

# The green process using alkylation technique in producing gasoline and the effect of the technique upon decreasing water pollution: A case study in the central refineries company /Al Dora

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## ABSTRACT

The research discusses some modern concepts in the sector of operations management represented in green design, the cleanest process and the green product. Enhancing the process could lead to enhancing the product and then achieving better environmental performance. Therefore, the research deals with addressing the problem of water pollution because of the production process as a result of the environmental effect resulting from the production of fuel in the Dora refinery. The research aims at showing the effect of applying the technique of (alkylation) in the production of (cars fuel) to reduce waste and to clarify the effect of the alternative situation in the treatment of the process. The research importance stems from the application of tools and appropriate technique to the process to provide a product more compatible with the environment. Therefore, we are interested in this research in two aspects: improving production and reducing environmental pollution. It was found in the research that the application of the alkylating technique project led to the reduction of solid pollutants (SWG) almost (zero) by dispensing with the use of furnaces that produce the material (carbon steel). This means that (SWG = Zero), as well as a decrease in water consumption by (31741,920) barrels per year.

**Keywords:** Green process, environmental performance, green design, green product, alkylation

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## 1. Introduction

The systems of manufacturing have been developing since the beginning of the industrial revolution until now. The process is the core of manufacturing system in the field of operations management, as enhancing the process helped improve manufacturing efficiency which passed through several phases to reach the green process. In establishing a vision for green design and green productivity, it was necessary to pay attention to the production process within the framework of social and economic responsibility and the growing interest in environmental awareness. One of the key reasons that called for improving the process and moving towards the green production process is the result of what the production process leaves behind in terms of exhausts and industrial residues affecting the environment. The research highlights the process in the petroleum products sector (Dora Refinery) and how it contributes to providing better quality products with less negative environmental impact. The research included the methodology and a theoretical framework for some of the concepts used and then the practical aspect of using alkylating technique in the Dora refinery, as well as providing the most important conclusions and recommendations.

## 2. Research methodology

Research problem: Recently, most oil refineries suffer from dealing with the problem of waste and how to dispose it by extracting it into the water, as well as using water in the production process. In order to address this problem, we searched for methods to manage waste, whether solid or gaseous. It was necessary to use a

technique that contributes to reducing pollution (pipe tail solutions) from manufacturing processes for the purpose of treating waste from the process, as well as improving the product. The research problem is represented by measuring the environmental impact resulting from enhancing the production process related to the operational aspect and measuring its impact on improving the product (gasoline) using the alkylation technique. The research importance: The importance of the research is to know the role played by the green process, the use of (alkylation) technique in improving the product and reducing the environmental waste resulting from the process, and intending to reduce the waste extracted into the water and increases pollution.

2.3. Research objectives: Evaluating the reality of Dora Oil Refineries Company and its operations of reducing environmental waste by using (alkylation). This technique would be a guide to enhance the product and reach the production process to the best performance and enhance the company reputation applying environmental management systems and adherence to international standards in the production process. The research community: It was represented in the Dora Refinery Company, a company affiliated to the Ministry of Oil in (Refining and Hydrogenation Department and Energy Department). Due to the importance of the role that oil products (gasoline fuel) play in terms of the impact upon the environment during the production process and upon the production of exhaust and the maintenance of the automobile engine in particular. Data collection methods: The researchers used the calculation of the current situation of the company using mathematical equations with the help of experienced engineers working in the oil industry and what the information network provides on the Internet to calculate what results from the process of (alkylation).

