Development of Computer Program for the Prediction of Electrical Energy Consumption Effect on Production and Failure Rates of Lubcon Oil Production Line

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Abstract

A computer program based on a generated model equation was developed by using JavaScript programming language to predict the expected value of the electrical energy consumption as a function of production and equipment failure rates. By comparing the primary data from Lubcon oil industry, Ilorin, Kwara state with the simulated data, it was discovered that the simulated electrical energy consumption is lower than the actual. In view of the data obtained from Lubcon Oil, it can be seen that increase in equipment failure brings about increase in energy consumption while the production rate might not actually increase. Therefore, if Lubcon Oil industry can reduce its failure rate by 3% or 5%, there will be significant reduction in the electrical energy consumed which will in turn lead to reduction in unit cost of production of oil. Hence, it is recommended that adequate attention be paid to preventive maintenance so as to forestall sudden breakdowns.

Key words: Computer program, prediction, electrical energy consumption, production rate, failure rate, lubricating oil.

1.0 INTRODUCTION

Software are nowadays extensively used to develop different kinds of software application efficiently. Software development is the process of conceiving, specifying, designing programmable program or process of writing and maintaining the source code in a broad sense.

In Manufacturing companies, and process plants within them, can define their strategies and competitive priorities on different key performance indicators for their production systems: flexibility, productivity, quality, but also safety, environmental protection, and energy efficiency. Maintenance is fundamental in assuring the availability and reliability of production facilities; thus, if Companies design proper maintenance policies which are a set of rules describing the triggering mechanism for the different maintenance actions, they could more easily reach their productivity goals and guarantee plants efficiency. Complex process plants contain several major-energy consuming equipment, and thus offer multiple opportunities for energy saving, that could be linked to a significant boost to the overall industrial productivity, as demonstrated by the review of more than 70 industrial case studies. To gain the above discussed benefits, most of all for plants where the energy efficiency policy is still under development, it is important to define a prioritization criterion for the multiple energy efficiency measures that could be identified, leading to a maximization of the implemented measures efficacy (Micaela *et al.*, 2018).

Software processes play an important role in helping project teams in software development organizations and they use similar and sound practices. Ideally, these processes should combine the need for rigor and discipline with the need for flexibility and creativity (Muhammad *et al.*, 2014).

As the complexity of such research software and program code is increasing, also the development of the program code is getting more complex, especially when developed and used in larger interdisciplinary groups. One way to deal with these issues is to use software engineering concept sand tools which can help to improve the whole process of software development and software project management. Although there are software engineering tools that are already well established in general software development, such concepts and tools are underused in research software development so far.

Traditionally, maintenance has been considered as a necessary evil, but in fact it is a profit center rather than just unpredictable and unavoidable expense (Al-Najjar *et al.*, 2004). Effective maintenance policies, such as Condition Based Maintenance (CBM), can significantly reduce failure rate which resulting in considerable savings of money, time and company's reputation in the market (Karanovi *et al.*, 2018).

The approach towards maintenance has changed throughout the years. It has been transformed from reactive (corrective) actions to ongoing predictive activities with an aim to optimize the time, costs and quality. While nowadays it could be foreseen as a competitive advantage or area, whose improvement may increase profit and bring many benefits, some still consider maintenance as the "necessary evil". In this paper, we identified four key maintenance concepts that correspond to the industrial revolutions. Nowadays the maintenance management aims to decrease both the unscheduled downtime and scheduled downtime, which both reduce the available time, in combination with optimization of safety, environmental risks and costs.

Industrialization is the process of manufacturing consumer and capital goods which have the tendency of creating the necessary social overhead capital that would stimulate the development of other sectors of the economy (Ziemerink and Bodenstein, 2004). Furthermore, industrial growth or industrialization is a deliberate and sustained application and combination of an appropriate technology, infrastructure, managerial expertise, and other important resources in the production of output. The survey by Manufacturing Association of

Nigeria (MAN) carried out in 2006 and in the first quarter of 2009 painted a dim picture of the Nigerian Industrial sector. According to the survey for instance, only 10 percent of manufacturing concerns in Nigeria could operate at 48.8% of installed capacity, 60% of the company's operations were unable to cover their average variable costs, while 30 percent had to completely shut down (Ogunjobi 2015). Abundance of energy is a pre-requisite of manufacturing and it is mainly utilized for powering machines for the production of various items. The manufacturing sector has always emphasized the need to improve various infrastructures, particularly, electricity which is in primary form of energy required for production (Ogunjobi, 2015).

