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A COMPREHENSIVE ANALYSIS OF THE SIMULATION, OPTIMIZATION, CORROSION, AND DESIGN ASPECTS OF CRUDE DISTILLATION UNITS

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ABSTRACT

The primary function of a crude distillation unit (CDU) within a petroleum refinery is to effectively segregate crude oil into its constituent fractions or products based on their respective boiling points. The Crude Distillation column often serves as the primary processing unit within most refineries, pivotal in producing a wide range of refinery products. This study examines research articles published between 2013 and 2023 that specifically investigate issues related to crude distillation units. The research endeavours to produce innovative designs and construct mathematical models to enhance production efficiency within this context. The research primarily centres on developing a mathematical model that accurately characterizes the distillation tower. This is achieved using either an Artificial Neural Network or a nonlinear model predictive control approach. The primary objective of simulation and optimization research is identifying optimal operating conditions, typically employing software tools such as Aspen HYSYS or PRO II. The corrosion treatment outcomes conducted at the tower's upper section were satisfactory. The study focused on the issue of corrosion in the overhead lines and pumps around exchangers. This design research aims to investigate potential modifications to the distillation tower's design or preflash process to optimize production outcomes.

I. INTRODUCTION

Distillation is a commonly employed technological process for separating mixtures across diverse industries and disciplines. The energy intensity of the rectification process is linked to the significant heat of vaporization exhibited by the constituent elements of the separated mixtures. The dimensions of the distillation columns are influenced by their relatively low energy efficiency. According to Olujić et al., there is a consistent increase in the size of distillation columns and their production despite the significant energy consumption associated with these processes [1].

Despite its extensive historical background, the crude oil distillation unit (CDU) is commonly recognized as the predominant separation process within the chemical industry. The simple oil distillation process involves substantial machinery, requiring significant energy consumption. The complexity of crude oil distillation units is mainly attributed to their wide range of products, which span from liquefied gases used for domestic cooking to asphalt used in roofing and road construction [2].

This review study aims to elucidate the scholarly literature released between 2013 and 2023 pertaining to atmospheric distillation towers utilized in refinery operations.

II. MODELLING OF CRUDE DISTILLATION UNIT

The CDU model described by Fupei Li et al. is a mixed-integer linear model incorporating a reasonable amount of binary variables. Its accuracy is comparable to more comprehensive tray-to-tray CDU models [3]. In their study, Bayomie et al. provide an algorithm designed to address the energy recovery challenges faced by contemporary refiners. This algorithm offers the potential for achieving more cost reductions beyond the energy objectives established by the current refining process. The algorithm is responsible for conducting the simulation and optimization of the process [4]. Badiea S. Babaqi demonstrated the application of mathematical models and the LINGO program to optimize energy consumption in a crude distillation plant. The objective was to minimize energy requirements and significantly reduce greenhouse gas emissions [5]. In their study, Yingjian Xiong et al. introduced a novel approach called the Bi-level Surrogate column model Aided Constrained Optimization Design. This approach aims to address the challenges caused by time-consuming objectives and constraints in the evolutionary optimization design of CDUs [6].

The authors, Fupei Li et al., utilize the tri-section CDU model proposed in their previous work (Li et al., 2020) to construct a precise refinery model. They employ a two-stage stochastic programming approach to identify the most optimal crude selection [7]. Shamna A. Rahman and R. Anjana endeavoured to develop a heat integration network for the crude distillation process. The researchers conducted investigations using steady-state simulations of scenarios featuring varying configurations of heat exchangers [8]. Filiz Al-Shanableh employed an Artificial Neural Network (ANN) as a computational tool to develop a model for predicting the quality of products in the Crude Distillation Unit (CDU). The ability to forecast product quality has the potential to decrease reliance on online sample analyzers and facilitate early identification of CDU operational malfunctions [9].

In this study, Jobson et al. sought to improve the efficacy of surrogate modelling for columns by developing additional screening and filtering correlations and surrogate models. These enhancements were aimed at establishing feasibility bounds [10].

