

# An Analytical assessment of Lean Manufacturing Strategies and Methodologies Applied to Kuwait Oil Company (KOC)

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**Abstract**— Effluent water is one of the significant volume waste streams in the industry of oil manufacturing; this report addressed the effluent water management in the Kuwait oil Company (KOC). A Research methodology adopted quantitative and qualitative analysis, in order to focus on the difficulties and barriers facing the process of effluent water management, it may be abridged that the parts of effluent water have an alternate possible effect on the surroundings. Subsequently, decreasing these segments, particularly the destructive ones, all together to achieve the most reduced level regarding diminishing the rate released with generated waste water, is the essential objective of the oil manufacturing industry. Due to effluent water disposal & injection practice which is being carried out at KOC can be observed some problems can be summarized as The water cut (W/C) in oil wells start increasing dramatically after water injection back to the reservoir which reduces the oil rate productivity of the wells, Scaling issue in the flow lines start taking place recently at KOC which also reduces the productivity of the wells and need some costly projects to resolve it., There is a great impact on the integrity of our facilities (corrosion issues) . It has been observed that the salinity of the brackish water which is produced from artesian wells is increasing dramatically as well due to effluent water disposal into shallow layers underground.

**Keywords**—Lean Manufacturing; KOC, effluent water, oil well

## I. Introduction

The effluent water is polluted or impure water conveyed to the surface alongside natural gas or crude oil. At the point once hydrocarbons are created, they are removed to the surface as a created liquid blend. Effluent water is one of the biggest secondary products by volume connected with oil manufacturing operations[1]. The synthesis of the liquid blend relies upon whether natural gas or crude oil is being manufactured, despite the fact that it by and large incorporates either fluid or gaseous hydrocarbons, broke down or suspended solids, deposits, for example, sand or sediment, and infused liquids which are added substances put in the development amid the exploratory stage and ensuing manufacturing exercises [2]. Effluent water can have an incompatible effect on nature, contingent upon where it is released. All in all, created effluent water comprises a substantial scope of natural and inorganic mixes, containing emulsified oil, natural acids, broke down

natural atoms, and salts [3]. The natural substance of produced waste water additionally incorporates benzene, toluene, ethyl benzene, and xylenes (generally alluded to as BTEX), which are exceptionally harmful. The poisonous quality and solvency of these mixes are high, and consequently mean a huge natural peril for people [4]. As per the U.S. Natural Protection Agency or what called (US EPA), there is proof that benzene can bring about malignancy and other noteworthy maladies in people, which is the reason lessening introduction to these chemicals is vital to ensuring marine and human life [5] Different researches have been directed to create suitable innovations for the effluent water treatment during oil manufacturing. Treatment procedures, for example, oxidation, extraction, stripping, sorption, and organic treatment have been broadly explored [6]. Effluent water is a significant volume waste stream found in the oil manufacturing industry nearly three water barrels for each oil barrel (one barrel =159 L) is produced as a by-product in oil production process [7]. It is available as an outcome of the generation of gas and oil from underground supplies, which comprise of arrangement water. The worldwide evaluated normal of waste water is about 210 million bbl per day, bringing about a yearly generation of 77 billion bbl/year [8]. The evaluation of effluent water in seaward stages worldwide is pretty nearly 107 million bbl per day, even as the assessment of aggregate seaward oil creation is 120 million bbl/day About 44 million bbl/day or more of waste water is released into the sea. The amount of waste water from the oil business has expanded significantly and it does not stay steady amid an oil well's operation time [9]. It has been demonstrated that the measure of waste water increments as oil generation perishes. In some more established oil fields, the water cut surpasses 95% [10]. In this paper, the lean manufacturing Strategies and Methodologies applied to Kuwait Oil Company (KOC) and the probability of implementing these techniques into this organization in order to minimize the waste production will be analyzed. To achieve this aim, the overall idea of the project will be discussed in five main chapters where each chapter will discuss certain ideas.