Energy is the capacity of a system to do work. In carrying out any activity by any system (animate or inanimate) energy is utilized (Asatu-Adjaye, 2000). This energy is obtained from various sources with photosynthesis while inorganic systems depend on a wide range of fuel sources. Energy plays a fundamental role in shaping the human condition. People's need for energy is essential for survival, so, it is not surprising that energy production and consumption are some of the most important activities of human life (Asatu-Adjaye, 2000). According to elementary physics, energy is of various forms, each form being transferrable or convertible to another. The major forms of energy are: mechanical energy, solar energy, thermal energy, electrical energy, electromagnetic energy and mass or nuclear energy (Asatu-Adjaye, 2000). Industrial-use energy like all other uses preys on the convertibility of forms of energy, such that a factory could generate electricity from solar panels (star or electrical conversion) or from mechanical generation (chemical to mechanical to electrical conversion) and so on (Asatu-Adjaye, 2000). Electrical energy is used in industries to power heavy machinery and smaller appliances (electrical to mechanical conversion). The electrical sector is a subset of the energy sector and access to electricity serves as the basic form of energy supply to the masses that play a vital role in the growth of a nation's economy. Odell (1965) in his study on the role of electricity in a rapidly developing economy, he observed that electricity is very important for industrialization which leads to economic growth and development.

Alam (2006), agreed that there is a departure from neo-classical economics which recognizes only capital, labour and technology as to a factor of production to include energy, according to him; energy drives the work that converts raw materials into finished products in the manufacturing process. Sanchins (2007), argued that electricity in industries is responsible for a great deal of output and it had effects not only on factors of production but also on the impacts of capital accumulation. She added that increase in the electricity will avoid the privatization of the industrial production. Iwayemi (1988), argued for the importance of energy sector in the socio-economic development of Nigeria, submitting that strong demand and increased supply would stimulate the increased income and high living standard. Also, Oke (2006), attributed the non-competitiveness of Nigeria's export goods to infrastructure, especially electricity supply, which drives the running cost of firms. In his contribution, Lee and Anas (2007), industrial establishments in Nigeria spend an average of 32% of their variable costs on infrastructure with electric power accounting for more than half of this share. Adenikinju (2005), examined the cost of electricity shortages on the Nigerian manufacturing sector using the data obtained from a nationwide survey. The study confirms that the cost of electricity failures to the Nigerian manufacturing sector is quite high. Nigerian firms were found to incur costs on the provision and maintenance of expensive back-up to minimize the expected outage costs. This includes high cost diesel and gas with the average costs as huge as three times the cost of publicity supplied electricity. The marginal cost estimates also indicate that the cost of Kwh of unserved electricity is very high. A lot of multinational corporations have closed their firms and relocated to the nearby countries that enjoy uninterrupted electricity supply.

Adenikinju (2005), opines that machine efficiency is one of the factors that are frequently overlooked by the management and this can lead towards losses which reduces the yield. Improper maintenance of machines will result in low standards of produced parts and increases the maintenance of machines. Machines are meant to work efficiently, but in some circumstances, machines can be less productive due to improper preventive maintenance. Preventive maintenance is a key factor that keeps the machine running efficiently through the production process. The maintenance activity on machines needs extra attention by the management along with the responsible personnel to ensure optimum usage of machineries which will eliminate unwanted wastages due to machine stoppages.

