NEW FUZZY PARAMETRIC LINEAR PROGRAMMING APPROACHES FOR OPTIMISING THE PERFORMANCE OF CRUDE OIL COMPANIES IN IRAQ

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UNIVERSITI SAINS MALAYSIA

2023

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by

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**Thesis submitted in fulfilment of the requirements
for the degree of
Doctor of Philosophy**

January 2023

ACKNOWLEDGEMENT

I would like to thank Allah, most gracious, most merciful and the creator, for without his help this thesis would never have existed. Also, I would like to express my sincere gratitude to my main supervisor Dr. Siti Amirah binti Abd Rahman. And thanks for my Co-supervisors Dr. Noor Saifurina binti Nana Khurizan and Dr. Norazrizal Aswad Abdul Rahman. Through they role as a supervisors and mentor, they has had a tremendous influence on both my professional and personal development. Without them guidance and encouragement, this thesis would not have been possible. It is my honour to become one of them students. And also I would like to express my sincere gratitude to my previous main supervisor, Assoc. Prof. Adam bin Baharum, and thanks for my field-supervisor Dr. Ammar Al-Bazi. Most importantly, they has dedicated precious time and energy to provide countless contributions in the shaping of this thesis. I am very grateful for them support and patience throughout my Ph.D work. Moreover, I had to take the help and guideline of some respected persons, who deserve our greatest gratitude; Dr. Rabha Waell Ibrahim, for what she gave me advice, guidance and direction. Thanks to all my friends too, especially those who have provided helpful suggestions and encouragements. I especially thank all of the brothers, Engineer Aqeel Hamdi Khammas and Taief Hameed Mansur, for their unlimited support me throughout my school years. Special thanks to Dr. Zaid Alyasseri for providing me the guidance needed in using Matlab Software. I am grateful to my wife Iman for believe and encouraging me all time, grateful to my beloved's daughters Zahraa, Zainab, and my son Mahdi for their patience. Thanks to my parents and my brothers and sisters for their affection. Without my family, this work would never have come into existence.

And I would like to thanks assistant chief engineer Idrees Mohammed Jasim and engineer Ali Barry Jaleel for their unlimited cooperation to provide me with the necessary data and explain it to me in midland refineries company under the study. I would also like to acknowledge all the faculty members of the School of Mathematical Sciences, Universiti Sains Malaysia for their cooperation and support whenever needed. A warm appreciation to all my friends especially fellow Ph.D students at the School of Mathematical Sciences, USM for their constant advice and sharing of knowledge.

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LIST OF SYMBOLS

$\Delta_{t(SF)}^{\rho}$	Fuzzy demand for production ρ in month t by spread function
$\Delta_{t(F\ and\ E)}^{\rho}$	Fuzzy demand for production ρ in month t by fractal and entropy
C	Selling cost
δ	Variance determined by the cost
δ_d	The spread function defined as a variance caused by selling prices
δ_C	The spread function defined as a variance caused by production yields
$\sigma(t)$	Probability density function
$\mathrm{BC}_{(SF)}$	Fuzzy buying cost given by spread function
$\mathrm{BC}_{(F\ and\ E)}$	Fuzzy buying cost given by fractal and entropy
$\mathrm{PC}_{(SF)}$	Fuzzy manufacture cost given by spread function
$\mathrm{PC}_{(F\ and\ E)}$	Fuzzy manufacture cost given by fractal and entropy
$\mathrm{IC}_{(SF)}$	Fuzzy inventory cost given by spread function
$\mathrm{IC}_{(F\ and\ E)}$	Fuzzy inventory cost given by fractal and entropy
$\mathrm{MC}_{(SF)}$	Fuzzy management cost given by spread function
$\mathrm{MC}_{(F\ and\ E)}$	Fuzzy management cost given by fractal and entropy
$\mathrm{TC}_{(SF)}$	Fuzzy transportation cost given by spread function
$\mathrm{TC}_{(F\ and\ E)}$	Fuzzy transportation cost given by fractal and entropy
φ	Refinery such that $\varphi = 1, \ldots, \Phi$
ρ	The item of production such that $\rho = 1, \ldots, P$
χ_i	The resources $i = 1, \ldots, n$
t	The time per month such that $t = 1, \ldots, \mathfrak{T}$
$\jmath$	The category of oil $\jmath = 1, \ldots, J$

$\overline{M}^{\rho}_{\varphi,t_{(SF)}}$	The maximum monthly yield of ρ in t from refinery φ given by spread function
$\overline{M}^{\rho}_{\varphi,t_{(F\ and\ E)}}$	The maximum monthly yield of ρ in t from refinery φ given by fractal and entropy
$\underline{M}^{\rho}_{\varphi,t_{(SF)}}$	The minimum monthly yield of ρ in t from refinery φ given by spread function
$\underline{M}^{\rho}_{\varphi,t_{(F\ and\ E)}}$	The minimum monthly yield of ρ in t from refinery φ given by fractal and entropy
$\underline{B}^{J}_{t\ (SF)}$	The minimum monthly buying oil type J in t given by spread function
$\underline{B}^{J}_{t\ (F\ and\ E)}$	The minimum monthly buying oil type J in t given by fractal and entropy
$\overline{\top}^{\rho}_{\varphi,t_{(SF)}}$	The maximum transportation amount of ρ in t from φ given by spread function
$\overline{\top}^{\rho}_{\varphi,t_{(F\ and\ E)}}$	The maximum transportation amount of ρ in t from φ given by fractal and entropy
$\chi^{J}_{t(SF)}$	The buying cost of oil type J in t by spread function
$\chi^{J}_{t(F\ and\ E)}$	The buying cost of oil type J in t by fractal and entropy
♭	The fuzzy buying cost of oil type J in t
$\Theta^{\rho}_{\varphi,t(SF)}$	The quantity of product ρ from φ in month t by spread function
$\Theta^{\rho}_{\varphi,t(F\ and\ E)}$	The quantity of product ρ from φ in month t by fractal and entropy
$\wp$	The fuzzy quantity of ρ from φ in month t
$I^{\rho}_{\varphi,t(SF)}$	The inventory of ρ from φ in month t by spread function
$I^{\rho}_{\varphi,t(F\ and\ E)}$	The inventory of ρ from φ in month t by fractal and entropy
ι	The fuzzy inventory of ρ from φ in month t
$\top^{\rho}_{\varphi,t_{(SF)}}$	The amount transportation of product ρ from φ in month t given by spread function
$\top^{\rho}_{\varphi,t_{(F\ and\ E)}}$	The amount transportation of product ρ from φ in month t given by fractal and entropy
τ	The fuzzy value of item transportation ρ from φ in month t

