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Planning a Small Scale Industry for Automatic Sliding Doors Manufacturing

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***Abstract*— Automatic sliding doors ease movements through buildings and gating systems and though highly patronized and marketed in Nigeria it suffers lack of an indigenous manufacturing company. Plant layout which is a perquisite to establishing a manufacturing company is hereby designed. The process through which the door is manufactured is analysed, departments are designed from the type of machines used and materials processed, the number of movements of materials through the designed departments is analysed, the number of movements is used to design all the possible layouts, the layout with no backtracking, low cross movements and low cost is then selected. To help conserve foreign exchange and the attainment of national self reliance, the establishment of a small scale industry to manufacture automatic sliding doors is highly recommended**

***Keywords*— Cross movement, Backtracking, Material flow, Cost matrix , Automatic**

1.0 Introduction

As the Nigerian economy expands, it is pertinent to diversify it by designing industries that not only provide employment at the micro level, but help propel other sectors of the economy. It is observed that, there is no known automatic door manufacturing company in Nigeria. The aim of this work is to design a plant layout for a small scale industry to manufacture the door. This will help entrepreneurs to, not only take interest in establishing companies to address the issue of automatic sliding door manufacturing in Nigeria, but make the establishment of the company easier. The design takes into consideration components that are manufactured in this country such as products from aluminium foundries, sheet metal manufacturing companies, etc. This will make the product cost effective. Expectedly, the successful outcome of this work will help conserve foreign exchange by reducing importation of the product, and help the attainment of national objectives of self reliance.
your paper.

2.0 PLANT LAYOUT

Kumar [1], states that a small business requires a smaller area or space and can be located in any kind of building as long as the space is available and it is convenient. He went on to add that plant layout for small scale business is closely linked with the factory building and built up area. He also states that plant layouts are mainly of four types: product or line layout, process or functional layout, fixed position or location layout, and combined or group layout. The most commonly used layouts are the product and process layout. A comparison between the two types of layouts tabled by Yawas [2] is given in table 1 below.

Table1: Comparison between product layout and process layout

	Product layout		Process layout
i	Employed when there is a continuous production of items.	I	Employed when there is an intermittent production of items
ii	Equipment of special design are used	ii	General purpose equipment are used
iii	Will be involved in producing relatively large quantities of each product.	Iii	Will be involved in producing relatively small quantities of each product

Source: Yawas [2].

3.0 Materials and Methods

3.1 *Layout Design Considerations*

Small business owners need to consider many operational factors when building or renovating a facility for maximum layout effectiveness. These criteria include the following:

3.1.1 *Ease of future expansion or change.*

Facilities should be designed so that they can be easily expanded or adjusted to meet changing production needs. "Although redesigning a facility is a major, expensive undertaking not to be done lightly, there is always the possibility that a redesign will be necessary," [3].

3.1.2 *Flow of movement.*

The facility design should reflect recognition of the importance of smooth process flow. In the case of factory facilities, J.K. Lasser Institute [4] state that "ideally, the plan will show the raw materials entering your plant at one end and the finished product emerging at the other. The flow need not be a straight line. Parallel flows, U-shaped patterns, or even a zig-zag that ends up with the finished product back at the shipping and receiving bays can be functional. However, backtracking is to be avoided in whatever pattern is chosen. When parts and materials move against or across the overall flow, personnel and paperwork become confused, parts become lost, and the attainment of coordination becomes complicated."

3.1.3 Materials handling

Small business owners should make certain that the facility layout makes it possible to handle materials (products, equipment, containers, etc.) in an orderly, efficient and preferably simple manner.

3.1.4 Output needs

The facility should be laid out in a way that is conducive to helping the business meet its production needs [5].

3.1.5 Space utilization

This aspect of facility design includes everything from making sure that traffic lanes are wide enough to making certain that inventory storage warehouses or rooms utilize as much vertical space as possible [5].

3.1.6 Shipping and receiving

The J.K. Lasser Institute [4] counselled small business owners to leave ample room for this aspect of operations.

3.1.7 Ease of communication and support

Facilities should be laid out so that communication within various areas of the business and interactions with vendors and customers can be done in an easy and effective manner [5].

3.1.8 Impact on employee morale and job satisfaction

Since countless studies have indicated that employee morale has a major impact on productivity, Weiss and Gershon [3] counsel owners and managers to heed this factor.

3.1.9 Promotional value

The small business owner may want to make sure that the facility layout is an attractive one that further burnishes the company's reputation.

