Optimization of the Sterilizer Unit in Imo Adapalm Nigeria Limited

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Abstract- This research work focuses on the Sterilizer Unit in Adapalm oil mill and considers what could be done to improve the dwindling performance of the unit which has kept the processing at low ebb. A study of the existing production processes was done to find out the reason(s) for low productivity in the company. The sterilizer unit was identified as one area of setback to achieving full potentials in the factory. Models were developed. MATLAB software was used to analyse the models so as to arrive at optimal performance. The result of the analysis showed that the sterilizer, having exceeded its lifespan which is evident in the Mean Time Between Failure (MTBF), must be replaced and proper maintenance attitude inculcated henceforth. It is believed that when this is done, the production system will be operating at its optimal state.

Indexed Terms- Optimization, Production Processes, Sterilizer, Productivity, Adapalm

I. INTRODUCTION

Production is a process or procedure developed to transform a set of inputs like men, materials, capital, information, and energy into a specified set of output (Umoh et.al., (2013). Hence, production aims at converting variety of inputs to specific output deriving utility in the process. In the light of this understanding, production planning is defined as a sequential step taken within a manufacturing setting in ensuring that strategic raw materials (materials, men, money, and machine) are available at the right time and in the right quantity to create finished products according to the schedule specified (Okah et. al., 2018). This definition implies that all activities carried out involving availability of raw materials, staff and equipment needed to create finished products in accordance with a specified schedule is production planning.

Bhaba et. al., (2015) opined that the function of production planning is based on establishing a plan, revising the plan, and adhering to the plan to accomplish desired objectives. It therefore follows that proper application of production planning techniques will help evaluate and appraise the quality and quantity of resources at input stage such as raw materials, labour data, etc. needed for production. It also helps the implementation of pre-planned process enabling optimum production. This optimization of production is the goal of all production outfits, absence of this leads to irregular operations and subsequently closure of such outfits as seen in the case of Adapalm Nigeria limited which was established in 1977 after the pattern of Kibutz farm settlement in Israel (Efosa, 2019). Adapalm has a refining capacity of 60MTPD of Olein (DeSmet, 2020), but has failed to live up to its capacity mainly due to improper management of money, materials, machines and men (Ishioma, 2020). These challenges enumerated by Ishioma (2020), are mainly as a result of poor or improper production planning. Hence, in the current bid by the present administration in Imo State to revitalize Adapalm, there is an urgent need to identify the loop holes in the production plan that led to the current moribund state of the company and hence proffer production planning procedure that will ensure optimization of production in the solutions as to how the production capacity of Adapalm can be optimized have eluded the various administrations. Production planning techniques utilized by various handlers of the company in time past has not yielded the needed results as challenges are still prevalent in the company. To this end, it is needful to carry out an assessment of the company viz-a-viz its production/work schedule, maintenance schedule, equipment/machines, palm fruit produce, etc. It is expected that an optimized production planning method will be achieved which will help to reposition the company for improved productivity.

The main objective of this study is to optimize the sterilizer in Adapalm Nigeria The outcome of this study, when implemented will lead to improved productivity in Adapalm Nigeria Limited which will in turn increase the internally generated revenue of Imo State.

II. MATERIALS AND METHOD

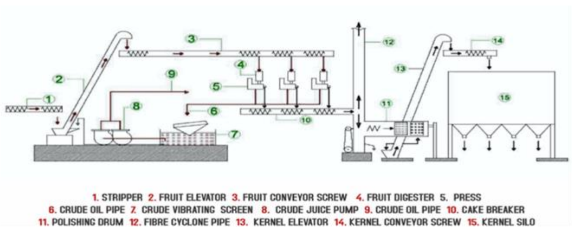


Fig. 1. Flow process diagram of Adapalm.

The sterilized fruits already detached from the stalk and emptied into the fruit stripper/ conveyor (1) discharges into the fruit elevator bucket (2) and emptied into the digester by the fruit conveyor screw (3). Meshed fruit at the digester (4) are discharged into the press (5) which squeezes out the crude juice.

While the juice is ducted through pipes (6) to the crude vibrating screen, CVS (7) the fiber and nuts are separated by gravity and cyclone action (10-12). Nuts are conveyed and stored in the silo (13-15) while fiber is conveyed to the boiler for more steam generation. The crude juice is now pumped from the CVS (7-9) to the primary/secondary decantation tanks where palm oil and sludge are separated. The oil is meant to flow through a purifier to remove every impurity/solid and then through a heater to get rid of every moisture content. Finally, it is pumped and stored in the oil storage tank ready for sales.

The materials used in this study include structured questionnaires, company quarterly/annual bulletins and oral literatures. The data collected from these materials were used for modelling and analysing the production process of ADApalm. Sources of these materials are listed as follows:

i.

ii. Records department: Information on the harvest of FFB, sale of FFB, Quantity of FFB utilized in Oil production, and Quantity of Oil produced were sourced.

iii.

iv. Production department: Information on the working drawings, work files, process operating conditions and machines specifications were obtained.

v.

vi. Maintenance department: Information on the maintenance schedule applied in the mill section of ADApalm Nig. Ltd.