$\lambda \geq 0$ The main parameter in the parameter spaces

$\lambda \in (0,1)$ The fractal parameter

$\Pi_{t_{(SF)}}$ The total net revenue in month t given by spread function

$\Pi_{t_{(F\ and\ E)}}$ The total net revenue in month t given by fractal and entropy

$\overline{\mathrm{B}}\mathrm{C}_{t_{(SF)}}$ Total BC in month t given by spread function

$\overline{\mathrm{B}}\mathrm{C}_{t_{(F\ and\ E)}}$ Total BC in month t given by fractal and entropy

$\overline{\mathrm{P}}\mathrm{C}_{t_{(SF)}}$ Total PC in month t given by spread function

$\overline{\mathrm{P}}\mathrm{C}_{t_{(F\ and\ E)}}$ Total PC in month t given by fractal and entropy

$\overline{\mathrm{I}}\mathrm{C}_{t_{(SF)}}$ Total IC in month t given by spread function

$\overline{\mathrm{I}}\mathrm{C}_{t_{(F\ and\ E)}}$ Total IC in month t given by fractal and entropy

$\overline{\mathrm{M}}\mathrm{C}_{t_{(SF)}}$ Total MC in month t given by spread function

$\overline{\mathrm{M}}\mathrm{C}_{t_{(F\ and\ E)}}$ Total MC in month t given by fractal and entropy

$\overline{\mathrm{T}}\mathrm{C}_{t_{(SF)}}$ Total TC in month t given by spread function

$\overline{\mathrm{T}}\mathrm{C}_{t_{(F\ and\ E)}}$ Total TC in month t given by fractal and entropy

LIST OF ABBREVIATIONS

FEFLP	Fractional Entropy Fuzzy Linear Programming
FLP	Fuzzy Linear Programming
FFLP	Fractal Fuzzy Linear Programming
TFN	Triangular Fuzzy Numbers
LP	Linear Programming
NLP	Non-Linear Programming
ILP	Integer Linear Programming
MILP	Mixed Integer Linear Programming
MINLP	Mixed Integer Non-Linear Programming
PFLP	Parametric Fuzzy Linear Programming
SFs	Spread Functions
SF_1	Spread Functions by using the ln method
SF_2	Spread Functions by using the variance method
STFNs	Symmetric Triangular Fuzzy Numbers
IPC	Iraqi Petroleum Company
IMRC	Iraqi Midland Refineries Company
ln	Natural Logarithm
3D	Three-Dimensional

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PENDEKATAN BARU PENGATURCARAAN LINEAR PARAMETRIK KABUR UNTUK MENGOPTIMUMKAN PRESTASI SYARIKAT MINYAK MENTAH DI IRAQ

ABSTRAK

Industri loji penapisan dan minyak mentah merupakan antara penjana hasil terpenting negara pengeluar minyak. Iraq merupakan antara negara pengeksport minyak. Walaupun ia mempunyai banyak kilang penapisan untuk memproses dan menapis minyak mentah, ia mengalami krisis pengeluaran teruk yang merosakkannya dari semasa ke semasa. Kajian ini bertujuan untuk mengoptimumkan penjadualan, perancangan pengeluaran dan kawalan inventori kilang penapisan berbilang tapak yang terletak di Iraq. Sampel kajian diperoleh dari *Iraqi Midland Refineries* (IMR) dari syarikat *Iraqi Petroleum Company* (IPC), yang merangkumi empat kilang penapisan yang terletak di empat tapak berbeza di Iraq. Dalam penyelidikan ini, pendekatan berbeza berdasarkan teori set kabur dianggap sebagai permintaan, manakala kos dijelaskan sebagai kabur. Masalah pengaturcaraan linear kabur parametrik (PFLP) dicadangkan berdasarkan nombor kabur segi tiga simetri (STFNs). Secara teknikalnya, model ini melibatkan tiga kaedah. Kaedah pertama menggunakan konsep Fungsi Taburan (SF). Kami menggunakan dua fungsi SF yang berbeza untuk mencari nilai parameter λ dan memaksimumkan model PFLP. Kaedah kedua adalah berdasarkan analisis fraktal, yang mana kuasa pecahan fraktal λ adalah parameter yang digunakan dalam kajian kami. Akhir sekali, kaedah ketiga adalah berdasarkan entropi Tsallis pecahan dengan tertib λ. Keputusan menunjukkan bahawa model yang telah dibangunkan boleh menyampaikan maklumat berharga kepada pendekatan pengeluaran keuntungan maksimum untuk menilai penapisan

minyak dalam tetapan kabur parametrik. Kebanyakan masalah yang dihadapi oleh kilang-kilang penapisan minyak di Iraq yang sedang dikaji adalah dilindungi, dan masalah pengeluaran di kilang penapisan minyak Iraq diselesaikan berdasarkan keadaan luar biasa yang sedang dilalui oleh negara tersebut. Semua pengiraan kami dikodkan menggunakan perisian MATLAB.

NEW FUZZY PARAMETRIC LINEAR PROGRAMMING APPROACHES FOR OPTIMISING THE PERFORMANCE OF CRUDE OIL COMPANIES IN IRAQ

ABSTRACT

Refineries and crude oil industries are amongst the most important revenue generators of oil-producing countries. Iraq is an oil-exporting country. Although it has many refineries to process and refine crude oil, it suffers from severe production crises that ravage it from time to time. This study aims to optimise the scheduling, production planning and inventory control of multisite refineries located in Iraq. The study sample was taken from the Iraqi Midland Refineries (IMR) of the Iraqi Petroleum Company (IPC) company, which includes four refineries in four different sites in Iraq. In this research, different approaches based on fuzzy set theory are considered as demand and cost are explained as fuzzy. The parametric fuzzy linear programming (PFLP) problem is suggested on the basis of symmetric triangular fuzzy numbers (STFNs). Technically, this model involves three methods. The first method utilises the concept of the Spread Function (SF). We utilise two different functions of SFs to find the parameter values of λ and maximise the PFLP model. The second method is based on fractal analysis, where the fractional power λ of the fractal is the parameter used in our study. Lastly, the third method is based on fractional Tsallis entropy of order λ. Results indicate that the established models can deliver valuable information to the maximal profit production approach to evaluate oil refineries in a parametric fuzzy setting. Majority of the problems faced by most Iraqi oil refineries under study are covered, and the production problem in Iraqi oil

refineries is solved on the basis of the abnormal conditions that the country is going through. All our computations are coded using MATLAB software.