Dauda Ibrahim and his team extensively studied developing a high-end crude oil distillation unit. Their approach involved a detailed analysis of each tray in the column and the implementation of advanced process simulation software. Additionally, they utilized an optimization algorithm to enhance their results. The outcome of their research was an intricately designed and highly efficient crude oil distillation unit [11]. Jin et al. (year) made enhancements to the economic-based nonlinear model predictive control (NMPC) approach employed for the optimization of the crude oil distillation (CDU) process [12]. The authors, Wissam Muhsin and Jie Zhang, conducted a study that employed a stacked neural network to model and optimize a crude distillation process [13]. The study conducted by Shankar Nalinakshan et al. primarily emphasized the importance of energy conservation in an industrial crude oil distillation unit. A proposed and modelled alternative to the typical model of crude oil distillation currently implemented in the Kochi Refinery is presented [14].

Diana C. López C. et al. introduced a mathematical framework for a Nonlinear Programming (NLP) model in their study. This model aims to optimize the blending of crude oil and the operational parameters of several Crude Oil Distillation Units (CDUs) within a refinery located in Colombia [15].

III. EXERGY OF CDU

W Yan et al. (year) enhance the energy utilization efficiency of the process in both qualitative and quantitative aspects. Theoretical analysis is conducted to derive the exergy loss of crucial components within the Crude Distillation Unit (CDU), including condensers, furnaces, and distillation columns [16].

In their study, Z. Nur Izyan and M. Shuhaimi conducted an exergy analysis and proposed various techniques to mitigate exergy loss by process change. The intake furnace was identified as the location with the highest exergy loss [17].

The individual in question is M.A. Waheed. A.O. Oni enhanced the energy and exergy efficiency of the plant. The methodology employed to improve plant performance involves using process simulation techniques and integrating exergy and traditional retrofit methods. This approach demonstrates the potential outcomes of the process by considering the significant costs associated with the necessary capital investment [18].

IV. SIMULATION AND OPTIMIZATION

In their study, Kunru Yang et al. propose an optimal operational strategy to enhance the energy efficiency of crude oil distillation units without modifying the unit's structure. The primary aim of the suggested methodology is to limit the usage of process energy while maintaining its economic advantages [19].

Ahmed Lawal Mashi and Abubakar Sani researched the crude distillation unit II of the Kaduna Refining and Petrochemical Company (KRPC). The primary objective of their study was to identify the most favourable operational parameters that would result in increased diesel output while minimizing the formation of residual byproducts. The investigation used simulation and optimization methods to ensure precise and reliable outcomes. In general, this study's results will enhance the operational effectiveness and output of the KRPC [20].

In their study, Mohamed A. Kishk et al. propose an optimal operational change to improve the energy efficiency of a pre-existing crude oil distillation plant. The process operation is simulated and analyzed using ASPEN HYSYS software, followed by the proposal of two improvements [21]. In their study, Martin et al. discuss the incorporation of Real-Time Optimization and Model Predictive Control into the multi-layer control framework of a pre-existing Crude Distillation Unit (CDU) within an oil refinery [22].

In their study, Shehata et al. conducted a retrofitting process on the current CDU to enhance its performance, mainly when processing light crude oil. Furthermore, this study aims to ascertain the appropriate pressure setting for the preflash drum and the ideal input tray configuration for preflash vapours into the crude distillation unit (CDU) [23].

In their study, Ahmed Fadhil Jumaah et al. achieved a proportional rise in the refinery's profit by effectively lowering emissions and obtaining high distillate products. This was accomplished by carefully selecting and implementing ideal conditions [24]. Muhsin and Zhang's study delves into the crucial use of multi-objective optimization techniques in crude oil hydrotreating processes, specifically within a crude atmospheric distillation unit. Their methodology employs data-driven models that are rooted in bootstrap aggregated neural networks. Ultimately, their research findings offer groundbreaking insights into how multi-objective optimization techniques can be effectively used to enhance the efficiency and effectiveness of HDT processes [25].

In their work, Abubakar Isah et al. employed the HINT program to conduct a case study exploring a minimal area target. Subsequently, they applied this methodology to a crude distillation unit (CDU). The researchers successfully obtained a solution that demonstrated a satisfactory level of accuracy, with a deviation of less than 1 per cent when compared to an established solution for a minimum area target [26]. In his study, Ali Nasir Khalaf analyzed the operational performance of the crude oil distillation column located at Basrah Refinery in Iraq, employing a steady-state simulation approach. Furthermore, a comparison was made between various products' experimental ASTM D86 curves and those derived from simulations [27].

