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## Effect of applying lean maintenance in oil and gas fields

M Nasr Hassan<sup>1</sup>, A F Barakat<sup>2</sup> and A S Sobh<sup>3</sup>

<sup>1</sup>Section Head Mechanical Engineer, Gas Affairs Department, Ministry of Petroleum and Mining Resources, Nasr City, Cairo, Egypt.

<sup>2</sup> Professor, Doctor, Mechanical Engineering Department, Faculty of Engineering, Helwan University, Helwan City, Cairo, Egypt and Professor, Doctor, Faculty of Engineering, Ahran Canadian University (ACU), 6<sup>th</sup> of October City, Giza, Egypt.

<sup>3</sup> Doctor, Mechanical Engineering Department, Faculty of Engineering, Helwan University, Helwan City, Cairo, Egypt.

Email: [eng.mohamed.nasr.h@gmail.com](mailto:eng.mohamed.nasr.h@gmail.com)

**Abstract.** Oil and Gas Sector are facing a huge increase and delay in Operations & Maintenance tasks for all facilities beside continuous demand from management to improve the productivity of wells and the efficiency of facilities. The top management decides to use Lean Maintenance as a new tool, technique and methodology to improve and modify the current operations, production and maintenance systems as done before by many researchers in the oil and gas sector. This improvement will be done through three real case studies by integrating Building Information Modelling with lean concepts, monitoring Key Performance Indicators within a modern Computerized Maintenance Management Software and finally using some LM tools such as Total Productive Maintenance, Value Stream Mapping and 5S Methodology to increase productivity, efficiency, and quality of the output production and services. The results of implementation since July 2017 till June 2018 show average increase in crude oil production by 6.72% per day in addition to overcome natural decline of oil wells, reduced Technician's total Preventive Maintenance tasks by 52.63% and transfer the less difficult inspections to Operator to be responsible for making checks to all parameters of all equipment and to enable Technicians to perform other maintenance tasks, Saving about \$724,770 in Water Injection Pumps Operation's Expense. Last but not least, accelerate the workflow of production and maintenance processes by 28% compared with the previous financial year.

### 1. Introduction

Currently, companies carry out planned routine maintenance, inspections, replacement, cleaning, painting, defect correction, etc. These set of actions are what we in general called maintenance activities which are considered as one of the basics of financial management [1]. The Word Lean meaning perfect use of manufacturing resources by cutting the Non- Value Adding (NVA) activities or wasting in product or service that doesn't add value to the customer's need [2]. Integrating lean thinking in maintenance is known as Lean Maintenance (LM) [3]. Lean Maintenance is necessary for the success of a Lean manufacturer, and it provides a complete approach to the function of maintenance [4, 5].

The paper Objective is to create the methodology of implementing lean Maintenance in Oil & Gas Fields and re-design the Maintaining System based on the concepts of Lean Maintenance. This paper is applied at Qarun Petroleum Company (QPC), which is one of the crude oil production companies



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and related to the Egyptian General Petroleum Corporation (EGPC). Nowadays, the company is facing a huge increase and delay of operations & maintenance for all facilities at QPC fields. So, the upper management decides to use new LM techniques and tools to improve the current operations & production system in order to meet EGPC demands. By creating two case studies similar to the published papers in Oil & Gas Sector in addition to new innovation.

Integrating Building Information Modelling (BIM) with lean concepts especially for the upper management in head office, in addition to using the CMMS software to monitor KPIs to get the required data for equipment per each field. The data include (Location, Tag, Status if it is running or in Stand-by, Availability, Reliability, Utilization, Online Hours, Up-set Hours, PM Hours, Shut-in Hours, comment if any) for implementing Lean Maintenance Techniques in the Case Study. Although using the most usable LM tools such as Total Productive Maintenance (TPM), Value Stream Mapping (VSM) and 5 S Methodology in implementation.

The primary objective of any maintenance function is to see that machines and equipment are maintained in a way that enables a plant to operate with the lowest unit cost consistent with the safety and well-being of the workers. Maintenance function becomes a significant contributor towards to achieve strategic objectives of an organization in today's competitive markets [6]. The maintenance process is to serve the production facilities of high productivity, it comprises planned and unplanned actions carried out to retain a physical asset to the acceptable operating conditions [7]. Maintenance aims at increasing the value of the reliability, safety, availability, and quality of an asset (e.g. production plant, equipment, or building) with acceptable economical costs [8].

