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Determination of Boiler Maintenance Effectiveness on productivity in a Palm Oil Producing Company: A Case Study

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ABSTRACT

Maintenance effectiveness on boiler on productivity in Siat Nigeria Limited was determined in this study. Equipment failure has been a big challenge to industries thereby reducing production rate. Boiler operation process in Siat Nigeria Limited and reasons for failure in operation was investigated. Various components of a boiler system such as vaporizer, superheater, economizer, rotary air preheater air fan and flue gas fan were examined for failure that can lead to its maintenance forecast and performance. Reliability analysis was conducted on the boilers and the result shows that for boiler K_1 mean time between failure is 2021.539h/failure, mean time to repair is 95.923h/repair, boiler failure rate is 0.000495 failure/h and availability is 95% respectively. Boiler K_2, mean time between failure is determined as 2190h / failure, meantime to repair is 103.717h/repair, failure rate is 0.000457failure/h and boiler availability is 95% respectively. After maintenance on the boilers, the output were 5.330 tones and 6.674 tones respectively.

1. INTRODUCTION

Maintenance is an important aspect of physical assets management in an industry. The physical assets are the systems structures and component (Obikwudo, 2015). According to Erebareba (2015) maintenance is the process used to preserve functional capabilities of physical assets at specific levels. Functional capabilities are those that affect directly the industry load factor such as equipment availability and reliability. Preserving physical assets in a certain state does not necessarily guarantee the capability of the system or equipment to perform within specified parameters or to limit the losses caused by their failures.

Maintenance is to repairs, replace or install a new thing, lubricate, overhaul, rebuild, service, inspect, calibrate, test and adjust in order to sustain the functionality of a system (Okwuduboi, 2015). Srivastava (2013) holds that the old idea of maintenance is about sustaining physical assets while the new idea of maintenance is about sustaining the functions of assets.

According to Al-Najjar and Alsyouf (2014), due to the importance and role of maintenance function has on other working areas it has led to the increase of maintenance function over the year in many organizations by improving machine availability and product quality.

Ashayeri *et al.*, (2015), asserts that industries have taken total quality management and total quality control as their watch word in order to improve productivity and customer's satisfaction. It would be unwise thinking of practicing total quality control and

skipping total quality management, or vice versa.

Otokolo *et al.*, (2015), asserts that practicing corrective maintenance will lead to further damages or breakdown in industry and as a result, lead to more cost in running the industry.

The right policy to counter any form of failure or breakdown is to improve/maintain the life cycle or span of industrial equipment by adopting proper maintenance policy in order to keep the machine/equipment going (Lilly, 2012).

According to Narayana *et al.*, (2016) maintenance, labour and energy are factors that have impact on the firm's productivity. These factors cannot be overemphasized as productivity cannot be effective without the role of these factors.

Cutting edge auto companies are using many tools to reduce cost, since reliability can be designed into the equipment by engineering, demonstrated by operations in careful use of the equipment and it can only be sustained by maintenance (Kumar *et al.*, 2014).

In order to respond to global challenges, European car companies have to reduce costs, shed labour, raise productivity by improving maintenance in order to improve their relationship with attempts to boost efficiency (Donnelly *et al.*, 2014).

2.MATERIAL AND METIIODS

2.1 Materials

The material used for this work includes company's maintenance and failure log books and annual production report sheet.

2.2 Methods

Reliability analysis was used in carrying out this work.

2.2.1 Description of Palm Oil Production Process.

Process engineering is basically concerned with the design and investigation of the series of manufacturing stages which results in the transformation of raw material to the finished product (Usher *et al.*, 2014).

Palm oil is an edible vegetable oil derieved from the mesocarp of the fruit oil palms. The oil is used in food manufacturing, beauty products and as biofuel. Palm oil accounted for about 33% of global oils produced from oil crops in 2014.

