Gasoline Blending of Future Libyan Refineries to Satisfy Future Local Demand

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الخلاصة

من المتوقع زيادة إنتاج النفط الخام والغاز الطبيعي في ليبيا في المستقبل القريب بسبب مشروع خليج سرت المستقبلي.حيث أجرت (NOC) دراسات مستفيضة بشأن الاحتياطيات الضخمة المتوقعة من النفط الخام والغاز الطبيعي في الحقل. تتوقع الدراسة إنتاجا كبيرا من النفط الخام والغاز الطبيعي.

تم توقيع عقد لحفر 14 بئر من قبل شركتين عالميتين كبيرتين ، إكسون موبايل وشركة البترول البريطانية. تم إجراء العديد من الدراسات لبناء مصفاة جديدة لمعالجة 500 ألف برميل يوميًا من النفط الخام المختلط المنتج من الصحراء والبحر. ستتألف المصفاة من عمود التقطير الجوي ، ووحدة التفريغ ، والتكسير التحفيزي ، وإعادة التشكيل التحفيزي ، ووحدة الأزمرة ، والألكلة ، والتكسير الهيدروجيني. الهدف الرئيسي من هذه المصفاة هو القضاء على النقص في إنتاج البنزين في ليبيا.

وستكون هذه المصفاة قادرة على إنتاج ما بين 100،000 إلى 170،000 برميل يوميًا من البنزين لتغطية احتياجات الاستهلاك في الأسواق المحلية. حيث تم فيها تعديل مواصفات البنزين باستخدام (MTBE) لتلبية متطلباترقم الأوكتان و البيوتان الطبيعي لضبط (Ried Vapor pressure). تم استخدام نموذج مزج البنزين في هذه الورقة واستخدام طريقة(Rung Kutta) لنمذجة النظام ثم استخدام) (MATLAP softلمحاكاة النظام. سيتم تلبية الاحتياجات الليبية من البنزين لسنوات عديدة قادمة.

Abstract

Production of crude oil and natural gas are expected to be boosted in Libya in near future because of gulf of Sirt future project. National oil company of

Libya (NOC) made extensive studies regarding the huge reserves of crude oil and natural gas expected in the field. The study expects a large production of crude oil and natural gas. A contract has been signed to drill 14 offshore wells by two major world companies, Exxon mobile and British petroleum. this study has been conducted to design a new complex refinery to process 500 thousand barrels per day of mixed crude oil produced from desert and offshore. The refinery will consist of Atmospheric distillation column, vacuum unit, catalytic cracking, catalytic reforming, isomerization unit, alkylation and hydrocracking. The main objective of this refinery is to eliminate the shortages of gasoline production in Libya.

This refinery will be able to produce from 100,000 to 170,000 barrels per day of gasoline to cover the consumption needs in the local markets. Gasoline specifications have to be adjusted using MTBE to satisfy the octane number requirement and n-butane to adjust the Reid vapor pressure. Gasoline blending model have been utilized in this paper. Rung Kutta method have been used to model the system and MATLAB soft were is utilized to simulate the system. Libyan requirement of gasoline will be met for many years to come.

Key words : Gasoline blending , Libyan refineries, MTBE.