The cost of maintenance activities ranges from 15 to 70% of the total production costs [6]. This is the second largest part, after energy costs, of the operational budget [5]. In the United States, the estimated cost of maintenance increased from \$200 billion in 1979 to \$600 billion in 1989 [9]. Maintenance activities account for an average of 28 percent of the total cost of finished goods. One of the reasons for such a significant portion of maintenance of the total operating cost is that the machinery has become highly automated and technologically very complex. For example, modern operating systems depend on sensor-driven management systems that provide alerts, alarms, and indicators. Consequently, maintenance costs are expected to be even higher in the future [10].

Generally, the maintenance costs are proportional to the downtime (DT). The DT is the time interval when the equipment/system is down for maintenance until it is back to the normal working conditions. The increased DT is caused by the non-value added (NVA) activities or wastes within the entire maintenance process. One of waste elimination strategies is the application of lean thinking in all activities between suppliers and customers. Integrating lean thinking in maintenance is known as lean maintenance (LM) [3]. Some researchers emphasized that LM is prerequisite for the success of a lean manufacturer as it provides a holistic approach to the function of maintenance [5].

The lean integration in any process is carried through adopting lean principles which begins with specifying the customer value [4]. In the maintenance environment, any maintenance service could be considered as a final intangible product. The service is provided to a customer, which, in this case, could be assumed as an asset (e.g. production line). Therefore, it is essential to identify the value from the asset perspective, which can improve its availability and reliability through efficient maintenance. Then, mapping the maintenance value stream, which fundamentally consists of all the collective activities to deliver the maintenance service. Later, improving the maintenance value stream by abolishing the waste, which assists in minimizing the lead-time [5].

The Results show that the implementation of lean maintenance in O&G fields increases productivity, Profit, improves quality, decreases wastes, cycles times, Inventory, raw materials, costs and number of Operators. This paper will be useful in developing a more generic approach to design a lean environment. Last but not least Applying KPIs, CMMS software, BIM and Lean Maintenance Tools, are recommended to be implemented in all Oil & Gas Companies, to get the same improvement.

## 2. Research methodology

This study employs a complete literature Survey in order to explore the effect of applying lean Maintenance in Oil & Gas Fields. Then, extracting and synthesizing the selected resources to group and analysis the suitable Lean tools and concepts. Finally, two real-word cases studies similar to the published papers in Oil and Gas Sector in addition to a new innovation case study is chosen to verify the integrated approach. The intensive case studies are conducted and focused on productivity improvement activities at the Oil & Gas Company. This research focuses scenarios simulation and role-playing which guided by seasoned managers and brainstormers were used to sort out the Oil & Gas industry maintenance process and collect the primary problems that relate to the process. The case studies were focused on the process of corrective maintenance. In addition, the discussion was conducted not only reside on the past implementation, but also focus on the future plans and developments via regular seminars.

The research criteria depend on reviewing the title and then the abstract which saves the researcher time and efforts. The following criteria has been considered to include/ exclude the articles:

- Articles published between 2000 and 2020, as the origin of LM, raise in 2001.
- Search for articles published in scientific journals or conference proceedings.
- Ensure that selected articles contain at least one of the below search keywords in the title or abstract; (Maintenance, Lean Maintenance, Lean TPM, Lean Principles, Lean Maintenance Tools, Oil & Gas).
- Search well in online databases like Taylor & Francis, EBSCO, Emerald, IEEE, Inderscience Publishers, ProQuest, Sage, Science Direct, and Springer Link.

## 3. Lean, Lean Tools and Lean Maintenance

### 3.1. Lean

The word lean means the efficient use of the available resources by cutting the NVA activities or wastes [2]. Lean represents a collection of tools that work together synergistically to create a streamlined, high-quality system that produces finished products at the same place as the customer demand [11]. Waste in lean is defined as any activities that add cost to a product/service without adding values from a customer's perspective. In recent decades, the lean system is gaining momentum across different industrial sectors. It has been originally started as Toyota production system (TPS) which describes the manufacturing philosophy of Toyota Motor Corporation [12, 26]. This lean system has been successfully extended to service industries, such as maintenance service, airlines, restaurants, public sector, education, food, and hospitals. Researchers stating that lean principles can be transferred to any organization [5, 13].