## II. LITERATURE REVIEW

In general, lean manufacturing provides a comprehensive approach toward manufacturing of services or products and aims to achieve the best quality, competitive cost and time delivery in order to satisfy the customer. The main objective of lean manufacturing is to minimize the manufacturing space, time to market, inventory and unnecessary human effort to become more responsive to the demands of the customer as producing highly quality products and services in the most economical and efficient way [11]. Lean manufacturing includes the best features of craft production and mass production, in other words, it has the ability of enhancing the quality significantly and minimizing the cost/unit, which will help in providing a more challenging tasks and a wider products range simultaneously [12]. Lean manufacturing is considered as one of the most effective manufacturing models that is applied on the majority of the manufacturing sectors in various countries around the world with various economic status. In this matter, being "first to market", reducing the costs of production, quick response to the demands of the customer and enhancing the quality of the products are vital to success and competitiveness. Lean methods and principles are focusing on the creation of a culture of continual improvement which employs the workers and employees in minimizing the capital, materials, intensity of time that are required for responding to the demands of the customer. Lean principles implementation on the various industrial sectors focuses on the elimination of the non-added value wastes and activities from the manufacturing process, which will lead to an improved and enhanced environmental performance [13]. Lean expresses a continuous improvement system that emphasizes on eliminating the wastes and losses in all forms by the implementation of best practices and appropriate techniques. [14]

### A. Lean manufacturing concept

According to [15] lean manufacturing as the process that is based on the performance to increase the advantage of competitive. Lean manufacturing basics use the processes of continuous improvement to emphasize on the non-added value activities or waste elimination within the manufacturing process. Creating a culture for maintaining a long commitment for the whole structure of the organization is the main challenge that faces the organizations that implementing the lean manufacturing principles. Any manufacturing process done without waste is termed as lean. The term waste in this matter is origin to the Japanese's term "muda" and it has almost seven types namely; product defects, motion waste, processing waste, inventory waste, transportation waste, waiting time and overproduction. Although there are many resources that describe and present lean, companies are having a hard time keeping lean [16] According to [17] the main aims of lean manufacturing are to minimize the waste in inventory and human effort, respond to the demands of the market at the right time, managing the highly responsive manufacturing stocks to the demands of the customer while producing products and services with high quality in the most economical and efficient way. Lean thinking concept (LT) is first known by the Toyota Production System (TPS) which used the

distinguishing of the non-added value activities from any process to find the value of the same process; at the end this will help in eliminating the waste to make every step a value step to the process [18]. Efficiency is the main focus of lean manufacturing in order to produce services and products at the shorter time and lowest possible cost. Kanban is one of the lean manufacturing tools that helps in controlling the buffer inventories levels in the production process; in other words, regulating the quantities of the production. The upstream machine is programmed to stop the [production of any part type that reaches its maximum buffer. Therefore, Kanban in the manufacturing operations are signals utilized to reload the repetitive inventory [19]. lean production or lean manufacturing are relatively new terms in the manufacturing processes, the first use of this term was by Jim Womack, Daniel Jones and Daniel Roos' book, *The Machine that changed the world* [1991], in their book, they examined the Toyota Production System's manufacturing activities. They defined lean manufacturing as the systematic elimination of waste. They used the term "lean" to define the lean manufacturing as cutting the "fat" or non-added activities from the production processes. Lean is not exclusive on the manufacturing processes; it is widely applied in the engineering and administrative activities too [20]. Most of the lean manufacturing tools are referred to the Gilbreaths and Fredrick Taylor at the beginning of the twentieth century. Lean has been packaged some of the good manufacturing, engineering and industrial practices into a vibrant system that can be implemented at any working environment [21].