Introduction

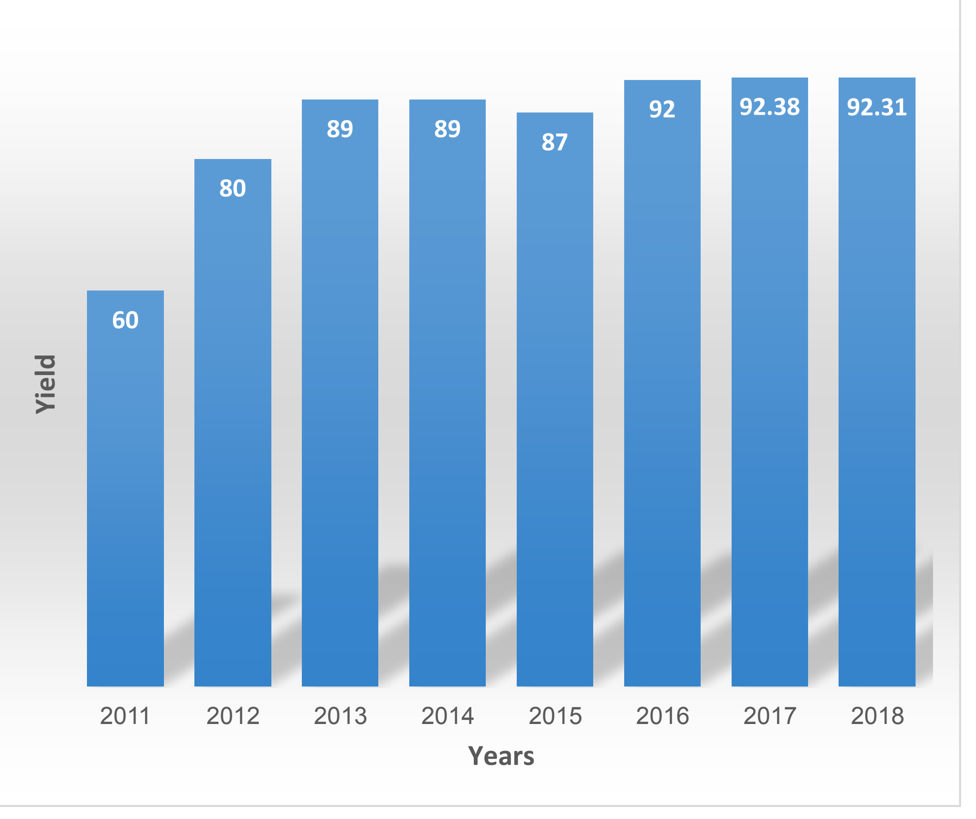
Gasoline is a complex of hundreds of different hydrocarbons. Most are saturated and contains 4 to 12 carbon atoms per molecules. Gasoline can be produced in various process in a modern oil refinery. Due to the different sources of gasoline streams, they contain both superior and inferior properties.

The gulf of Sirt gas and crude oil future project is expected to be the largest project in the world in near future. National Oil Corporation (NOC) in Libya signed a contract with EXXON mobile and British petroleum oil companies to assess the project where 14 Wells to be drilled in the gulf of Sirt at cost 7 billion dollars in near future due to the huge depth of sea water in this location. An estimated production rate of 40 billion cubic meters of natural gas with several million barrels per day of heavy crude oil is expected. A huge pipe line will be built to transport 80% of the gas to Italy where the other 20% will be processed in gulf of Sirt to satisfy local demand in Libya in the near future.

This paper will concentrate on building a new crude oil refinery in gulf of Sirt with a capacity of 500 thousand bbl per day to satisfy the Libyan consumption of gasoline in future. A huge shortage of gasoline in Libya reaching 70% of local demand will the eliminated.

Besides, different marketing locations served by a refinery may have different requirement and regulatory specifications that may also vary seasonally. Therefore, refiners need to select optimal combinations of various intermediate gasoline intermediates in a particular blending ratio to produce on-specification products[1].In general, gasoline are blended from several petroleum refinery process streams that are produced by the following methods: direct distillation of crude oil, catalytic and thermal cracking, hydrocracking, catalytic reforming, alkylation and polymerization[2]. For instance, the production of gasoline involves mixing a variety of ingredient, such as: alkylate reformate, fluidized catalytic cracking unit(FCC), gasoline and an oxygenated additive named Methyl Tert-Butyl Ether(MTBE) to satisfy the octane number requirement and i-butane to adjusted Ried vapor pressure.The objective of gasoline blending is to find the optimal recipe to achieve a best overall profit while satisfying the environmental regulations and market demand. The blending process of gasoline using the linear software MATLab by using Runge-Kutta method. The overall purpose of this research is to enhance the properties and the gasoline production by adding new units to the major units in Libyan refineries. To accomplish this, the project will be divided into several individual objectives:

1. Collecting data from Azawia and RasLanuf refineries.
2. Add new units to produce gasoline.
3. Material balancing work for major units that used to produce gasoline.
4. Gasoline blending process will be simulated using MATLAB software.
5. Gasoline blending models available in literature will be used to calculate the major physical properties (RVP and ON).
6. Enhancement RVP and OC by using MATLAB program.



Fig(1)Consumption of Gasoline in Libya

Fig (1) shows the consumption of gasoline in the previous year's according to the U.S. Energy Information Administration[2].

The main objective of this paper is to produce enough gasoline in Libya to balance the deficiency of supply demand of gasoline in future. Fig (1) illustrates the consumption of gasoline in the last eight years.

