

Analysis of Maintenance Activities in Oil Lubrication Refinery Using Statistical Techniques

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Abstract

In this research the maintenance activities is investigated for lube oil factory (3) as this factory is the newest and largest in its production capacity compared to lube oil factories (1) and (2) at Daura refineries. Data of different equipment's failure are collected for ten consecutive months.

The frequency of breakdowns and type of maintenance were identified and analyzed employing certain statistical techniques are; Pie and Pareto charts. Results indicate that %95 of breakdowns for different equipment's in lub oil factory 3 (pumps, heat-exchangers, compressors, docks, filters, furnaces and towers) are due to mechanical causes, and the rest are related to electrical causes. Pareto charts highlight that most frequent failures for pumps and exchangers followed by compressors and other equipment of lube oil factory 3. Types of maintenance classification shows that Pumps are dominating corrective maintenance activities in terms of frequency of occurrence. Although the frequency of breakdown in exchangers is the same as that for pumps, but these pumps suffer from both mechanical and electrical breakdowns. Equipment failures lead to many problems such as loss of production time, loss of material and lack of achieved production order. It is recommended to focus upon planned programmed maintenance and adopting decision support systems.

Keywords: Maintenance Activities, Frequency of Failure, Pie Chart, Pareto Chart, Oil Lubricants, equipment breakdown.

تحليل أنشطة الصيانة في مصفى الدهون باستخدام التقنيات الأحصائية

الخلاصة:

في هذا البحث تم الاستقصاء عن أنشطة الصيانة لمعمل دهنون 3 كون هذا المعمل هو الاحدث والاكثر انتاجية مقارنة مع المعملين رقم 1 و 2 في مصفى الدورة وتم جمع البيانات حول فشل المعدات المختلفة لعشر اشهر متتاليه. ان تكرار الاعطال ونوع الصيانة تم تحديده وتحليله باستخدام بعض التقنيات الاحصائية مثل المخطط الدائري, ومخطط باريتو. بينت النتائج بأن 95% من الاعطال لمختلف المعدات في معمل 3 (مضخات ,مبادلات حرارية ,كابسات ,اوعية ,مرشحات ,افران و ابراج) ناتجه عن أسباب ميكانيكية والبقية لأسباب كهربائية. مخطط باريتو استخدم للإشارة الى المضخات والمبادلات لأنها اكثر المعدات تكراراً للأعطال يتبعهما الضاغطات ثم باقي المعدات لمصفى دهنون 3. حيث تبين ان أنشطة الصيانة التصحيحية هي السائدة نظراً للأعطال المتكررة التي تحدث في المضخات , بالرغم من ان تكرار الاعطال للمبادلات هي نفسها للمضخات. علاوة على ذلك فإن تلك المضخات تعاني من الاعطال الميكانيكية والكهربائية معاً. ان تكرار الفشل يؤدي الى الكثير من المشاكل كالحسارة في الانتاج والوقت في المواد والعجز عن تلبية الانتاج المطلوب. والتوصية بالتركيز على الصيانة المبرمجة والمخططة واعتماد نظام داعم للقرار.

الكلمات المرشدة: أنشطة الصيانة, تكرار الاعطال, المخطط الدائري, مخطط باريتو , زيوت التشحيم , اعطال المعدات.

INTRODUCTION

Maintenance of equipment is still a challenging issue because of various factors including complexity, cost, and competition. Each year billions of dollars are spent on equipment maintenance worldwide, and it means there is a definite need for effective asset management and maintenance practices that can positively influence success factors such as quality, safety, price, speed of innovation, reliable delivery, and profitability [1].

