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# Comparative analysis of static and dynamic facility layouts design using the modeling of plantain flour as case study

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**Abstract**

Profit optimization at the expense of minimal resource utilization for product development has been the major focus of prospective investors. In an attempt to realize this goal, the present research consideration is tailored towards investigating the effect of introducing dynamic facility layout design. Therefore, this research study uses an existing designed plantain flour processing plant that consists of a washing machine, grating machine, dryer, milling machine and sieving machine. Modeling techniques incorporated with software development were employed on the existing static plant layout to optimize production time and cost of each of the processing units along with the layout. Also, dynamic constraints were introduced into the layouts while mathematical models were formulated to visualize how the output and production process would be. With these models, software for the optimization of static and dynamic layouts was developed. The comparative study was carried out based on the processing time, the number of machines needed for each layout type, the cost of operation and machine procurement cost for both static and dynamic layouts. The constraints introduced ensured that the system improved within the cost limit based on the current market situation and prevented unnecessary enlargement in the plant facility size while minimizing material congestion in the system. The distinction between static and dynamic layout configurations was further established by comparing the results from the layout configurations for a set of throughput masses ranging from 50 kg to 250 kg. Results showed that the cost of operation drops drastically by 69.6 % under dynamic layout configuration.

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## 1. Introduction

Developing a robust process plant for plantain products is becoming a compelling necessity with the ever-growing market for plantain products. The increase in the level of demand for plantain flour, owing to its application in food and medicine, has led to the quest for considerable improvement in the technology involved in the production of plantain flour.

Facility layout has been described as a problem that is concerned with finding the most efficient and non-overlapping arrangement of some indivisible departments with equal or unequal area requirements within a process plant (Amine et al., 2007). Effective facility layout improves the material handling system in plant, reduces throughput time, reduces space for layout and, generally, improves the total performance of the manufacturing system in terms of material flow, total process time required, and productivity (Xiaohong, 2012).

Studies have shown that the design and automation of process plants for a given product will increase the output quantity, improve the quality of the product especially by a considerable level of reduction in direct contact with the product, and reduction in total processing time for such product (Adegun et al., 2011 and Ayodeji et al., 2015). The design of a dynamic facility layout can further increase this output quantity, reduce the total processing time and allow for flexibility in throughput sizes. Without flexibility, as pressure to meet up with the ever-increasing volume of demand from customers heightens, manufacturers may be prompted to demolish existing structures in a bid to increase the capacity of their plants resulting in increased cost of manufacturing (Ulutas and Islier, 2008). Facility layout problems are classified as static facility layout problem (SFLP) and dynamic facility layout problem (DFLP). The facility layout problem is regarded as SFLP if the flow of material between equipment within the plant are fixed over a planning horizon (Balakrishnan and Cheng, 1998). Amir and Tidke, (2013) posited that a facility layout is considered static if once the layout is planned and executed, it will not be subjected to change for a very long period. However, static facility layout has proven inadequate with increased market competition and pressure to meet demand. The constant change in the volume of products demanded is one of the common manufacturer's challenges. This makes it necessary to update the layout accordingly to achieve efficient operations (Ulutas and Islier, 2008). Next-generation manufacturing systems should be responsive to market situations to survive and this can be achieved through customizing policy such that system elements are dynamically adjusted to fit with new circumstances. The need for a response to market situations has called for redesigning or reconfiguration of existing facilities. It is very important to have a robustly developed plant layout for all the available resources in an optimum manner, to get the best out of the facility. A good layout facility keeps the production cost low, reduces processing time and eradicates unnecessary bottlenecks while maintaining the production flow (Xiaohong, 2012; Amir and Tidke, 2013).

The layout of the plantain flour plant is generally set up as a flow line production system in a definite sequence of operations. Studies on existing plant layouts had shown that congestion of product at some point along the production line is inevitable. This was largely attributed to differences in rates of production capacities in-unit machines that make up the production sequence (Adegun et al., 2011 and Ayodeji et al., 2015). Therefore, this paper focusses on the optimization of existing plantain flour process layout using comparative approach with the help of simulation techniques to establish the differences therein.

## 2. Literature review

Recent research on plantain flour production has shown that plantain flour process plant has processing points (machines) along its production line with longer processing time relative to other process points (Adeleye, 2017; Olutomilola 2019; Akinnoso et al., 2012; Ayodeji et al., 2015). The design of a dynamic facility layout could be aimed at generating an arrangement of the machine in the process plant such that congestion is removed from the production line, thus minimizing the material handling cost. Points that are affected by congestion could be investigated and the machine production capacity at such point could be optimized using the rate of production of the affected equipment. This enhances the capacity of equipment and new machine configuration is generated (Adeleye, 2017; Desta, 2010; Ayodeji et al., 2017; Adeyeri et al., 2021). Gyorgy and Sebastian 2017) suggested that introducing flexibility could allow the throughput capacity of the system to be increased or varied at will, depending on the volume of required output and throughput capacity for that given period.