Interview with production, electrical, process engineers involved in the production of palm oil in ADApalm Nig. Ltd.

III. METHODS

The sterilizer was identified as key to maximizing palm oil production in the facility.

- Sterilizer The model was used to optimize the mass flow rate of steam needed to sterilize the FFB. Sterilizer unit model variables include the following:

Ms = Total steam mass , M_{F1} = mass of FFB
M_{F2} = mass of FFB after sterilization , C = Condensate
I = heat capacity of sterilizer unit material , t = sterilization time
U = Internal specific energy

Constraints defined for the model are as follows:
$34.9 \leq M_{F2} \leq 37.96 \quad C \leq 3.662 \quad t \leq 2700 \quad Ms \leq 4.66$ I = 4189 kJ/kgK
$M_{F1} = 22.5 \quad Ms + M_{F1} = M_{F2} + C$ *mass conservation*
From first law of thermodynamics, we deduce that:
$$Energy\ input = Energy\ output + Loss \qquad 3.1$$

In the sterilizer, the source of energy is the heat coming from the superheated steam.

Hence, equation 3.1 can be expressed in terms of sterilization time as:

$MsU_1 = CU_2 + M_{F2}U_2 + 15.63I$ ……………………………………. 3.2

From steam table, saturated steam at 275kPa will possess an internal specific energy (U_1) of 2540.53kJ/kg while steam leaving at 175kPa will possess a specific energy (U_2) of 2524.90kJ/kg. Therefore, equation 3.2 becomes:

$\frac{2540.54Ms}{t} = 2524.90\ \frac{c}{t} + 2524.90\ \frac{Mf2}{t} + 15.63l$ ………………………………………………3.3

Equation 3.3 is the Energy model equation needed to optimize the inlet steam flow needed for shorter sterilization time that will culminate into more production time due to time saving.

- Data analysis

Data collected from the maintenance department from the January 1999 to January 2020 was used to determine the reliability of the existing machines used in the facility. These data were based on the sterilizing unit which plays major role in the production of palm oil in the mill. The reliability study examines the longevity and dependability of the machines. Factors considered include the following: Failure rate, mean time between failures (MTBF), and reliability prediction using Weibull distribution.

Failure rate: This is the total number of failures within an item population, divided by the total number of life units expended by that population, during a particular measurement interval under stated conditions. It is estimated using equation 3.17. $\lambda = r/T$ ………………………………………………… …………………………….(3.17)

where λ = failure rate, r = the total number of failures occurring during the investigation period, T = Total running time during an investigation period for both failed and non-failed items. Mean Time Between Failure (MTBF): MTBF is a basic measure of reliability for repairable items. It represents the mean number of life units during which all parts of the item perform within their specified limits, during a particular measurement interval under stated conditions. It is expressed mathematically using equation 3.18

$\theta = 1/\lambda$ …………………………………………………… …………. (3.18)

Reliability Prediction: This was carried out using Weibull distribution to first determine the probability density function (failure frequency distribution) of a set of failure data in order to characterize the failures of the various machines in the mill as early life, constant (exponential) or wear out (Gaussian or log normal) by plotting time to failure data with the log of the time to failure plotted a log scaled X-axis versus the cumulative) percent of the population represented by each failure on a log-log scaled Y-axis. Since production process is majorly affected by these five process points, the overall system reliability was calculated by first determining the reliability of the subsystems using the formulae stated in equation (3.19).

$R(t) = e^{-\left(\frac{t}{\eta}\right)\beta}$ …………………………………………… ………………………….(3.19)

Where:
β = Shape parameter of the Weibull plot
t = Failure time being considered
η = Characteristic life
β shows the class of failure mode i.e infant mortality, constant or wear out. It is obtained from the slope of the Weibull plot.

η shows the age (time) at which 63.2% of the unit will fail. It is obtained at the point on the time axis which corresponds to the point on the graph where the 63.2% line on the y axis meets on the graph.

The overall system reliability which gives the longevity and dependability of the system was analysed as a series system because the operation is such that subsystem A is followed by subsystem B. Hence, a breakdown in subsystem A will affect the running of subsystem B. Equation (3.20) was used to determine the reliability of the system.

$Rs_{(t)} = R1_{(t)} \times R2_{(t)} \times R3_{(t)} \times R4_{(t)} \times R5_{(t)}$ ……………………………………(3.20)

The failure rate of the major process points was determined using equation 3.17.

Failure rate of Sterilizer: From figure 2, it is observed that on the average, the number of failures experienced within an average of 21633.42 hours is 9.36538E-08, this means that equipment failure is recorded at least once in every 494 hours of operation.

Data obtained from the failure rate and the time to fail was used to plot the 'bath tub' curve of the sterilizer, as seen in figure 2.

