

PERANCANGAN AWAL EVAPORATOR PADA SISTEM RANKINE ORGANIK MEMANFAATKAN AIR PANAS BUANG GEOTERMAL WAYANG WINDU

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INTISARI

Saat ini kebanyakan PLTP di Indonesia menggunakan teknologi *single-flash plant*, salah satunya adalah PLTP Wayang Windu. Air panas buang geotermal setelah proses *flashing* langsung direinjeksikan kembali ke dalam bumi. Sementara itu, air panas buang geotermal dengan suhu 150°C dan laju alir massa 48 kg/s masih menyimpan potensi energi sekitar 30000 kW . Penelitian ini bertujuan untuk merancang sistem pembangkit listrik biner yang memanfaatkan air panas buang geotermal untuk menghasilkan listrik tambahan.

Siklus Rankine organik dengan penukar kalor internal dipilih sebagai model termodinamika pada rancangan sistem pembangkit listrik biner. Empat fluida organik, yaitu R245fa, R245ca, R236ea, dan R365mfc merupakan kandidat fluida kerja yang akan disimulasikan pada perangkat lunak *Cycle Tempo 5.0*. Kondisi operasi optimal masing-masing fluida kerja diperoleh dengan cara memvariasikan tekanan evaporasi dan suhu *pinch point* rekuperator. Selanjutnya, variasi suhu masukan evaporator dan suhu reinjeksi air panas buang geotermal dilakukan untuk mengoptimasi kinerja penukar kalor dan performansi sistem secara keseluruhan.

Performansi optimal diperoleh ketika fluida R236ea dipanaskan mencapai tekanan 30 bar dengan suhu *pinch point* rekuperator sisi lebih panas 10°C dan sisi lebih dingin 5°C . Suhu fluida R236ea masuk evaporator ditetapkan $95,37^{\circ}\text{C}$ dan suhu reinjeksi air panas buang geotermal ditetapkan 125°C . Sistem yang telah dirancang mampu menghasilkan daya bersih sebesar $1857,38\text{ kW}$ dengan efisiensi termal 16,09%. Efektivitas rancangan komponen evaporator yang dihasilkan sebesar 0,77 dengan koefisien transfer kalor keseluruhan hasil perhitungan sebesar $520,979\text{ W/m}^2\text{C}$.

Kata kunci: siklus rankine organik, efektivitas penukar kalor, pembangkit listrik panas bumi

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INITIAL DESIGN OF EVAPORATOR FOR ORGANIC RANKINE CYCLE SYSTEMS UTILIZES GEOTHERMAL BRINE IN WAYANG WINDU

by

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ABSTRACT

Nowadays, most geothermal power plants in Indonesia use single flash plant technology, for instance Wayang Windu Geothermal Power Plant. The geothermal brine from the flashing process is injected back into the Earth. Meanwhile, the temperature of geothermal brine remains high -150°C- with mass flow rate of hundreds of tons per hour, which is equal to 48 kg/s. Therefore it contains heat energy potential approximately 30000 kW. The purpose of this study is to design a binary power plant system which uses geothermal brine to generate additional supply of electricity.

Organic Rankine Cycle with internal heat exchanger has been selected as a thermodynamic model for the design of a binary power plant. Four types of organic fluids - R245fa, R245ca, R236ea, and R365mfc - were the prospective working fluids to be simulated in the Cycle Tempo 5.0 software. Operational condition of each fluid was obtained by varying evaporation pressure and recuperator pinch point temperature. In addition, the variation of evaporator inlet temperature and brine reinjection temperature were taken to optimize the performance of heat exchanger and entire systems.

The optimal performance was obtained by heating R236ea fluid at 30 bar with recuperator pinch point temperature at 10°C on the hot side and 5°C on the cold side. Evaporator inlet temperature of R236ea fluid was adjusted at 95,37°C and brine reinjection temperature was adjusted at 125°C. The designed system generated net power 1857,38 kW and thermal efficiency of 16,09%. The effectiveness of the design of evaporator was 0,77 with overall heat transfer coefficient was 520,797 W/m²°C.

Keywords: organic rankine cycle, heat exchanger effectiveness, geothermal power plant

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