Fresh fruit binches (FFB) and loose fruits from the plantations are offloaded daily at the factory's offloading bay. This ramp can contain up to 120 tons of FFB. Weighing of the fruits takes place at the electronic weighbridge at the entrance gate before offloading. The fruit are loaded into cages on a rail system. The purpose of receiving and transferring the fresh fruits bunches (FFB) is to avoid excessive production of free fatty acids due to a natural enigmatic

process in the mesocanp, transportation of the FFB from harvesting to sterilizing does not exceed 72 hours.

1. Sterilization

FFB are sterilized in order to inactivate the natural enzymatic activity and loosen the fruit as well as to soften the mesocarp, resulting in easier extraction of oil Sterilization is carried out in autoclaves of 25 tones FFB capacity with the application of live steam from the steam boiler at high pressure for about 90 minutes.

2. Threshing

The sterilized FFB are sent to rotary drum threshers to separate the sterilized fruits from the burch stalks. The generated residues from this process includes empty fruit burches (EFB) which contains moisture. EFB can be used as organic fertilizer and soil conditioner as it maintains soil humidity. It can be sold to local farmers as a substract for mushroom cultivation. EFB is subsequently used as biomass fuel in suitable boiler systems for steam/electricity production.

3. Digestion

The separated fruits are discharged into vertical drums (digester) with live steam injection and treated mechanically to convert the steam into a homogeneous oily mash. This mash is subsequently put into the oil extraction press (Screw press).

2.2.2 Analytical Model

Data will be collected from Siat Nigeria Ltd for reliability analysis of their mill performance. The data will be analyzed and rearranged according to the common troubleshooting method followed. Secondly, the traditional standard maintenance techniques that is suitably used in mill maintenance will be applied to choose the best statistical analysis approach.

2.3 Reliability Analysis Method

Reliability is the probability that a machine or equipment or the entire line will perform a required function under specific operating conditions for a given period of time t. The time between failures of the line is defined with T; T≥ 0, the reliability can be expressed as;

$$R_{(t)} = P(T \geq t) \qquad (2.1)$$

Boilers' mean time between failure (MBF)

For K_1 boiler mean time between failure MTBF is determined as calculated below.

From equation (2.2)

$$MTBF = \frac{\sum t_1}{n} \quad (2.2)$$

Where $\sum t_1$ = total running time in operation of the boilers during an investigation period for both failed and non-failed item.

n = number of failures (breakdown) of boiler or its parts occurring during the investigation period.

(i) Boilers' Mean Failure Rate (λ)

For K_1 boiler, the mean failure rate (λ)calculated as shown below

$$\lambda = \frac{1}{MTBF} = \frac{n}{\sum t_1} \quad (2.3)$$

where $\sum t_1$= total running time in operation of the boiler during an investigation period for both failed and non-failed items.

n = number of failures (breakdowns) of boiler or its part occurring during the investigation period.

(ii) Boilers Mean Repair Rate (μ)

For K_1 boiler, the mean repair rate (μ) is calculated as given below:

From equation (2.4)

$$\mu = \frac{1}{MTTR} \quad (2.4)$$

Where MTTR = Mean time to repair

(v) Boilers' Availability (A):

For K_1 boiler, the availability is determined as given below:

From equation (2.5)

$$A = \frac{MTBF}{MTBF + MTTR} \times 100 \quad (2.5)$$

$$A = \frac{T_o}{T_0 + T_1} \times 100 \quad (2.6)$$

Where T_0 = Time that boiler works

T_1 = time that boiler do not work, includes repair and maintenance time.

Productivity (P) = Output V/ IputValue

2.4 Desanding Tank

This is a conventional procedure of separation of raw crude oil from heavy suspended solids by setting method.

2.4.1. Vibrating Screen of Raw Crude Oil

Screening of raw crude oil is carried out in order to separate large size of solids such as dirts, fibres, and fragments of the pericaps from the liquid phase.

2.4.2. Clarification Settling Tank

Due to the fact that crude palm oil crudles under normal temperature which makers it hard to flow, it is heated with close steam coils which facilitates gravity separation.

As a result, either the separated oil still contains a high concentration of suspended solids or the settled residue (setting bottom sludge) contains high content of oil.