U.S. Department of Defense defines maintenance engineering as a discipline that assists in acquisition of resources needed for maintenance, and provides policies and plans for the use of resources in performing or accomplishing maintenance [2]. In contrast, maintenance activities are viewed by those whom use resources in physically performing actions and tasks attendant on the equipment maintenance function for test, servicing, repair, calibration, overhaul, modification, and so on. World-class companies are in continuous need of a very well organized maintenance programmed to compete world-wide [3]. While European Committee for Standardization(2001)defined maintenance as “the combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to a state in which it can perform the required function”. The definition of maintenance often states maintenance as an activity carried out for any equipment to ensure its reliability to perform its functions [4]. In the maintenance literature it is generally recognized that maintenance philosophies can be grouped into three broad categories Corrective Maintenance (CM), Preventive Maintenance (PM) and Predictive Maintenance (PdM).

One of the most important issues in oil refiners firms is that the refineries are constantly falling under the pressure of market demands due to the fact that the basic refining process allows the firms to extract only a fixed amount of different products from a unit of input (crude oil). So in order to satisfy the market demand, firms are compelled to apply more complex processes, which demand costly investments. This pressure increases with the need for frequent maintenance activities on refining machinery and equipment. In the majority of cases these kinds of works incur not only costs but also demand the stoppage of production for the period of maintenance. With growing demand

on petroleum products, refining firms have a strong incentive to produce at maximum production rates and capacity possibilities. Refining facilities process several hundred thousand barrels of crude oil per day. Taking this into consideration, one understands that the supply side of the market and the prices of final products significantly depend on capacity possibilities, unexpected refinery outages and decisions on frequency of maintenance works. It is clear that choosing the “right” time for stoppage is a challenge for refinery firm [5, 6].

An importance of maintenance decisions can also be seen from the perspective of complexity of refinery systems: the sophistication of the refining process has grown since the beginning of technological revolution due to competition among firms and the need for frequent changes in the fractions of different refined products to satisfy the constantly changing demand. As a result, vulnerability of refinery system and machinery to breakdowns (even in small areas) has greatly increased and brought up new reasons for increasing frequency and quality of machinery maintenance [7].

These maintenance decisions have become crucially important in preventing disasters in safer cases huge costs to the refineries. There were numerous explosions and fires at oil refineries in different countries during the past decades, majority of which happened due to the failure in machinery system or leakages. British Petroleum oil refinery explosion in Texas (March 2005) led to fifteen deaths, more people were wounded. This event led to huge losses for society, environment and for the refinery firm itself. The reports claimed that the explosion happened due to a breakdown in certain system. The fire in Bombay High oil field in India (2005) is another example, when four people were killed and the platform itself was completely destroyed in the fire. The reason for this event was a leakage in a naphtha pipeline [5]. In the next paragraph different literatures are reviewed to highlight the potential in maintenance activities in oil refineries, further the data that are collected for lube oil 3 factory throughout ten consecutive months are analyzed and the failures were identified according to the type of maintenance (planned, and emergency) also according to the type of failure i.e. (mechanical, and electrical). The last paragraph reveal the conclusions deduced from this research and the recommendations for future work.

Literature survey

Many researches that are directed towards different maintenance activities in oil refineries at different stages of oil production activities. Samuel Telford, et al (2011) studied Condition Based Maintenance (CBM) in the oil and gas industry. In their research they reinforces the fact that the role of CBM is critical to the smooth, uninterrupted, efficient and safe running of oil and gas facilities. This in turn can promote optimized utilization of plant equipment with higher levels of certainty and safety [8].

M. Bertolinia et al (2009) studied the development of risk-based inspection and maintenance procedures for an oil refinery; they found that the management of failure analysis has a strategic importance within a refinery from the organizational, engineering and economic points of view. In their work they reported the application of the risk-based inspection and maintenance method into two specific stages in the maintenance activities of the refinery, i.e. the oil refinery turnaround and work orders management.

These results highlighted a clear improvement in the indices which measure the quality of maintenance [9].

Anar Yusifov (2008) studied Oil Refinery Maintenance as a Strategic Decision; He constructs a model of interaction of refinery firms which decide on their maintenance and production levels. The results of static model suggested that refineries should be produced at a low level with a less need for maintenance. Dynamic model suggests that it is better to skip the production in the first period and take up maintenance instead [7].