### 3.2. Lean tools

The lean tools are representing the lean principles for the implementation process. Reducing the NVA within maintenance activities can be accomplished through implementing Lean tools. To achieve LM improvement effectively, key lean tools such as VSM, 5S, and visual management need to be employed [5]. A comprehensive lean tool developed for maintenance activities within an organization include 5S, TPM, OEE, Kaizen, Poka-Yoke, process activity mapping, Kanban, computer managed maintenance system (CMMS), enterprise asset management (EAM) system, Value Stream Mapping (VSM), mapping, inventory management, visual management, seven wastes, single minute exchange of die (SMED) and Takt time [15-18].

### 3.3. Lean Maintenance

LM term was coined in the last decade of the twentieth century. Some researchers define LM as a proactive maintenance operation employing planned and scheduled maintenance activities through TPM practices using maintenance strategies developed through application of Reliability-Centered maintenance (RCM) decision logic and practiced by empowered (self-directed) action teams [14]. LM

generates a desirable outcome by minimizing consumption of inputs. LM represents adopting lean principles into the maintenance, repair, and overhaul (MRO) operations. It could reduce unscheduled DT through optimizing maintenance support activities and maintenance overhead. [15, 19].

#### **4. Case Study (I): Re-organize Operations Dept. Using Building Information Model (BIM)**

The highly critical nature of Oil and Gas (O&G) activities leads to the high demand for smooth, uninterrupted and safe running of O&G facilities. Operations and Maintenance (O&M) departments in O&G Sector are facing many problems during repair or during any activities, as Maintenance Staff usually used original blueprints & as-built drawing and most of those data need an upgrade by time. In addition to the difficulty of transmission of data between departments which cause low productivity, labor wastage, and high cost [20].

Building Information Model (BIM) is a 3D information model for Operations & Maintenance Process coordination. Recent years, many types of research paid close attention to cooperation between BIM and lean concepts but little has published on lean concepts and BIM in O&M management. In this case study, we will combine BIM with Lean concepts to improve the reliability of flows and waste estimation. The case study extracted from an actual case study in O&G Sector with little modifications due to the change in organization structure from one company to another but both of case studies is facing the same problems [20-22].

The case study focused on the process of corrective maintenance of Qarun Petroleum Company (QPC) and the discussion was conducted not only reside on the past implementation, but also focus on future plans and developments via regular seminars.

##### *4.1. Old Organization Process & Phases:*

Based on the QPC old organization, there were two departments carry out the corrective maintenance work. Operations Dept. is responsible for the facilities operation management, quality assurance (QA) and quality control (QC) under the supervision of two head General Managers (Engineering & Fields). Projects Dept. is responsible for implementing the constructions and repairs required by the Operations Department. The workers divided into three levels: Managers, Engineers, and Operators.

Oil & Gas industry mainly composed of a large number of pipelines & Equipment and the production is highly relying on them. The uninterrupted production process is the key factor for the performance and success of Oil & Gas plants. There are a series of problems can be pointed out in Oil & Gas plants, such as (Time consuming or insufficient facilities procurement - a Large incidence of no value-adding activities in the maintenance process, resulting in long duration and not enough time for generating maintenance solutions - Maintenance requirements between different departments are not all identified).