Benjaafar and Sheikhzadeh, (2000) stated that introducing flexibility into a facility layout could minimize the excess cost of production that arises from the demolition of structures due to re-designing and frequent installations, as the volume of demand from market increases. Also, dynamic facility layout could further reduce the processing time for a given throughput in a plant, even after it has been automated.

According to Xiaohong, (2012), for each period within a production planning horizon, some facilities are bound to have more material in-flow than others. The in-flow dominant equipment may change during the subsequent period if machine capacity cannot cope with the heavy material flow as a result of an increased level of throughput. Congestion occurs at such points along with the plant, hence the need to model the layout problem as a dynamic facility layout problem. Benjaafar and Sheikhzadeh, (2000), opined that maintaining a good facility layout for multiple periods requires a continuous assessment of the product demand, flow between departments and evaluation of the layout to determine the time at which redesign should be performed. In a plantain flour process plant the points along the plant where congestion occurs are the focus of designing for the process plant. Based on the performance evaluation of existing process plants, the point of bottleneck along the plant is expected to be predominant at the drying section while the grating section may also experience the bottleneck in the course of processing (Ayodeji, et al., 2015). Rearrangement of the facility in a bid to eradicate bottleneck is not workable in a product dependent layout as against what is obtainable in a process dependent layout plants (Rahime et al., 2011). Facilities in the plantain flour process plant cannot be repositioned because an established sequence of operations must be followed. However, the periodic reconfiguration of the plantain flour process plant layout based on machine rate or capacity required at every point along the plant with a given throughput capacity could be done while optimizing the processing time at every section (Adeleye, 2017).

Minimizing workflow congestion is an important concern in the manufacturing system. Alternative paths have been used as a means to reduce congestion in recent research works. Ulutas and Islier, (2008) made a proposition on the workflow congestion in the context of material handling equipment interruption in a manufacturing facility. The duo suggested that rerouting of traffic in congested facilities can significantly alleviate congestion delay and improve the efficiency of material movement. However, re-routing or rearrangement becomes constrained if the manufacturing process involves a single product with a pre-fixed sequence of operation. An alternative means to the removal of congestion other than re-routing or rearrangement is a systematic integration of facilities into the layout. This is expected not only to remove congestion but also reduces the processing time through the plant (Kikolski and Ko, 2018).

Rahime et al., (2011) defined simulation as the process of testing an existing or new invention for modification or use utilizing a designed model or prototype. The efficiency of a facility layout design can only be tested either by physical changes to an existing layout and measurement of output result or through modelling and simulation of the system results. These results can be used to develop the final facility layout design. The resulting data can be used to evaluate various layout alternatives for new construction or re-organization (Vivekanand et al., 2014).

Flexsim is a process simulation software that is notable among other simulation software because of its ease of use and rich functionality that allows users to focus on simulation concepts (Zhang et al., 2009). It is particularly useful in modelling, analyzing, visualizing and optimizing the manufacturing process from its supply chain process (Gyorgy and Sebastian, 2017).

## 3. Methodology

The approaches used for the research are based on the formulation of models for static layout configuration, the model formulation for optimization of static layout generation, development of algorithms for static layout configuration, optimization of initial layout configuration and development of optimization software for dynamic process flow. These five approaches are discussed in this subsection.

### 3.1. Formulation of models for static layout configuration (Reference layout)

Having studied the existing process plant for plantain flour production at the Federal University of Technology, Akure, Ondo State and other research outputs resulting from the processing plant as reported in Adeyeri et al., 2020, Adeyeri et al., 2021, Olutomilola et al., 2021a, and Olutomilola et al., 2021b, models were formulated using data and parameters adopted from the performance evaluation results of the existing process plant. Rate of production at each section along with the plant, product variation in material weight and processing time were parameters used in the development of the static layout model (Ayodeji et al., (2015) & Olutomilola, 2019). Table 1 summarizes the developed model for material weight variation and corresponding processing time required at each processing point.

The percentage weight relation of the input to output ratio of each machine was established through the data obtained from the existing process plant. According to Ayodeji et al., (2015), the change in weight after washing was insignificant as 0.9986, 0.9980 and 0.9976 were the output ratio at the grating, grinding and sieving machines respectively. The percentage moisture content of plantain flour was estimated to be 59.77%, while the dried mass with the required moisture retention was approximately 44.4%. Equation 1 was derived to estimate the processing time at each point while Eq. 2 represents the weight relationship based on material input and output weights.