CHAPTER 1

INTRODUCTION

1.1 General Information

This study investigates the problem of production planning and scheduling of petroleum products in multi-refineries in Iraq. A Parametric Fuzzy Linear Programming (PFLP) model is developed to determine an overall optimal production plan for the refineries. However, this proposal addresses the problem of production planning, and inventory control in multi-site oil refineries.

Several studies have been conducted in the field of optimisation of refineries using different approaches. Aburukba and El-Fakih (2018) suggested an integer linear programming model to minimise energy consumption. Lundgren and Persson (2002) proposed a mixed-integer linear programming (MILP) model to solve a problem concerning the planning and utilisation of a production process consisting of one distillation unit and two hydrotreatment units. Zheng and Zhang (2016) proposed an MILP model that addresses the problem of production management at a refinery. Menezes and Grossmann (2019) proposed a mixed-integer nonlinear programming (MINLP) formulation and then solved it by an iterative MILP-NLP decomposition scheme with domain reduction. Considering the scheduling and operations in a terminal for vessels and crude oil scheduling, Li and Qian (2009) improved an existing MILP model. They tested the improved model on a real-life scheduling problem of a petroleum refinery plant. Additionally, Castro and Mahalec (2017) stated that optimising scheduling is an effective algorithm to improve the profit of refineries by using the mixed integer nonlinear scheduling model to describe complex and nonlinear refining processes.

The smooth running of a refinery is crucial. This research addresses the problem of production planning and scheduling at four oil refineries located in a Middle Eastern country. In each refinery, crude oil is transformed into complete products and prepared for export and/or domestic consumption. The present study develops a mathematical optimisation model that considers the uncertain behaviour of demand and cost. The techniques in this research are proposed on the basis of fuzzy set theory because the environment of Iraqi industries fluctuates and is directly affected by the unstable political and economic situation. Generally, Iraqi industries suffer from the following uncertainties: uncertain market demand, fluctuating unit buying cost, varied unit production cost, varied unit inventory cost, varied unit transportation cost and varied unit management cost. The proposed model is used for the planning and scheduling of oil production from each refinery, either individually or combined. The present study suggests a new style of mathematical formulation, i.e. PFLP technique, which is based on the STFN and consequently the objective function. This model is applied on the oil market in Iraq. Additionally, the current study presents three solution methods to obtain global optimal or near-optimal solutions. It also studies the scheduling problem of crude-oil operations, thereby maximising the gross margin of crude-oil distillation. The proposed techniques can be applied to any refinery around the world.

1.2 The Motivation of Recent Research

Oil is considered an engine of the economic and development process. The petroleum refining industry plays a predominant role in the world economy. Given the increasing demand for petroleum products, the cost of crude oil extraction and the maintenance of these products soar. The availability and affordability of petroleum products and the export surplus of these products have become challenging. Therefore, in this research, the fuzzy demand and cost are explained. Hence, the need for integration and coordination between refineries emerged due to a shortage of companies containing four refineries in four different sites in a producer and oil-exporting country, such as Iraq.

The crude oil refining industry plays a vital role in the present world economic situation. Oil constitutes up to 42.3% of the overall energy usage worldwide. By contrast, the commercial industry represents 39% of the forecasted increase in global oil usage, typically in chemical and petrochemical procedures. About 50% of oil usage from 2003 to 2030 is expected to be consumed in the field of transportation. According to the International Energy Agency, the financial development and enhanced populace will maintain high international demand for such petroleum products in the near future (Analysis & Washington, 2006). Meeting such demand will require huge financial investments and appropriate optimisation tools for the tactical preparation of these productions. They enable systems to transform raw materials into fundamental parts, such as plastic, artificial rubber, asphalt and many beneficial industry products. Competitors in the industry are an additional pressing objective for companies to pursue approaches that can help them acquire a competitive edge, i.e. looking for possibilities to enhance their coordination and harmony (Porter, 2011). The advantages forecasted from the coordination of multisite refineries do not just concern supply but also address expenditures. These two levels are defined in coordination, specifically ‘multisite coordination’. The first class considers multisite coordination, generally addressing manufacturing planning problems. The second class integrates various tasks, such as supply, production and distribution. The research emphasised the importance of establishing and developing general and clear structures for multisite coordination (Kumar & Kawalek, 2018). Many previous research focused on limited supply chain networks and have not offered a comprehensive analysis of ventures (Essila, 2019). Moreover, they concentrated on coordinating the several system tiers of companies where less attention was offered to the structure to coordinate the exact same planning level at multisites through process network integration.

Nevertheless, in production planning, resources of system uncertainties can be classified as short-term, or long-term depending on the level of time perspective. Considering the high level of preparation decisions, particularly with the presence of an unstable market environment, requires uncertainties effect (Postma & Liebl, 2005). Long-term uncertainty might consist of supply and demand rate irregularity and changes in cost. The short-term uncertainties primarily describe functional variants, equipment failing, and so on (Elder & Zhou, 2019). In the context of production, planning can be considered to have an uncertainty in the left side transactions in different processes. Therefore, it is an important factor from uncertainty factors (Grossmann, 2005; Mula *et al*., 2006; Ebrahimnejad, 2017; Ramaraj, 2017).

Iglesias *et al*. (2019) proposed parametric analysis as the main instrument for studying trouble in optimisation issues. They used a PFLP technique to determine the optimal result, and the fuzzy optimal objective values of parameters were used as a function. By contrast, the fuzzy cost coefficients are confused laterally with an original fuzzy cost function. Stanojević and Stanojević (2020) proposed a parametric technique of the efficiency in a multiobjective linear programming (MOLP) problem to generate fuzzy set theory solutions.

The present study defines the coordination and scheduling problems of multisite refineries as follows:

i. development of integration and coordination of different sites and scheduling models of single-site and multisite refineries,
ii. modelling satisfies fuzzy constraints,
iii. development of efficient models to provide solution techniques for planning and scheduling problems.

The major advancement of this thesis is the scheduling of each refinery and then the integration and coordination of four refineries, considering constraints and inequalities along with fuzzy processing of demand quantities and production costs.

1.3 Aim of the Study

This study aims to develop a fuzzy set theory-based PFLP model, which can optimise oil production planning, scheduling and inventory control in multisite refineries in Iraq. By using this model, refinery integration problems can be solved on the basis of the STFN technique, which can reduce complexity in calculation. This model can assist in deciding the mode of operation to be used in each processing unit at any refinery to satisfy the demand quantities and production costs. In addition, this model can be applied to any refinery in the world.