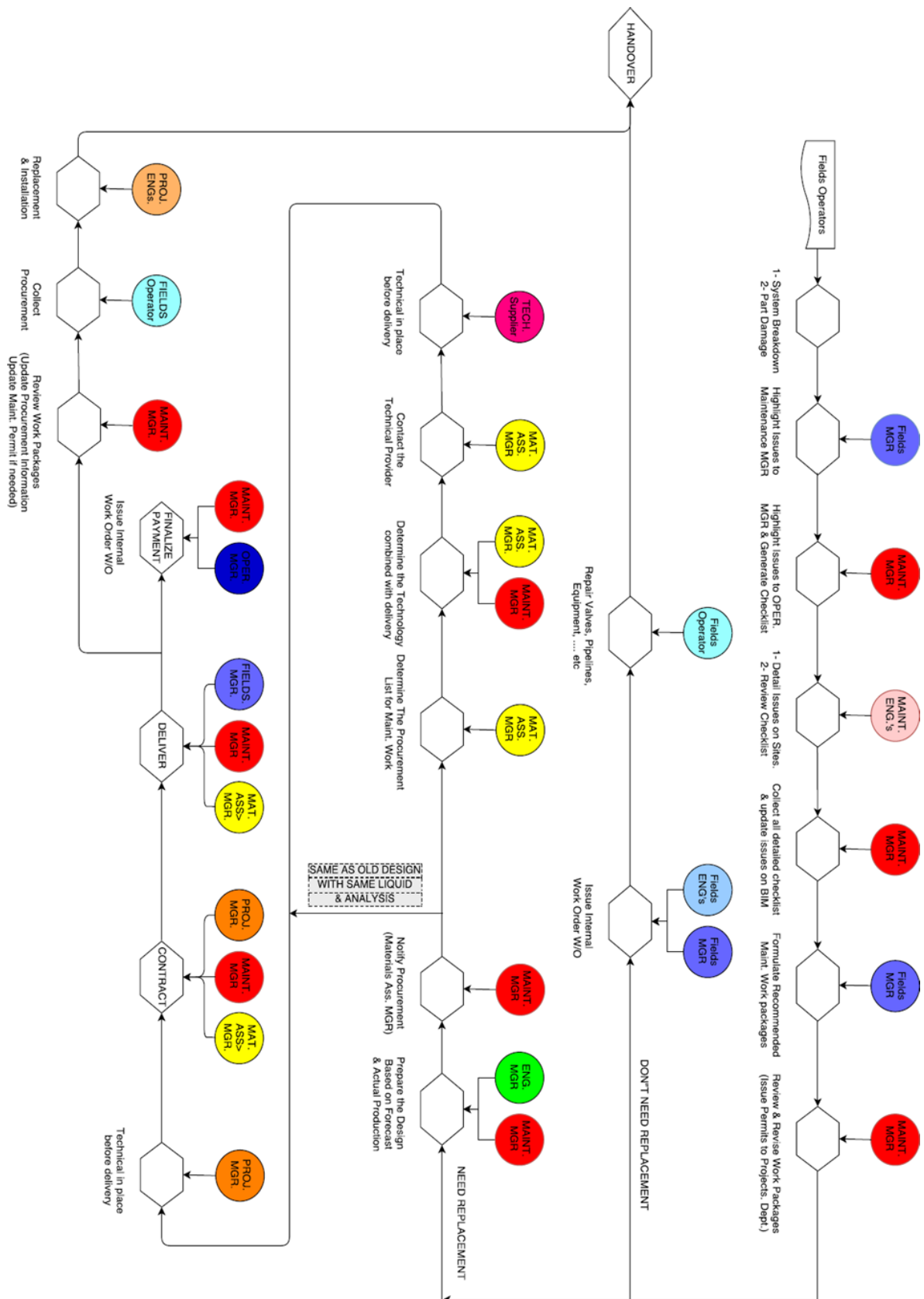


Figure 1. Optimized maintenance road within integration of BIM and Lean Concept.

#### 4.2. *New Organization After Using Building Information Modelling (BIM):*

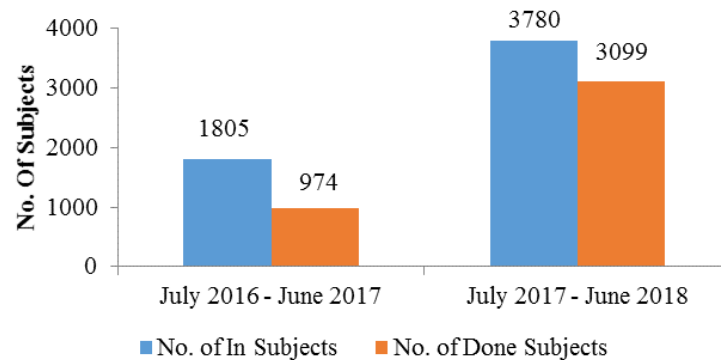
The main target of applying BIM in Maintenance process is to create a complete database for facilities (e.g. location, maintenance status, product information, and process), also to guarantee the complete control of information management (information integration and sharing in different departments and workers), in addition to allow actions of automatically collect and update the maintenance information [20, 25].

