ejector enhances the pressure of the steam exiting the high-pressure turbine. The steam exits the diffuser of the ejector at a two-phase state. The dry saturated vapour separated from this two-phase steam is expanded through a low-pressure turbine to produce some power output. It is observed that the use of the ejector helps to reduce the exergy loss with the mass of geothermal water entering into the injection well. For 210 °C geo-fluid temperature, the maximum achievable power output of the flash steam cycle with ejector (FSCWE) is 6.67% higher compared to that of the baseline DFSC. While delivering the maximum power at said geo-fluid temperature, the use of the ejector also reduces the levelized cost of electricity (LCOE) by 4.5% compared to that of the baseline cycle.

1. Introduction

Global demand for the secondary energy is ever increasing [1]. This secondary energy demand is mostly catered by fossil fuel based power plants which are also major sources of globally emitted greenhouse gases. Under these circumstances, increasing electricity production from renewable resources is becoming more important. Geothermal heat driven secondary energy production units are preferred as renewable options due to their larger capacity and assured uninterrupted supply. Geothermal power plants are hence suitable for even the base-load electricity supply [2], unlike many other small capacity interrupted distributed renewable options. Single flash and dual flash geothermal steam cycles are proven technologies to produce power from the geothermal water obtained from high enthalpy wells [3]. Pambudi et al. [4] showed that the 2nd law efficiency of the Dieng single-flash geothermal power plant had been close to 36.48%. According to this study, about 17.98% of the total available exergy was lost with the waste brine. Rudiyanto et al. [5] recently optimized the performance of the Dieng single-flash geothermal power plant by varying incoming steam pressure to the turbine. The resulting exergy efficiency of the optimized power plant had been close to 38.19%.

More flashing enhances the overall performance of a flash geothermal steam cycle significantly. Ratlamwala and Dincer [6] reported that increasing the number of flash from one to five would enhance the exergy efficiency of the flash geothermal steam cycle from 6.52% to 47.29%. Jalilinasrabady et al. [7] showed that a double flash steam cycle in the Sabalan geothermal field of Iran would yield 49.7 MW output power which was significantly higher than that (i.e.,31 MW) of the single flash steam cycle. According to the simulation study conducted by Martínez et al. [8] in the Cerro Prieto geothermal field, maximum achievable power outputs with single flash and double flash steam cycles would be 36.667 MW and 102.112 MW respectively. Pambudi et al. [9] claimed that modification of the existing single flash steam power plant of the Dieng geothermal field to a double flash unit would yield about 19.97% higher power output. Dagdas [10] showed that a double flash steam cycle would generate about 11488 kW of electricity if 210 kg / s of geo-fluid at 210 °C were available from the production wells. Bina et al. [11] reported that while using the same geo-fluid, a double flash steam cycle yielded a higher power output compared to that of a single flash steam cycle. However, the cost of unit electricity generation of the single flash cycle had been somehow lower compared to that of the double flash cycle. Mathieu-Potvin [12] proposed the self-superheating flash geothermal steam cycle in which the

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