3.1.10 Safety

The facility layout should enable the business to effectively operate in accordance with Occupational Safety and Health Association guidelines and other legal restrictions [5]

3.2 Layout Design Methodology

The following culled from Sharma [6] are the major stages in planning a plant layout:

3.2.1 Analyse Manufacturing Requirements.

The basic-data needed to design a layout include: a complete list of parts to be manufactured and assembled; their drawings; operation sequence and method of manufacture of each part and estimated process time for each operation.

3.2.2 Determination of space Requirements

The space for production departments is determined by generating the following data. (i) Activities to be carried out in each department. (ii) What operations to be performed on which machines and in which department. (iii) Standard times for each individual operation are calculated and listed in operation planning sheets. The required number of machines of each type is calculated. The space needed for each machine and the requirements of other equipment needed are determined. Space for Utilities, Production Related-Activities, Administration Offices and Personal Services is finally determined.

3.2.3 Choice of Plant Layout

A choice has to be between a product or line layout, process or functional layout, group technology or combined layout and fixed position or location layout.

3.2.4 Determination of Flow of Materials.

The smooth flow of work into, through and out of the factory depends, to a large extent, on the type of production and on the success of the layout chosen. In flow production (product layout), the work movement will be predetermined with the equipment arranged in operation sequence and the components and subassemblies flowing into the main assembly line at the correct position. For process layout, it is possible to establish only a general direction of work movement, due to the difference in operation sequence of different parts of the product. A better way is to take the help of Travel Charts.

3.2.5 Synthesis of Alternate Department Layout

By analysing travel charts for different arrangement of departments, sketches or drawings are made of the possible relative arrangement of the various departments. In this manner, we get a number of rough layouts of departments considering the shape and size of each department.

3.2.6 Planning Stores and Service Areas.

The size and position of the various store areas are determined. Normally raw materials stores are located at one end of the company and finished products warehoused at the other, with a component store between the manufacturing and assembly areas.

3.2.7 Choice of the Best Overall Layout.

To select the best layout, Materials Handling Costs of the layouts is compared. The alternative which results in the minimum total materials handling cost is selected.

3.2.8 Detailed Factory Layout Planning.

The next step is to plan the detailed layout of each department. This is done by considering each department separately and determining the best arrangement for machines, equipment and facilities within the department.

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4.0 LAYOUT DEVELOPMENT

4.1 Operations Process Chart

The manufacturing, assembly and installation procedure is summarized in an operation process chart (figure 1). The total main components are sixteen.

In this chart, the materials entering are indicated by horizontal lines and the processing of these materials is shown vertically. Only two symbols arc used to prepare this chart: ◯ for operation and □ for inspection.

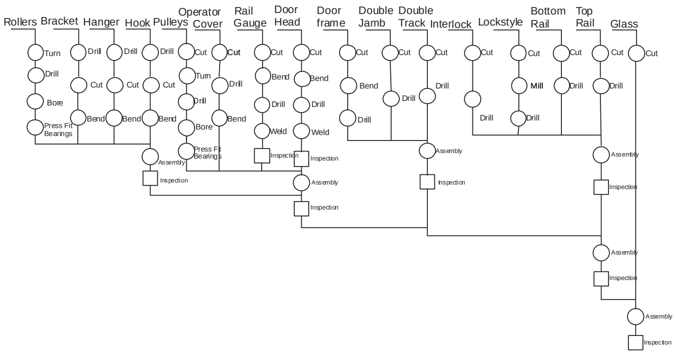


Figure 1 Operations process chart for automatic sliding door

4.2 Number of Machines Required.

The number of machines required can be calculated from the time taken for a particular operation, number of components to be produced per day and the total working time per day [7]. Machine requirement is calculated using equation 3 provided by Harold, Amrine and Hulley [7].

Number of machines required =

$$\frac{\text{total time to produce one component}\left(\frac{\text{min}}{\text{unit}}\right) \times \text{number of items to be produced}}{\text{total working time per day}}$$

.... 1

From the calculation, the machines required are: power saw, 1; lathe, 2; hydraulic press, 1; drilling machine, 1; welding machine, 1; guillotine, 2; bending machine, 1; aluminium milling machine, 1; aluminium cutting machine, 1; and aluminium punching machine, 1. This makes a total of 12 machines.

4.3 Daily Door Units Manufactured.

From proportional principle, the number of door units to be manufactured /day

$$= \frac{\text{working time/day}}{\text{critical time}}$$ 2

Critical time is the longest time spent on any one of the machines in the plant. From table 2 below the longest time is spent on power saw i.e. 60 minutes.