$$T_i = \frac{W_{Bi}}{R_i} \tag{1}$$

$$W_{Ai} = W_{Bi} \times \%(W_r) \tag{2}$$

Where $W_r$: $0 \le \%W_r \le 1$

**Table 1.** Material Weight Variation and Machine Processing Time Models for Static Layout

| Machine Type | Rate of Production $\boldsymbol{R_i}$ (kg/min) | Average weight before processing $\boldsymbol{W_{Bi}}$ (kg) | Average weight after processing $\boldsymbol{W_{Bi}}$ (kg) | Processing Time $\boldsymbol{T_i}$ (min) |
|---|---|---|---|---|
| Washing (W) | R1 | $W_{in}$ | $W_1$ ($W_{in} = W_1$) | $T_1 = \frac{W_{in}}{R_1}$ |
| Grating (gr) | $R_2$ | $W_1$ | W2 ($W_2 = 0.9986 \times W_1$) | $T_2 = \frac{W_1}{R_2}$ |
| Drying (d) | $R_3$ | $W_2$ | W3 ($W_3 = 0.44 \times W_2$) | $T_3 = \frac{W_2}{R_3}$ |
| Grinding (g) | $R_4$ | $W_3$ | W4 ($W_4 = 0.998 \times W_3$) | $T_4 = \frac{W_3}{R_4}$ |
| Sieving (Si) | $R_5$ | $W_4$ | W5 ($W_5 = 0.9976 \times W_4$) | $T_1 = \frac{W_4}{R_5}$ |
| Total Processing Time per Throughout ($T_t$) | | | | $T_1 + T_2 + T_3 + T_4 + T_5$ |

Adapted from Ayodeji et al., (2015)

### 3.2. Models formulation for the optimization of the generated static layout

The machine layout model shown in Table 1 is characterized by a bottleneck at some points along with the process plant, owing to the static nature of the layout configuration. To solve this problem, optimize the processing time and cost of operation, a static layout optimization model was formulated. This helps to generate a dynamic facility layout configuration. The model objective for minimizing the total processing time for a given throughput is as represented in Eq. 3.

$$T_t = \sum_{i=1}^{n} T_i + T_{b/c} \tag{3}$$

$T_t$ is the total time required by the processing plant to completely process a given throughput. It is the summation of the processing time of the individual machine and time to get the product from one machine to another. The material handling problem that is bound to occur at the point of congestion is solved by the installation of the buffer with several conveyors determined by an increment in the number of machines at the point of congestion. Eq. 4 represents the processing time at the conveyor sections.

$$T_{b/c} = N_c \times \frac{L}{S} \quad (4)$$

Where $T_{b/c}$ is the processing time at conveyor section, $N_c$ is the number of conveyors, L is the length of conveyor in meters and S is the speed of conveyor. To ensure that the processing plant produces at an optimal cost, a cost constraint was developed as stated in Eq. 5.

$$\sum_{i=1}^{n} O_{ci} N_i + nC_v \leq W_o \times M_v \quad (5)$$

$$C_v = P_{cv} \times t_{cv} \times U_e \quad (6)$$

where; $O_{ci}$ is the cost of operation for a unit machine at position i, $N_i$ is the number of the machine at position i, $C_{vi}$ is the cost of a unit conveyor, n is the number of conveyors, $t_{cv}$ is the time of conveyor from a pick up to drop off point, $U_e$ is the unit cost of electricity per KWh, $W_o$ is the expected output weight. A time constraint was also set to iteratively increase the service points at the regions where material congestion is much pronounced to an optimal level as stated in Eq. 7 and Eq. 8.

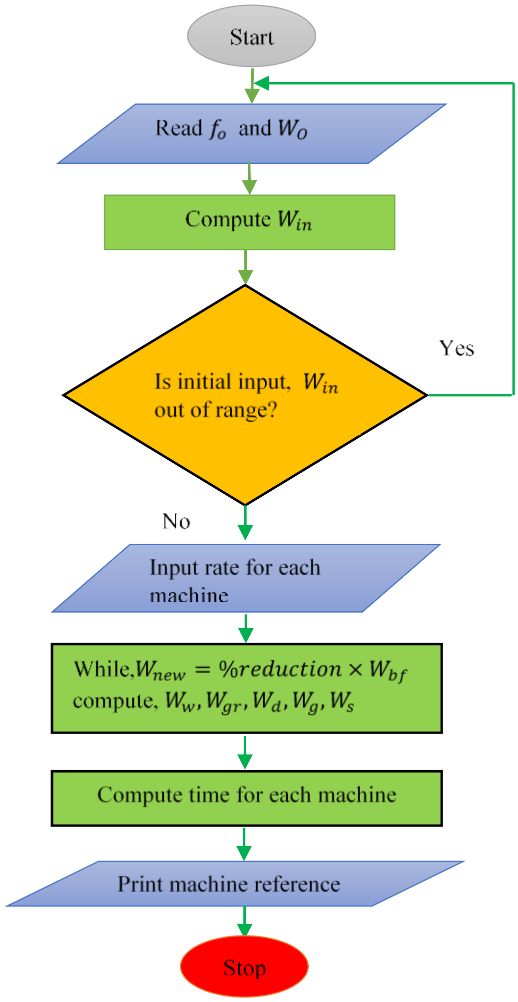
$$T_d \leq \sum_{i=1}^{n} T_{bi} \quad (7)$$

$$T_{gr} \leq T_1 + t_c \quad (8)$$

Where $\sum_{i=1}^{n} T_{bi}$ is the summation of all processing time of machines before the drying section, $T_d$ is the processing time at the drying section after optimization, $T_{gr}$ is the processing time at the grating section after optimization, $t_c$ is time to convey material between washing and grating. While $T_1$ is processing time at the washing section.

