Development of a Flexible Plant Layout System for Small and Medium Scale Industries in Nigeria.

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ABSTRACT

Facilities are expanding everyday as a result of changes in technology. Facility layout must be flexible to cater to modern changes. This research proposes the development of a flexible plant layout system to minimize facility arrangement cost, demolition of existing facilities, and gives room for future expansion, using developed software. In this study, a flexible plant layout system was developed for small and medium scale industries in Nigeria to take care of future additions of new facilities. The approach involves identifying and solving plant layout problems (especially future expansion problems) thereby generating an ideal layout through the use of flexible plant layout software which was developed using the programming language known as Visual Basic.

A fish feed mill's production factory plant in Akure, Nigeria was used as a case study in the research. It was discovered that the flexible plant layout software developed (FLEXPLAYS) could be used to generate an alternative layout which was more effective and provided room for future expansion. The results derived from the application of FLEXPLAYS to the case study company shows that the flexibility of the old layout could be improved by 75% based on the flow of equipment and future changes. The modified existing layout gives room for additional facilities for further expansion and also enhances productivity.

(Keywords: facility arrangement, flexibility, future expansion)

INTRODUCTION

In recent years, industrial engineers have broadened their prospect toward professional career development and it has become increasingly important for small and medium scale industries to look for ways to promote the efficiency and flexibility of physical facilities to facilitate interrelationships among operating personnel, material flow, information flow and the methods required in achieving sufficient working space for present and future expansion. A smooth manufacturing process can be achieved if plant layout is flexible in the flow of workers, materials and machines. This flexibility can bring about desired goals of minimizing production costs with little or no industrial accidents (Kareem et al., 2013).

Plant layout optimization seeks to find the best arrangement of physical facilities to provide an efficient operation (Hassan and Hogg, 1991). Plant layout is a complex and broad subject that covers several disciplines. It involves civil, electrical, industrial, and mechanical engineers, as well as architects, and even managers and urban planners are not left out (Li Weng, 1999).

Plant layout can be divided into two components: Plant location and Plant design. Plant location is about placement of the plant on a specific plot of land in relationship to customers demand. Plants design consists of the plant systems, plant layout design and the material handling systems design. The material handling system consists of the mechanisms needed to satisfy the required facility interactions. Plant layout planning also includes decisions regarding the physical allocation of the economic activity centers in a facility. An economic activity center is any entity occupying space.

The plant layout process starts at an aggregate level, taking into account the different departments. As soon as the details are analyzed, different issues arise and the original configuration maybe changed through a feedback process. Most layouts are designed properly for the initial conditions of the business, although as long as the company grows and has adapted to internal and external changes, a re-layout may become necessary. A computerized technique for layout planning is a method that can be used to do this.

The use of computer programming to plan and re-plan layout will reduce congestion, cost of materials arrangement, and will facilitate a plan that will meet future needs. On the other hand, an effective layout can provide an environment for effective productivity. This research aims to develop computerized techniques for layout planning. This type of technique will maximize the utilization of the building and land facility when the need for expansion arises. In our environment there are many low and medium sized industries that, for one reason or the other, need re-planning and for a new outfit or need proper planning from the beginning.

MATERIALS AND METHODS

The method used in carrying out this research includes visitation to Nigerian small and medium scale industries for information and also by direct determination of the plant dimensional characteristics, that is, direct measurement of plant facilities. The measurements cover the area of each sections/departments, this includes manager's offices, material stores, grinding section, and all other work centers. Other investigations cover the degree of closeness that exists between departments/sections, degree of flow of material between departments and degree of relationship between departments, etc.

The data collected from the plant was used to develop flexible plant layout software that is capable of generating efficient plant layouts, modified the existing one and also gives room for future expansion.

The problem of demolition of existing work centers for the addition of new facilities was identified and software was developed to eliminate the identified problems. All the data collected from the visited factories are put together to validate the model which would be able to select the best arrangement of facilities in a layout for small and medium scale industries.

An algorithm was written from which software was developed named (FLEXPLAYS) using Visual Basic programming language. All the data collected are put together to validate a model which would be able to select the best arrangement for any new and existing industrial environment.

Basic Theory

The aims of this project is to arrange a specified department with difference area into a rectangular plant building to minimize the total facility arrangement cost and give room for future expansion without demolition.

Departmental Area

Total Departmental Area = $\sum_{i=1}^{n} L_i B_i$ **(1)**

Where
L_i = department i length (mm)
B_i = department i breadth (mm)

Unused Area = Building Area - $\sum_{i=1}^{n} L_i B_i$ **(2)**

Building Area = BL × BB **(3)**

Where
BL= Building length (mm)
BB= Building breadth (mm)

Distance between Departments

$G_i = \sum_{i=1,j=1}^{n} g_{ij}$ **(4)**

Where
g_{ij} = distance between department i and department j.(mm)
G_i is the total distance for department i.

