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Supercritical CO_2 Rankine Cycle System with Low-Temperature Geothermal Heat Pipe

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Abstract

Extracting thermal energy from the geothermal reservoir, a new design of heat pipe (thermosyphon) is introduced in this paper in details. The analytical result indicated that substantial amount of heat can be transferred into the methanol (the working fluid in the heat pipe) through the outer wall in the region of high-temperature geothermal reservoir, and the heat can be transferred upward by vapour phase effectively to a CO_2/methanol heat exchanger at the surface of the ground. In application of the heat pipe, a high-performance energy generation system Rankine cycle with methanol (heat pipe) using the geothermal reservoir, carbon dioxide (CO_2) was selected as a model working fluid to run power cycle. The system is feasible for low temperature (low-grade) geothermal reservoir, and should be sustainable in a sense that no hot water (spa) can be wasted, in comparison with the ordinary geothermal power plant.

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Keywords: Rankine cycle; Supercritical CO_2; Geothermal energy; Heat pipe

1. Introduction

The low-temperature geothermal energy has being the greatest growth in recent year [1]. In typical, the binary cycle system is used to produced energy from low-temperature geothermal reservoirs such as from the hot spring resource (small scale geothermal power plant), in which hot water (temperature around 100 °C) is pumped up from the underground reservoir and heat low boiling medium in secondary cycle for electric power generation [2]. It can be obviously seen that the high rate of energy is required

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(and waste) to drive (pumping power) the geothermal fluid in the power plant process and some geothermal water after process is mostly wasted to natural resource.

To deal with above issues, the heat pipe system, which asorbs heat from undergraound without mass pumping is introduced. In the present study, the supercritical CO_2 Rankine cycle system, which was originally invented for solar energy usage [3] is used as a model secondary cycle (power generation cycle).

This paper particularly presents some detailed design of a heat pipe, using the principle of thermo-syphon in exacting the geothermal energy, where methanol is thought to be utilized as a working fluid to absorb thermal energy ranging from 80 °C to 100 °C reservoir. In the present study, the performance of the Rankine cycle (system) with the heat pipe is further discussed on the basis of supercritical CO_2 Rankine cycle system.

2. Supercritical CO_2 Rankine cycle system with geothermal heat pipe

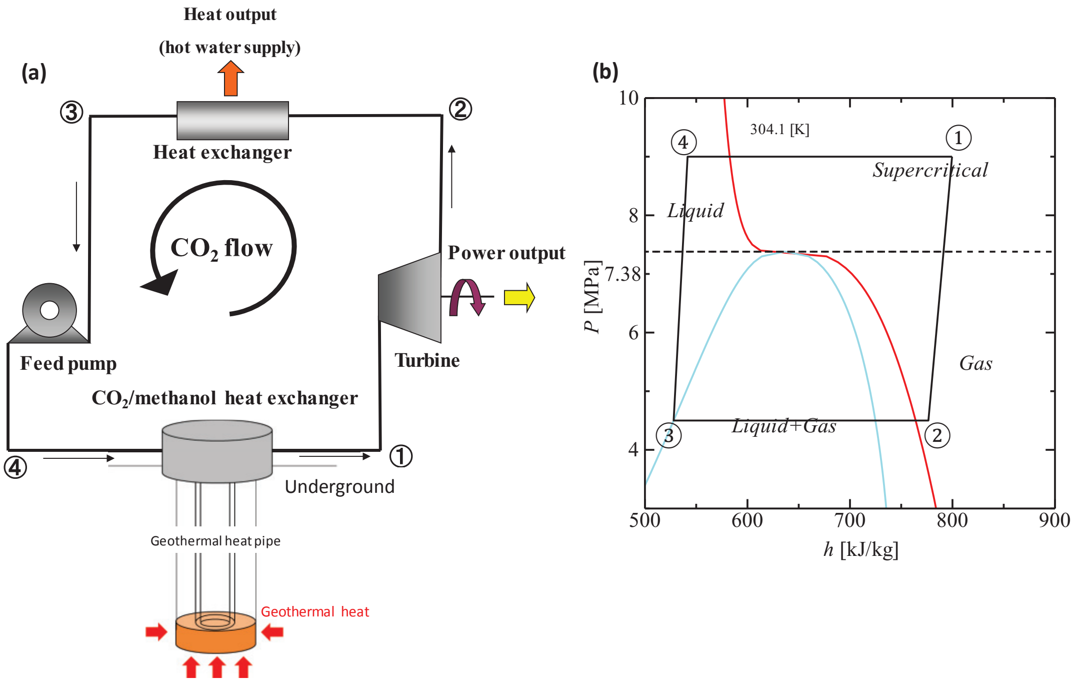

Fig. 1: (a) Schematic diagram of supercritical CO_2 Rankine cycle with geothermal heat pipe and (b) *P-h* diagram

2.1 Model Rankine cycle with geothermal heat pipe

The purposed model Rankine cycle with geothermal heat pipe consists of main four components, as shown in Fig. 1 (a) and the *P-h* diagram of the cycle shown in Fig. 1 (b). The CO_2/methanol heat exchanger with geothermal heat pipe, using methanol as working fluid, is installed at high pressure side of Rankine cycle, ④ → ①, to absorb the heat from underground, in which CO_2 is heated geothermal heat underground and turns to a supercritical state. The expanded supercritical CO_2 drives a turbine and generate electric energy, ① → ②. After leaving turbine, due to the remaining thermal energy, CO_2 is