## 3.3. Development of algorithm for static layout configuration

With reference to the material weight variation and processing time models presented in Table 1, the initial static layout configuration was established. This involved using the expected output weight to determine the required material input weight into the processing plant and with the production capacity of the individual machine predicts the time required to process the input at each point along with the process plant The point with bottlenecks is identified and used as a reference for the optimization of the layout configuration. Fig. 1 shows the flow chart illustrating the steps involved in generating the initial static layout configuration.




Legend

| Notation | Full Meaning |
|---|---|
| $W_{in}$ | Initial input to the plant (Throughput) |
| $W_o$ | Expected output from plant |
| $f_o$ | Increment factor |
| $W_{bf}$ | Input to a machine |
| $W_{new}$ | Output from machine |
| $W_w$ | Output from washing machine |
| $W_{gr}$ | Output from grating machine |
| $W_d$ | Output from drying machine |
| $W_g$ | Output from grinding machine |
| $W_s$ | Output from sieving machine |

**Fig. 1.** Initial Machine Configuration Flow Chart (Machine Reference Chart)

### 3.4. Optimization of initial layout configuration

Using the initial static layout data as reference, an optimization of the layout was effected to allow for variation in throughput size and minimize bottlenecks that were inherent in the initial static layout configuration. Service points at the regions of bottlenecks were increased and to ensure the optimization of the layout was within profit limit, the current market value of the expected output weight in respect of the cost of production was set as a constraint as shown in Eq. 7. That is the total operation cost for a given throughput and the cost of material handling. Fig. 2 is the flow chart showing steps involved in the optimization of the initial layout configuration, the processing time and cost of operation derived in the initial configuration are optimized. Where $f_o$, $T_w$, $T_n$, $T_p$, $T_d$, $T_{gr}$, $T_{new}$, $N_p$, $N_d$, $N_i$, $N_{new}$, $C_i$, $C_v$, $M_v$, $O_w$ are weight variation factor, operation time at washing section, summation of machine time before a point, operation time of machine at a point, operation time at drying point, operation time at grating point, operation time at a point after optimization, number of machine at a point before optimization, number of machine at drying point, number of machine at position $i$, number of machine at a point after optimization, operation cost at position $i$, cost of conveyor, current market value of output per kg, and total operation cost for a throughput respectively.

The resulting configuration from the optimization of the static layout is the dynamic layout. In other words, it is a layout that allows periodic variation in the size of material flow from one machine station to the other without encountering bottleneck. Table 2 presents the model generated for the optimization of the static layout.