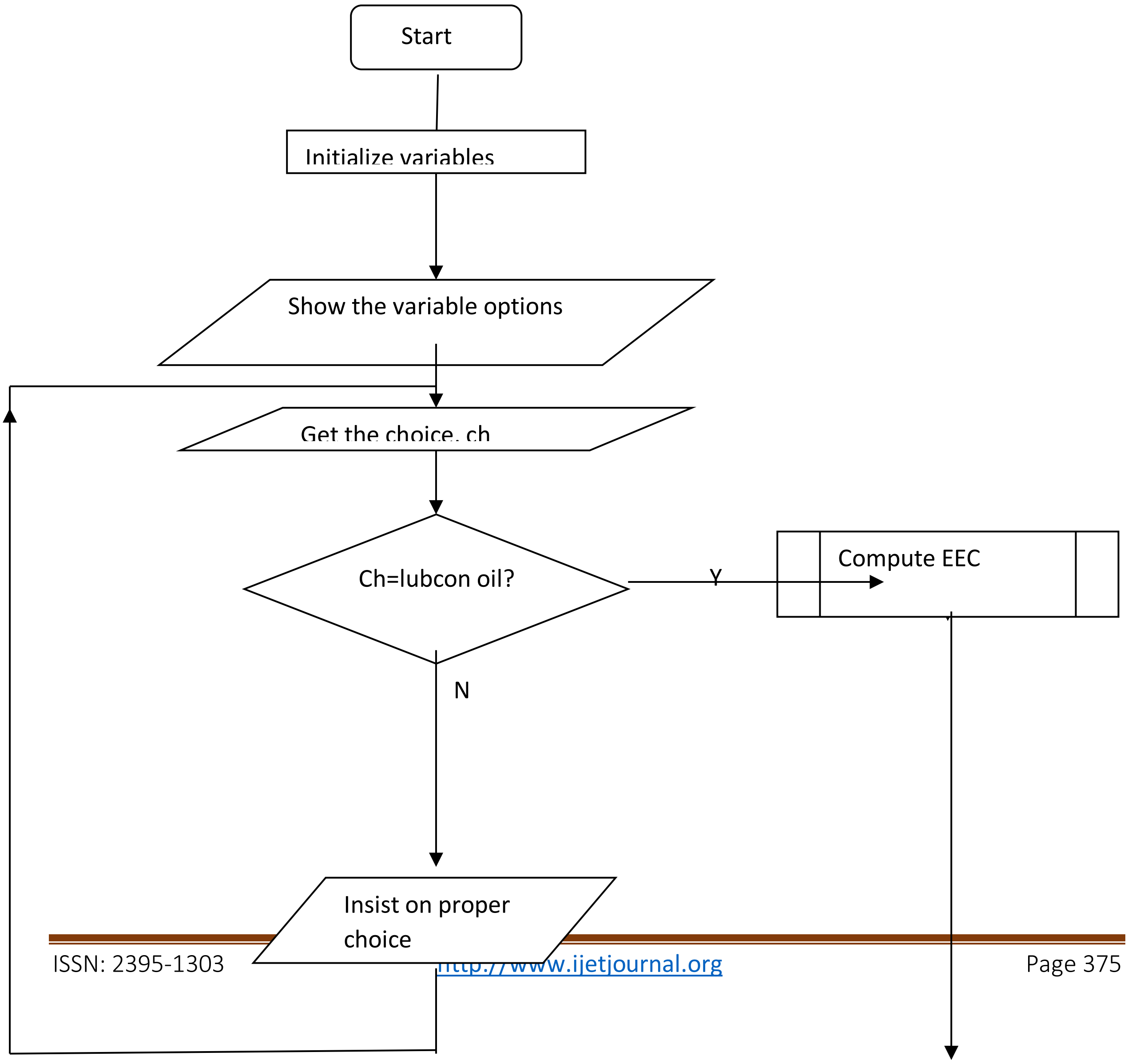
2.0 Development of Computer Program for the Prediction of the Effect of Electrical Energy Consumption on Production and Failure Rates of Lubcon Oil

A computer program based on model equation developed by Olorunnishola and Oladebeye (2022) as shown by equation 1 was developed by using JavaScript programming language to predict the expected value of the electrical energy consumption as a function of production and equipment failure rates.

$$Exp(EEC_{Lo} / FR, PR) = 49.728 - 0.373FR + 0.0001PR \quad \text{...Eqn. 1}$$

2.1 Algorithm and flowchart development

Algorithms are nothing but sequence of steps for solving problems. The use of algorithms provides a number of advantages. One of these advantages is in the development of the procedure itself, which involves identification of the processes, major decision points, and variables necessary to solve the problem. Developing an algorithm allows and even forces examination of the solution process in a rational manner. So a flow chart can be used for representing an algorithm. A flowchart, will describe the operations (and in what sequence) are required to solve a given problem. The flowchart is a diagram which visually presents the flow of data through processing systems. This means by seeing a flow chart one can know the operations performed and the sequence of these operations in a system, (Amir yasseen Mahdi 2013). The developed computer aided program for predicting the electrical energy consumption of lubcon oil international (CAPPEEC, 2018) is expected to input the production and failure rates in litres and hours such that when the command button is pressed, estimated electrical energy consumptions are presented. the computer program interface is as shown in plate 5. the flowcharts for the development of the program are shown in Figures 1 to 2.