### B. Benefits of Lean manufacturing concept

Lean scheduling is a strong tool that designed in order to meet the recent challenges of the manufacturing enterprises' in decreasing the delivery times, cost, human errors, and the lead-time with rising in the continuous flow in the manufacturing process and rising the final product quality [22]. Knowing the lean practices benefits can generate a more profoundly understanding of them in the organization. Through adopting the Lean scheduling (LS), the organization can develop quality and responsiveness of the customer, and decrease the cycle time. Knowledge management, Increasing levels of customer satisfaction, reducing process wastes and inventories and financial savings are some of benefits that proposed by [23]. There are a lot of other benefits that relating to the Lean scheduling adoption; it can supplement the efforts of the human, generate the manufacturing space and develop the quality. Lean scheduling (LS) has the ability to play a very significant role towards the production activities improvement, not in automobile industries only but in the other types of the industries if it is modified. According to [24], LS (Lean scheduling) can assist to reduce the customer response time, cut costs, increase efficiency, improve the organization's image and improve the profitability. Furthermore, Lean scheduling leading to sustainable improvement through increasing customer communication and satisfaction, and reducing the delivery time and cost, since it is a systematic approach which it helps managers to identify and omit the wastes from organisation on each stage in the operation, that will lead to better organizational performance and make the company free from the waste [25]. Nevertheless, all these benefits cannot be done if not

the organization addresses the significant issues that involved in Lean scheduling. But, prior to go through the individual principles, requirements and Lean scheduling CSF, there is a need to know the eight wastes which they are connected with Lean scheduling. So, the organization is able to measure them and know from where they are coming [26].

### C. *Eight wastes associated with LS*

Factually, lean scheduling aims to eliminate the generated wastes from organization or within its structure since these waste doesn't added any value to the end customer as illustrated by[27]. The first and most important step in waste elimination is to identify the wastes sources and the impacts of these wastes [28]. As given by[29], one of the most powerful methods for any organization to minimize cost and preserving competition is to apply lean concept through minimizing and if possible eliminating the waste. On the other hand, Jones and Womack (2003) stated that any action that doesn't lead to produce value is defined as waste in a lean scheduling; while this value must be identified depend on the customer viewpoint; or in additional words it can be illustrated as every activity, movement or step that the customer is not keen to pay for is defined as waste, and then the organization have to eliminate it. Nevertheless, despite the main focus in LS is on the value added action that the customer is willing to pay for, but many actions are necessary to create the product; where these known as "necessary non-value-added actions". Furthermore, there are certain actions that are known as "non-value-added actions"; where these actions do not add value to products or customer, but the organization must not eliminate them as they are necessary by regulations and rules [30]. In general, three kinds of values are available which are; non-value added action, necessary non-value added and valued added. For any organization to be lean it require to distinguish between these actions and try to remove all non-value-added action that does not insert value to customer or product, and is not necessary by regulations and rules as given by [31].

## III. ANALYSIS

The analysis showed there are various researches, which focus and emphasize on the oil industry and its history in Kuwait as well as researches that aim to enhance the productivity and reduce the waste of this field in Kuwait, thus conserving the Kuwaiti economy by minimizing the expenditures associated with the oil industry. There are no studies about the implementation of lean manufacturing in Kuwait, but the existing studies are talking about the implementation of lean in the world in general as well as the lean manufacturing in Kuwait industry. These studies can help in devising how to apply the lean manufacturing in oil industry in Kuwait, and also it can explain the positive effect of lean manufacturing implementation in oil industry in Kuwait. Data analysis that will be adopted in this project will be consisted of two different types, which are qualitative and quantitative analysis. In order to perform such analysis, data have been recorded and handed out to a considerable group of employees that are familiar with the company's strategies and tendency toward waste management. Due to the large number of employees in the KOC, the researcher faced indeed significant challenges in

choosing a large sample to question in order to get precise answers, so he made sure to choose a small sample but represents different assemblies of people. In addition, there was an interview conducted with some managers of the Kuwait Oil Company

The following questions have been asked to the managers in the KOC;

1. What are main types of wastes produced from Oil and gas industries?
2. Can you mention the most important issues related to each type of waste?
3. Does the company have clear strategies in dealing with different types of wastes? Please mention one strategy.
4. How good the employees are qualified to deal with waste management?
5. Explain how a company's production would be affected by the amount of resultant
6. Is waste management considered as a profitable business for the company?
7. How efficient the company deals with produced wastes?

### A. *Types of waste*

The interview results show the solid waste is one of the wastes in the KOC but it's not the main source of the waste because the overall production is liquid, the solid waste is produced with about 15 ton per day approximately and the main resources of the waste are:

- Maintenance residuals (mechanical parts like tires,, spare parts ..Etc)
- Municipal waste

The results of interview shows the formation water is the main source of the waste, the company produces about 6 million barrels of formation water per year, the company has different issues to control this amount of water as will be discussed in the following questions.