Safaa Mohammed (2005) used operation research techniques in estimation of preventive maintenance cycle and applications in oil Projects Company; Some (OR) techniques are applicable to maintenance management. The aim is to give estimation of preventive maintenance cycle cost, and give an opportunity for the manager to select the one from among the alternatives to develop maintenance policy. The policy of maintenance is to go for preventive maintenance once every three months [10].

Therefore decision maker(s) time and efforts must combine multi criteria such as time, cost and priorities etc. when adopting the appropriate maintenance strategy. Accordingly, decision support system in oil refineries is crucial to boost and enforce maintenance decisions so as to take the best type and/or combination of alternatives that may enhance productivity and save resources and time.

Data Collection, Analysis and Discussion

In Daura refinery there are three lube oil factories, these are; lube oil (1), lube oil (2), and lube oil (3), the total production capacity of these three factories at Daura refinery is 121000 tons / yr. lube oil (3) started producing in 1978 has production capacity of 60,000 tons / year. Therefore, lube oil (3) produces half of lubricating oils Daura refinery, also it is the newest factory with capacity equal both capacities of lube oil 1 and 2. Figure (1) shows the flow diagram of the operational units for Lube Oil Factory (3) [11]. Also it contains additional hydrogenation and oxidizer units and its equipment's are of high level of sensitivity.

Data were collected for maintenance activities in lube oil factory (3) for ten consecutive months for the above mentioned operational units (pumps, exchangers, compressors, towers, docks, filters and furnaces). The frequency of breakdowns and type of maintenance are identified and analyzed using certain statistical techniques are; Pie and Pareto chart.

Results and Analysis

Pie Chart Analysis

Pie chart was employed to determine the frequency of equipment's breakdown for ten months are shown in Figure (2) for the whole ten months of this study. The total number of failures occurring is monitored and categorized according to different types of maintenance, that are employed at Daura refinery. These are categorized to Corrective Maintenance (CM) and Programmed Maintenance (PM) for equipment breakdowns for ten months as shown in Figure (3).

From this figure it could be noticed that corrective maintenance is the most frequent compared with programmed maintenance. Corrective maintenance represents 80% of the rest of the other types of maintenance, including replacement of equipment and parts.

Maintenance activities are carried out according to annual programmed maintenance that is supplied by Iraqi Oil Ministry according to significant timetable [3].

Maintenance type and frequency of failure for each equipment, and total frequency all are summarized in Table (1). From this table it could be noticed that through the whole research period no programmed maintenance was recorded for filters, or for vacuum equipment. This is almost acceptable for vacuum equipment since there is only one failure recorded throughout ten months. But it is not acceptable for compressors that suffer from 30 failures and filters 10 failures throughout these ten months. Therefore, the central programmed maintenance supplied from the Ministry of Oil should be considered and updated according to the status of refinery equipment as this programmed maintenance does not match the real status of production activities in lub oil (3) factory.

Pareto Charts Analysis

Pareto chart can recognize the most important among (typically large) set of factors. Thus Pareto chart is used to analyze frequency of equipment breakdown as in Figure (4.) The most common equipment failure are pumps followed by exchangers, compressors, towers, filters, docks, and then furnaces. Also Pareto chart reveals that through the ten months only two types of maintenance (CM, PM) for the pumps, exchangers, docks, towers and furnaces are recorded except compressors and filters, one type of maintenance (CM) is noticed. Further analysis is employed using Pareto chart to categorize the maintenance type, (mechanical or electrical failure) and depending on the data collected from Daura refinery that are illustrated in Figure (5) below. Detailed frequency of equipment failure and type of Maintenance for the ten months in Figure (5), is tabulated in Table (2). In this Table each equipment failure is recorded according to the position of the equipment as service or operation unit, also according to the type of maintenance.