1.4 Problem Statement

Many countries suffer from political situation volatility. For instance, Iraq is one of the countries in the Middle East that has suffered from economic crises due to unstable political situations. Consequently, many countries in this region get involved in internal and regional conflicts, which result in difficult economic situations. These abnormal conditions lead to shortages, obstacles and challenges in the Iraqi economy, which is dominated by the oil industry.

By studying the manufacturing processes in Iraqi oil refineries, specifically the IMR, we found uncertainties in cost and demand quantities, in addition to the absence of actual models to manage production operations during critical situations. Given the uncertainty in the demand and costs in the Iraqi market, a case was studied through field visits and encounters with officials, engineers and technicians to determine the challenges and reasons that lead to the failure of a company to complete production plans.

Through this study, we found a close link between the problems of uncertainty and the use of fuzzy models. Most of the methods used were promising and had good results. For instance, some used MINLP to improve their crude oil production processes. Hybrid problems for finding the optimal assignment were also used. Others used the integer programming model, along with many other methods and techniques, to decide which mode of operation to use in each processing unit at each point in time in an oil refinery process. We found that the fuzzy linear programming (FLP) model is more appropriate and most commonly used to solve uncertainty issues, as in the case of Iraqi refineries (Carlsson & Fullér, 1996; Fang, Hu, Wang, & Wu, 1999; Tanaka & Asai, 1984; Van Hop, 2007; H. F. Wang & Zheng, 2013b).

The problem is investigated in four refineries located at four different cities. These refineries produce several kinds of products along with different production capacities, where the IMR faces major challenges. The main problem in Iraqi refineries is the inability to supply the refineries with the electrical energy necessary for the continuity of the workflow. Without this important source, the refinery cannot work, and accordingly, production will stop, causing substantial loss, especially in the periods of July–August and December–January, according to actual data (see Figures 1.1 and 1.2).

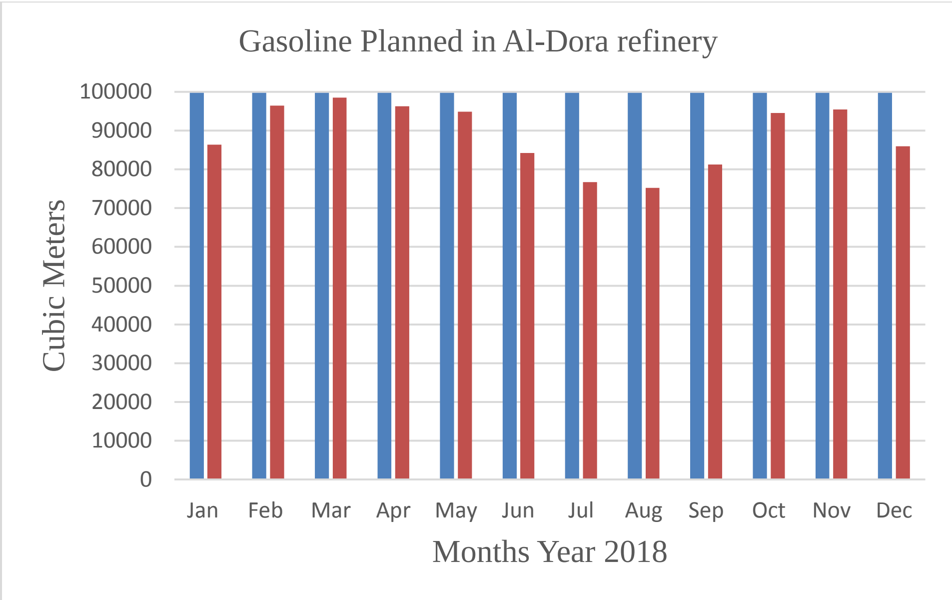


Figure 1.1 Illustrate behaviour of real data for Gasoline product in AL-Dora refinery