### B. *Main issues faces waste management in KOC*

The results of interview shows the no specific waste management unit but there is a department for water management , actually this unit just control the disposal method which is usually disposed on the empty oil wells, or in open pools without taken into consideration the environmental issues. The managers said that this formation water, also the oil reservoirs were affected by this water because this water causes oil immigration and increase the amount of water in reservoirs, affected salinity of the underground water in different fields of Kuwait. Most of the respondents to the survey felt that the workforce training in the principles of lean production is vital for successful waste management implementation into their company. The interviews showed that the upper management of the responded companies was aware about the waste production, while the workers were ignorant about it and needed a professional training. The amount of waste is only evaluated for the water management unit and a rough numbers can be taken from the solid waste disposal . The



amount of waste is not determined specifically because some of them are direct disposed in the empty wells as the formation water.

The techniques that are used to manage the waste can be limited as:

- Landfill disposal: in the desert
- Water and hydrocarbons in the empty wells
- Water disposal in open pools

These techniques are not professional because they cause environmental issues as discussed before, as well as they effect on the underground water and the climate change. Where the interviews results shows the waste handling is arranged to amount of production and it is not periodic process but it can be described as a process related to the production. However, at this point some of answers explained a new method will be used in the future with arrangement with solid waste management unit in Mina Abdullah. The main purpose of constructing the unit is to recycle, reuse, and rehabilitate the solid wastes to be used in eco-friendly projects such as paving highways and roads. To obtain a successful waste management analysis many selection criterions should be taken in consideration and extensively studied for every case separately; those criterions includes waste generation, waste characteristic and composition, waste reuse and recycle fraction, available methods and means of waste transportation, future integration and management scheme flexibility for upcoming variations. Selection criterion is the main key in integrated solid waste management; waste minimization is the best solution for waste management. However, there are some limitations on waste minimization methods and should not be accounted solely, otherwise waste accumulation will occur on the long run. Minimization should be a first step in the waste management scheme, followed by a well-studied integrated scheme. The main aim of any waste management analysis is to come out with the optimum solution for the case study, which is varying greatly from place to another; for example, in developing countries the waste management scheme should take in consideration the economic and technical consideration. Due to the lack of financial resources and talented labor in such countries, in the contrary in modernized countries that aspect does not acquire the same importance as financial resources and talented labor are available wherein environmental assessment is for great importance.

*C. The response of the company to the problem*

The interviews results shows that ; the company tried to get agreement and to establish an unit it as shown in previous question where The following are some specific improvements that can be achieved in the early phases of implementing lean manufacturing in KOC :

GC	effluent water	disposed into the well	transferred to reinjection	disposed into the pit
15	3005636	2356456	0	648363
23	1905452	1208586	651081	39804
24	2644599	0	2641243	0
25	2499278	111668	2429595	0

- It can reduce break-down and failures of machines
- It helps in improving performance of central control system;
- It helps in reducing the amount of solid wastes producing in refinery process;

Type of Water	Ground Reservoirs		Elevated Tanks (Towers)	
	Number	Capacity (MIG)	Number	Capacity (MIG)
Fresh	64	2143	39	25
Brackish	26	498.8	15	9.6

- It can organize workplace inside the company
- It helps in achieving higher level of safety;
- It helps in reducing procurement time.

The amount of effluent water dispose was recorded as shown in the following table for (15, 23, 24 and 25 GC) in BPM. Where three different water disposing methods are used, which are;

- 1- Direct disposed into the wells
- 2- transferred to reinjection
- 3- disposing into the pit ( open to atmosphere )
- 4-

Table 1: The effluent water production in KOC

**Table 1: the effluent water disposes**

Using cftool/matlab software the amount of waste can be forecasted for the future where the amount of water will increase to reach 3500 MBPY and the amount of oil will be reduced to 500 MBPD which means the amount of oil will be reduced 80% in 2030 if the problem of the effluent water is not solved.