Methodology

Blending gasoline process

In most cases, refining procedures don't result in fully finished goods that can be sold directly; instead, they generate semi-finished goods that must be combined to fulfill the requirements of the desired products. The basic goal of product blending is to determine the most effective approach to combine various intermediate products that are accessible from the refinery with some additives in order to modify the product specifications. For instance, the production of gasoline involves mixing a variety of ingredients, such as alkylate, reformate, FCC gasoline, and an oxygenated additive such (MTBE), in order to raise the octane number[3]

Oxygenated fuels, such as alcohols and ethers, may be able to meet the world's rising energy needs in the future while also being environmentally friendly. Since they may be produced locally and from a variety of renewable sources, oxygenated fuels have a promising future. There are two crucial requirements for every gasoline blend, however they are not the only ones. Both the RVP, and the ON of the gasoline must be at the right levels. While a certain grade's octane remains the same all year long.

In this stage, gasoline cuts obtained from the distillation unit were blended in gasoline pool using MATLAB software[4]

Gasoline blending with MTBE

This step will be divided into three sections:

1. Quantities of materials used for the blending process.

2. Time of blending.

3. Enhancement physical properties of gasoline produced.

Quantities of additives materials

For the process of blending gasoline, the quantities of materials used are required, as well as the time of mixing the mixture. In order to accomplish this, several steps were performed. The values of octane numbers and Reid vapor pressure of different technologies unit streams are listed in TABLE 2. The results of octane number and Reid vapor pressure are needed to be adjusted to satisfy the Libyan standard specifications. Methyl tertiary butyl ethers and isobutene are added to Gasoline pool to satisfy the requirement.

TABLE 1: Octane numbers and Reid Vapor pressure of Refining units

Component	RVP(psia)	RON	MON	$ON = \frac{RON + MON}{2}$
FCC	1.4	92.1	77.1	84.6
Catalytic reformate	2.8	94	84.4	89.2
Delayed Coker	3.6	67.1	60.2	63.7
Isomerization	13.5	83	81.1	82.05
Alkylation	4.5	97.3	95.9	96.6
Hydrocracking	12.9	82.8	82.4	82.6
Total	$\sum \frac{39}{6} = 6.5$			$\sum \frac{500.3}{6} = 83.4$
i-C4	71	93	92	92.5
MTBE	9	101	118	110

In this paper, the process of blending gasoline, the quantities of material used are required, as well as the time of mixing the mixture; where important properties of additives are identified and then calculated the amount of MTBE and i-C4 that are calculated by using the following mathematical equation:

$$\begin{aligned}(MTBE * OC_{MTBE}) + (FCC * OC_{FCC}) \\ + (Cataytic\ reformate * OC_{cat\cdot ref}.) \\ + (Delayed\ Coker * OC_{Dela\cdot Cok}) \\ + (Isomerization * OC_{Iso}.) + (Alkylation * OC_{Alky}.) \\ + (Catalytic\ Hydrocracker * OC_{Cata\cdot Hydro}.) \\ = (Gasoline\ Pool * OC_{Gas\cdot Pool}) \qquad (1)\end{aligned}$$

$$(i - C4 * RVP_{ic4}) + (FCC * RVP_{FCC}) + (Cataytic\ reformate * RVP_{Cat \cdot ref}\ .) + (Delayed\ Coker * RVP_{Del_{Cok}}.) + (Isomerization * RVP_{Iso}.) + (Alkylation * RVP_{Alky}.) + (Catalytic\ Hydrocracker * RVP_{Cata \cdot Hydro}\ .) = (Gasoline\ Pool * RVP_{Gas \cdot Pool}) \qquad (2)$$

Where:

MTBE: The amount of MTBE (BPD).

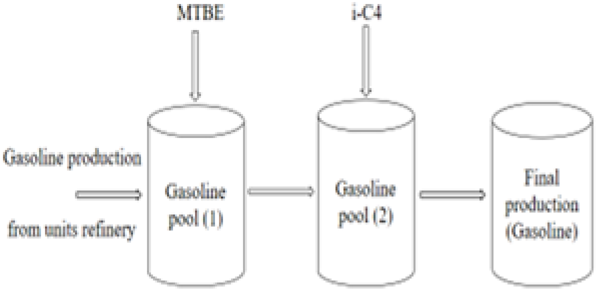
OC : The octane number of all material.

i-C4 : The amount of iso-butane (BPD).

RVP : The Reid vapor pressure (psia).