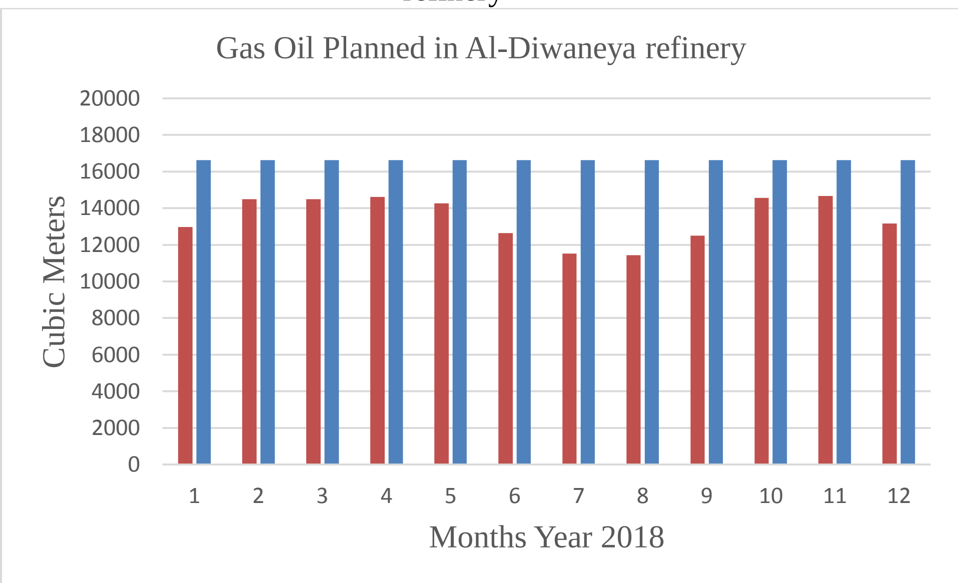


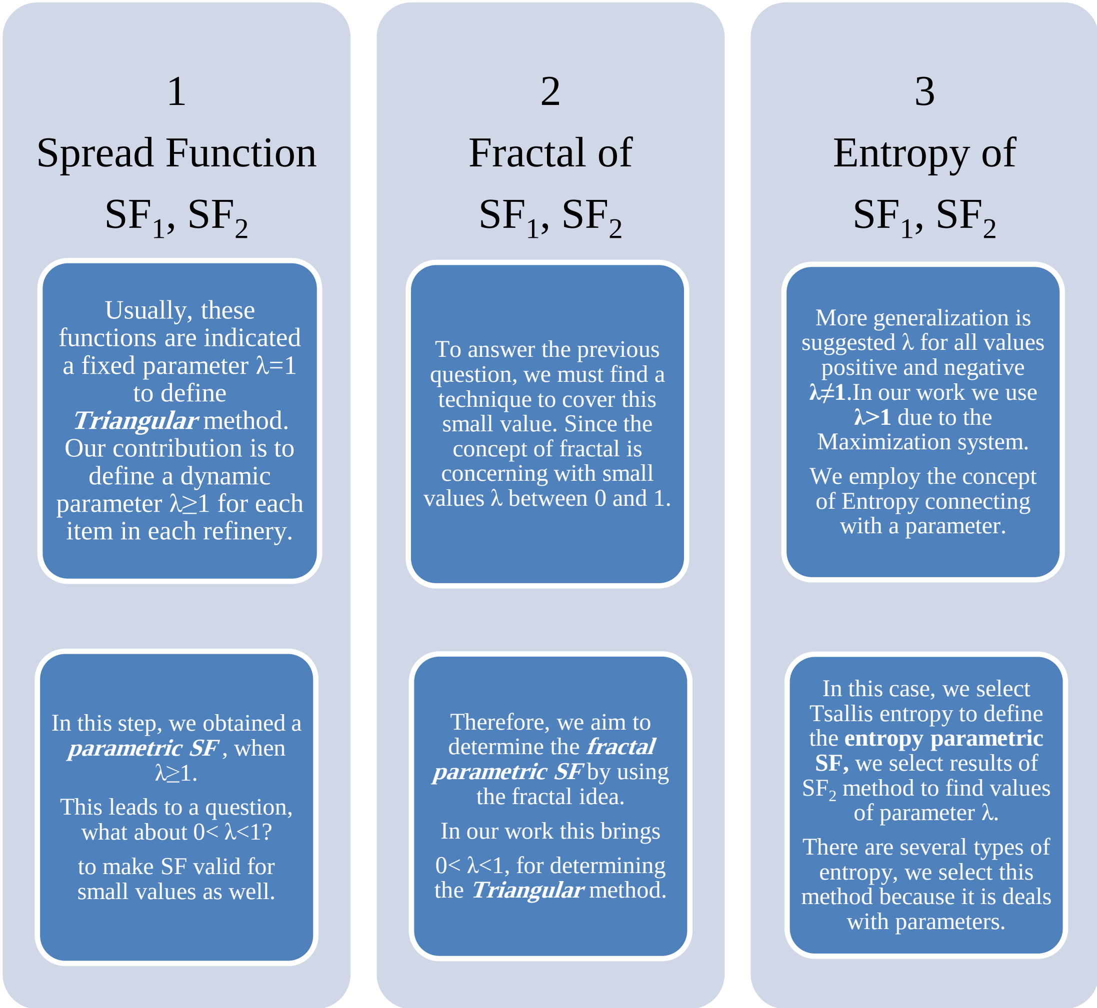
Figure 1.2 Illustrate behaviour of real data for Gas Oil product in AL- Diwaniya refinery

Planned
Actual production

We classify this problem in the management category (e.g. buying new generators, fixing old equipment, buying some necessary implementation, technicians' salaries to annual checking, etc). To cover this issue, we must maximise the other categories, such as production costs, management costs, buying costs, transportation costs, inventory costs and demand quantities. Then, questions, such as 'What is the system that corresponds to such a problem to obtain the best solution?' and 'What kind of parameters are suitable for the problem?' emerge. Only then is it possible to compare the results that will be obtained through the techniques used to solve this problem. For this reason, we indicate that the operation must be developed on the basis of a new mathematical modelling technique by using STFNs to reduce complexity in calculation.

Therefore, we use a parametric fuzzy concept to obtain the optimal solution, and we apply the three techniques of parametric spaces. The main processes in this thesis are a new concept called parametric SF in three techniques, i.e. dynamic, fractal and entropy. The normal distribution is attached to the triangle, the fractal technique is generalised into a fuzzy triangle, and then the entropy technique is generalised into a fuzzy triangle to solve the problems of refineries in Iraq. Next workflow illustrates the streamlining workflow sequence of the techniques used in the thesis and their relationships.

Workflow sequence and the reasons that led to the use of the proposed techniques



Following from here, we have the following objectives.

1.5 Research Objectives

The objectives of this research are listed as follows:

1. To construct STFNs from data collected from IMR company by using techniques of Spread Function, Fractal operator and fractional Entropy.
2. To construct a fuzzy multi-objective linear programming from constructed STFNs to reduce complexity in calculation.

3. To obtain the optimal solution for the IMR company by using different types of fuzzification parameters.
4. To perform comparison between solutions obtained by using the suggested three techniques.

1.6 Scope of Study

The refineries are crucial in this time because they execute certain types of operations and jobs required to process with a variance of operations. The fuzzy set theory, along with the Parametric Fuzzy Linear Programming (PFLP) technique, was used to find the optimal production planning and scheduling of individual/combined refineries in Iraq to solve integration problems on the basis of the STFNs technique to reduce the complexity in calculation.

Generic optimisation models with fuzzy demand quantities and production costs were developed. The required data were then collected from the company under study to model the current workflow of operations. Additionally, it was reviewed in previous studies on planning and scheduling of petroleum production operations with consideration types of resource restrictions. This review included techniques that were used to optimise the scheduled operations of single and multiple refineries.

1.7 Limitation of this Study

An approachable and elastic manufacture scheduling system was industrialised to continue with indefinite external/internal manufacture conditions. Dynamics and the outcomes indicated that the industrialised system provides beneficial data to increase profit-effective oil refinery approaches in an indefinite sit-in. Therefore, the three suggested methods in this thesis can be used in different study cases including industry, financial and microeconomic systems. The parameters set brought a wide area of investigations based on the conditions of the cases. Overall, the parameter fuzzy value of lambda is an excellent tool in solving many problems, including the PFLP problem. The lambda is a short block of code which takes in fuzzifying parameters and returns a value. Lambda takes the shape λ and can be implemented right and direct in the equations according to certain conditions. This tool can be controlled to determine the parameters that can improve the looked-for system by testing the system in maximal or even in a minimal value.

A fuzzy multi-objective linear programming constructed from STFN was built on the basis fuzzy set theory. Data were collected from the Iraqi Midland Refineries (IMR) company. Then, the problems faced by the company were solved by using the SF, fractal operator and fractional entropy techniques. The results showed that the proposed methods were promising and satisfactory. SF_1 using the ln method was more sufficient and acceptable than SF_2 by variance method using the SF technique. In general, the fractal technique is maximised when $\lambda = 0.2$.

By using the concept of fuzzy triangle, the optimal solution was obtained through different parameters of lambda, which led to parametric fuzzy methods. Our development was adopted on numerous concepts in mathematics and statistics using the parametric spread function, fractal operator and fractional entropy techniques, in addition to making a comparison between the solutions obtained using different models.