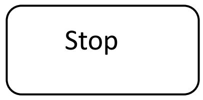


Figure 1: Electrical Energy Consumption Computer Program Development Flowchart

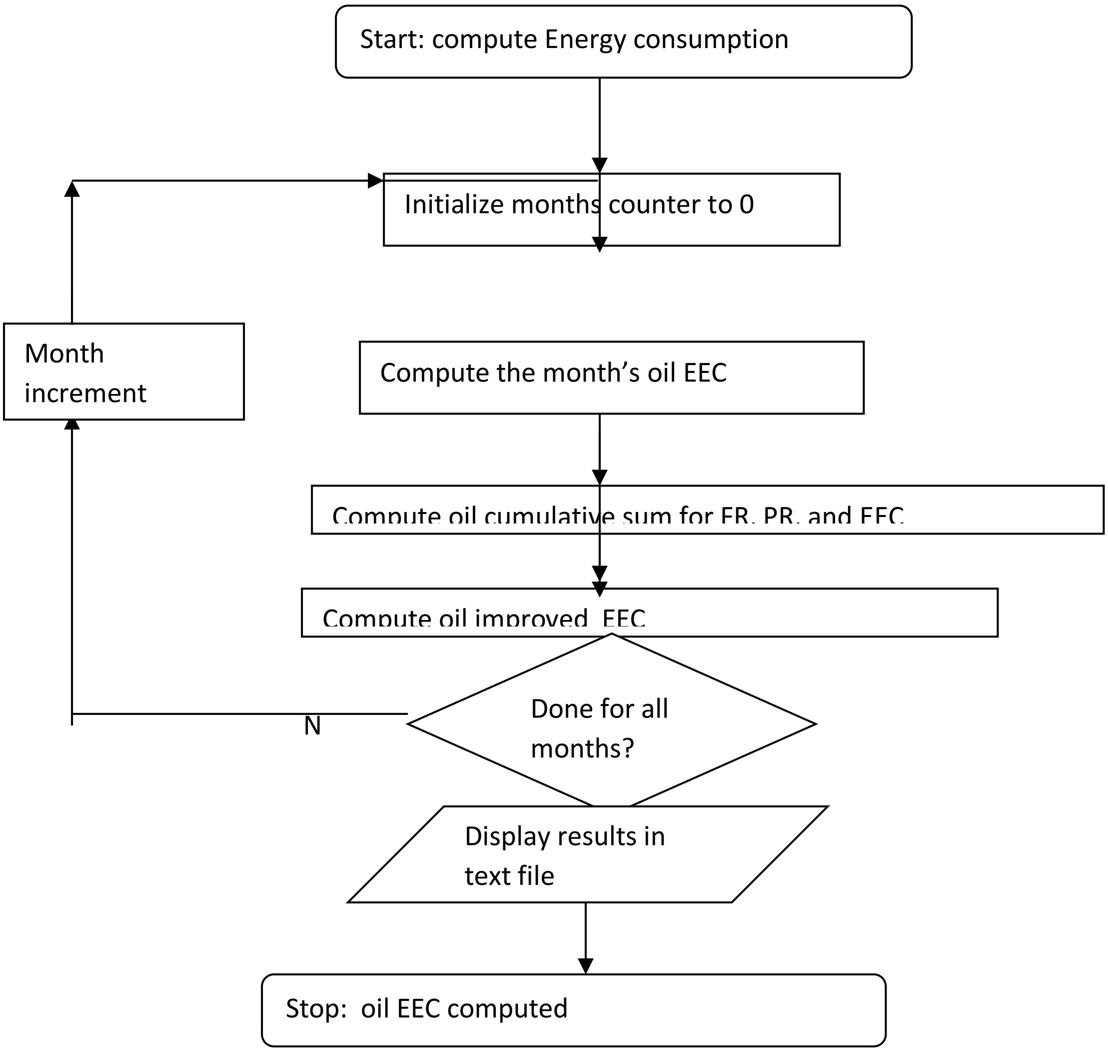


Figure 2: Electrical Energy Consumption Computer Program Development Flowchart for Lubcon oil

Plate 1: Computer program interface

2.2 Comparative Analysis of the obtained and Simulated Electrical Energy Consumption

The simulated electrical energy consumption (EEC) data of lubcon oil as obtained from the developed computer program is shown in Table 1. Also, the monthly percentage reduction in simulated EEC when compared with the original EEC (obtained data from the company) is presented as well in Table 1.

Table 1: Simulated data of lubcon oil

Failure rate (FR) h/m	Production rate (PR) l/m	Electrical energy consumption (EEC) kwh/l	Percentage reduction in EEC
25	58045.0	46.2	33.0
38	45109.0	40.1	28.0
29	54060.0	44.3	29.7
51	29550.0	33.7	23.4
20	60000.0	48.3	32.3
26	57442.0	45.8	32.3
13	69226.0	51.8	33.2
54	27940.0	32.4	23.0
38	45923.0	40.1	28.5
24	58000.0	46.6	32.2
13	69030.0	51.8	32.7
43	40770.0	37.8	26.2
17	64230.0	49.8	33.2
66	18020.0	26.9	30.0
34	48550.0	41.9	29.5
20	60520.0	48.3	31.5
10	70000.0	53.0	34.3
21	59480.0	47.8	32.5
50	30240.0	34.1	24.1
33	49930.0	42.4	29.3
26	57770.0	45.8	32.5
25	58000.0	46.2	32.4
27	56900.0	45.3	32.4
35	47880.0	41.5	29.1
22	59100.0	47.4	32.5
44	38940.0	37.2	25.2
20	60030.0	48.3	30.3