Flow/Relationship between Departments

$T_i = \sum_{i=1,j=1}^{n} t_{ij}$ **(5)**

Where
t_{ij} is the flow rate between department i and department j, for $0 \le t_{ij} < 5$.

0= Undesirable, 1= Not close, 2= fairly close, 3= close, 4= very close, 5= extremely close.
T_i is the total flow rate for department i.

$$G = \sum_{i=1, j=1}^{n} G_{ij} \quad \textbf{(6)}$$

$$T = \sum_{i=1, j=1}^{n} T_{ij} \quad \textbf{(7)}$$

Where
G = total distance between all departments (mm).
T = total flow rate between the entire departments (mm).

Cost of Facilities Arrangement

$$\text{Minimize } P = \sum_{i=1}^{n} \sum_{j=1}^{n} T_{ij} G_{ij} \quad \textbf{(8)}$$

where
P = total facility arrangement cost
T_{ij} = flow rate between department i and department j.
G_{ij} = distance from department i and department j.
n is the number of departments.

Software Algorithm

(a) Start
(b) Input building length, breadth and compute the building area.
(c) Input number of departments or facilities.
(d) For each department read length, breadth and title.
(e) For i:=1to number of departments/facilities,
    For j:=1to number of departments / facilities, read distance, flow and compute cost = Distance × Flow,
    [End of for i].
    [End of for j].
(f) Save the relationship setting into file.
(g) Display flow table, distance table and cost table.
(h) Display existing flow layout
(i) Arrange existing flow layout
(j) Display modified flow layout
(k) Add any additional number of departments or facilities
(l) For i:=1to new number of departments/facilities, For j:=1to new number of departments/facilities, Read distance, flow and compute cost = Distance × Flow,
    [End of for loop]
    [End of for loop]
(m) Save the relationship setting into file.
(n) Arrange new flow layout.
(o) Display modified flow layout.
(p) Exit.

Computer User Interfaces for the Software

The graphical user interface (GUIs) were constructed for inputting the password and computing the dimensions of the building, length and breadth of the department and flow between departments.

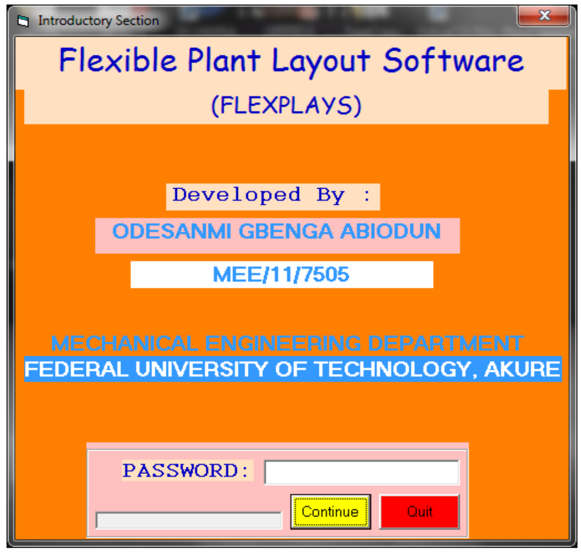


Figure 1: Graphical User Interface for the Welcome Page.

RESULTS AND DISCUSSION

The model was tested with a small scale fish meal located in Akure, Ondo state Nigeria. Base on the existing layout of the factory, there was nothing like a set rule for the facility arrangement and future expansion plans. The factory is divided into eight sections which are pelleting section, material section, manager's office, packaging and weighing section, maintenance section, grinding section, drying section and mixing section. The building dimension, number of department or section and dimension of each section/department was imputed using graphical interface for plant layout setting form after inputting the password from Figure1.

Figure 2 shows the summary of the result generated for the plant layout flow/relationship table.

Figure 3 shows the summary of result generated for the plant layout distance table.

Figure 4 shows the summary of result generated for the plant layout cost table.

From the look of things, Figure 5 has demonstrated that if a layout was not initially planned very well, the use of this program will modify it to bring about the correct which is in Figure 6.