Table (2) shows that in spite of maintaining pumps (planned or emergency) still these pumps suffer from failure regardless they are operational or service pumps. Also table (2) shows that compressors suffers from different types of failures and are not maintained according to pre-programmed maintenance throughout the ten months of this study. Although filter failures are less than compressor but further consideration is also needed regarding programmed maintenance. Additionally, in table (2) it is noticed that most of the failures occurs in the DW unit equipment, i.e. excess downtime which will require detailed and effective maintenance programs.

From Figure (5) it is noticed that most common failures are mechanical. Where mechanical failures of 95%, while 5% of failure are electrical. This may also affect the planned maintenance as well as the maintenance team qualification that should be involved in conducting maintenance programs of lube oil factory (3) operation units. Frequency of breakdowns either (Electrical or Mechanical) is summarized in Table (3) below according to each equipment. From this table it could be noticed that only pumps suffer from electrical as well as mechanical failure, other equipment either did not need electrical maintenance such as furnaces, filters, or towers, or frequently need certain maintenance to assure continuous equipment operation such as exchangers and docks.

According to the previous analysis the followings remarks are concluded:

1. Pareto chart shows that pumps have the most frequency of failure followed by exchangers. Thus pumps are still dominating corrective maintenance activities in terms of

frequency of occurrence. Although the frequency of breakdown in heat-exchangers is the same as that for pumps, but these pumps suffer from both mechanical and electrical breakdowns and less maintained as programmed.

2. Due to the importance of timely market demands for oil products, maintenance decisions are strategic and decision support systems are crucial because refineries have to compromise between time, frequency of failure and maintenance type. This choice of best alternative affects profit, therefore productivity.

3. Equipment failures lead to many problems such as loss of production time, loss of material and lack of achieved production order.

Conclusions

It could be concluded from this study that:

1. The failure of the equipment of DW unit is the most frequent occurring, that means it is a bottleneck in the refinery.
2. The requirement of construct database on equipment failure. This DB will offer feedback to manager in the case of similar issues and help planner to predict the proper maintenance strategies.

Recommendations

1. Maintenance department at Dora refinery need to program maintenance different activities instead of that supplied by oil ministry so as to be more realistic and conform production different activities.
2. Maintenance staff have to develop plans that focus on programmed , and preventive maintenance rather than corrective maintenance.
3. maintenance activities should extract all equipment even those that are not recorded in this study.

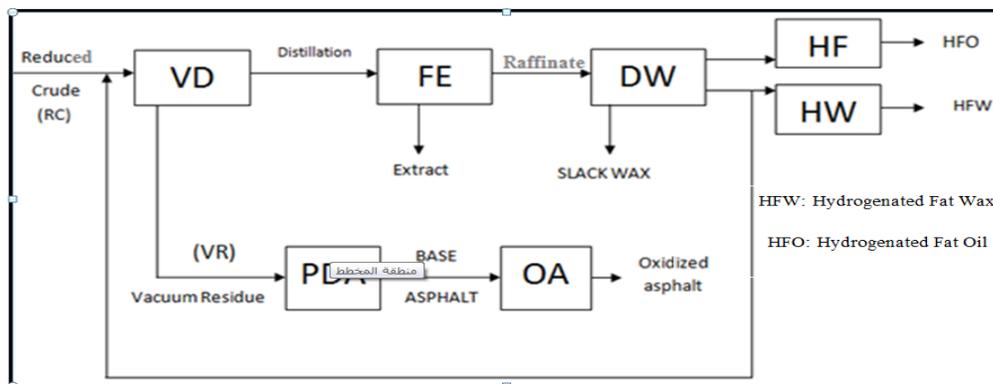
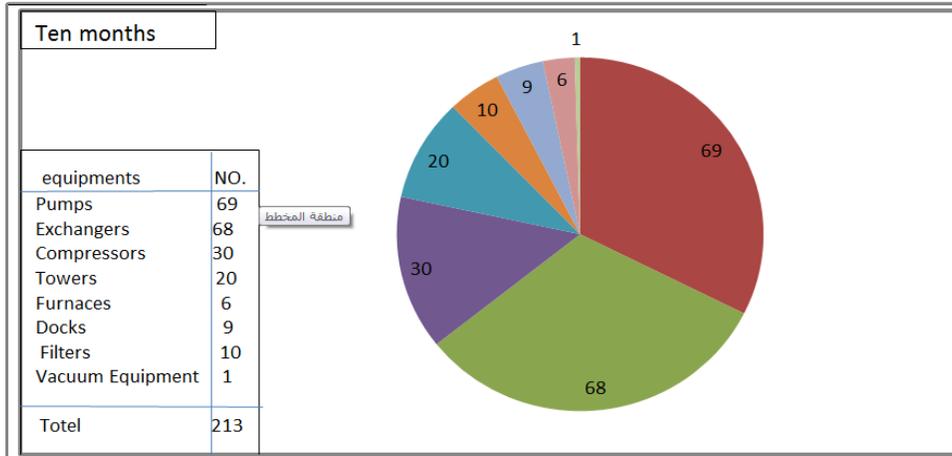