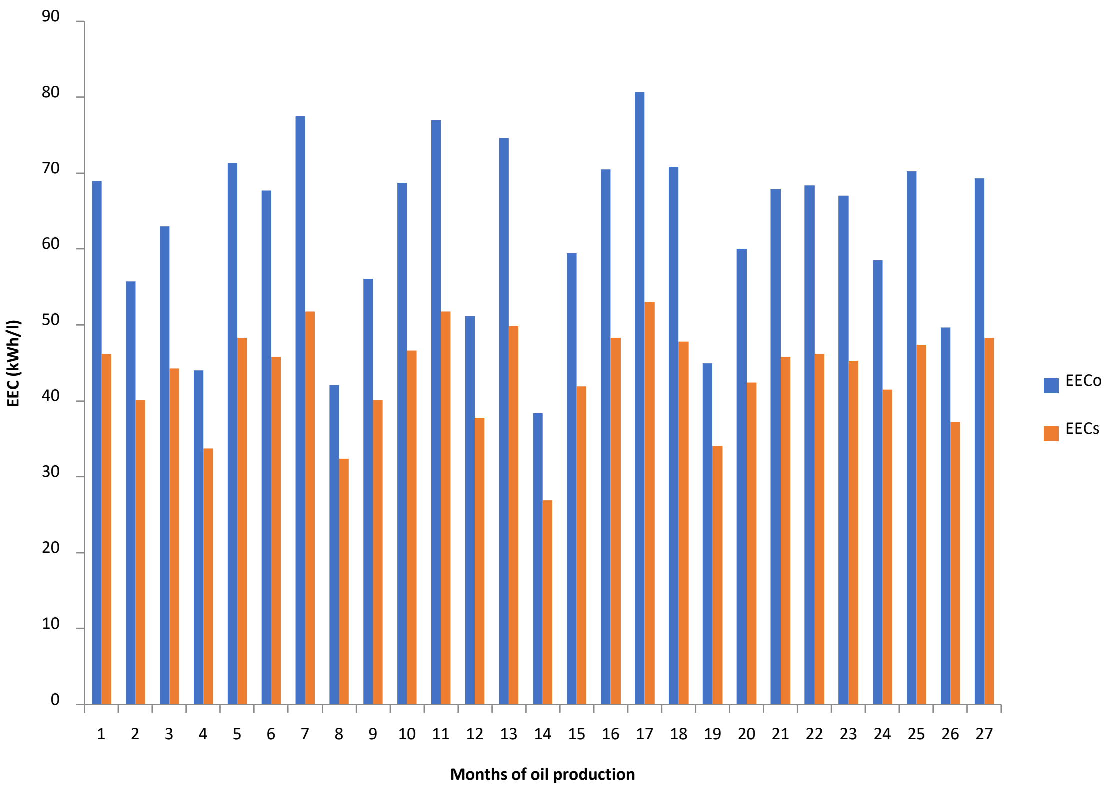


Figure 3: Original EEC vs simulated EEC

Legends:

EECo- Original electrical energy consumption

EECs- Simulated electrical energy consumption

After comparing the obtained data from the visited company, lubcon oil international with the simulated data, it was discovered that the electrical energy consumption of both data varies. The EEC from the simulated data is lower than the original EEC. For example, from the simulated data, it can be seen that at 25 h/m of failure rate, 46.2 kwh/l of electrical energy was consumed, while from the original data, 69 kwh/l was consumed. Also, at 38 h/m of failure rate, 40.1 kwh/l of electrical energy was consumed, while from the original data 55.7kwh/l of electrical energy was consumed. Considering the percentage reduction in electrical energy consumption, at 25 h/m of failure rate from the simulated data, it can be seen that 33% of electrical energy was reduced when compared with the original data at the same level of failure rate. therefore, on the average the reduction in failure rates ranges between 23 % and 34.3 %.

The results of the comparison showed that ordinarily at the same level of failure and production rates, the Lubcon Oil International Company has been consuming more than the required energy for the oil production. This implies that proper attention should be given to the production equipment in terms of maintenance and replacement where necessary.

2.3 Comparative Analysis of the original and obtained Electrical Energy Consumption after 3% reduction in failure rate

The obtained electrical energy consumption (EEC) data of lubcon oil after reducing the failure rates by 3 % and then analysed using the developed computer program is as shown in Table 2. Also, the monthly percentage reduction in simulated EEC when compared with the original EEC (obtained data from the company) is presented as well in Table 2.