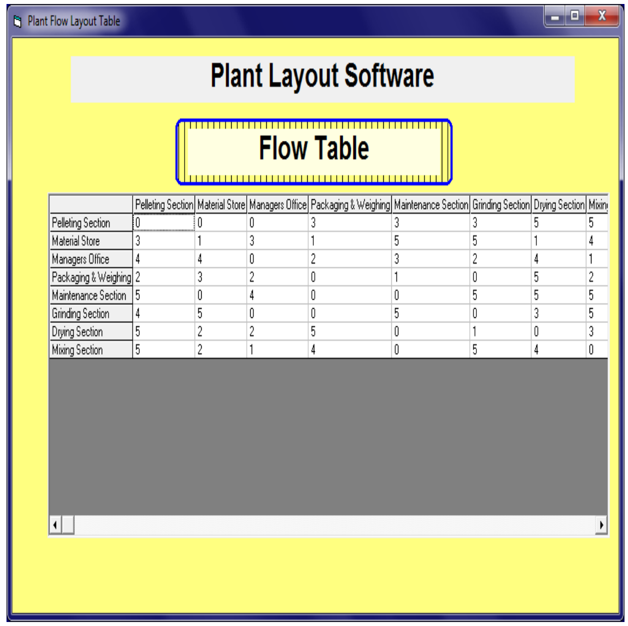
Considering the process flow of a feed mill, material store should be extremely close to grinding section, grinding section should be extremely close to mixing section, mixing section should be extremely close to pelleting section, pelleting section should be extremely close to drying section, drying section should be extremely close to packaging and weighing section. All these were achieved in the result obtained for modified plant layout structure in Figure 6.

Also, two section/department was also added in order to achieve the flexibility of the model, these two section/department that was added are product store and the security post (exit).

Figure 7 shows the graphical user interface for addition of new department and dimension.

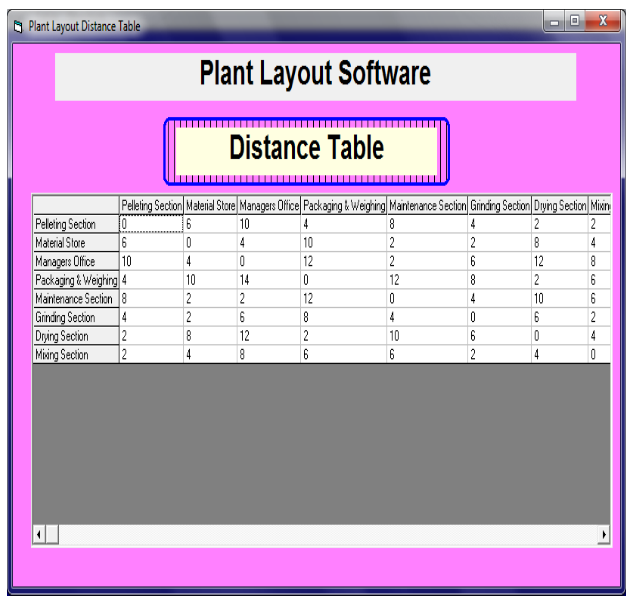
Figure 8 show the summary of the result generated for additional plant layout flow/relationship table.

Subsequently, additional department has proof that the newly modified plant from the existing one provides better position without destroying the newly arranged layout in Figure 9. This is the improved program as expected from an existing facility. The same thing will appear for construction program which generally developed a flexible layout in an open area, using correct input with adequate information about the flow rate of one department to another. A new layout using this program can also be achieved, with new additional department in future; the result is expected to be fantastic.



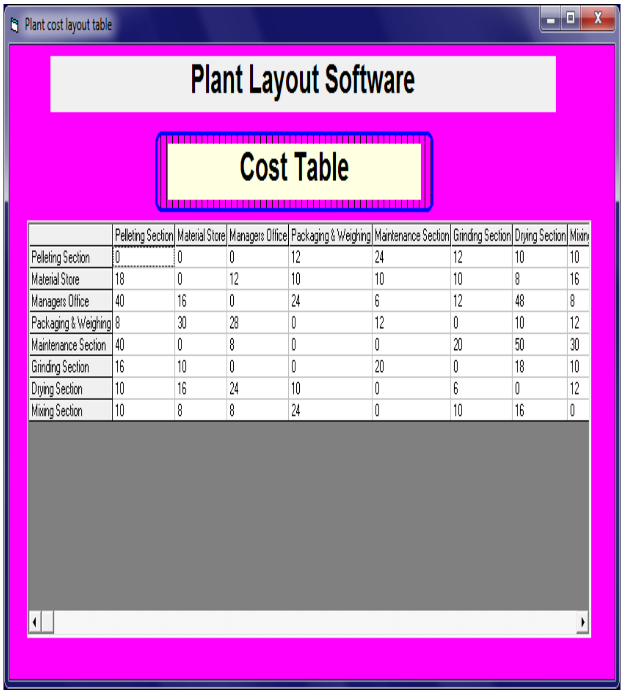
	Pelleting Section	Material Store	Managers Office	Packaging & Weighing	Maintenance Section	Grinding Section	Drying Section	Mixin
Pelleting Section	0	0	0	3	3	3	5	5
Material Store	3	1	3	1	5	5	1	4
Managers Office	4	4	0	2	3	2	4	1
Packaging & Weighing	2	3	2	0	1	0	5	2
Maintenance Section	5	0	4	0	0	5	5	5
Grinding Section	4	5	0	0	5	0	3	5
Drying Section	5	2	2	5	0	1	0	3
Mixing Section	5	2	1	4	0	5	4	0