### 3. Theoretical framework

#### 3.1. The green process

The green process is concerned with everything that manufactures products with the least possible waste and energy efficiency, as well as reducing the producing pollutants in the production process [1]. Process improvement leads to a reduction in waste and gas emissions [2]. The use of inputs that increase the efficiency of the product and reduce the impact on the environment is one of the positive indicators of green manufacturing [3]. Incorporating various forms of reused materials during the manufacturing process and dismantling or recycling using efficient technique represents a green manufacturing methodology [4]. In the eighties of the last century, the concept of cleanest production techniques began as one of the means used to improve the efficiency of the production process and decrease pollution to reduce waste before the end of the manufacturing process [5]. The interest in developing green manufacturing processes was consistent to the strict environmental regulations imposed by society [6]. Some green manufacturing indicators [3]:

- 1- Using raw materials and environmentally friendly energy in the production process.
- 2- Reducing the amount of materials and energy used in the process.
- 3- Reducing the amount of waste and gaseous emissions resulting from the process.
- 4- Reusing waste or conducting treatment on it to reduce its impact on the environment.

#### 3.2. The green design

Designing the product is a vital decision on which the operations management of any industrial organization depends. Green design is concerned with a set of activities represented by design to reduce waste at the source. It means reducing materials released to the environment that pose a threat to the health of living organisms, or for recycling by separating the materials of the product and reprocessing it after the end of its useful life [7] or incorporating different materials during the manufacturing process, dismantling, renovation or remanufacturing [4]. Green design improves production efficiency and reduces environmental waste, thus improving the image of the organization [8]. It also represents the design for the purpose of reusing the product or parts of it [9]. One of the most important ways to implement green design is [10] :

- 1- Choosing the type of green energy in production.
- 2- Choosing a process that reduces material and labor waste.
- 3- Designing a product that can be recycled or disposed of in a way that is less harmful to the environment after the end of its useful life.

#### 3.3. The green product

The green product is everything that contributes to triggering responsibility towards environment by the organization [11]. It is any tangible product undergone some enhancements to reduce damage or waste which

is compatible with environmental sustainability [12]. The value is formed through a new product or process that achieves an increase in profits or an increase in value for stakeholders and improves the image of the organization in front of the customer [13]. Also, the development of environmentally friendly product is a goal of the organization [5]. We also call the green product an environmentally friendly product, as it is a non-toxic product that is made from green materials and consumes the least amount of materials that have a negative impact on the environment [4]. Improving product quality increases production speed and prompt response to meet customer requirements [14].

#### 4. Evaluating the environmental impact

Thinking of developing the product or improving the production process was triggered by the environmental impact, because knowing the associated effects from the results of the product life cycle is the way for a specific manufacturing system [15]. The product manufacturing process requires using techniques that decrease pollution while keeping pace with product improvement where clean technique plays a role in [16-18]. The environmental responsibility on the organization requires studying the production system in terms of inputs, processes, outputs and the impact of the production process on the environment [19, 20]. The effect of the product must be directly related to its performance during its use by the customer [21]. The environmental impacts are represented, whether in the method of material extraction or manufacturing processes, product treatment and waste disposal [22, 23]. In essence, offering products that meet environmental requirements is offering green products that are high quality products.

#### 5. The practical aspect (alkylation process)

The purpose behind using this technique is to produce high-octane gasoline by converting light components into high-value gasoline ones by linking small hydrocarbon molecules with each other to produce high-octane gasoline. This gasoline helps to eliminate the knock that occurs in the car's engine. The refinery dispensed with the use of tetraethyl lead, which is one of the previously improved materials to raise the octane number as a carcinogen over time, with a negative impact for its workers and the residents of the neighboring area. So, through the alkylation technique, it will reduce the severity and danger of the aromatic compounds to be less than (1 VOL%) or less. Within this paragraph, the environmental impact of the pollutants related to the gasoline product, which are three pollutants, will be calculated for the purpose of making improvements in the situation based on the positive results that the alkylation project will achieve as an alternative to the current situation of the project's importance in raising the octane number.