A new BIM was built and re-organized the Operations Dept. by issue two sub-department under the Operations General Manager to handle the Maintenance & Materials issues besides the Engineering & Projects Departments all over QPC fields. The new BIM enabled the workflow to start from system breakdown warning till handover as shown above in figure 1 and as explained in the following steps:

- The system breakdown warning and part damage warning problems sent by Field's Operators to Fields General Managers to highlight the urgent issues to Maintenance General Managers.
- The Maintenance General Manager create and generate the checklist to Operations General Managers based on priority from high to low urgency.
- Maintenance Engineers start to collect the details of issues in sites and review again the checklist with Maintenance General Manager to update in the new BIM model created based on the revised checklist.
- Maintenance General Managers Formulate Recommended Maintenance Work Packages after review & revise with Fields General Managers.
- In case of do not need replacement, Fields issue internal work orders W/O to concerned dept. to repair valves, pipelines, equipment through Fields Operators and then handover it for process operation.
- In case of need replacement, another maintenance roadmap taken between different department to facilitate and minimize the cycle of study of each issue and eliminate the wasted time taken per each department.
- Maintenance & Engineering Managers prepare the design based on Forecast and actual production to review if the replacement will need an upgrade or not.
- In case of an upgrade is required during the replacement. Maintenance & Engineering Dept. prepare the procurement list for maintenance work and export it to Materials Ass. General Manager to check the latest technology in the market with all Technical suppliers and vendors, in addition, to review the delivery of list before shipment to match with projects time.
- Maintenance Managers in both cases of upgrade or not will issue permits to the Projects Department to coordinate with the contractors who will proceed with the installation and replacement under the supervision of Projects, Maintenance and Materials. To finalize the project in time and handover it to Operations for process and pay all bending invoices on this project.
- In this maintenance workflow, including the following: procurement, delivery, permission, installation, and handover, all the participants shared work-related information such as how is the work going on and gave feedback for updating the BIM model, which allowed the other workers to real-time tracking and adjust the work plan in time [20].

#### 4.3. *Results of Implementation*

- The results of applying this method increased workflow of maintenance and production processes by 28% since applying it in July 2017 till June 2018 compared to the previous financial year as shown in figure 2.



**Figure 2.**No. of Subjects (In and Done).

- This case study demonstrated that the integration of BIM and lean concepts had strong application prospects in Oil & Gas maintenance, and the maintenance process was primarily satisfied with efficiency improvement.
- BIM mainly used for the inspection, assessment, repair and 3D visualization.
- Lean concepts focus on reducing the variability, reduce non-value adding work and increase the process transparency.
- The implementation of lean thinking and BIM in the process of maintenance enabled complete control of information management for entire works by focusing on complete process and by transferring data information flow from 2D-based information to 3D virtual models.
- Increased process transparency by providing an accurate model for all facilities, all the information introduced in the model was real-time tracking and in time adjusting which allow workers from different positions to communicate and coordinate in the whole process.

The completion of further studies for the development of a more comprehensive BIM lean platform will enable the maintenance process in the Oil & Gas industry to adopt this emerging technologies and management thinking for actual field practice [20].

## 5. Case Study (II): Improve Maintenance Service Using TPM & 5S Methodology

Qarun Petroleum Company "QPC" is one of the biggest Oil Production Company in Egypt, QPC has mainly four large fields (Qarun, Karama, EBAH & Beni-Suef) with total production 40,000 Barrel Per Day and each one of those fields has its own organization & structure and also has its shipping facilities, Oil production wells, workshops, and warehouse. Each facility has storage tanks, shipping pumps, motors and control room. The maintenance of those facilities was carried by Maintenance Dept. Engineers and technicians based on preventive maintenance plan while the supervision of facilities is done by production Dept. Engineers and operators.

QPC Always looking for improve the maintenance service that is currently provided, this study aims to investigate and intervene in the points where it is possible to improve the current system of maintenance management. It is also intended to start the implementation of new techniques for industrial maintenance, namely the Total Productive Maintenance and the 5S Methodology. The case study extracted from an actual case study in O&G Sector with little modifications due to the change of equipment's type & structure from one company to another but both of case studies are facing the same problems and both of them are focusing to use the TPM & 5S methodology in implementation [1, 23].

This case study will focus on the implementation of Autonomous Maintenance which is one of the most important pillars of TPM. The application of autonomous maintenance aims to reduce the major stops of the machines/equipment for repairs, thus increasing their availability. This method allows achieving more appropriate and efficient management of human resources. It is through self-



maintaining activities that begins the process of training the operators to make them responsible for their workplace and equipment.