Figure 2: Summary of the Result Generated for Plant Layout Flow (Relationship) Table.



	Pelleting Section	Material Store	Managers Office	Packaging & Weighing	Maintenance Section	Grinding Section	Drying Section	Mixin
Pelleting Section	0	6	10	4	8	4	2	2
Material Store	6	0	4	10	2	2	8	4
Managers Office	10	4	0	12	2	6	12	8
Packaging & Weighing	4	10	14	0	12	8	2	6
Maintenance Section	8	2	2	12	0	4	10	6
Grinding Section	4	2	6	8	4	0	6	2
Drying Section	2	8	12	2	10	6	0	4
Mixing Section	2	4	8	6	6	2	4	0

Figure 3: Summary of the Result Generated for Plant Layout Distance Table.



	Pelleting Section	Material Store	Managers Office	Packaging & Weighing	Maintenance Section	Grinding Section	Drying Section	Mixin
Pelleting Section	0	0	0	12	24	12	10	10
Material Store	18	0	12	10	10	10	8	16
Managers Office	40	16	0	24	6	12	48	8
Packaging & Weighing	8	30	28	0	12	0	10	12
Maintenance Section	40	0	8	0	0	20	50	30
Grinding Section	16	10	0	0	20	0	18	10
Drying Section	10	16	24	10	0	6	0	12
Mixing Section	10	8	8	24	0	10	16	0

Figure 4: Summary of the Result Generated for Plant Layout Cost Table.

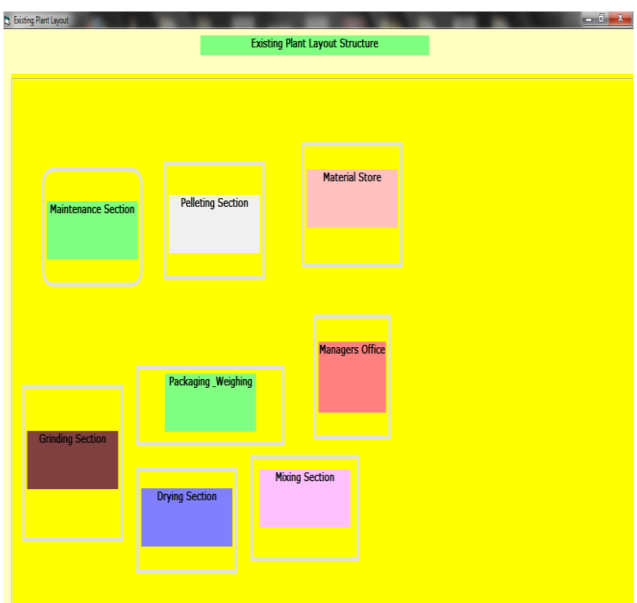


Figure 5: Existing Plant Layout Structure.

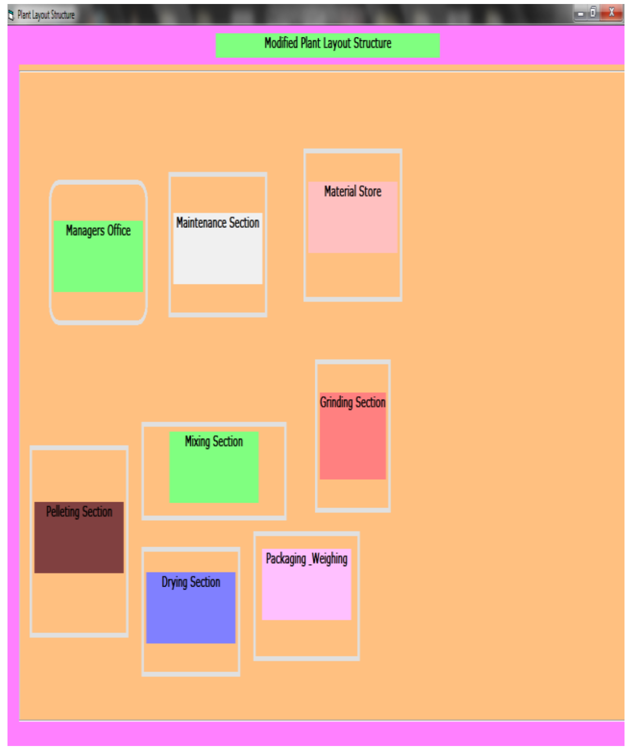


Figure 6: Result Obtained for Modified Plant Layout Structure.