Model development

1) Consider an empty cylindrical tank represent final product (gasoline tank) in which gasoline from product units is to be prepared (blended) by adding MTBE in (gasoline pool (1) tank) and i-C4 in (gasoline pool (2) tank) as shown in Figure (2).
2) The three components are gasoline from product units have (low octane) and MTBE have (high octane), i-C4 have (high RVP) and gasoline pool (low RVP).
3) The percentage volume of the cylindrical tank is 100% by volume.
4) The sum of the percentage volume of the three components flowing in is equal to the volume flowing out.
5) The gasoline products from units in refinery and the MTBE enters to tank of gasoline pool (1) with RON1, RVP1.
6) The gasoline pool (1) and i-C4 enters to the tank of gasoline pool (2) with RON2, RVP2.
7) The tank is well mixed after transferring the components into the cylindrical tank.
8) Final product (Gasoline) leaves tank after mixing process, where the final blend is homogeneous with specific RON, RVP.



Fig(2) Model Development

Model Equations:

The rate of change of the dependent variable is equal to the **rate of flow from tank1 plus the rate of flow from tank2 minus** the rate of flow from tank3.

$$\frac{dA(t)}{dt} = (r1A1 + r2A2) - r3A(t) \qquad ; A(t) = ON$$

$$\frac{dB(t)}{dt} = (r1B1 + r2B2) - r3B(t) \qquad ; B(t) = RVP$$

r_1 and r_2 are determined using simultaneous equation from material balance

$$A1 + A2 = 94$$

Where : A1 and A2 are the MTBE and gasoline from units of refinery for the blend respectively.

Fourth Order Rung-Kutta numerical Solution:

To find the initial value and solve the differential equations we can use the Rung-Kutta method as follows:

$$\frac{dy(t)}{dt} = f(t, y) \qquad ; \quad a \leq t \leq b \, ; y(t = a) = ya$$

$$k1 = hf(ti, yi)$$

$$k2 = hf(ti + \frac{h}{2}, yi + \frac{k1}{2})$$

$$k3 = hf\left(ti + \frac{hyi}{2}, \frac{k2}{2}\right)$$

$$k4 = hf(ti + h, yi + k3)$$

$$y(i+1) = yi + \frac{1}{6}(k1 + 2k2 + 2k3 + k4)$$

Where: k_1,k_2,k_3 and k_4 are the slopes used to calculate y(i+1)

Simulation of blending gasoline

With the development of technology, the gasoline blending process has evolved to become more efficient and in the least amount of time so that the process can be carried out to the fullest extent. Francis[4,5] proposed three high-quality first-order differential equations in addition to a computer program (MATLAB) where Runge-Equations were used Kutta class IV for blending two gasoline components, model predictions RON (Research Octane Number), RVP (Reid Vapor Pressure) and density of the gasoline mixture were made. The gasoline blending was executed by employing the linear programming solver application in Microsoft excel using four blending components namely the Fluid catalytic cracking gasoline (FCCG), Straight run naphtha (SRN), Straight run gasoline (SRG), Butane, and varying Oxygenates.

In this paper, the MATLAB program will be used for the final blending process of gasoline with oxygenates and iso-butane to modify OC and RVP.

MATLAB programs

This program's goal is to calculate the ON and RVP of the gasoline mixture. The octane number and RVP will remain the same because the gasoline mixing process is for MTBE and iC4. A1 is the gasoline pool's Ron, A2 is the MTBE's Ron, and B1 is the gasoline pool's RVP (RVP OF THE i-C4) as inputs in order to compute R1 and R2 thus the fractions of the components to be blended together. The following diagram shows the process of blending gasoline with improved additives.

I. Gasoline pool (1)

Since the ON values of the units producing gasoline as well as the materials used for mixing are constant see table 2, the output values will be equal for the two ratios used.

Gasoline produced from production operations (refinery units) enters the gasoline pool to be blended with the oxygenating substance MTBE so that the octane number is adjusted to suit the Libyan specification.