Critical time = 60 min Working time per day(8 hours day) = 480 min/day

∴ No of door units' manu factured /day = $\frac{480}{60}$

= 8 units/day

4.4 Automatic Sliding Door Part List and Machine Requirement

To manufacture a product a comprehensive part list is needed. The parts that make up the automatic sliding door are enumerated in Appendix A. The Appendix also provide information on the raw materials for manufacturing the parts, the number of components in an assembled door and the total number needed to produce eight components which is the daily output of the company.

The machine required for the plant and their capacities are summarized in table 2 (Appendix A). The table also shows the calculated floor space occupied by each machine.

4.5 Material Flow in Plant

Departments are developed from the manufacturing activities taking place on the product from the raw materials required to the finished product. The departments developed are: stores, machining, sheet metal fabrication, aluminium sections fabrication mechanism assembly and final assembly.

The movements from stores to the various production departments and the movements from one production department to the other are developed and the movements summarised in the travel chart of figure 2 below.

	1	2	3	4	5	6	
1	\	63	50	100	55	200	Stores
2		\	0	0	25	0	Machinig
3			\	0	75	80	Fabrication
4				\	0	180	Aluminium Fabrication
5					\	40	Mechanism Assembly
6						\	Final Assembly

Figure 2: Material flow travel chart

4.6 Layout Development

The factory floor layout is designed using the travel chart of figure 2. The cost of movement is calculated from the product of the number of movements and the cost per movement. To get the best floor arrangement, the departments are arranged so that the cost of movements is a minimum. Since the total departments designed are six, there are then 6! or 720 ways to arrange them

The cost matrices calculate the cost implication of using the layouts. The best layout must have no backtracking, must have very low cross movements and should have low cost in that order.

4.7 Work Flow Diagram

The work flow diagram according to Sharma [6] is the plan view of the work place under study to a certain scale. A line diagram indicates the path-followed by the object under study. In the case of work/material movement, it represents sequence of operations. A work flow diagram is developed from the selected layout and shown in figure 3 below.

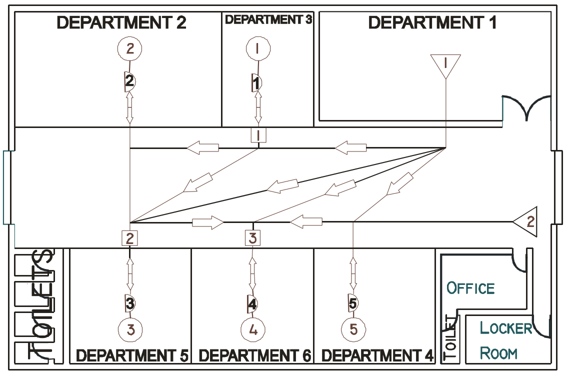


Figure 3: Work-flow diagram of manufacturing plant

4.8 Company Layout

The final layout of the small scale company, as shown in figure 4, is located on a 30m x 45m land (i.e. 3 plots). There is enough space for an administration block in front of the company and the production plant at the rear as suggested by Sharma [6].

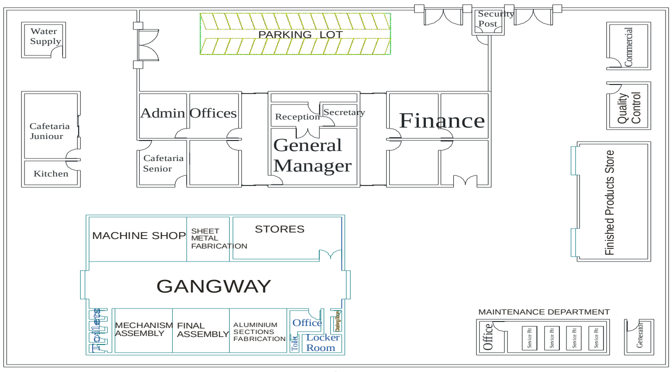


Figure 4: Layout Plan of a Small Scale Company

4.9 Planning Stores

The plan view of a store room is shown in Figure 5 indicating various spaces required. The various spaces, on which store keeping operations take place, as suggested by Kanna [9], are Incoming material receiving gate, Place for dumping raw material, Place for sorting and checking of raw materials, Place for raw material inspection, Place for temporarily storing the materials before putting them on racks, etc Proper place for storing each type of material, Main aisles, Side aisles, Service window, Boxes containing materials to be issued, and Counters for keeping materials, to be issued.