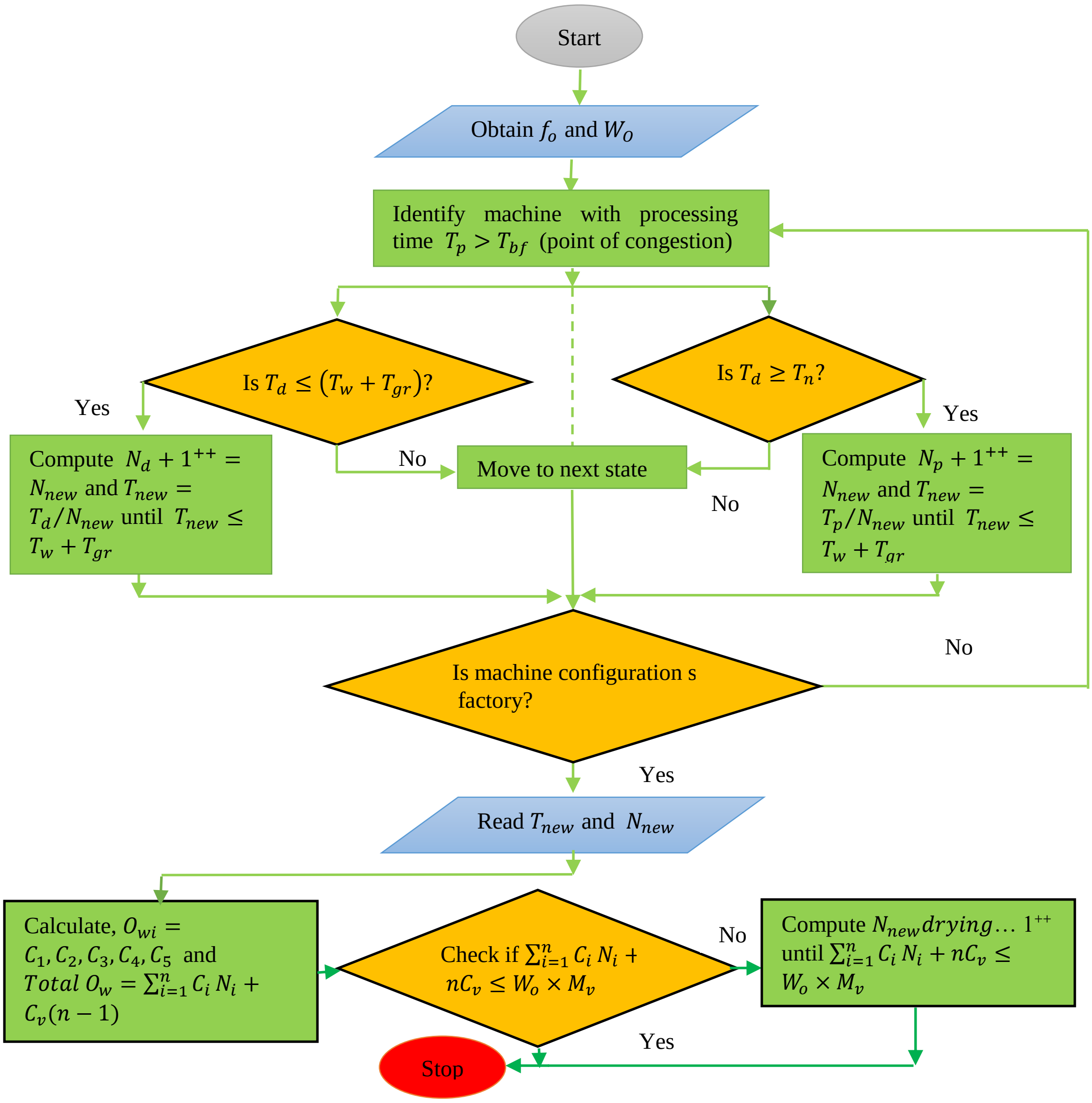



**Fig. 2.** Dynamic layout configuration flow chart showing process time and cost optimization

**Table 2**. Machine layout model for the dynamic layout configuration

| Machine type | Rate of machine (kg/min) | Average material weight (kg) | The material weight after processing (kg) | No of machines Required after optimization | Processing time T(minute) per unit m/c after optimization |
|---|---|---|---|---|---|
| Washing | $R_1$ | $W_{in}$ | $W_1 \ni (W_{in} = W_1)$ | $N_1$ | $T_1' = T_1/N_1$ |
| Crating | $R_2$ | $W_1$ | $W_2 \ni (W_2 = 0.9986 \times W_1)$ | $N_2$ | $T_2' = T_2/N_2$ |
| Drying | $R_3$ | $W_2$ | $W_3 \ni (W_3 = 0.44 \times W_2)$ | $N_3$ | $T_3' = T_3/N_3$ |
| Milling | $R_4$ | $W_3$ | $W_4 \ni (W_4 = 0.998 \times W_3)$ | $N_4$ | $T_4' = T_4/N_4$ |
| Sieving | $R_5$ | $W_4$ | $W_5 \ni (W_5 = 0.9976 \times W_4)$ | $N_5$ | $T_5' = T_5/N_5$ |
| Total processing time, $\boldsymbol{T_t = T_1' + T_2' + T_3' + T_4' + T_5'}$ | | | | | |

### 3.5. Development of optimization software for dynamic process flow

The initial layout model (static layout) in Table 1, the dynamic layout configuration model in Table 2 and equation 1 through to equation 8 were integrated into the development of optimization software for the dynamic layout configuration of the plantain flour process plant. This software becomes a useful tool in the comparative analysis of the developed static and dynamic layout models. Fig. 3 presents part of the interface menu of the layout configuration in the optimization software. Types of the machine, material input to output weight ratio, expected output weight and production rate of the machine are declared as input parameters required to generate or forecast process time for each machine along with the process plant.

With reference to Table 2, the initial layout was used as a reference for generating the corresponding dynamic facility layout configuration. Points with excessive processing time were identified to determine the regions of the envisaged bottleneck.

In the iterative interface, the number of service points was constrained based on the total operation cost and material handling cost as stated in Equation 5 to ensure that the dynamic layout generated is economically efficient. The variables considered as input into the iterative interface are power utilization cost for each machine in the process plant; the number of operators; average wage per hour for an operator; market value for a kilogram of fresh plantain pulp; market value for a kilogram of the finished product; and machine procurement & installation cost.