- Solid Wastes Generation
- Gaseous Wastes Generation
- Water consumption

As for the weights of the environmental indicators corresponding to each of the three types of pollutants, which are indicated in the Environment Sustainability Index), they are [24]:

$$(W1, W2, W3). \text{Environment Impact (ET)} = \text{SWG}(W1) + \text{GWG}(W2) + \text{WC}(W3)$$

Table (1) will show the weights of the environmental indicators corresponding to each type of environmental pollutants, using the equal weighted sums aggregation method, which are indicated in the Environmental Sustainability Index.

Table 1. Derivation of the three weights (W1, W2, W3)

No	Equivalent Environmental Sustainability Index Indicators Equivalent ESI	Green Productivity Index Indicators GPI Indicators	Combined weights X	Weight in ESI	Weight in (GPI) X/0.3
1	- air quality - Reducing air pollution - greenhouse gas emissions	Gaseous Waste Generated. GWG	0.15	0.05 0.05 0.05	0.50
2	Reducing solid waste and consumption	Solid Waste Generated SWG	0.05	0.05	0.17
3	- amount of water - the quality of the water	Water consumption	0.10	0.05 0.05	0.33
Total			0.30	0.30	1.0

The process of calculating the environmental impact is completed by finding [24].

$$\text{Environment Impact (ET)} = 0.17 \text{ SWG} + 0.50 \text{ GWG} + 0.33 \text{ WC}$$

It is necessary to calculate the quantities of the three main pollutants from the refining process of Crude Oil (C.O) and for the different units of measurement for each. It is calculated in the tripled meter (M3) and (Ton), therefore, the units of measurement are the same to complete the calculations. Accordingly, the environmental impact equation (EI) will be calculated in a unit of mass (Ton).

## 5.1. Calculating the environmental impact of the current situation (before using the calcination technique)

### 5.1.1. Calculation of the amount of solid waste generated SGW

The solid waste that is generated from the C.O product, which is called (Sludge), is the residue of heavy materials, clays and chemicals that are deposited in the alum and poly unit by adding a substance to it, which is an exothermic reaction for the purpose of reducing the percentage of water it contains. Sludge is collected in tanks and was buried in the past, but in light of technological development, these pollutants are operated in incinerators working to extract the hydrocarbon element, then they become more like dirt that can be used in agriculture. Therefore, the quantity of Sludge for the year 2018 was obtained from the Solid Waste Treatment Division in the amount of (78190m<sup>3</sup>) for oil refining (4594410M3). To calculate the amount of solid waste (Sludge), it is according to the equation below:

$$\text{Density (D)} = \frac{\text{mass } M}{\text{Volume}}$$

(D)= Density

(M) = Mass

(V)= Volume

Converting the unit volume

$$M3=L$$

$$M = V * P \quad 1M^3=1000 \quad M = 78190 * 1.015 \text{ kg/L} \quad \text{converting the unit of mass}$$

$$M = 78190 * 1015 \text{ kg /M}$$

$$M = 79362850 \text{ Ton Sludge}$$

$$\text{Tons} = \text{Kg}, 1\text{Tons} = 1000\text{kg}$$

### 5.1.2. Calculation of the amount of gaseous waste generated GWG

Various types of gaseous wastes are generated during the refining of crude oil (CO), represented by (COX, NOX, SOX) that originate from the furnaces and what is generated from them (gaseous fuels), boiler pollutants represented by (liquid pollutants) and burners pollutants represented by (gaseous pollutants). These pollutants are weighted (3419327) tons.

### 5.1.3. Water Consumption (WC) Calculation

The refinery consumes quantities of the water it needs for the purpose of performing its various operations. It is treated by withdrawing the amount of water from the Tigris River and then returning part of it again to the river after carrying out the appropriate treatments for it. Therefore, it becomes less impactful on the environment, as follows:

Water consumption:

$$WC = DW - TW$$

$$WC = 15044321 - 23345162 = 12,709,786$$

DW= Dran water , TW= Theater Water

Therefore, we are able to calculate the environmental impact (EI) in the current situation before using the alkylation technique

$$\text{Environment Impact (ET)} = 0.17 \text{ SWG} + 0.50 \text{ GWG} + 0.33 \text{ WC}$$

$$= 0.17(79362850) + 0.50(3419327) + 0.33(12709786) = 435124287 \text{ Tons}$$

## 5.2. Calculating the environmental impact in the alternative situation (after using the alkylation technique):

Interviews with those in charge of this technique were conducted for the purpose of identifying the positive effects it leaves attached to the oil refining process to obtain a gasoline product with a high octane number, which contributes to reducing the volume of environmental pollutants.