In their study, Samborskayaa et al. estimated the total capital investments and operation costs per year for the basic flowsheet. The technique of incrementally raising the flow rate of crude oil is employed to identify areas of vulnerability within the flowsheet and to approximate the upper limit of the oil flow rate [28]. Ledezma-Martínez et al. introduced a design technique based on simulation, aiming to minimize the system's heat demand [29].

Ledezma-Martínez et al. (year) proposed an approach grounded in optimization principles to facilitate the design of crude oil distillation systems incorporating preflash units. The primary goal is to reduce the amount of heat the system requires [30]. Salah M. Ali et al. predicted the optimum operating conditions required to operate an existing atmospheric distillation column to distillate heavier crude oils in the same unit, designed mainly to fractionate moderate and lighter crude oils [31]. Fethi Kamişli and Ari Abdulqader Ahmed used the Aspen HYSYS simulation program to optimize a crude oil distillation unit in a refinery, resulting in unparalleled efficiency and effectiveness [32]. The research conducted by Patrascioiu and Jamali employed the Unisim Design simulator to mimic the process of crude distillation. This investigation yielded significant findings and identified areas that may be enhanced [33]. Lekan T. Popoola and colleagues developed optimization models for crude oil distillation columns that factor in the market prices of products. These models apply to both limited and unlimited feedstocks. The effort put into refining crude oil is impressive [34].

A study conducted by Arjmand et al. investigates the optimization of a crude oil atmospheric distillation unit. Significant energy reduction was accomplished by implementing minor alterations and tweaks to the flash zone within the tower [35]. In their study, Akbar Mohammadi Doust and colleagues employed commercially available software to simulate a crude oil distillation plant. The study's outcomes indicate that dynamic simulation, which entails the solution of numerous state equations and the application of control theory, exerts a more significant influence than steady-state simulation. The aforementioned insightful perspective can provide substantial advantages to experts within the oil business striving to enhance their operational procedures [36]. In this study, Mamdouh Gadalla and colleagues present a novel methodology for concurrently improving the distillation column and heat exchanger network. The researchers successfully achieved the highest possible utilization of the available equipment by employing a rigorous simulation and optimization approach [37]. In their study, Gadalla et al. proposed a systematic approach that utilizes simulation techniques to adapt a pre-existing crude distillation column. The algorithm considers the proposed heat recovery system [38].

In their study, Gu et al. conducted optimization techniques to improve the yield of sidestreams obtained from various distillation columns, simultaneously boosting their distillation load. The researchers utilized maximum energy in a multistage distilling crude oil method. Technological advancements and scientific research contribute to developing more efficient production systems [39]. In their study, Le Quang Minh et al. conducted a comprehensive global sensitivity analysis to streamline the uncertainty quantification process for a crude distillation unit. This particular unit was characterized by many uncertainties [40]. In their study, Seegulam et al. developed a dynamic model to simulate the behaviour of the CDU column at a refinery with a capacity of 160,000 barrels per day (BPD). The authors then validated the model using operating data and obtained favourable outcomes [41]. In their study, Shankar et al. conducted simulations and performed analysis on a set of four raw data points. The system is subject to energy analysis using an Aspen energy analyzer [42]. The study conducted by SHI Bin et al. focuses on the modelling and optimization of an industrial-scale crude distillation unit (CDU). This study introduces an enhanced wavelet neural network (WNN) to model a complex CDU. The proposed WNN incorporates innovative parametric updating laws that accurately reflect the specific properties of the CDU [43].

In their study, Diana-C. López et al. introduced an optimization model designed to enhance the performance of a Crude Distillation Unit (CDU) system. The study successfully determined the optimal operational parameters for three air Distillation Towers, specifically for crude oil with a constant composition. Additionally, the research accurately computed the quantities and characteristics of the air products obtained from the distillation process [44]. The authors, Yamashita et al., investigated the optimization of Model Predictive Control (MPC) parameters. The presented scenario illustrates a realistic depiction whereby the inputs of the CDU system are equipped with optimizing targets provided by the Real-Time Optimisation layer within the control structure [45].