Table 2: Obtained data after 3% reduction in failure rate

Failure rate (FR) h/m	Production rate (PR) l/m	Electrical energy consumption (EEC) kwh/l	Percentage reduction in EEC
24.25	58045.0	46.5	32.6
36.86	45109.0	40.5	27.3
28.13	54060.0	44.6	29.2
49.47	29550.0	34.2	22.3
19.4	60000.0	48.5	32.0
25.22	57442.0	46.1	32.0
12.61	69226.0	51.9	33.0
52.38	27940.0	33.0	21.6
36.86	45923.0	40.6	28.0
23.28	58000.0	46.8	31.9
12.61	69030.0	51.9	32.6
41.71	40770.0	38.2	25.4
16.49	64230.0	50.0	33.0
64.02	18020.0	27.7	27.9
32.98	48550.0	42.3	28.8
19.4	60520.0	48.5	31.2
9.7	70000.0	53.1	34.2
20.37	59480.0	48.1	32.1
48.5	30240.0	34.7	22.7
32.01	49930.0	42.8	28.7
25.22	57770.0	46.1	32.1
24.25	58000.0	46.5	32.0
26.19	56900.0	45.6	31.9
33.95	47880.0	41.9	28.4
21.34	59100.0	47.7	32.1
42.68	38940.0	37.7	24.1
19.4	60030.0	48.5	30.0

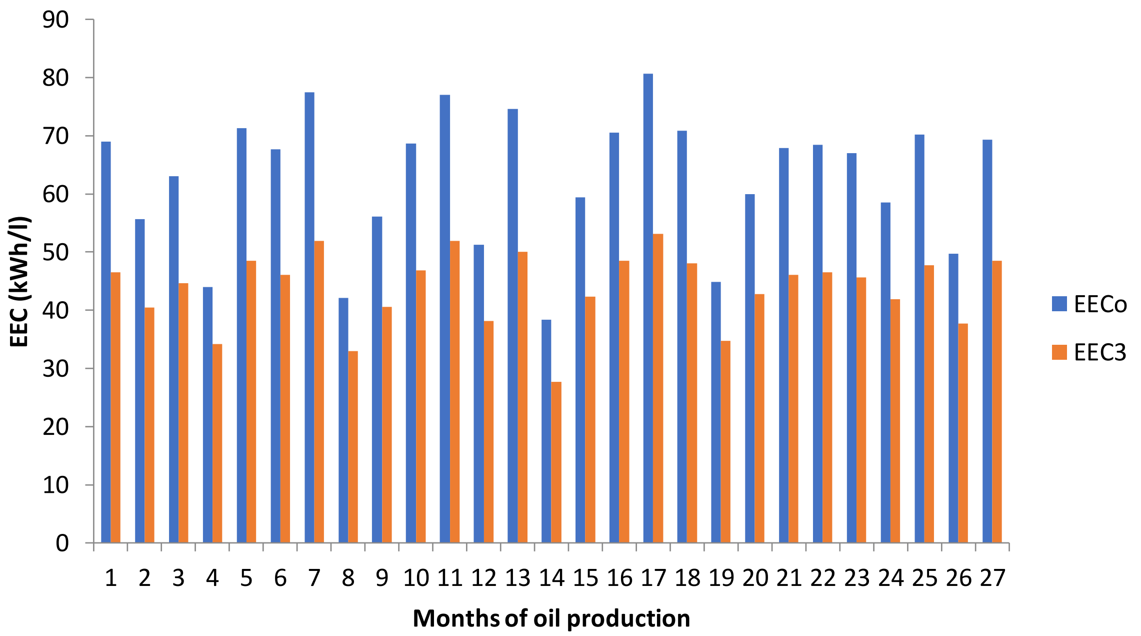


Figure 4: Original EEC vs EEC of 3% FR Reduction

Legends:

EECo: Original Electrical Energy Consumption

EEC3: Electrical Energy Consumption after 3 % Reduction in Failure Rate

After comparing the original data from the visited company, lubcon oil international with the obtained electrical energy consumption of 3 % reduction in failure rate, it was discovered that the electrical energy consumption of both data varies. The EEC from the 3% reduction in failure rate is lower than the original EEC. For example, from the EEC of 3% reduction FR, it can be seen that at 25 h/m of failure rate, 46.5 kwh/l of electrical energy was consumed, while from the original data, 69 kwh/l was consumed. Also, at 38 h/m of failure rate, 40.5 kwh/l of electrical energy was consumed, while from the original data 55.7kwh/l of electrical energy was consumed. Considering the percentage reduction in electrical energy consumption, at 25 h/m of failure rate from the obtained EEC of 3% reduction in failure rate, it can be seen that 33% of electrical energy was reduced when compared with the original data at the same level of failure rate. therefore, on the average the reduction in failure rates ranges between 21 % and 34 %.