Figure (1) Flow Diagram of the Operational Units of Lube Oil Factory (3)

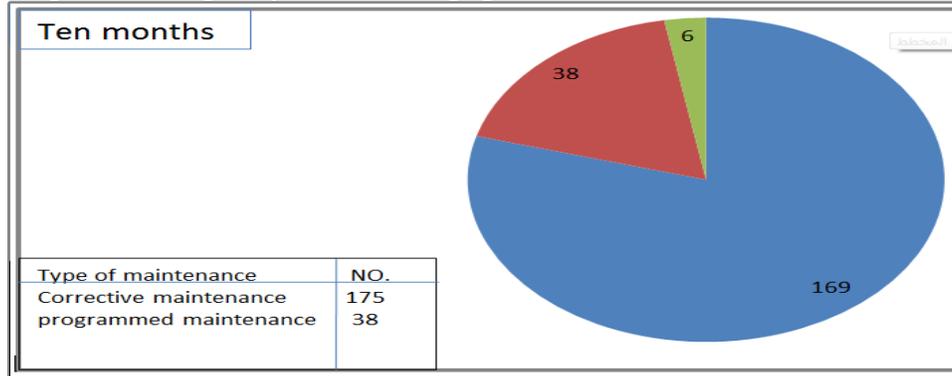
Lube oil production units at Daura Refinery may consist of certain operational units, these are;

- VD: Vacuum Distillation Unit.
- PDA: Propane De- Asphalter Unit.
- FE: Furfural Extraction Unit

DW: De Waxing Unit.
 HF: Hydrogenation Fats Unit
 HW: Hydrogenation Wax Unit, and
 OA: Oxidizer Asphalt Unit.



Figure(2) Frequency of Failure Equipment in Lube Oil (3) for ten months.