V. CORROSION IN CDU

In this study, Yogesh Kumar examines a case of corrosion occurring in the top pump around exchangers within the Crude Distillation Unit. The objective is to identify the primary source of this corrosion and propose appropriate remedial techniques that can effectively reduce such corrosion, ultimately enhancing the integrity and dependability of the system [46]. Sunil Kumar and Avinash Mhetre conceptualized the integrated design of a crude distillation column (CDU). The researchers observed that implementing the new strategy improved the distillate output from the atmospheric distillation column [47]. A study was undertaken by Philipp Schempp et al. to investigate the corrosion of overhead lines within a crude distillation tower. The researchers analyzed crucial process parameters and data obtained during a one-year monitoring period to ascertain the underlying reason for the degradation. Significant insights were acquired [48]. The reduction of salt and water content in Khurmele crude oil has been shown to effectively mitigate equipment corrosion, which is consistent with the study conducted by Humooudi et al. To enhance efficiency and prolong the lifespan of equipment, it is recommended that refineries implement the following methods [49].

VI. DESIGN OF CDU

In their study, Xu et al. introduce a tradeoff indigenous design approach for developing heat exchanger networks in crude oil distillation units (CDUs). This approach's primary objective is to mitigate excessive energy consumption and reduce CO2 emissions associated with CDUs [50]. In their study, Sunil Kumar and Avinash S. Mhetre compared existing crude oil distillation schemes employed in operational refineries, juxtaposing them with two novel techniques that utilized distinct crude oils. The evaluation focused on energy consumption and energy cost metrics. Seven scenarios were devised for each crude to conduct a comprehensive techno-economic assessment of these plans [51].

Mohammad A. Al-Mayyahi and his colleagues conducted a study on the impact of preflash designs on energy efficiency and C.O. emissions of CDUs. Their findings provide insights into optimal design choices and emphasize distinctive features. Different decisions can significantly impact the CDU's environmental impact [52]. Kim et al. (year) introduced a novel crude distillation unit (CDU) design that prioritizes energy efficiency. The researchers proceeded to assess and contrast its performance with that of the traditional CDU [53].

VII. CONTROL OF CDU

The study conducted by Venkata Vijayan S et al. centres around the advancement of nonlinear adaptive soft sensors to forecast the initial boiling point (IBP) and end boiling point (EBP) of naphtha within the crude distillation unit. The study presents the development of adaptive inferential sensors that utilize linear and nonlinear local models. These sensors are designed using a recursive just-in-time learning (JITL) approach [54]. In their research, Fayruzov et al. developed a control system specifically for a crude distillation unit. The system has proven effective in ensuring optimal efficiency and safety, highlighting the importance of continued research in industrial control systems [55].

VIII. CONCLUSION

Several challenges associated with the atmospheric distillation tower can be mitigated through operating conditions to achieve optimal performance, design alterations, or corrosion-resistant materials to prevent degradation at the upper section of the tower. The atmospheric distillation tower plays a crucial function in petroleum refineries. The atmospheric distillation tower possesses numerous advantages but also presents particular challenges.

IX. AUTHOR'S CONTRIBUTION

Conceptualization: Abdulrazzaq Saeed Abdullah and Hassan Wathiq Ayoob.
Methodology: Abdulrazzaq Saeed Abdullah and Hassan Wathiq Ayoob.
Investigation: Abdulrazzaq Saeed Abdullah and Hassan Wathiq Ayoob.
Discussion of results: Abdulrazzaq Saeed Abdullah and Hassan Wathiq Ayoob.
Writing – Original Draft: Abdulrazzaq Saeed Abdullah and Hassan Wathiq Ayoob.
Writing – Review and Editing: Abdulrazzaq Saeed Abdullah and Hassan Wathiq Ayoob.
Resources: Abdulrazzaq Saeed Abdullah and Hassan Wathiq Ayoob.
Supervision: Abdulrazzaq Saeed Abdullah and Hassan Wathiq Ayoob.
Approval of the final text: Abdulrazzaq Saeed Abdullah and Hassan Wathiq Ayoob.

X. REFERENCES

[1] Ž. Olujić, M. Jödecke, A. Shilkin, G. Schuch, and B. Kaibel, "Equipment improvement trends in distillation," Chem. Eng. Process. Process Intensif., vol. 48, no. 6, pp. 1089–1104, 2009.

[2] R. J. Hengstebeck, "Petroleum processing: principles and applications," (No Title), 1959.