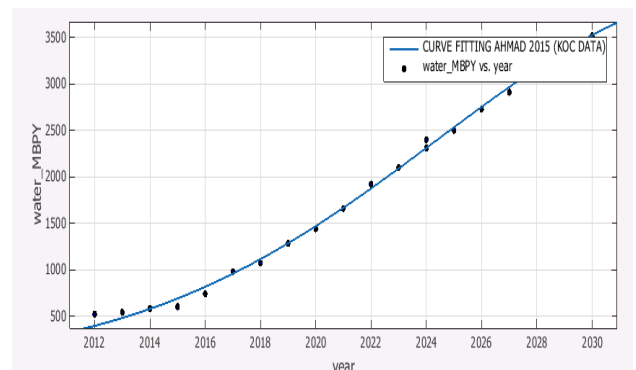


Figure 1: Effluent water Vs. year

$$f(x) = a1 * \exp\left(-\left(\frac{t-b1}{c1}\right)^2\right)$$

*Coefficients (with 95% confidence bounds):*

**a1 = 3969 (3604, 4333)**

**b1 = 2035 (2033, 2037)**

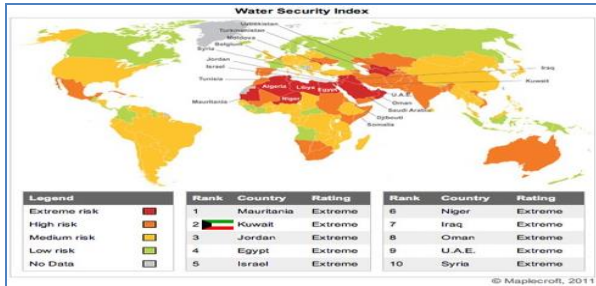
**c1 = 15.3 (13.95, 16.66)**

R-square: 0.9971

Where t: time in (y)

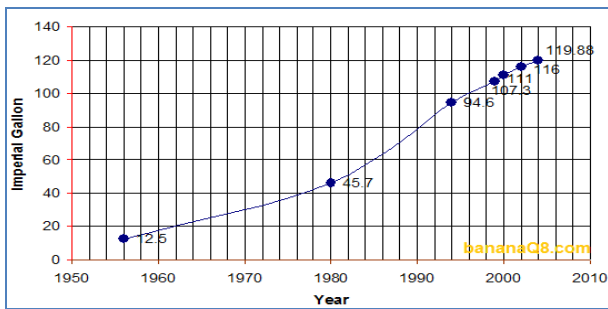
**Table2 : water demand in Kuwait**

Table 2 shows capacity of water in Kuwait , where the ground reservoir is the largest water supply in Kuwait .Where the water consumption in Kuwait is very high and the Kuwait was ranked as second country as shown in the Figure.2.



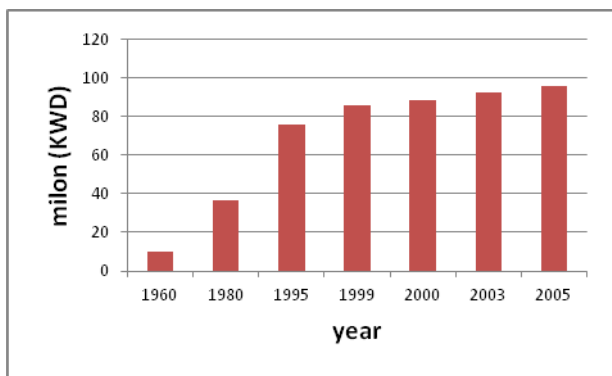
**Figure.2: The ranks of water risk in world.**

For the yearly consumption, Figure.3 shows the growth of water consumption in Kuwait in millions imperial Gallon:

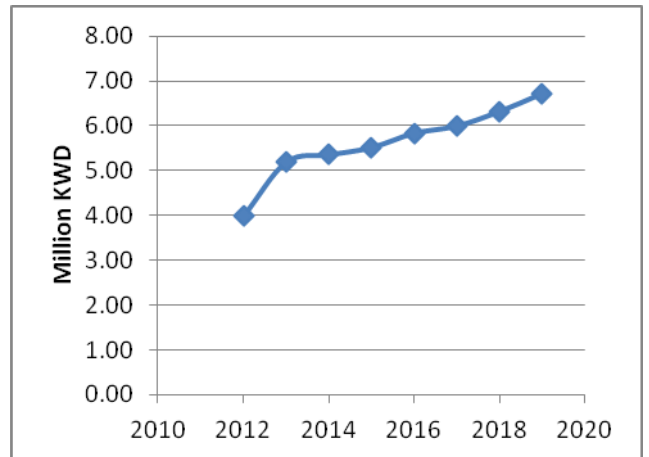


**Figure.3: The water consumption in Kuwait.**

The cost of water is 800 files per imperial Gallon and depending on the Figure.4 the prices of water consumption.