1.8 Organisation of the Thesis

This thesis is divided into the five chapters and is organised as follows:

Chapter 1 provides a general introduction, the motivation of the research, the aim of the study, the problem statement and research objectives. Chapter 2 presents relevant works in FLP and a background of the petroleum industry. Chapter 3 deals with three types of parametric methodology, including the parametric SF, fractal operator with the parametric fractal power, and fractional entropy with the parametric fractional power. Chapter 4 presents the results of the case study. This chapter also shows numerical examples, discussion, conclusions and comparison between the solutions for the PFLP systems. Chapter 5 includes the modelling system, case study and future work recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Linear programming (LP) is a well-known optimisation method that uses decision-making assistance in numerous industries, financial institutions, service administrations and organisations. Programming problems can be categorised into two types: linear and nonlinear. Several of these problems must be indicated in the fuzzy point of view because in this situation, decision-makers have additional flexibility to model and resolve issues.

Tanaka and Asai (1984) firstly introduced fuzzy mathematical programming. Fuzzy linear programming (FLP) problems are not exclusive, and investigators recommend several formulas of FLP problems. To explain an FLP problem, fuzzy approaches have been extensively considered in recent decades. Amongst the numerous methods planned for explaining an FLP problem, the technique based on the concept of a judgement of fuzzy numbers by the support of ranking functions is one of the most suitable. Carlsson and Korhonen (1986) proposed a parametric method of FLP and showed that the proposed model parameterised in such a technique that the optimal solution is a function of precision outcomes.

Parameter spaces are the spaces of potential constraint values that explain a particular mathematical style, usually a subset of finite-dimensional Euclidean space. Frequently, the parameters are the function's inputs, in which case the practical term for the parameter space is the domain of a function. Parameter spaces can yield flexible strategies. Mathematical models offer various assessment techniques. Recovering product conception, as you can create with simple items with minimal information. Restored integration with downstream requests and summary engineering and managers cycle time.

Recently, researchers have investigated FLP using parametric analysis and parametric spaces. The term parametric fuzzy linear programming (PFLP) is utilised when the objective function coefficients and/or the right-hand fixed can differ with a parameter, such as λ. We constantly find a path in parametric analysis in which the accurate function gradient or the right-hand vector of the constraints is interrupted. Then, we attempt to evaluate the corresponding course of optimal solutions. Therefore, by disrupting either the objective coefficient path or the suitable side vector along a fixed line, we evaluate optimal solutions to a class of problems. Continuous shifts in parameters are investigated in three states: parameterising the objective function coefficients, the right-hand-side vector and all the parameters of objective function coefficients and the right-hand-side vector.

Payan and Noora (2014) offered a linearisation process to resolve the multiobjective linear fractional programming problem with fuzzy parameters. Soleimani and Hoseinpoor (2016) labelled the concept of parametric analysis in FLP, whereas the objective function measurements were parameterised. Ebrahimnejad (2017) introduced a study of parametric analysis as the primary tool for studying perturbations in optimisation issues. He delivered a PFLP to determine the optimal result and the fuzzy optimal objective values as parameters when the fuzzy cost coefficients are disconcerted in an original fuzzy cost function laterally. At the same time, Akbari and Asadollahi (2017) presented a partial PFLP method, which was extended later by Akbari & Hesamian (2019). Recently, Akbari and Chachi (2020) introduced a hybrid technique involving nonparametric kernel-based style and the least absolute method and suggested the parameters of the model and the fuzzy nonlinear function of the improvements. Stanojević and Stanojević (2020) suggested a parametric analysis of the effectiveness of a multiobjective LP problem to create a fuzzy set solution.

In this work, the methodology is based on a PFLP model. The parameter is selected from different recourses, including a generalisation by three techniques. The first technique, which uses PFLP in two ways of spread function (SF). In the first step, the parameters of λ are determined, taking the numbers of $\lambda_{(SF)} \geq 1$; it computes spaced intervals, and the optimal solution is calculated by using (i) the ln method and (ii) the variance method. The second technique uses the fractal fuzzy linear programming (FFLP) model. The effect parameters of λ are determined; it moves linearly (step by step) and take the numbers between zero and one, as shown in $0 < \lambda_{(fractal)} < 1$. The third technique uses the fractional entropy fuzzy linear programming (FEFLP) model, and this technique computes convergent steps, dealing with parameters of λ, where $\lambda_{(entropy)} > 1$. On the basis of the symmetric triangular fuzzy number and consequently the objective function, we apply the recommended oil marketing models in Iraq in accordance with parametric fuzzy set theory. The fuzzy demand and cost are clarified, and the models clasp a maximal profit production attitude with an evaluation.

In the first part, we introduce a technique of PFLP model based on the symmetric triangular fuzzy number and consequently the objective function. This model is intended to clasp a maximal profit production attitude with an evaluation. The significance indicates that the recognised models can bring valuable information for developing profit-effective oil refinery approaches in a parametric fuzzy setting.

In the second part, we illustrate that fractal derivatives are a subclass of the local fractional calculus for which the fractal measurement strictly exceeds the topological measurement. One method in which fractals vary from finite geometric facts is the mode in which they measure. This part suggests a new FFLP model founded by the symmetric triangular fuzzy number. Consequently, the objective function, an FFLP model, is projected to obtain the maximal profit production approach with an evaluation. The result shows that the standard model can bring valuable information for developing oil refinery methods in a parametric fuzzy situation (Naderi & Khalilpourazary, 2020).

In the third part, we discuss the entropy associated with the aggregate of supplementary information to identify the exact physical form of a system, prearranging its property specifications. For this purpose, it repeatedly yields that entropy is a communication of the disorder, parameter or randomness of a scheme or of the nonexistence of information about it. The notion of entropy shows a dominant role in information theory. Recently, many researchers have used the idea of fractional entropy to introduce the formula of fractional fuzzy entropy and use it to solve and develop different problems in complexity dynamics, computer science, communication studies and information theory (Tsallis, 1988 and He *et al*., 2018).

2.2 Process Description

Assessing the eligibility of the achievement and effect of industries, such as oil refineries, is of paramount importance. The global concern with externalities and internal political and global stability, especially in the Middle East, is increasing because of its considerable effect on the oil industry, which is the leading supplier of

Iraq's financial returns. The energy sector plays an essential strategic role in the Iraqi economy, requiring a continuous evaluation of oil refineries long-term efficiency.