[3] F. Li, F. Qian, M. Yang, W. Du, and V. Mahalec, "Product tri-section based crude distillation unit model for refinery production planning and refinery optimization," AIChE J., vol. 67, no. 2, Feb. 2021, doi: 10.1002/aic.17115.

[4] O. S. Bayomie, O. Y. Abdelaziz, and M. A. Gadalla, "Exceeding Pinch limits by process configuration of an existing modern crude oil distillation unit–A case study from refining industry," J. Clean. Prod., vol. 231, pp. 1050–1058, 2019.

[5] B. S. Babaqi, "Mathematical Model for Reducing Energy Consumption and Greenhouse Gas Emissions in the Crude Distillation Unit Using the LINGO Program," in 2019 First International Conference of Intelligent Computing and Engineering (ICOICE), IEEE, 2019, pp. 1–8.

[6] Y. Xiong, X. Shi, Y. Ma, and Y. Chen, "Optimization design of crude oil distillation unit using bi-level surrogate model," Front. Control Eng., vol. 4, p. 1162318, 2023.

[7] F. Li, F. Qian, W. Du, M. Yang, J. Long, and V. Mahalec, "Refinery production planning optimization under crude oil quality uncertainty," Comput. Chem. Eng., vol. 151, p. 107361, 2021.

[8] S. A. Rahman and R. Anjana, "Unisim Based Simulation and Analysis of Crude Oil Distillation," in IOP Conference Series: Materials Science and Engineering, IOP Publishing, 2021, p. 12094.

[9] F. Al-Shanableh, "Product Quality Prediction of 95% Naphtha Cut Point in Crude Distillation Unit Using Artificial Neural Networks," in The Proceedings of the International Conference on Smart City Applications, Springer, 2021, pp. 1011–1021.

[10] M. Jobson, L. M. Ochoa-Estopier, D. Ibrahim, L. Chen, G. G. Gosálbez, and J. Li, "Feasibility bounds in operational optimization and design of crude oil distillation systems using surrogate methods," Chem. Eng. Trans., vol. 61, pp. 1849–1854, 2017.

[11] D. Ibrahim, M. Jobson, and G. Guillén-Gosálbez, "Optimization-based design of crude oil distillation units using rigorous simulation models," Ind. Eng. Chem. Res., vol. 56, no. 23, pp. 6728–6740, 2017.

[12] Q. Jin, Z. Feng, Q. Liu, X. Du, Y. Zhang, and W. Cai, "An improved economic-based nonlinear model predictive control strategy for the crude oil distillation process," Can. J. Chem. Eng., vol. 96, no. 11, pp. 2408–2419, 2018.

[13] W. Muhsin and J. Zhang, "Modelling and optimal operation of a crude oil hydrotreating process with atmospheric distillation unit utilizing stacked neural networks," in Computer Aided Chemical Engineering, Elsevier, 2017, pp. 2479–2484.

[14] S. Nalinakshan, V. Sivasubramanian, V. Ravi, A. Vasudevan, M. S. R. Sankar, and K. Arunachalam, "Progressive crude oil distillation: An energy-efficient alternative to conventional distillation process," Fuel, vol. 239, pp. 1331–1337, 2019.

[15] D. C. López C, L. J. Hoyos, C. A. Mahecha, H. Arellano-Garcia, and G. Wozny, "Optimization model of crude oil distillation units for optimal crude oil blending and operating conditions," Ind. Eng. Chem. Res., vol. 52, no. 36, pp. 12993–13005, 2013.

[16] C. Yan, L. Lv, S. Wei, A. Eslamimanesh, and W. Shen, "Application of retrofitted design and optimization framework based on the exergy analysis to a crude oil distillation plant," Appl. Therm. Eng., vol. 154, no. June 2018, pp. 637–649, 2019, doi: 10.1016/j.applthermaleng.2019.03.128.

[17] Z. N. Izyan and M. Shuhaimi, "Exergy analysis for fuel reduction strategies in crude distillation unit," Energy, vol. 66, pp. 891–897, 2014.

[18] M. A. Waheed and A. O. Oni, "Performance improvement of a crude oil distillation unit," Appl. Therm. Eng., vol. 75, pp. 315–324, 2015.

[19] K. Yang, S. Liu, C. He, B. Zhang, Q. Chen, and M. Pan, "Improving energy saving of crude oil distillation units with optimal operations," J. Clean. Prod., vol. 263, p. 121340, 2020.