### 5.3. Calculating the amount of solid waste generated

Through the alkylation technique project, we were able to make the solid pollutants (SWG) almost zero, as by using them we were able to dispense with the use of furnaces that produce solid carbon, so there is no solid waste, this means (SWG = Zero). As for gaseous pollutants (GWG), the process of refining crude oil (C.O) occurs in a closed manner, that is, there is no direct discharge of any of the gases or gaseous pollutants to the atmosphere. This means: GWG=Zero

As for water consumption (WG), it became clear when using this technique that the water drainage for the Dora filter is much less than it was in the previous case, and the amount of water consumed per day in the form of aerosol (1m<sup>3</sup>) hour, then the rest is returned to the tanks:

$$1M^3 = 3.29$$

Barrel

$$Br = 120$$

$$\text{Daily consumed per hour } 120 * 3.29 = 394.8$$

$$\text{Daily consumed } 394.8 * 24 = 9475.2$$

$$\text{Yearly consumed } 9475.2 * 335 = 31741,920$$

$$\text{Therefore, Environment Impact (ET)} = 0.17 \text{ SWG} + 0.50 \text{ GWG} + 0.33 \text{ WC}$$

$$\text{Environment Impact (ET)} = 0.17 (0) + 0.50 (0) + 0.33 \text{ WC}(31741920) = 1047483$$

The number (1047483) tons represents the amount of environmental impact of the alternative situation, which is less than the amount of environmental impact of the current situation, which is (435124287) tons. The reason behind is the use of alkylating technique, which made a significant change in the reduction of the volume of the aforementioned pollutants, which contributed to preserving the biological properties of the water surrounding the filter. In addition, leaving off the use of tetraethyl lead which is considered a carcinogen where combusting it would generate lead oxide (LO) from a health point of view. From a financial point of view, the cost of purchasing this enhancer is too expensive for the management of the refinery, so the alternative situation is considered to have positive results on the size of the environmental impact.

## 6. Conclusions and recommendations

### 6.1. Conclusions

1. The management of the Dora refinery realizes the importance of reducing waste in the production process, which contributes to improving the product to reach environmentally friendly products.
2. Using modifications in the process, by alkylating technique instead of water in the process of producing gasoline, contributes to enhancing operational performance and trying to reach a cleaner technique in its production processes to reduce waste thrown into the environment.
3. The adoption of production using the alkylation technique led to the improvement of the product (gasoline) as it was free of improved materials. In addition, it also led to decreasing waste and the adoption of providing environmentally friendly products that contribute to improving the reputation of the product.
4. The alternative situation by using the alkylation technique achieved a reduction in the amount of polluted water discharged to the Tigris River.

### 6.2. Recommendations

1. The use of alkylation process contributes to improving the product and reducing the negative effects on the environment as a result of reducing the use of water in the process.
2. The adoption of the green process contributes to reducing waste and reducing the effects resulting from the process on the environment when moving to the use of alkylation in the process.
3. Working to develop production techniques and use technique that is compatible with the requirements of the environment.
4. The intention of Central Oil Refineries Company towards improving the product by producing low-octane gasoline works to perpetuate the life of the engine, as well as reduce gas emissions from cars that pollute the environment.

### Declaration of competing interest

The authors declare that they have no any known financial or non-financial competing interests in any material discussed in this paper.

## Funding information

No funding was received from any financial organization to conduct this research

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