While the expected output parameters are the optimized machine layout configuration table for the given throughput sizes and their corresponding cost implications. Also, the number of machines required at optimal process time for a given throughput and the corresponding cost of production for both the static and the dynamic configurations were as well generated on the iterative platform of the developed software. For clarity, the 43.7453 kg throughput used for showcasing this claim is as illustrated in Fig. 3.

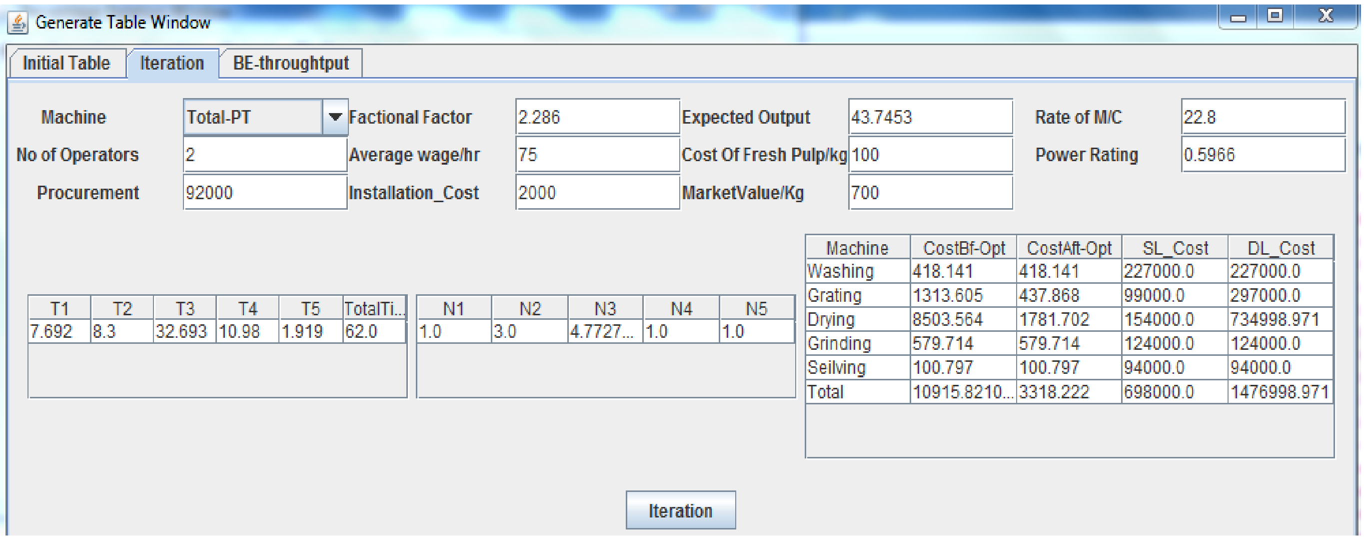



**Fig. 3**. Layout optimization software iteration interface at 43.7453 kg expected output

To validate the developed optimization software, parameters generated by the software before and after the layout optimization were used to simulate the two layout configurations at a throughput capacity of 21.87 kg. Flexism simulation software was used in the validation of the generated facility layout configurations. The material congestion challenge in the static layout was found to have been completely removed in the resulting dynamic layout configuration model.

## 4. Results and discussion on comparative basis

The resulting outcome of the methods used in the research is as presented in the following subsection.

### 4.1. Comparative analysis of the static and dynamic layout models

Formulated models were tested with the following values of expected output masses to validate the improvement noted on static layout configuration as a result of the developed dynamic layout models. The expected output masses are 21.8720 kg, 43.7453 kg, 65.6174 kg, 87.4905 kg and 109.3632 kg. Also, the following machine rates as established by Adeleye, (2017) and Ayodeji et al., (2015) in the performance evaluation of facilities of poundo yam and plantain flour process plants were used as secondary data to validate the dynamic layout configuration. Due to this, the output production rates computed at each machine unit are 13.0 kg/min, 4.0 kg/min, 0.64 kg/min, 4.0 kg/min and 22.8 kg/min for washing machine, grating machine, drying machine, milling machine, and sieving machine respectively. The processing time at each point along the process plant was generated and the initial machine configuration which represents the static layout configuration was as well established.

It should be noted that in the static configuration, the number of the unit machine at every point along the process plant was taken to be one (Adeleye, 2017). The processing time in the static layout configuration revealed the points of bottlenecks along with the plant and this information was used in the model to generate an optimized layout configuration where congestion was minimized. The values for initial machine configuration (static layout) and the optimal machine configuration (dynamic layout) were generated using the developed software. The static layout machine configuration and the layout optimization results obtained over the processing cycles are as summarized in Tables 3 and 4.

The processing time required was drastically reduced after optimization was achieved. To buttress this, the expected simulated output of 21.87 kg plantain flour in Table 3 showed that it would take 100.816 minutes to produce it under the static layout and 30.841 minutes under the dynamic layout. Similarly, in Table 4, it would take 202.134 minutes to produce 43.75 kg of plantain flour under the static layout and 61.588 minutes in the dynamic layout.