[20] A. L. Mashi and A. Sani, "ENHANCED DIESEL PRODUCTION VIA MODELLING AND SIMULATION OF CRUDE DISTILLATION UNIT II OF KADUNA REFINING AND PETROCHEMICAL COMPANY," FUDMA J. Sci., vol. 4, no. 1, pp. 383–388, 2020.

[21] M. Kishk, W. M. El-Maghlany, A. Attia, and Y. A. Eldrainy, "Investigation of the Opportunity of Heat Integration in a CDU in Egypt," Int. Energy J., vol. 22, no. 4, 2022.

[22] P. A. Martin, A. C. Zanin, and D. Odloak, "Integrating real time optimization and model predictive control of a crude distillation unit," Brazilian J. Chem. Eng., vol. 36, pp. 1205–1222, 2019.

[23] W. M. Shehata, M. I. Mohamed, and F. K. Gad, "Optimal pre-flash drum pressure and optimal inlet tray for pre-flashing vapor in a crude distillation unit".

[24] A. F. Jumaah, A. A. Amooey, and S. R. Nabavi, "Simulation Multi-Objective Particle Swarm Optimization of a Crude Oil Distillation Unit," Chem. Eng. Technol., vol. 46, no. 2, pp. 270–278, 2023.

[25] W. Muhsin and J. Zhang, "Multi-Objective Optimization of a Crude Oil Hydrotreating Process with a Crude Distillation Unit Based on Bootstrap Aggregated Neural Network Models," Processes, vol. 10, no. 8, p. 1438, 2022.

[26] A. Isah, O. Azeez, D. Kolo, I. Mohammed, and K. Onifade, "Pinch analysis of crude distillation unit using the HINT software and comparison with nonlinear programming technique," Authorea Prepr., 2020.

[27] A. N. Khalaf, "Steady state simulation of Basrah crude oil refinery distillation unit using aspen hysys," Univ. Thi-Qar J. Eng. Sci., vol. 9, no. 2, pp. 29–39, 2018.

[28] M. A. Samborskaya, I. A. Gryaznova, and A. V. Volf, "Pre-design optimization of crude oil distillation flowsheet," Procedia Chem., vol. 15, pp. 134–142, 2015.

[29] M. Ledezma-Martínez, M. Jobson, and R. Smith, "Simulation–optimization-based design of crude oil distillation systems with preflash units," Ind. Eng. Chem. Res., vol. 57, no. 30, pp. 9821–9830, 2018.

[30] M. Ledezma-Martínez, M. Jobson, and R. Smith, "A new optimization-based design methodology for energy-efficient crude oil distillation systems with preflash units," Chem. Eng., vol. 69, 2018.

[31] S. M. Ali, H. S. Moshref, H. A. Mohammed, Z. M. Shakor, and S. Mohmud, "Studies and Modeling for Upgrading Units for Heavy Oil Refineries," J. Pet. Res. Stud., vol. 8, no. 2, pp. 240–255, 2018.

[32] F. KAMIŞLI and A. A. Ahmed, "Simulation and Optimization of A Crude Oil Distillation Unit," Turkish J. Sci. Technol., vol. 14, no. 2, pp. 59–68, 2019.

[33] C. Patrascioiu and M. Jamali, "Crude distillation process simulation using Unisim Design simulator," Int. J. Chem. Mol. Eng., vol. 12, no. 7, pp. 340–346, 2018.

[34] L. T. Popoola, J. A. Adeniran, and S. O. Akinola, "Investigations into optimization models of crude oil distillation column in the context of feed stock and market value," Adv. Chem. Eng. Sci., vol. 2, pp. 1–7, 2012.

[35] M. Arjmand, L. Moreno, and L. Liu, "Energy saving in crude oil atmospheric distillation columns by modifying the vapor feed inlet tray," Chem. Eng. Technol., vol. 34, no. 8, pp. 1359–1367, 2011.

[36] A. M. Doust, F. Shahraki, and J. Sadeghi, "Simulation, control and sensitivity analysis of crude oil distillation unit," J. Pet. Gas Eng., vol. 3, no. 6, pp. 99–113, 2012.

[37] M. Gadalla, D. Kamel, and F. Ashour, "A new optimization based retrofit approach for revamping an Egyptian crude oil distillation unit," Energy Procedia, vol. 36, pp. 454–464, 2013.

