

**SCHEDULING OF UPSTREAM AND DOWNSTREAM
OPERATIONS IN CRUDE OIL REFINERY**

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**SCHEDULING OF UPSTREAM AND DOWNSTREAM
OPERATIONS IN CRUDE OIL REFINERY**

by

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submitted

*in fulfilment of the requirements of the degree of Doctor of Philosophy
to the*



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Certificate

This is to certify that the thesis titled “Scheduling of upstream and downstream operations in crude oil refinery” being submitted by Mr Feleke Bayu in the Department of Chemical Engineering, Indian Institute of Technology Delhi, for the award of the degree of Doctor of Philosophy, in Chemical Engineering, is a record of the original, bonafide research work carried out by him under our guidance and supervision. In our opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree. The results contained in this thesis have not been submitted for the award of any other degree, associateship or similar title of any university or institute.

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Abstract

Global consumption of crude oil has been growing on average by 1.2 % annually for the last 10 years and has reached around 95 million barrels per day in the year 2018. The viability of refinery and the impact of the refinery to the environment mainly depend on the choice of crude oil, the refinery configuration, the desired product quality and types, and the environmental regulations. The lighter and sweeter the crude oil is, the more expensive the cost will be, but it requires less refinery upgrading and minimal disposal of wastes to the environment. However, the supply of such crude oil is decreasing, and the refinery process is becoming more complex to handle the heavy and poor-quality crude oils.

Desalting is one of the operations that became an integral part of the refinery in the last few decades. Moreover, targeting and maximizing economically more relevant product such as gasoline has become the strategy of refinery operations. Scheduling of crude refinery is crucial to maximizing the profitability of refinery without compromising the environmental regulations, the product quality and customer demand. However, the difficulty to handle the nonlinearities and multiple criteria naturally existing in the scheduling of refinery operations, particularly in the scheduling of gasoline blending and distribution (SGBD) has remained unresolved. Besides, gasoline blending is a dynamic process due to its susceptibility to seasonal, geopolitical and socioeconomic conditions. Nowadays, to increase the use of renewable energy sources in gasoline, several nations are targeting ethanol as a blendstock in gasoline blending. However, few studies are reported on scheduling the blending of ethanol in gasoline.

In the present study, a mathematical model that incorporates desalting as a separate task and that allows a desalting tank to feed multiple distillation units is formulated to schedule the crude oil

operation. The model is based on state task network (STN) formulation using a unit-specific event-based time representation.

Subsequently, a graphical genetic algorithm (GGA) based model involving a discrete-time representation is developed for both single- and multi-objective SGBD. In the single-objective formulation, the production cost is minimized, whereas, in the multi-objective formulation, the sum of the square of fluctuation in inter-period blending rate is additionally minimized. Further, the study is extended to formulate continuous time based graphical genetic algorithm model for both single and multi-objective in SGBD. The model uses the global event-based continuous-time representation. The proposed model is used to solve three industrial problems. Lastly, the continuous-time GGA model is used to handle demand uncertainty for bio-fuel surrogated gasoline. Minimizing the total production cost is the first objective in the single-objective optimization while minimizing the Reid vapour pressure inter-event fluctuation of the biofuel-gasoline blend is the additional objective in the multi-objective optimization. Four industrial problems involving biofuels (ethanol/ethanol-butanol blend) are solved to demonstrate the efficacy of the model.

सार

कच्चे तेल की वैश्विक खपत पिछले 10 वर्षों से औसतन 1.2% सालाना बढ़ रही है और वर्ष 2018 में प्रति दिन लगभग 95 मिलियन बैरल तक पहुंच गई है। रिफाइनरी की व्यवहार्यता और रिफाइनरी का पर्यावरण पर प्रभाव मुख्य रूप से निर्भर करता है। कच्चे तेल की पसंद, रिफाइनरी कॉन्फ़िगरेशन, वांछित उत्पाद की गुणवत्ता और प्रकार, और पर्यावरणीय नियम। कच्चा तेल जितना हल्का और मीठा होगा, लागत उतनी ही महंगी होगी, लेकिन इसके लिए कम रिफाइनरी उन्नयन और पर्यावरण के लिए कचरे का न्यूनतम निपटान आवश्यक है। हालांकि, ऐसे कच्चे तेल की आपूर्ति कम हो रही है, और भारी और खराब गुणवत्ता वाले कच्चे तेल को संभालने के लिए रिफाइनरी प्रक्रिया अधिक जटिल होती जा रही है।