The results of the comparison showed that ordinarily at the same level of failure and production rates, the Lubcon Oil International Company has been consuming more than the required energy for the oil production. This implies that proper attention should be given to the production equipment in terms of maintenance and replacement where necessary.

2.4 Comparative Analysis of the original and obtained Electrical Energy Consumption after 5 % reduction in failure rate.

The obtained electrical energy consumption (EEC) data of lubcon oil after reducing the failure rates by 5 % and then analysed using the developed computer program is as shown in Table 3. Also, the monthly percentage reduction in simulated EEC when compared with the original EEC (obtained data from the company) is presented as well in Table 3.

Table 3: 5% REDUCTION IN FAILURE RATE

Failure rate (FR) h/m	Production rate (PR) l/m	Electrical energy consumption (EEC) kwh/l	Percentage reduction in EEC
23.75	58045.0	46.7	32.3
36.1	45109.0	40.8	26.8
27.55	54060.0	44.9	28.7
48.45	29550.0	34.6	21.4
19	60000.0	48.6	31.8
24.7	57442.0	46.3	31.6
12.35	69226.0	52.0	33.0
51.30	27940.0	33.4	20.7
36.1	45923.0	40.9	27.1
22.8	58000.0	47.0	31.6
12.35	69030.0	52.0	32.5
40.85	40770.0	38.6	24.6
16.15	64230.0	50.1	32.8
62.7	18020.0	28.1	26.8
32.3	48550.0	42.5	28.5
19	60520.0	48.7	31.0
9.5	70000.0	53.2	34.1
19.95	59480.0	48.2	32.0
47.5	30240.0	35.0	22.0
31.35	49930.0	43.0	28.3
24.7	57770.0	46.3	31.8
23.7	58000.0	46.7	31.7
25.65	56900.0	45.9	31.5
33.25	47880.0	42.1	28.0
20.9	59100.0	47.8	32.0
41.8	38940.0	38.0	23.5
19	60030.0	48.6	29.9

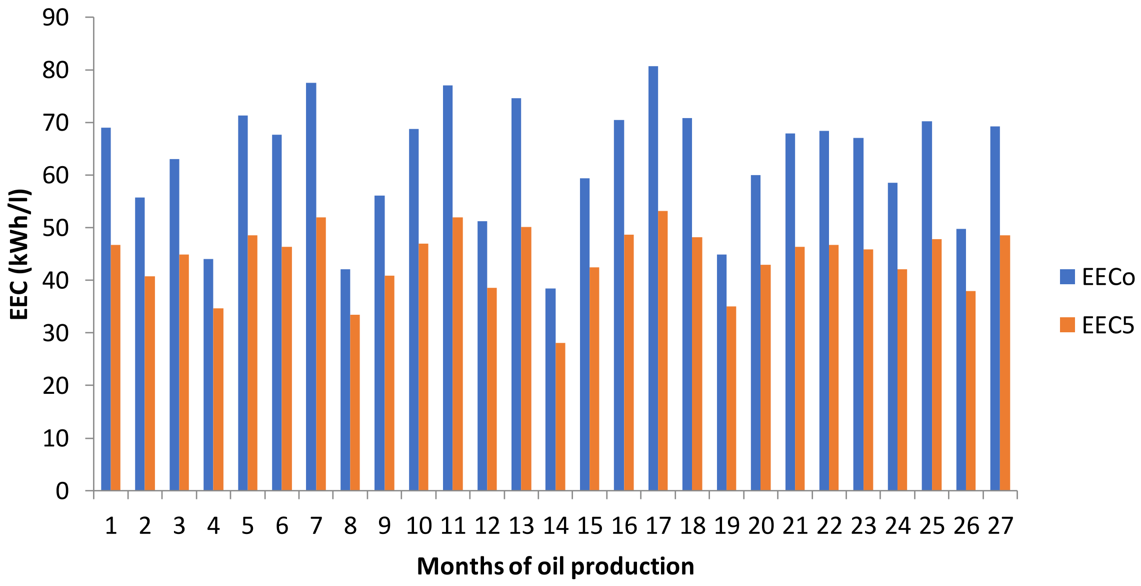


Figure 5: Original EEC vs EEC of 5% FR reduction

Legends:

EECo: Original Electrical Energy Consumption

EEC5: Electrical Energy Consumption after 5 % Reduction in Failure Rate

After comparing the original data from the visited company, lubcon oil international with the obtained electrical energy consumption of 5 % reduction in failure rate, it was discovered that the electrical energy consumption of both data varies. The EEC from the 5% reduction in failure rate is lower than the original EEC. For example, from the EEC of 5% reduction FR, it can be seen that at 24 h/m of failure rate, 46.7 kwh/l of electrical energy was consumed, while from the original data, 69 kwh/l was consumed. Also, at 36 h/m of failure rate, 40.8 kwh/l of electrical energy was consumed, while from the original data 55.7kwh/l of electrical energy was consumed. Considering the percentage reduction in electrical energy consumption, at 24 h/m of failure rate from the obtained EEC of 5 % reduction in failure rate, it can be seen that 32 % of electrical energy was reduced when compared with the original data at the same level of failure rate. Therefore, on the average the reduction in failure rates ranges between 20 % and 34 %.

The results of the comparison showed that ordinarily at the same level of failure and production rates, the Lubcon Oil International Company has been consuming more than the required energy for the oil production. This implies that proper attention should be given to the production equipment in terms of maintenance and replacement where necessary.

2.5 Comparative Analysis of the obtained 3 % reduction in FR and obtained 5% reduction in failure rate.

Comparing the obtained 3% reduction in failure rate with the obtained 5% reduction in failure rate, and then analysed using a bar chart as shown in figure 6.

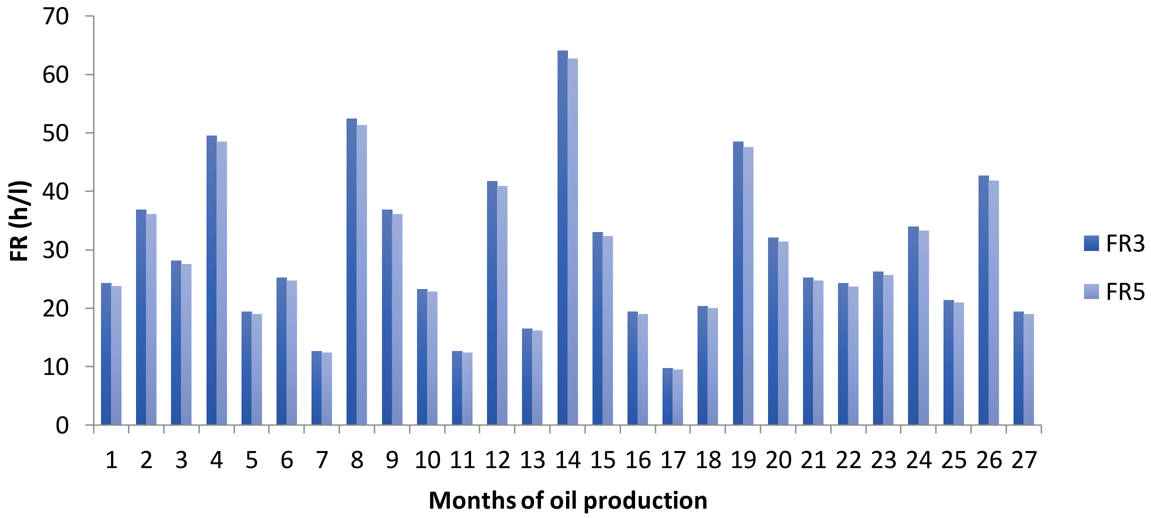


Figure 6: EEC of 3% Reduction in FR Vs EEC of 5 % Reduction in FR

Legends:

FR3: Failure rate after 3 % reduction

FR5: Failure rate after 5 % reduction

From figure 6, a comparison between FR at 3% and at 5% shows that the 5% is more economical. The differences between these two variables showed that 5 % reduction in failure rate is lower than 3% reduction in failure rate for all the months. This shows that the company can adopt 5% reduction in failure rate for high productivity,

3.0 Conclusion

The high energy consumed by equipment occurs usually from equipment breakdowns like sudden failure and unplanned maintenance. From various analysis carried out in this research work, it can be concluded that the energy consumed has a negative effect on the productivity of Lubcon Oil which is uneconomical. On the other hand, when the failure rate is high, unnecessary energy will be consumed which can be for equipment startups. With this, it can be seen that the variable EEC has an effect on production and equipment failure rates. Therefore, if Lubcon Oil can reduce her failure rate by 3% or 5%, there will be siginifcant reduction in the electrical energy consumed which will in turn lead to reduction in unit cost of production of oil. The simulation results further established a significant relationship between electrical energy consumption, failure and production rates of the Lubcon oil production line, thus, call for additional efforts for integrating this program (method for ensuring conformance to a standard maintenance culture) inside the production facility.

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