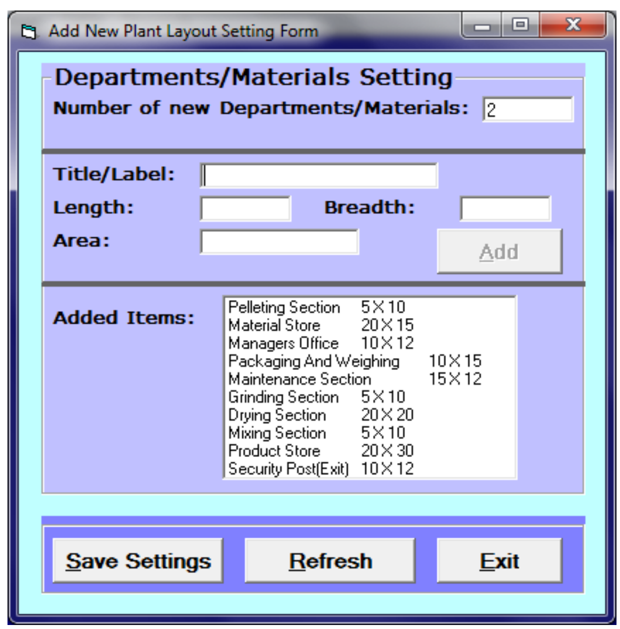
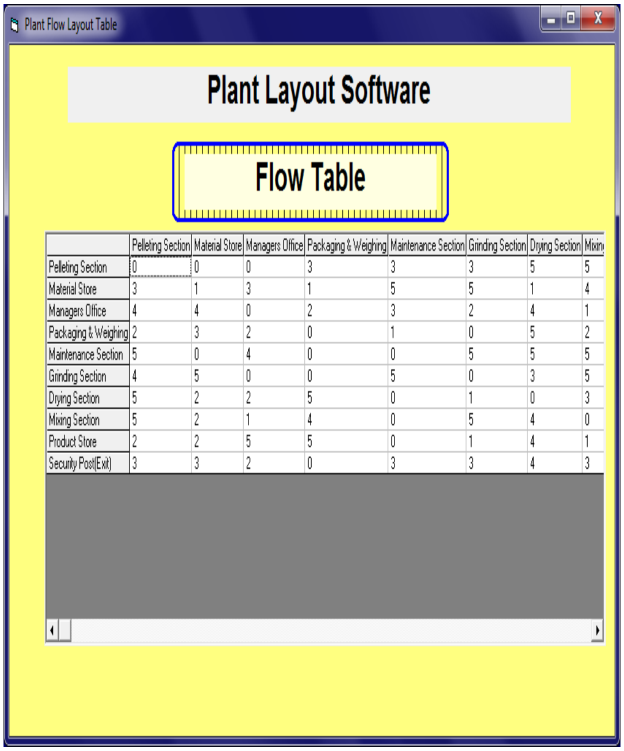


Figure 7: Graphical User Interface for Addition of New Department and Dimension.



	Pelleting Section	Material Store	Managers Office	Packaging & Weighing	Maintenance Section	Grinding Section	Drying Section	Mixin
Pelleting Section	0	0	0	3	3	3	5	5
Material Store	3	1	3	1	5	5	1	4
Managers Office	4	4	0	2	3	2	4	1
Packaging & Weighing	2	3	2	0	1	0	5	2
Maintenance Section	5	0	4	0	0	5	5	5
Grinding Section	4	5	0	0	5	0	3	5
Drying Section	5	2	2	5	0	1	0	3
Mixing Section	5	2	1	4	0	5	4	0
Product Store	2	2	5	5	0	1	4	1
Security Post(Exit)	3	3	2	0	3	3	4	3

Figure 8: Summary of the Result Generated for additional Plant Layout Flow Table.

Figure 9: Result Obtained for Additional Plant Layout Structure.

CONCLUSION

It was found from this study that the newly software developed (FLEXPLAYS) would address the problem facing the Nigerian low and medium scale industries in the area of plant layout (both for new and existing factories).

In this case, the use of FLEXPLAYS would facilitate in arranging and re-arranging facilities, even when expansion is needed, without demolition of existing facilities and modified layout.

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