Another observation is that the static layout revealed congestion at the grating point and a more pronounced bottleneck at the drying point. The optimization of the layout resulted in an increased number of machines at these points until a balance in material flow was achieved. Some constraints were set to avoid an unending increase in the number of service points and to maintain optimum configuration generated at an economically viable state.

### 4.2. Comparative results based on cost implication of the optimized layout

Using the expected output of 21.87, 43.74, 65.62, 87.49 and 109.36 kg as input in the optimization software, the extent of improvement on the initial layout as shown in the dynamic layout configuration was also established by comparing operation cost involved in the initial layout with the cost involved in the dynamic layouts. At the expected layout weight of 65.6 kg, the initial cost of operation of 16373.7 Naira (39.79 dollar) dropped drastically after optimization to 4977.3 Naira (12.10 dollar). At 87.5kg, the cost of operation at 21831.592 Naira (53.05 dollar) reduced considerably to 6636.4 Naira (16.13 dollar) and so on. The cost of operation at each point along the process plant for a given throughput was found to have dropped by 69.6%.

**Table 3.** Static and optimal machine configuration at varying throughput within a production planning horizon at 21.87 kg expected output

| Machine type | Machine rate (kg/min) | Processing time$_{(static)}$ (min) | Processing time$_{(dynamic)}$ (min) | No. of Machine (static) | No. of Machine (dynamic) |
|---|---|---|---|---|---|
| **Washing** | 13.00 | 3.846 | 3.845 | 1 | 1 |
| **Grating** | 4.00 | 12.500 | 4.200 | 1 | 3 |
| **Drying** | 0.64 | 78.017 | 16.346 | 1 | 5 |
| **Milling** | 4.00 | 5.492 | 5.490 | 1 | 1 |
| **Sieving** | 22.80 | 0.961 | 0.960 | 1 | 1 |
| **Total** | | 100.816 | 30.841 | 5 | 11 |

**Table 4.** Static and optimal machine configuration at varying throughput within a production planning horizon at 43.75 kg expected output

| Machine type | Machine rate (kg/min) | Processing time$_{(static)}$ (min) | Processing time$_{(dynamic)}$ (min) | No. of Machine (static) | No. of Machine (dynamic) |
|---|---|---|---|---|---|
| Washing | 13.00 | 7.692 | 7.692 | 1 | 1 |
| Grating | 4.00 | 25.500 | 8.300 | 1 | 3 |
| Drying | 0.64 | 156.034 | 32.693 | 1 | 5 |
| Milling | 4.00 | 10.985 | 10.980 | 1 | 1 |
| Sieving | 22.80 | 1.923 | 1.923 | 1 | 1 |
| **Total** | | 202.134 | 61.588 | 5 | 11 |

### 4.3 Summary of comparison using processing time and other indices

The summary of comparative evaluation between static and dynamic layouts on the premise of processing time, number of machines required and machine procurement cost as obtained from the study is as shown in Table 5 of the appendix.

Drawing an inference from Table 5, it is quite evident that the dynamic facility layout is an improvement of its corresponding static layout. Therefore, for prospective plantain flour investor(s), production size spanning through any specified production planning horizon could be planned and forecasted.

## 5. Conclusion

A layout that ensures effective utilization of facilities will minimize bottlenecks in its process plant and maintains an appreciable economic efficiency in its production system. The study has established the benefits associated with the introduction of dynamism in the plantain flour production layout through the use of developed models and software. The developed software was used to generate an optimal machine configuration for a dynamic process flow for each machine by comparing adjacent machine and thereby identifying points of congestion along with the process plant. A comparative analysis of the static and dynamic layout models showed that the processing time was drastically reduced in the optimal machine layout configuration (dynamic layout). Also, the cost of operation of the static layout was minimized after the layout was re-modelled to a dynamic layout. Thus, the optimized dynamic layout accommodates an increase in throughput size without bottleneck challenges in its operation process. This proves to be better than the static layout as it gives room for flexibility and accommodation of changes as customer's demand and taste vary.