As a result of the development of the oil industry and its derivatives globally and the increasing demand for its various products, this industry faces considerable changes and fluctuations. For example, crude oil prices fluctuate worldwide, whereas locally, the industry faces a weakness and lack of productive potential, especially that Iraq has been going through challenging stages since the US invasion in 2003. Using quantitative methods and managing production processes has emerged in oil refining facilities to represent an urgent need. These techniques have good and practical ability to analyse problems and design appropriate models after studying the obstacles and solving them in mathematical ways to reach optimal solutions. Moreover, production plans can be developed, thus helping management make optimal decisions.

The companies produce oil derivatives, which are one of the essential products. These products are an essential engine for many vital activities and other industries. Therefore, these companies must optimise their production lines to achieve the most considerable quantities with low cost and high quality to meet the need and come up with ways to develop them in the future.

To collect data, FLP was used for each refinery of the company under study (Midland Refineries Company) of the Iraqi Ministry of Oil. These refineries are situated at four different locations (Al-Doura refinery in Baghdad; Al-Samawa refinery in Al-Muthanna Governorate; Al-Najaf refinery in Al-Najaf Governorate; Al-Diwaniya refinery in Al-Qadisiyah Governorate). These refineries were included to develop and plan each refinery's production capacities and identify future production plans, according to the rate of change in each petroleum product's production rates under study.

In general, the operation of a conventional oil refinery is usually deterministic and closed. The process of converting crude oil into a final product is expensive. Therefore, the profits of crude oil sales are directly affected by the quality of crude oil refining operations. At the same time, the demand for finished products depends on the amount of refined crude oil products. In addition, the ongoing fluctuation of crude oil costs, wars and global economic crises negatively affect most countries of the world. Oil refining operations in Iraq have recently been forced to import improved gasoline and mix it with the local product due to the misuse of oil refineries in Iraq. Importing and exporting crude oil or petroleum products is no longer as complex as before due to transportation, which has become much easier and more straightforward (e.g. pipelines, ships and vehicle transport, etc.). Therefore, vertical integration in the oil industry must be considered to achieve the maximum profit of these operations.

This chapter includes clarifications on what an oil refinery is and the types of planning that occur in it. The literature review has two sections. Section 2.13.1 is a literature review of the most general solution methods that use major classifications of LP to solve oil refinery problems. Section 2.13.2 contains a literature review of previous works to solve the problems of oil refineries by using fuzzy set theory, with most of them solving problems by utility parametric spaces.

2.3 What is the Oil Refinery

Crude oil goes through several boilers in special furnaces to obtain products of high value and utility. Oil refineries are an industrial facility. Its primary goal is refining crude oil and converting it from a nonconsumable raw material to a high-value and ready-to-use secondary substance, such as jet fuel, gasoline, white oil, kerosene, oils, etc. When the crude oil reaches the refinery, it enters the distillation tower. This step is the first of the refinery's operation, as the temperature in this tower reaches 360 °C to separate the different hydrocarbons. Considering oil refinery facilities is a secondary stage of crude oil extraction from the ground, i.e. drilling rigs. Figure 2.1 shows the main stages of oil refining in the refineries under study.

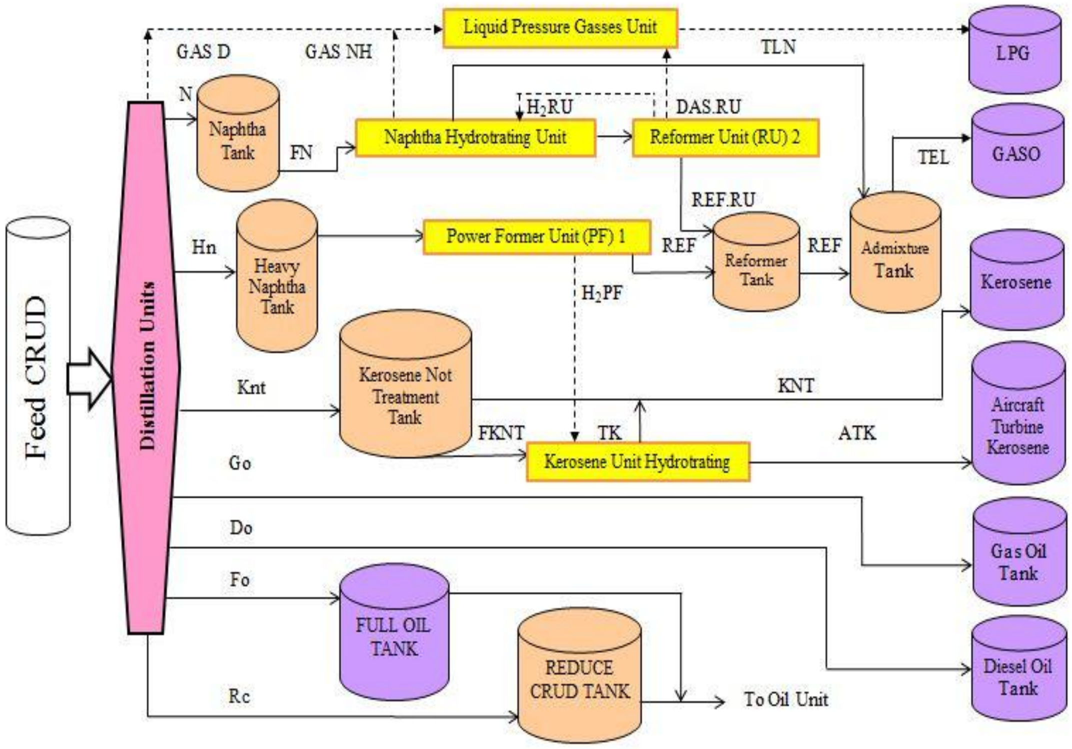


Figure 2.1 Stages of the production process of the studied refinery plant (Iraqi Midland Refineries, 2018)

2.4 Planning in Oil Refineries

Neiro and Pinto (2006) believed that refineries are much willing to improve planning operations. Therefore, complex yet productive and widely applauded technologies and tools are utilised for refinery planning. However, evolutionary changes may occur. For instance, Ejikeme-Ugwu (2012) said models of refineries should be accurate and must improve its efficiency. Crude selection, allocation of crude for various refinery situations, partnership model for negotiating raw material supply and operations planning are part of the application of planning models in the oil industry and refinery. Furthermore, process operations can largely be enhanced with the support of sound planning. Refiners increasingly face problems related to size and scope. As a result, they are compelled to use optimisation software as a swift and efficient means of maximising the profit. Usually, the optimisation of raw material supply, processing and later commercialisation of final products across different time spans are conducted during planning (Pinto *et al.*, 2000). Similarly, petrochemical plans are developed to tackle the wide-scale issues that occur in refineries. Different software can be used to solve refinery and petrochemical modelling systems (RPMS), such as GAMS software (Shah *et al*,. 2011), or process industry modelling systems (Qian *et al.*, 2015) for petroleum planning.