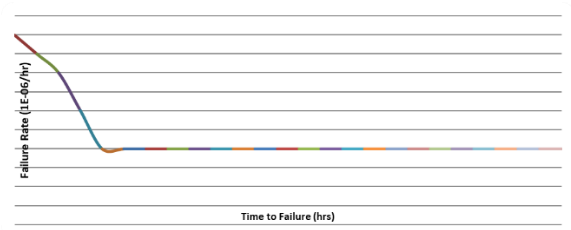


Figure 2: Sterilizer Bathtub Curve

This curve as opined by Troyer, (2020) is instructive to effectively demonstrate a machine's three basic failure characteristics viz: declining, constant and increasing.

- Sterilizer Optimization. The linear programme (m-file) for the optimization of the crane was written using MATLAB. Images of a graphical representation and the codes in command window are shown in figures 3.

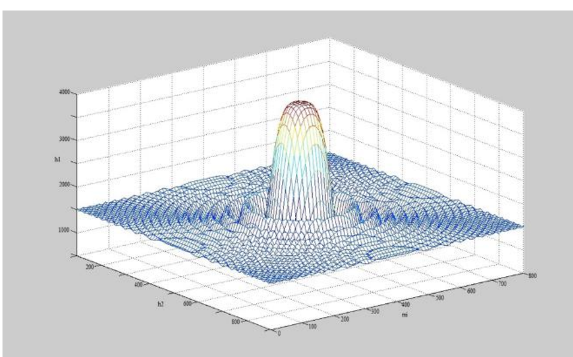
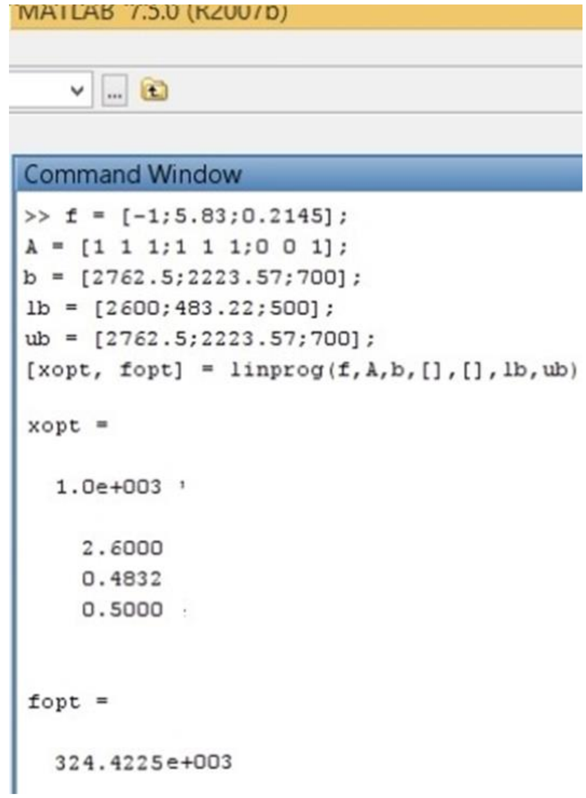


Figure 3: 3D Contour Plot of Solution

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>> f = [-1;5.83;0.2145];
A = [1 1 1;1 1 1;0 0 1];
b = [2762.5;2223.57;700];
lb = [2600;483.22;500];
ub = [2762.5;2223.57;700];
[xopt, fopt] = linprog(f,A,b,[],[],lb,ub)

xopt =

  1.0e+003 *

    2.6000
    0.4832
    0.5000


fopt =

  324.4225e+003
```

The result shows that for the optimal running of a sterilizer which will process 4.66 Tonnes per batch, steam in let enthalpy should be at least 2600kJ/kg as against 2540.53kJ/kg. Also, the insulation material should have a value not less than 500 J/gK instead of the initial 4189 J/gK. This will lead to a residual steam content of 483.2 kJ/kg and not 2524.90kJ/kg which was initially obtained. Table 4.4 shows a comparison of the Initial Run Condition (IRC) and the optimized results

Table 1: Comparison between Initial Run Condition (IRC) and Optimized Results

Parameter	IRC	Optimized value
Steam inlet enthalpy	2540.53 kg/K	2600 kJ/ K
Steam outlet	2524.9 kJ/kg	482.2 kJ/kg
Heat capacity	4189 J/gK	500 J/gK

CONCLUSION

In this study, equipment reliability analysis was carried out on the sterilizer unit in ADAPalm with a view to optimizing palm oil production.

The production system overall reliability is 0%. This means that the production system is unreliable and at every point in time there is always a breakdown of equipment during operations.

From the Weibull plot, the unitary value of β which suggests that the subsystem of the plant, the Sterilizer, should be within the constant failure rate region. However, the reliability values of 3.9% for Sterilizer, show that it is rather in the worn out region.

This disparity between the β-value and reliability value depicts poor management, misuse or abuse of the production equipment.

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