### *5.1. Applying lean concepts using TPM & 5S methodology:*

A first approach to the autonomous maintenance was to implement it to the equipment associated with the shipping facility which requires more maintenance and stronger control by the operator and equipment whose proper functioning is critical to the continuity of the process. The maintenance is guided through documents that serve as a guide to the operators when performing maintenance [11, 17].

Before the implementation, we should know that the operators had not at his charge any maintenance activities, except for some visual inspection tasks. Equally, the shipping facility operators had no maintenance responsibility, while there was a person exclusively to maintain this division. With the introduction of TPM techniques, it was possible to migrate the most basic maintenance tasks to the operators and free the technician for other maintenance tasks. It is also necessary to assess the tasks to be delegated to the operator, as well as evaluating the equipment manufacturer's recommendation.

Implementation of the 5S methodology in maintenance activities is done by eliminating any kind of materials that no longer used or obstruct access to materials and equipment [27]. Pack the materials and equipment of the maintenance services by creating labels for all component and by improving the identification of the workshop components. Clear all the areas of the maintenance service by removing floor garbage. Standardize all equipment service by creating quality standards, cleanliness standards, safety standards & standards of working procedures. Finally, respect the change made in the maintenance service.

First, QPC has to select and sort all types of equipment used inside the shipping facility which has a critical effect on production. Some of the equipment which needs criticality evaluation is Oil Storage Tank, Valve, Strainers, Booster Pump, HPS pump, Motors, and controllers. There are several methods that let us analyze this need, one of those is IPINZA Method.

After estimating the scores for all equipment by summing grades as shown in table 1, we can select the type of maintenance to be applied to the equipment according to the criticality of each one (Optional: Score (0 to 6) – Convenient: Score (6 to 13) – Important: Score (13 to 19) – Critical: Score (19-22)). In order to guide the technician in their inspections, we were created maintenance procedures for each machine. These documents contain a list of activities that should be undertaken by the operator or maintenance technician, aimed to ensure the proper functioning and cleaning of equipment.

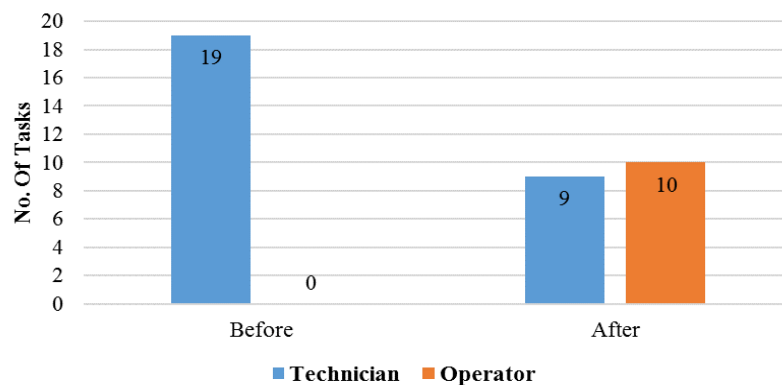
After selecting Horizontal Pumping System (HPS) which has the largest score results in IPINZA method, the list of preventive routine maintenance was sorted and reclassified between the Technician and Operator to migrate the most basic maintenance tasks to the operators and free the technician for other maintenance tasks (Monthly, 3 Months and 6 Months) such as inspection, oil change, clean, grease, visual check of mechanical parts. In addition to the standards and internal procedures created called "TPM TAG". These documents are no more than labels that inform you whether the equipment has been inspected and what tasks were undertaken during the inspection.

### *5.2. Results of implementation*

- The implementation of this method reduced total PM tasks done by Technicians for HPS Pump by 52.63% and transfer the less difficult inspections to Operator to be responsible for making checks to all parameters of all equipment and to enable Technicians to perform other maintenance tasks. As shown in figure 3.