[38] M. A. Gadalla, O. Y. Abdelaziz, D. A. Kamel, and F. H. Ashour, "A rigorous simulation-based procedure for retrofitting an existing Egyptian refinery distillation unit," Energy, vol. 83, pp. 756–765, 2015.

[39] W. Gu, K. Wang, Y. Huang, B. Zhang, Q. Chen, and C. Hui, "Energy optimization for a multistage crude oil distillation process," Chem. Eng. Technol., vol. 38, no. 7, pp. 1243–1253, 2015.

[40] L. Q. Minh, P. L. T. Duong, and M. Lee, "Global sensitivity analysis and uncertainty quantification of crude distillation unit using surrogate model based on Gaussian process regression," Ind. Eng. Chem. Res., vol. 57, no. 14, pp. 5035–5044, 2018.

[41] N. Seegulam, F. Coletti, and S. Macchietto, "Effect of Fouling on Control and Energy Recovery in an Industrial CDU Column," in Computer Aided Chemical Engineering, Elsevier, 2017, pp. 1555–1560.

[42] N. Shankar, V. Sivasubramanian, and K. Arunachalam, "Steady state optimization and characterization of crude oil using Aspen HYSYS," Pet. Sci. Technol., vol. 34, no. 13, pp. 1187–1194, 2016.

[43] B. Shi, X. Yang, and L. Yan, "Optimization of a crude distillation unit using a combination of wavelet neural network and line-up competition algorithm," Chinese J. Chem. Eng., vol. 25, no. 8, pp. 1013–1021, 2017.

[44] D.-C. López, C.-A. Mahecha, L.-J. Hoyos, L. Acevedo, and J.-F. Villamizar, "Optimization model of a system of crude oil distillation units with heat integration and metamodeling," CT&F-Ciencia, Tecnol. y Futur., vol. 3, no. 5, pp. 159–173, 2009.

[45] A. S. Yamashita, A. C. Zanin, and D. Odloak, "Tuning the model predictive control of a crude distillation unit," ISA Trans., vol. 60, pp. 178–190, 2016.

[46] Y. Kumar, "Corrosion of Top Pump around (TPA) exchangers in Crude Distillation Unit and its remedial measures".

[47] S. Kumar and A. Mhetre, "A new crude processing method for increasing distillate yield and energy efficiency of the crude distillation unit," 2019.

[48] P. Schempp, S. Köhler, M. Menzebach, K. Preuss, and M. Tröger, "Corrosion in the crude distillation unit overhead line: Contributors and solutions," in Proceedings of the European corrosion congress, 2017.

[49] M. R. Hamoudi, A. A. Hamooudi, and B. M. Ali, "Corrosion mitigation in crude oil process by implementation of desalting unit in Erbil refinery," ASRJETS, vol. 36, no. 1, pp. 224–241, 2017.

[50] Y. Xu, L. Zhang, G. Cui, and Q. Yang, "A heuristic approach to design a cost-effective and low-CO2 emission synthesis in a heat exchanger network with crude oil distillation units," Energy, vol. 271, p. 126972, 2023.

[51] S. Kumar and A. S. Mhetre, "Comparative techno-economic evaluation of potential processing schemes for petroleum crude oil distillation," Results Eng., vol. 14, p. 100480, 2022.

[52] M. A. Al-Mayyahi, A. F. A. Hoadley, and G. P. Rangaiah, "Energy optimization of crude oil distillation using different designs of pre-flash drums," Appl. Therm. Eng., vol. 73, no. 1, pp. 1204–1210, 2014.

[53] Y. H. Kim, "An Energy-Efficient Crude Distillation Unit with a Prefractionator," Chem. Eng. Technol., vol. 40, no. 3, pp. 588–597, 2017.

[54] H. K. Mohanta and A. K. Pani, "Support vector regression modeling in recursive just-in-time learning framework for adaptive soft sensing of naphtha boiling point in crude distillation unit," Pet. Sci., vol. 18, no. 4, pp. 1230–1239, 2021.

[55] D. K. Fayruzov, Y. N. Bel'kov, D. V Kneller, and A. Y. Torgashov, "Advanced process control system for a crude distillation unit. A case study," Autom. Remote Control, vol. 78, pp. 357–367, 2017.