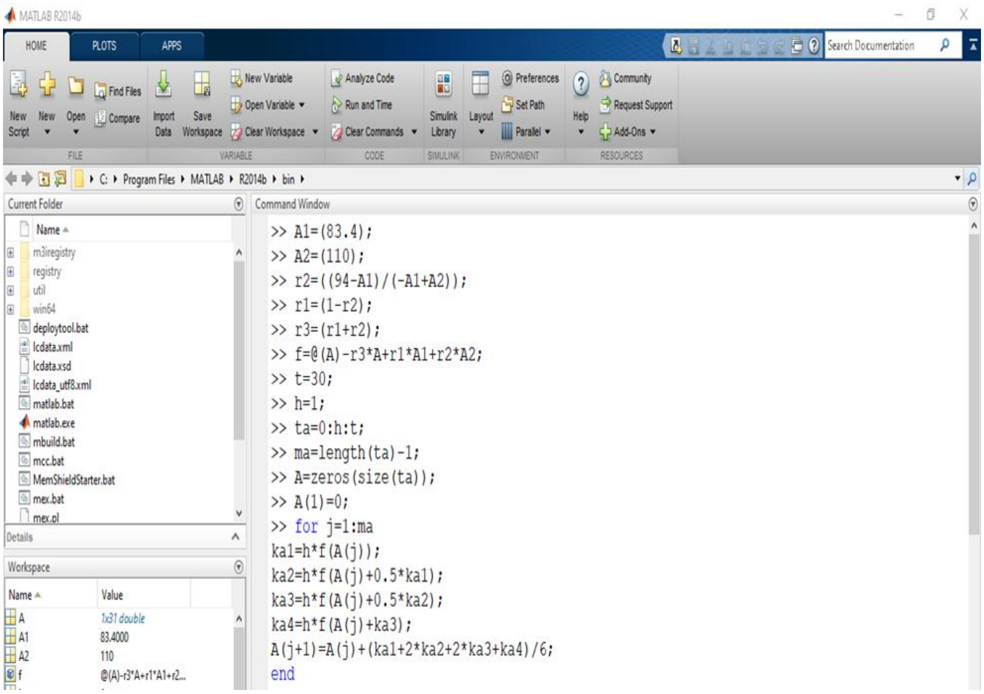


Fig.3 blending ON of gasoline pool with ON of MTBE

Results of blending observed that the process to modify the octane number needs 15 hours for homogenous blending,
After modify ON, we have to modify the value of RVP that changed with time of mixing, so the RVP will be calculated in gasoline pool (1).

II. Gasoline pool (2)

Since the RVP values of the units producing gasoline as well as the materials used for mixing are constant see table 5, the output values will be equal for the two ratios used >> B1=7.5