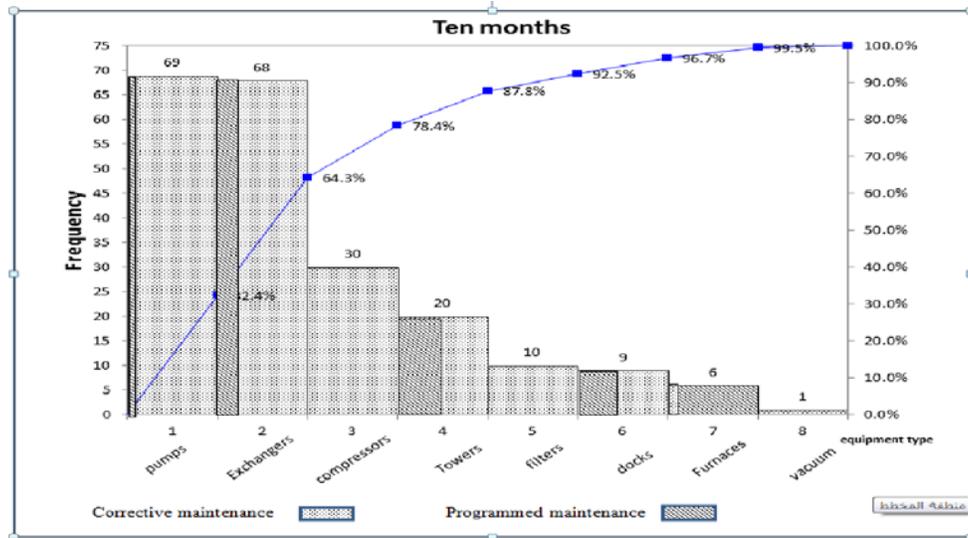


Figure(3) Frequency of Maintenance Type for Ten months at lube oil (3).

Table (1) Frequency of Failures and Maintenance Type for Equipments

Type of maintenance equipment	Corrective maintenance	Programmed maintenance	Total frequency of failures
Pumps	64	5	69
Exchangers	53	15	68
Compressors	30	-	30
Towers	11	9	20
Furnaces	1	5	6
Docks	5	4	9
Filters	10	-	10
Vacuum Equipment	1	-	1
Total frequency type of	175	38	213

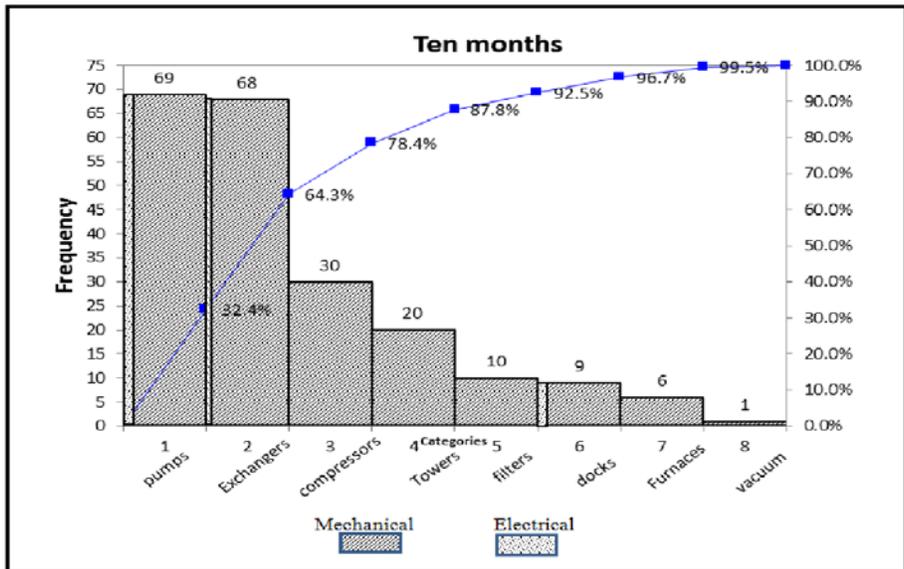
maintenance



Figure(4) Detailed Frequency of Equipment Failure and Type of Maintenance for ten months

Table (2) Detailed Frequency of Failures at Operation and services units and Maintenance for Equipment from Ten Months

Equipm ent	Operation and services units								Type of maintenance	
	VD	PDA	FE	DW	HF	HW	OA	Services Unit	Corrective maintenance	programmed maintenance
Pumps	3		10	33	4		1	18	64	5
Exchang ers	3	4	26	31	1	2	1		53	15
Compre ssors		2	5	13	10				30	
Towers	2	1	9	8					11	9
Furnace s	1		3				2		1	5
Filters				10					10	
docks	1		2	5			1		5	4
Vacuum			1						1	



Figure(5) Frequency of Failure either Mechanical or Electrical for ten months

Table (3) Frequency of Breakdowns (Electrical or Mechanical)

Type of equipment	Electrical breakdowns	Mechanical breakdowns	total
Pumps	7	62	69
Exchangers	2	66	68
Compressors	-	30	30
Towers	-	20	20
Filters	-	10	10
Docks	1	8	9
Furnaces	-	6	6
vacuum	-	1	1

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