3. RESULTS AND DISCUSSION

3.1 Results

This chapter is devoted to the presentation, analysis and interpretation of data collected in the course of this work. Operational reliability analysis results are used to determine techniques for maintenance and achievement of the set objectives.

In Siat, operational reliability study is justified by the fact that the two boilers were put into service in the period (2013-2019). The two-boiler work on joint bar (Stean, is charged for the same collector bar).

Table 3.1 Specifications of Boilers Subject to Operational Reliability Analysis

Specification	**Boilers**	
	K_1	**K_2**
Nominal steam pressure(t/h)	155	250
Nominal pressure (bar)	136.2	136.2
Nominal temperature (^oC)	500	500
Fuel used:	Fiber	Fiber
Fuel calorific power [kJ/Nm^3]; [kJ/kg]	55.88	35.588

Table 3.2 Operational Indices for the Boilers in Siat Nigeria Ltd

S/N	Boiler	MTBF (h/Failure)	MTTR (h/Repair)	$\lambda\ x\ 10^{-3}$ (Failure h^{-1})	$\mu\ x\ 10^{-3}$ (Repair h^{-1})	A(%)	Productivity (Tonnage)
1	K_1 155 t/h	2021.539	95.923	0.495	0.01043	95	5.330
2	K_2 250 t/h	2190	103.717	0.457	0.0962	95	6.674

Basic indicator values (MTBF, MTTR, and failure rate indices) evaluated for the boilers respectively are shown in Fig. 3.1, Fig. 3.2 and Fig. 3.3.

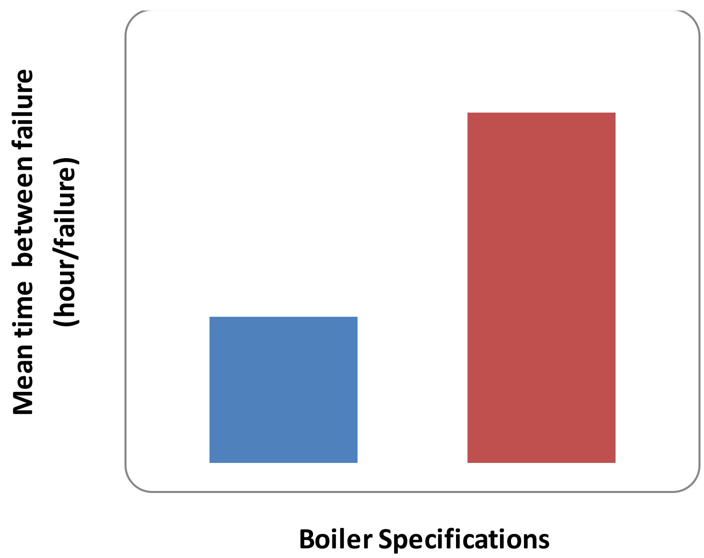

Figure 3.1: Boilers Mean Time between Failure (MTBF)

The results shown in Figure 3.1 above shows that boiler K_1 steaming with a capacity of 155 tonnes of wort per hour with a total running time in operation of wort boiling during the investigation period from 2013-2019 for both failed and non-failed items at 52,560 hours has a mean time between failure of 2190 hour 2021 .539hours. The result fig 3.1 is also indicates that boiler K_2 steaming with a capacity of 250 tones of work per hour with a total running time in operation of worth boiler during the investigation from 2013 – 2019 for both failed and non-failed items at 52.560 hours has a mean between failure of 2190 hours.