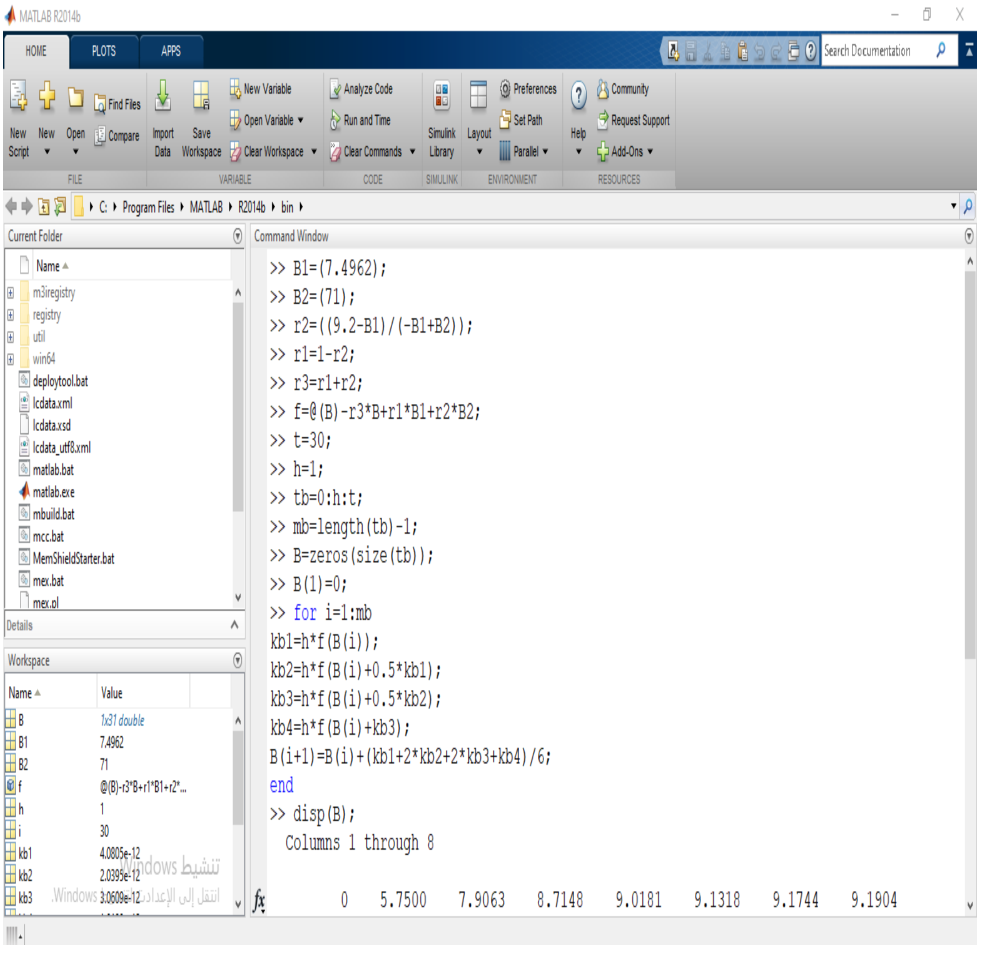


Fig. 4 blending RVP of gasoline pool with RVP of MTBE

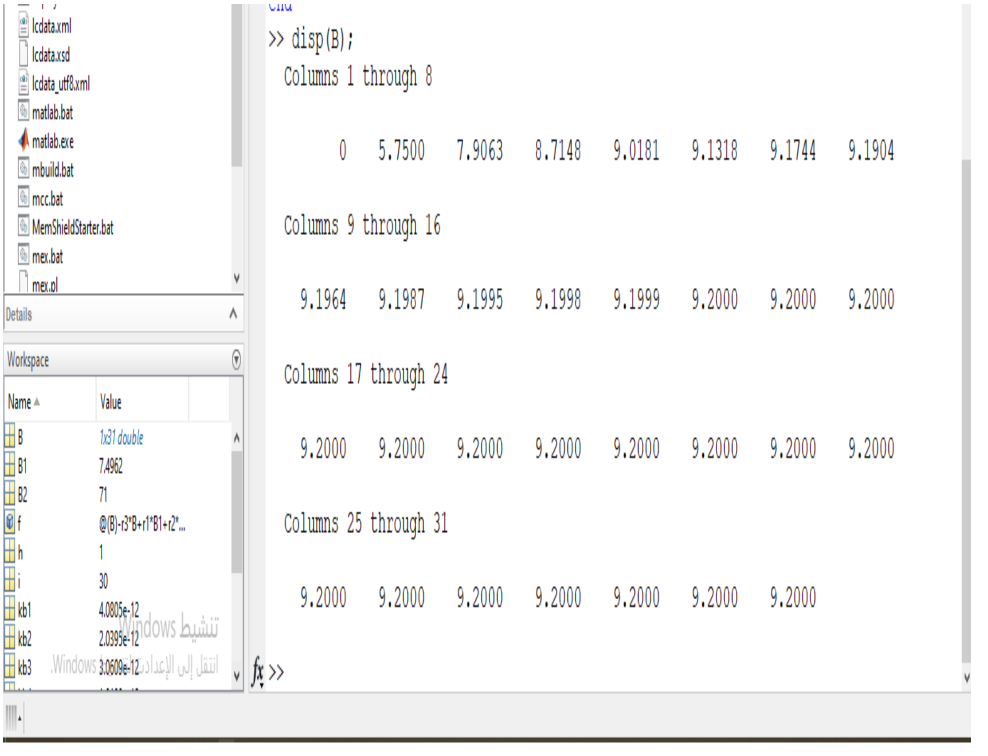


Fig. 5 Result of blending RVP

From fig.5 the RVP needs 13 hours to modify it.

Discussion of simulation results

The total amount that suggested of 500,000 barrels per day of new crude oil entering the atmospheric distillation unit of two different types of Libyan crude oil has been proposed to increase the amount of gasoline production, the results were as shown in Table 2. Table 2 summarizes the results of production of gasoline obtained from two mixtures of crude oil of different quality by using several different units. Where it was found that the second mixture produces 177,675 BPD, which is a profitable production compared to the first mixture, which produced 86,270 BPD, and according to the total consumption of gasoline in Libya, it is possible to satisfy Libyan demand of Gasoline in future.

Table 2 : Results of gasoline by BPD from different units

Description	First mixture	Second mixture
FCC	16,606	33,411
Catalytic reformate	22,710	44,914
Delayed cooker	4,097	2,892
Isomerization	18,398	22,391
Alkylation	8,846	17,885
Catalytic hydrocracking	6,427	4,619
Gasoline pool	∑77,084	∑126,112
Enhanced gasoline	86,270	177,675

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