Desalting एक ऑपरेशन है जो पिछले कुछ दशकों में रिफाइनरी का एक अभिन्न अंग बन गया है। इसके अलावा, गैसोलीन जैसे आर्थिक रूप से अधिक प्रासंगिक उत्पाद को लक्षित और अधिकतम करना रिफाइनरी संचालन की रणनीति बन गई है। पर्यावरण नियमों, उत्पाद की गुणवत्ता और ग्राहक की मांग से समझौता किए बिना रिफाइनरी की लाभप्रदता को अधिकतम करने के लिए कच्चे रिफाइनरी का निर्धारण महत्वपूर्ण है। हालांकि, रिफाइनरी संचालन के समय निर्धारण में, विशेष रूप से गैसोलीन सम्मिश्रण और वितरण (एसजीबीडी) के समय-निर्धारण में स्वाभाविक रूप से मौजूद असमानताओं और कई मानदंडों को संभालने की कठिनाई अनसुलझी रह गई है। इसके अलावा, मौसमी, भू-राजनीतिक और सामाजिक आर्थिक स्थितियों के लिए संवेदनशीलता के कारण गैसोलीन सम्मिश्रण एक गतिशील प्रक्रिया है। आजकल, गैसोलीन में नवीकरणीय ऊर्जा स्रोतों के उपयोग को बढ़ाने के लिए, कई राष्ट्र गैसोलीन सम्मिश्रण में एक मिश्रण के रूप में इथेनॉल को लक्षित कर रहे हैं। हालांकि, गैसोलीन में इथेनॉल के सम्मिश्रण के बारे में कुछ अध्ययनों में बताया गया है।

वर्तमान अध्ययन में, एक गणितीय मॉडल जो डिसाल्टिंग को एक अलग कार्य के रूप में शामिल करता है और जो एक डिवेल्टिंग टैंक को कई आसवन इकाइयों को खिलाने की अनुमति देता है, कच्चे तेल के संचालन

को निर्धारित करने के लिए तैयार किया जाता है। मॉडल एक यूनिट-विशिष्ट इवेंट-आधारित समय प्रतिनिधित्व का उपयोग करते हुए राज्य कार्य नेटवर्क (एसटीएन) फॉर्मूलेशन पर आधारित है।

इसके बाद, एक असतत-समय प्रतिनिधित्व वाले एक ग्राफिकल आनुवंशिक एल्गोरिथ्म (GGA) आधारित मॉडल को एकल और बहु-उद्देश्य SGBD दोनों के लिए विकसित किया गया है। एकल-उद्देश्य निर्माण में, उत्पादन लागत कम से कम होती है, जबकि बहु-उद्देश्यीय निर्माण में, अंतर-अवधि सम्मिश्रण दर में उतार-चढ़ाव के वर्ग का योग इसके अतिरिक्त कम से कम होता है। इसके अलावा, अध्ययन SGBD में एकल और बहुउद्देश्यीय दोनों के लिए निरंतर समय आधारित ग्राफिकल आनुवंशिक एल्गोरिथ्म मॉडल तैयार करने के लिए बढ़ाया गया है। मॉडल वैश्विक घटना-आधारित निरंतर-समय प्रतिनिधित्व का उपयोग करता है। प्रस्तावित मॉडल का उपयोग तीन औद्योगिक समस्याओं को हल करने के लिए किया जाता है। अंत में, निरंतर समय GGA मॉडल का उपयोग जैव ईंधन सरोगेट गैसोलीन के लिए अनिश्चितता की मांग को संभालने के लिए किया जाता है। कुल उत्पादन लागत को कम करना एकल-उद्देश्य अनुकूलन में पहला उद्देश्य है जबकि जैव-गैसोलीन-गैसोलीन मिश्रण के रीड वाष्प दबाव अंतर-घटना उतार-चढ़ाव को कम करना बहु-उद्देश्यीय अनुकूलन में अतिरिक्त उद्देश्य है। मॉडल की प्रभावकारिता को प्रदर्शित करने के लिए जैव औद्योगिक (इथेनॉल / इथेनॉल-ब्यूटेनॉल मिश्रण) से जुड़ी चार औद्योगिक समस्याओं का समाधान किया जाता है।

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