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## APPENDIX

**Table 5.** Summary of comparative analysis result

| Comparative indices | Mass of Yam | Washing machine | | Grating Machine | | Drying machine | | Milling machine | | Sieving machine | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **S** | **D** | **S** | **D** | **S** | **D** | **S** | **D** | **S** | **D** | **S** | **D** |
| No of Machine(s) required | 21.87 | 1 | 1 | 1 | 2 | 1 | 5 | 1 | 1 | 1 | 1 | 5 | 10 |
| | 43.79 | 1 | 1 | 1 | 2 | 1 | 5 | 1 | 1 | 1 | 1 | 5 | 10 |
| | 65.62 | 1 | 1 | 1 | 2 | 1 | 5 | 1 | 1 | 1 | 1 | 5 | 10 |
| | 87.49 | 1 | 1 | 1 | 2 | 1 | 5 | 1 | 1 | 1 | 1 | 5 | 10 |
| | 109.64 | 1 | 1 | 1 | 2 | 1 | 5 | 1 | 1 | 1 | 1 | 5 | 10 |
| Processing Time (min) | 21.87 | 3.82 | 3.82 | 12.50 | 4.2 | 78.0 | 16.3 | 5.5 | 5.5 | 0.96 | 0.96 | 100.78 | 30.83 |
| | 43.79 | 7.69 | 7.69 | 25.0 | 8.3 | 156.0 | 32.69 | 10.98 | 10.98 | 1.92 | 1.92 | 201.62 | 62.00 |
| | 65.62 | 11.50 | 11.5 | 37.5 | 12.5 | 234.1 | 49.0 | 16.5 | 16.5 | 2.88 | 2.88 | 302.45 | 92.00 |
| | 87.49 | 15.38 | 15.38 | 50.0 | 16.7 | 312.07 | 65.37 | 21.97 | 21.97 | 3.84 | 3.84 | 403.27 | 123.00 |
| | 109.64 | 19.23 | 19.23 | 62.49 | 20.28 | 390.07 | 81.73 | 27.46 | 27.46 | 4.80 | 4.80 | 504.07 | 154.00 |
| Machine Cost (₦) procurement and installation | 21.87 | 227000 | 227000 | 99000 | 297000 | 154000 | 734998 | 124000 | 124000 | 94000 | 94000 | 698000 | 1476998.97 |
| | 43.79 | 227000 | 227000 | 99000 | 297000 | 154000 | 734998 | 124000 | 124000 | 94000 | 94000 | 698000 | 1476998.97 |
| | 65.62 | 227000 | 227000 | 99000 | 297000 | 154000 | 734998 | 124000 | 124000 | 94000 | 94000 | 698000 | 1476998.97 |
| | 87.49 | 227000 | 227000 | 99000 | 297000 | 154000 | 734998 | 124000 | 124000 | 94000 | 94000 | 698000 | 1476998.97 |
| | 109.64 | 227000 | 227000 | 99000 | 297000 | 154000 | 734998 | 124000 | 124000 | 94000 | 94000 | 698000 | 1476998.97 |
| Operation Cost (₦) | 21.87 | 209.07 | 209.07 | 656.80 | 218.93 | 4251.80 | 890.85 | 289.85 | 289.85 | 50.39 | 50.39 | 5457.93 | 1659.12 |
| | 43.79 | 418.14 | 418.14 | 1313.6 | 437.86 | 8503.56 | 1781.70 | 579.71 | 579.71 | 100.71 | 100.71 | 10915.82 | 3318.22 |
| | 65.62 | 627.21 | 627.21 | 1970.4 | 656.80 | 12755.3 | 2672.55 | 869.57 | 869.57 | 151.19 | 151.19 | 16373.71 | 4977.33 |
| | 87.49 | 836.27 | 836.27 | 2627.2 | 875.73 | 17007.0 | 3563.39 | 1159.42 | 1159.42 | 201.59 | 201.59 | 21831.59 | 6636.43 |
| | 109.64 | 1045.3 | 1045.31 | 3283.9 | 1094.63 | 21258.2 | 4454.11 | 1449.24 | 1449.24 | 251.98 | 251.98 | 27288.69 | 8295.29 |

Legend: S stands for Static Layout, while D represents Dynamic Layout in Table 5

# 以车前草粉建模为案例的静态和动态设施布局设计对比分析

**關鍵詞**
加工厂设施布局
物资拥堵
约束
布局配置
静态和动态布局

**摘要**
以产品开发的最小资源利用率为代价的利润优化一直是潜在投资者的主要关注点。为了实现这一目标，目前的研究考虑是专门研究引入动态设施布局设计的效果。因此，本研究使用现有设计的车前草面粉加工厂，该工厂由洗衣机、磨碎机、烘干机、磨粉机和筛分机组成。在现有的静态工厂布局上采用了与软件开发相结合的建模技术，以优化每个处理单元的生产时间和成本以及布局。此外，在布局中引入了动态约束，同时制定了数学模型以可视化输出和生产过程。利用这些模型，开发了用于优化静态和动态布局的软件。比较研究是基于处理时间、每种布局类型所需的机器数量、静态和动态布局的操作成本和机器采购成本进行的。引入的约束确保了系统在基于当前市场情况的成本限制内改进，并防止了工厂设施规模的不必要扩大，同时最大限度地减少了系统中的材料拥堵。通过比较一组从 50 kg 到 250 kg 的吞吐量质量的布局配置的结果，进一步确定了静态和动态布局配置之间的区别。结果表明，在动态布局配置下，运营成本急剧下降了 69.6%。