

DESIGN AND RETROFIT OF CRUDE FRACTIONATION UNITS

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ABSTRACT

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Crude fractionation units are designed to separate the crude in several product streams (naphtha, gas oil, diesel, etc.). Crude fractionation is a highly energy intensive process and represented one of the most important areas for energy integration in a refinery by modifying the existing plants and generating improved designs. Important heat exchange also takes place, and the energy efficiency is related to the column design parameters. First, the optimal condenser and pump-around duties were determined for three types of crudes; light, intermediate, and heavy crudes with using the heat demand-supply diagram, an important tool for modification. These crudes constitute the targets for the design of a multipurpose heat exchanger network. The multipurpose design problem for which several alternative solutions of similar cost exist. Such property is suspected to be true for the retrofit case, that is several retrofit scenarios aimed at improving energy efficiency and/or throughput can exist and be competitive. The result was observed that when the optimal condenser and pump-around duties were located in these designs, the energy consumption and operating costs were reduced.

บทคัดย่อ

รจุกร บัวบุชา: การออกแบบและปรับปรุงหน่วยกลั่นน้ำมันดิบ (Design and Retrofit of Crude Fractionation Units) อ. ที่ปรึกษา: ดร. กิติพัฒน์ สีมานนท์ และ ศ. ดร. มิเกล บากาเฮ วิช 117 หน้า ISBN 974-9651-12-x

หน่วยกลั่นน้ำมันดิบ จัดเป็นหน่วยแรกของโรงกลั่นน้ำมัน ซึ่งทำหน้าที่แยกน้ำมันดิบออกเป็นผลิตภัณฑ์ต่างๆ ได้แก่ แนฟทา น้ำมันก๊าซออยล์ น้ำมันดีเซล เป็นต้น การกลั่นน้ำมันดิบเป็นกระบวนการที่ใช้พลังงานสูง และเป็นขอบเขตที่สำคัญสำหรับการรวบรวมพลังงานในโรงกลั่นน้ำมัน โดยปรับปรุงและออกแบบให้ดีขึ้น ปัญหาของการออกแบบหน่วยกลั่นน้ำมันดิบไม่เฉพาะการออกแบบการกลั่น แต่ยังรวมถึงสาเหตุอีกหลายประการที่ซับซ้อน กล่าวคือ หน่วยกลั่นน้ำมันดิบควรที่จะสามารถดำเนินไปกับชนิดน้ำมันดิบที่มีความแตกต่างกัน ตั้งแต่ น้ำมันดิบหนักจนถึงน้ำมันดิบเบา แม้กระทั่งควรพิจารณาถึงการแลกเปลี่ยนความร้อนซึ่งก็มีความสำคัญเช่นกัน ประการต้น การหาปริมาณพลังงานที่ใช้ใน Condenser และ Pump-Around Circuits ให้เหมาะสมที่สุดสำหรับน้ำมันดิบ 3 ชนิด คือ น้ำมันดิบเบา น้ำมันดิบปานกลาง และน้ำมันดิบหนัก โดยใช้ heat demand-supply diagram เป็นเครื่องมือในการหาปริมาณพลังงาน จากประการต้นนี้จะนำไปสู่การออกแบบเครือข่ายแลกเปลี่ยนความร้อน (Heat Exchanger Network) ซึ่งคาดว่าจะสามารถใช้การออกแบบนี้กับน้ำมันดิบทุกชนิด ซึ่งผลจากการหาปริมาณพลังงานที่ใช้ใน Condenser และ Pump-Around Circuits ที่เหมาะสมแล้ว พบว่าปริมาณการใช้พลังงานและค่าใช้จ่ายในการปฏิบัติงานในหน่วยกลั่นน้ำมันดิบก็ได้ผลที่ดีที่สุดตามไปด้วย

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ABBREVIATIONS

| | |
|-------------|--|
| CR | (Hot) Crude oil |
| F | Mass flow rate, kg/s |
| F_{pi} | Mass flow rate of product i , kg/s |
| F_{si} | Mass flow rate of steam i , kg/s |
| h_{FZ}^W | Enthalpy of water (steam) at the flash zone, kJ/kg |
| h_{FZ}^O | Enthalpy of hydrocarbon vapor at the flash zone, kJ/kg |
| $h_{L,j-1}$ | Enthalpy of liquid falling from tray $j-1$, kJ/kg |
| $h_{L,o}$ | Enthalpy of liquid falling into the flash zone, kJ/kg |
| h_{pi} | Enthalpy of product i , kJ/kg |
| h_{si} | Enthalpy of steam i , kJ/kg |
| h_v^W | Enthalpy of water (steam) rising from tray j , kJ/kg |
| h_v^O | Enthalpy of hydrocarbon vapor rising from tray j , kJ/kg |
| L_o | Overflash rate, kg/s |
| Q_k | Duty of pump-around circuit k |
| R | Reflux ratio |
| R_{min} | Minimum reflux ratio |
| RES | Residue |
| S | Steam |
| SD | Diesel stripping steam |
| SG | Gas oil stripping steam |
| SK | Kerosene stripping steam |
| SR | Residue stripping steam |
| V_j^W | Water (steam) flow rate at tray j |
| V_{FZ} | Vapor flow rate at flash zone |
| V_{FZ}^W | Water (steam) flow rate at flash zone |
| V_{FZ}^O | Hydrocarbon vapor flow rate at flash zone |

| | |
|---------|---|
| V_j | Vapor flow rate at tray j |
| V^o | Hydrocarbon vapor flow rate at tray j |
| E | Energy consumption |
| H_i^s | Enthalpy of stripping steam i |
| U | Minimum heating utility excluding steam |