INTISARI

Peningkatan kebutuhan energi global serta keterbatasan sumber energi fosil mendorong pengembangan pemanfaatan energi terbarukan yang efisien dan ramah lingkungan. *Organic Rankine Cycle* (ORC) merupakan salah satu teknologi yang dapat dimanfaatkan untuk mengonversi sumber panas bersuhu rendah hingga menengah menjadi energi listrik melalui penggunaan fluida kerja organik bertitik didih rendah, seperti n-butana. Dalam sistem ORC, evaporator merupakan komponen utama yang berfungsi untuk menguapkan fluida kerja, dan salah satu tipe evaporator yang umum digunakan yaitu *shell and tube heat exchanger*.

Penelitian tugas akhir ini membahas perancangan dan prediksi unjuk kerja evaporator tipe *shell and tube* menggunakan dua pendekatan, yaitu perhitungan analitik dengan metode Bell-Delaware dan prediksi numerik menggunakan perangkat lunak *Heat Transfer Research, Inc.* (HTRI) *Xchanger Suite*. Evaporator dirancang berdasarkan standar *Tubular Exchanger Manufacturers Association* (TEMA), dengan fluida kerja n-butana mengalir pada sisi *shell* dan fluida pemanas berupa air mengalir pada sisi *tube*. Metode Bell-Delaware digunakan untuk menganalisis kinerja termal dan penurunan tekanan dengan mempertimbangkan faktor koreksi aliran, termasuk kebocoran (*leakage*) dan aliran pintas (*bypass*). Desain akhir beserta kondisi operasinya disimulasikan menggunakan perangkat lunak HTRI untuk mengevaluasi dan memprediksi kinerja sistem pada berbagai kondisi operasi. Variasi kondisi operasi yang dianalisis meliputi perubahan laju aliran massa pada sisi *tube* serta variasi ukuran *baffle cut* terhadap unjuk kerja evaporator.

Penelitian ini menghasilkan rancangan evaporator tipe *shell and tube heat exchanger* dengan arah aliran *counter flow* konfigurasi AEM dan menggunakan *single segmental baffle*. Pada kondisi desain yang sama, perhitungan analitik menghasilkan nilai *overall heat transfer coefficient* sebesar 939,36 W/m²·K, sedangkan prediksi menggunakan HTRI *Xchanger Suite* menghasilkan nilai sebesar 1025,1 W/m²·K. Deviasi antara kedua pendekatan tersebut berada di bawah 10%, sehingga hasil perancangan berbasis perhitungan analitik dapat diterima. Hasil simulasi variasi laju aliran massa fluida pemanas pada sisi *tube* sebesar 2,512 kg/s, 3,14 kg/s, dan 3,768 kg/s menunjukkan peningkatan nilai total *heat transfer coefficient* masing-masing menjadi 1000,4 W/m²·K, 1025,1 W/m²·K, dan 1037,4 W/m²·K. Namun, peningkatan laju aliran massa tersebut menyebabkan kenaikan *pressure drop* pada sisi *tube* dari 1,562 kPa menjadi 2,438 kPa dan 3,509 kPa. Pada variasi ukuran *baffle cut* sebesar 20%, 30%, dan 40%, nilai *total heat transfer coefficient* mengalami penurunan berturut-turut dari 1048,3 W/m²·K, 1025,1 W/m²·K, hingga 976,1 W/m²·K, sementara nilai *pressure drop* pada sisi *shell* menurun dari 5,015 kPa menjadi 4,423 kPa dan 3,532 kPa.

Kata kunci: Evaporator, *Shell and Tube*, Perancangan, ORC, *Baffle Cut*

ABSTRACT

The increasing global energy demand and the limited availability of fossil energy resources have encouraged the development of efficient and environmentally friendly renewable energy utilization. The Organic Rankine Cycle (ORC) is one of the technologies that can be employed to convert low- to medium-temperature heat sources into electrical energy by using organic working fluids with low boiling points, such as n-butane. In an ORC system, the evaporator plays a crucial role in vaporizing the working fluid, and one of the most commonly used evaporator types is the shell and tube heat exchanger.

This undergraduate thesis focuses on the design and performance prediction of a shell and tube evaporator using two approaches, namely analytical calculations based on the Bell–Delaware method and numerical prediction using the Heat Transfer Research, Inc. (HTRI) Xchanger Suite software. The evaporator was designed in accordance with the standards of the Tubular Exchanger Manufacturers Association (TEMA), with n-butane flowing on the shell side and hot water as the heating fluid flowing on the tube side. The Bell–Delaware method was applied to analyze thermal performance and pressure drop by considering flow correction factors, including leakage and bypass flows. The final design and its operating conditions were subsequently simulated using HTRI software to evaluate and predict system performance under various operating conditions. The analyzed operating variations included changes in tube-side mass flow rate and variations in baffle cut size on the evaporator performance.

The results indicate that the designed evaporator is a shell and tube heat exchanger with a counter-flow configuration of TEMA type AEM and a single segmental baffle. Under identical design conditions, the analytical calculation yielded a overall heat transfer coefficient of 939.36 W/m²·K, while the HTRI prediction produced a value of 1025.1 W/m²·K. The deviation between the two approaches was below 10%, indicating that the analytical design results are acceptable. Simulation results for tube-side heating fluid mass flow rates of 2.512 kg/s, 3.14 kg/s, and 3.768 kg/s showed an increase in the total heat transfer coefficient to 1000.4 W/m²·K, 1025.1 W/m²·K, and 1037.4 W/m²·K, respectively. However, the increase in mass flow rate led to a significant rise in tube-side pressure drop from 1.562 kPa to 2.438 kPa and 3.509 kPa. Furthermore, variations in baffle cut size of 20%, 30%, and 40% resulted in a successive decrease in the total heat transfer coefficient from 1048.3 W/m²·K to 1025.1 W/m²·K and 976.1 W/m²·K, while the shell-side pressure drop decreased from 5.015 kPa to 4.423 kPa and 3.532 kPa.

Keywords: Evaporator, Shell and Tube, Design, ORC, Baffle Cut