**Table 1.**Scoreboard IPINZA Method and Assessment.

Description	Answer	Score	Oil Storage Tank (Eq-01)	Valve (Eq-02)	Strainers (Eq-3)	Booster Pump (Eq-4)	HPS Pump (Eq-5)	Motor (Eq-6)	Controller (Eq-7)
1 Effect in production	Stop	4	4	4			4		
	Slow Down	2			2	2		2	2
	No effect	0							
2 Economical Value of the Equipment	High	4	4				4	4	
	Medium	2				2			2
	Low	1		1	1				
3 Consequences of Failure Machine	Yes	2	2	2		2	2	2	2
	No	0			0				
4 Consequences of Failure of Process	Yes	3	3	3			3	3	3
	No	0			0	0			
5 Consequences of Failure to Staff	Dangerous	1						1	1
	Not Dangerous	0	0	0	0	0	0		
6 Dependence on Logistics	Foreign	2				2	2		1
	Local	0	0	0	0			0	
7 Manpower	Subcontract	2					2		
	Own	0	0	0	0	0		0	0
8 Reliability	High	1	1	1	1	1	1	1	1
	Low	0							
9 Repair Difficulty	High	1	1				1	1	1
	Low	0		0	0	0			
10 Flexibility and Redundancy	Simple	2							
	By-Pass	1	1			1	1		1
	Double	0		0	0			0	
Total Score			16	11	4	10	20	14	14
			Important	Convenient	Optional	Convenient	Critical	Important	Important

**Figure 3.** Classification of Preventive Maintenance Tasks for HPS Pumps Before & After Implementation LM Tool.

- With the application of this methodology, companies can improve not only the costs and efficiency but also the quality, flexibility, and innovation.
- The new guidelines employee motivation will increase and it will contribute to the increase in discipline and safety levels and
- The standardization of procedures and tasks is now company policy.
- This autonomous maintenance policy generates a reduction in waste such as the motion of technical maintenance, as well as the allocation of a technician to a specific activity in 100%.

### **6. Case Study (III): Check the availability, Reliability & Utilization of each equipment by Integrating Key Performance Indicators with Computerized Maintenance Management System**

Qarun Petroleum Company "QPC" have a Computerized Maintenance Management System (CMMS), this system consists of two software (GMS) Global Maintenance System and (MMS) Materials Management System. The GMS is used by fields Engineers & Technicians and responsible for issuing the work orders for each department based on the PM Plan of each equipment according to the maintenance instruction book. While MMS is the main general software used by Operations & Office engineers to review the Materials Requisition (MR) & purchase orders (PO) from ordering till receiving in Fields warehouse. CMMS can reinforce reporting and analysis capabilities[24].

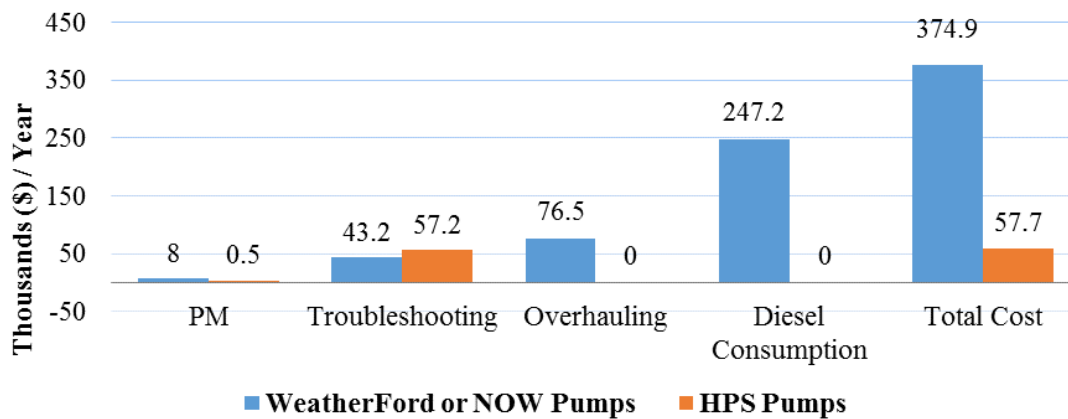
Accessibility and accuracy of information can provide more reliable decisions in CMMS because of closer working relationships between maintenance and production. So, the Planning Department is responsible to review and supervise the update of that information with each department to ensure that each item is up to date and each preventive maintenance "PM" is done in time [25].