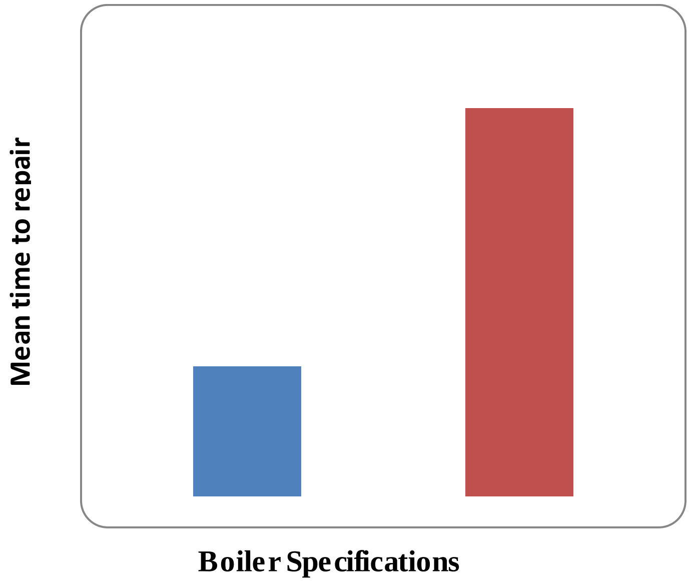

Figure 3.2: Boilers' Mean Time to Repair (MTTR)

The result in figure 3.2 shows that boiler K_1 steaming with a capacity of 155 tonnes of wort per hour with a total running time of 52,560 hours within the investigation period from 2013-2019 for both failed and non-failed items has a mean to repair of 95.923 hour/repair.

Figure 3.2 also shows that boiler K_2 steaming with a capacity of 250t/h with a total running time in operation during the investigation period from 2013-2019 for both failed and no-failed items at 52,560hours has a mean time to repair of 103.717 hours/repair.

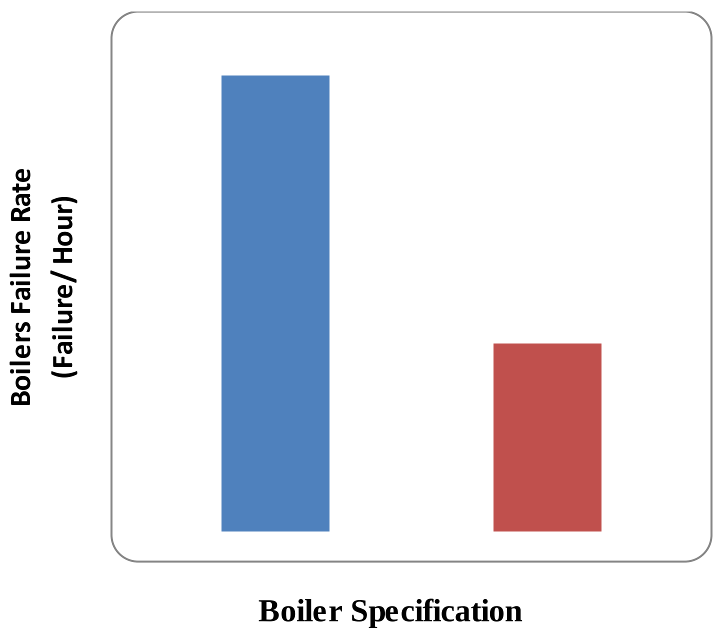

Figure 3.3: Boilers' Failure Rate

The result in Figure 3.3 above shows that boiler K_1 steaming with a capacity of 155 tonnes of wort per hour with a total running time in operation of wort boiling during the investigation period from 2013-2019 for both failed and non-failed items at 52,560 hours has a failure rate of 0.495 failure/hour. The result also indicate that boiler K_2 steaming with a capacity of 250 tonnes of wort per hour with a running time in operation of wort boiling during the investigation period from 2013-2019 for both failed and non-failed items at 52,560 hours has a failure rate of 0.457 failure/hour.

4. Conclusion

An attempt was made in the study to evaluate the reliability of a system of boilers used in palm oil industry. The boiler is a very relevant machine in a palm oil industry. A boiler is a closed vessel in which water or fluid is heated under pressure. The hot fluid is then circulated out of the boiler for use in various process or heating application.

The research work is geared towards conducting reliability analysis on boiler operation of palm oil industry. The aim of this dissertation had been to understudy the operations of a boiler in a palm oil industry and to investigate the reasons for failure in the boilers system operation such as leaks, auxiliary element failure, electric failures and protection shut down. To examine the various component of boiler system such as vaporizer, over heater, economizer, rotary air preheater, air fan and flue gas fan.

Conclusively, reliability model at boiler line level was developed, thereby ensuring that line operation forecasting at least in the short term is feasible.

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