Pinto *et al*. (2000) revealed that RPMS is created on a simple model which is primarily composed of linear relationships. The production plans established by these tools are interpreted as general trends. Ejikeme-Ugwu (2012) developed a planning model for a refinery, utilising simplified empirical nonlinear process models. The formulation and application of FCC, CDU and product blending models are practically demonstrated.

The refinery comprises of different parts which comprise the overall production mechanism, as shown in Figure 2.2.

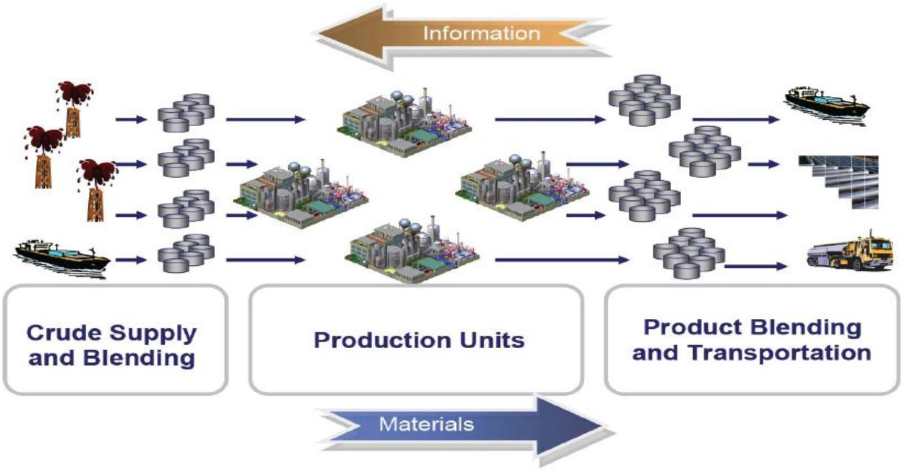


Figure 2.2 Schematic of standard refining configuration (Al-Qahtani, 2009)

2.5 Types of Models Planning

Planning models have two primary types.

2.5.1 Rigorous models

This model is based on the theoretical understanding of the system and process variable interactions. Moreover, the application of conservation principles is the basis of this method (i.e. energy and material balances) and equilibrium phase relationships. Al-Qahtani (2009) said that this model can formulate them prior to operationalising the system.

2.5.2 Empirical models

These models are driven by data and are called black box models. Empirical models are convenient when rigorous models cannot be used due to complexity or dearth of resources. The systems in this form of model are observed in terms of inputs, outputs and their relationship irrespective of any knowledge of the internal mechanism of the system.

2.6 Recent Advances in Refinery Planning

In a bid to maximise the benefit, the problems related to size and scope of refineries have been addressed by the experts Jarnicki and Pflug (2011) with the latest software and technology. The use of software has provided a swift solution to the problems and resulted in achieving high targets within less time. The software is used to simulate the different units and generate operationalising conditions (pressure and temperature), yields and its properties to be optimised in the model of planning. Moreover, some oil factories and refineries customise the simulators to solve the issues on the basis of their requirements (e.g. issues in supply chain planning, inventory control, production planning, transportation, refining, crude oil selection and evaluation, resource requirement planning, etc.) Siamizade (2019) believed that empirical correlations can be used in the design and planning of the refinery process. This empirical correlation generates cuts which would be optimised.

2.7 Scheduling in Oil Refineries

In the past decade, refinery scheduling has gained considerable attention due to the following reasons:

i. to reduce costs and improve productivity,
ii. to increase computational power rapidly,
iii. to develop solution techniques and modelling.

In a refinery, scheduling operations are challenging and complicated and have been the catalyst towards the development of optimisation models. A refinery scheduling operation has three key functional subsystems:

i. crude unload scheduling,
ii. production unit scheduling,

iii. product distribution scheduling.

An important part of the entire system is the unloading, storage, blending and charging of crude oil distillation (CDU).

2.7.1 Types of scheduling models

The scheduling of crude oil operations has two main methods. One is known as discrete-time formulation, whereas the second is called continuous-time formulation. The two methods may be combined and is known as the mixed-time formulation approach; however, it is not popular.

2.7.1(a) Discrete-time formulation

The scheduling horizon in discrete-time formulation is split into the number of intervals of a predetermined period. However, the time may not remain constant and equal. The complete set of activities, such as the start and end of a task, is forced to occur within the allotted boundary of the time horizon. Within the set of boundaries, variables of binary nature are utilised to enforce a decision as to when a task is conducted. Resultantly, the model is easily solved. The increase in problems within the model directly increases the size of the binary variables, thus complicating the model. The size of time interval that usually determines the accuracy of models as discrete-time representation is just an approximation of the real problem. A well-set time interval produces encouraging results. The complication of scheduling problems subject to the number of units engaged in, the number of tasks, the resources available and the scheduling time interval using a complex cube has been well elaborated by Bassett *et al*., (1996).

2.7.1(b) Continuous-time formulation

The start and end time of continuous-time formulation is included as optimisation variables. Models based on continuous time permit the incident to happen along the scheduling horizon irrespective of time, leading to mathematical models of smaller sizes with less time and work. Al-Qahtani (2009) categorised this type of representation as global and unit specific on the basis of the model. The size of interval is determined by the algorithm optimisation. A uniform grid to the entire event is applied in the global type on the basis of the model, whereas a nonuniform grid is applied to the unit-specific, event-based model. Furthermore, each unit has time intervals and is used in a manner wherein the corresponding task to the same event in other areas happens in different times. According to Al-Qahtani (2009), majority of the work showed in literature is global event based.

Jia *et al*. (2003) pioneered the MILP model for distribution scheduling and gasoline blending. The model is based on the continuous representation of the time domain. Regarding the blending stage, continual recipes are presumed. To solve the resulting MILP formulation, GAMS/CPLEX was used. Jia and Ierapetritou (2004) also developed a wide-ranging mathematical model for efficient short-term scheduling of the operations of a refinery on the basis of continuous-time formulation. Similarly, Neiro and Pinto (2006) established a model of scheduling for the operations of an oil refinery. The said model is based on unit-specific, event-based point formulation by using the state task network representation. The state task network representation was first used by Kondili *et al*., (1993). A comparison of these scheduling approaches suggests that continuous-time models permit occurrences to happen along the scheduling horizon irrespective of time. By contrast, the discrete-time formulation is split into numerous intervals. The duration is determined beforehand, and time would