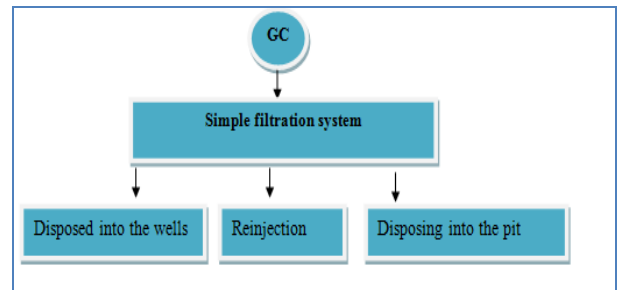
**Figure4: The prices of water consumption in Kuwait.**



**Figure5 : the price of formation water in KOC.**

With the increase in water production an increase in scaling tendency sparked the creation of the scale management taskforce. Who in turn recommended the creation of a management team headed by the team of R&T and other departments as shown in the following figure , further installation of scale inhibitor injection pumps was the best solution all wells being affected. The purpose of this solution to minimize for the production loss due to the increase blocking due to scaling in wells and flow lines by adopting and managing proper management procedures

The recommended system for flirtation will include in-site filtration system to remove the high salinity from the water this system will reduce the economical and the environmental effect of the effluent water.



**Figure6: Filtration system.**

#### IV. CONCLUSION AND RECOMMENDATIONS

Based on the data analysis, it can be concluded that there are many problems associated with implementing waste management in Kuwait Oil Company (KOC). The most common barriers are; the hazardous materials that are produced in oil and gas industry as waste especially at Mina Abdullah Refinery, no sufficient training courses supplied to the employees in the purpose of training them on dealing with hazardous wastes.

In addition, there is no qualified-enough employees to deal with waste management systems, the company does not include a specialized department of waste management applications, disturbed vision and conflicting data collected about the exact amounts of waste produced in each facility

of (KOC) and the type of waste generated from oil and gas fields that is mainly the formation water.

The employees linked between their social responsibilities and the waste management according to their needs for specialist training in waste water management and treatment.

The results of interview shows the wastewater problem is the main problem faces the oil companies in Kuwait where the amount of formation water growth randomly so it should be studied clearly. However, it has been suggested some solutions that may help in solving the aforementioned problems, which are stated in the following recommendations.

1. Specify types of hazardous materials that are produced in oil and gas industry according to the international standards, which are:
  - a) ISO/TC 67 Materials, equipment and offshore structures for petroleum
  - b) UPS standards for ground and air hazardous materials
  - c) OPITO standards
2. set a training course for the employees and how they can deal with the waste management, the OPITO standards will be suitable for developing the skills of the employees
3. Establish a new department managed in corporation with the Environment Public Authority in Kuwait with the following roles :

3.1 Set a plan to manage the produced waste and how can be recycled especially the formation water and the hazardous water.

3.2 Measure and estimate the amount of waste according to amount of production

3.3 Monitoring the waste disposal methods

3.4 Continuously measuring the environmental issues related to the produced waste

3.5 Set feasibility studies for recycling projects

3.6 Set a forecasting for the future waste

label, present them within parentheses. Do not label axes only with units. In the example, write "Magnetization (A/m)" or "Magnetization (A ( m(1)," not just "A/m." Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K."

### **Acknowledgment (HEADING 5)**

We would like to thank my god for his blessing to me to complete this project. Then I wish to express my special thanks to KOC in Kuwait for their assistant and continual guide. A special note of thank to our friends and our families for their support during the period of work on the project.

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