Generally, the CMMS have all required features like Work Order Management, Planning Function, Scheduling Function, Budget/Cost Function, Spares Management and Key Performance Indicators. CMMS software prices vary depending on method of deployment, number of users, and level of functionality and customizations. For a web-hosted CMMS, small businesses with only one or two users might pay \$50 to \$100 per month, while mid-sized companies will probably pay several hundred dollars. Companies can also purchase an off-the-shelf CMMS without customizations for \$750 to \$1000. For customized on-premise solutions, vendors typically charge a base fee for the software and a separate fee for each user. Small companies might pay between \$1,500 and \$10,000, while larger businesses with more comprehensive needs can spend \$10,000 to \$40,000. These prices don't include support and software upgrades, which can run about 20% of the total purchase price each year.

This case study is a new innovation method done based on the integration of Key Performance Indicators within the CMMS system to check the availability, Reliability & Utilization of each equipment from 2012 to 2017. By getting the required data for each equipment which exist in Qarun & Karama Fields. The case study focused on the Weatherford Pumps & National Oil Well Pumps "NOW" (Triplex Reciprocating Pumps), those pumps are in operations since 2008 at Qarun & Karama Fields. Weatherford & NOW pumps have a lot of downtime due to repeated problems Compared to current new Water Flood "WF" Horizontal Pumping System "HPS" pumps (REDA & WOODGROUP). The Selection of those pumps was done based on the results of Key Performance Indicators: "Mean Time Between Failure" (MTBF), "Mean Time to Repair" (MTTR) and "Mean Time Between Repair" (MTBR) during financial year (July 2017 till June 2018). After reviewing the total Existing Water Flood Pumps (Weatherford & NOW) Skids at QPC we found that 50 % of those skids are down.

Also, we found that the Operational Costs of one Weatherford pump per year exceed the price of purchasing a new HPS pump by \$144,954, it means that the payback for HPS Pump will be less than one year and the replacement of five skids per one financial year will save about \$724,770 in addition to the availability, Reliability & Utilization of HPS Pumps will be better than Weatherford Pumps. In addition to the Operations Cost of HPS pump per year is very low comparing to the Operations costs of Weatherford pumps. Those Problems cause QPC a lot of costs especially in spare parts replacement during the repair & Overhauling. In addition to the operational cost of Diesel consumption, Field

Service Representative “FSR” Site visit and delay of supply, while in other side comparing to HPS Pumps the availability & Reliability, Replacement, and Repair of those are perfect as shown in figure 4.



**Figure 4.** Cost Comparison between Triplex Pumps and HPS Pumps/ One year/ One Skid.

#### 6.1. Results of Implementation

- The Results of the new innovation Case study demonstrated that the integration of Key Performance Indicators within the CMMS system had strong application prospects in Oil & Gas maintenance.
- The Operational Costs of one Weatherford pump per year exceed the price of purchasing new HPS pump by \$144,954 it means that the payback for HPS Pump will be less than one year and the replacement of five skids per one financial year will save about \$724,770 in addition to the availability, Reliability & Utilization of HPS Pumps will be better than Weatherford Pumps.
- Weatherford & National pumps must be replaced by another HPS pumps due to the low cost of operation of HPS pumps compared to Weatherford & National pumps.

### 7. Conclusions

The implementation of Lean Concepts for maintenance in Oil and Gas Sectors will bring great economic benefits and powerful techniques support for the equipment maintenance reform. Applying Lean Maintenance strategy also can ensure a high degree of utilization, reliability, and availability of facilities especially in a continuous production process. In addition to increasing productivity, Profit, improving quality, decreasing wastes, cycling times, Inventory, costs and number of Operators.

Propose three case studies using lean maintenance tools, two case studies similar to the published papers in Oil & Gas Sector: Integrating Building Information Modelling (BIM) with lean concepts and Improve Maintenance Service Using (TPM) & (5S) Methodology. In addition to a new innovation case study by monitoring Key Performance Indicators (KPIs) within a modern Computerized Maintenance Management Software (CMMS). The results of case studies from July 2017 till June 2018 is as follows:

- An average increase in crude oil production by 6.72% per day besides to overcome the natural decline of oil wells.
- Reduced Technician's total Preventive Maintenance (PM) tasks by 52.63% and transfer the less difficult inspections to Operator to enable Technicians to perform other maintenance tasks.
- Saving about \$724,770 in Water Injection Pumps Operation's Expense and accelerate the workflow of maintenance and production processes by 28% comparing to the previous year.

Last but not least Applying KPIs, CMMS software, BIM and Lean Maintenance Tools, are recommended to be implemented in all Oil & Gas Companies, to get the same improvement.

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