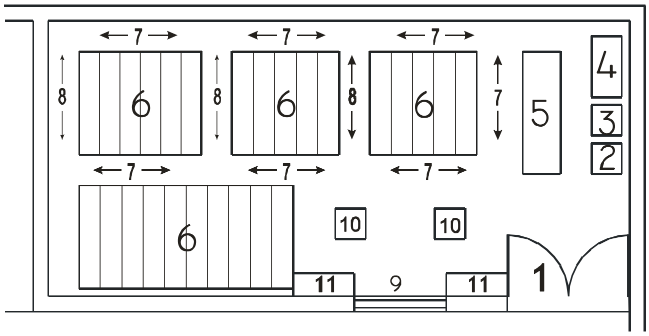


Figure 5:Store

4.10 Planning Machine Tools Department

This department has power saw, lathe, and hydraulic press installed. Using equation 3 one power saw is required to manufacture eight sliding doors. Provision is made for four lathes as indicated figure 6 below. The six machines are arranged close to the wall to provide access to power and give enough room close to the gangway for materials.

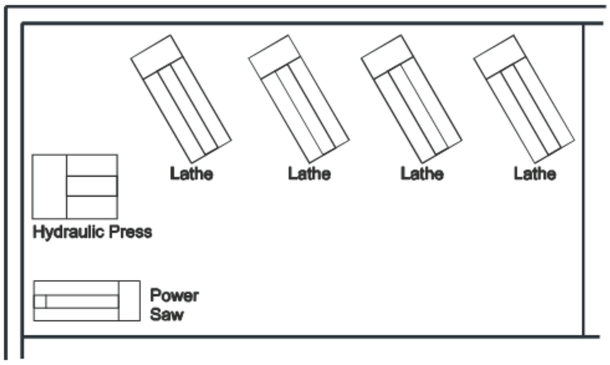
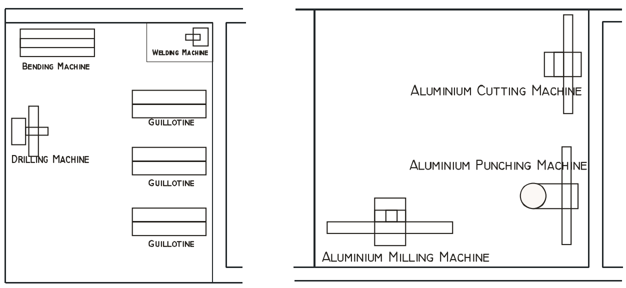


Figure 6: Machining Department

4.11 Planning Sheet Metal Fabrication Department

This department is made up of drilling machine, welding machine, bending machine and guillotine. This shop floor is arranged so that the welding machine is well screened and located between walls to shield off harmful rays. Provision for three guillotines, one drilling machine and one bending machine is provided. The machines are so located that enough room is provided for finished work and inventory as shown in Figure 7



(a) Sheet Metal Fabricationepartment (b) Aluminium Sections Fabrication department

Figure 7 Sheet Metal and Aluminium Sections Fabrication Departments

4.12 Planning Aluminium Sections Fabrication Department

This department has the Aluminium Milling Machine, Aluminium Cutting Machine, and Aluminium Punching Machine. The aluminium sections fabricated are long (about three meters long), therefore, enough space is allocated to handle them. Room is also provided for movement to the assembly departments without re-entering the gangway. Fabrications of aluminium sections start with cutting, punching and then milling, therefore, the machines are arranged in that order as shown in Figure 7.

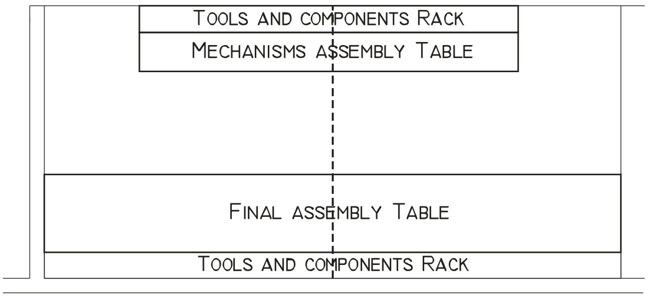
4.13 Planning Assembly Departments

Since both mechanisms assembly and final assembly have similar operations and procedure, merging them offer mutual advantage. The first is the use of long assembly tables which offers the opportunity of having more assembly on the assembly table. One technician can assemble more than one assembly concurrently and also the ease of supply of similar components to each station. The second advantage of merging the two departments is the sharing of tools, work rack and space. The third advantage is the great reduction in cost. The reduction in cost is achieved is this case about by removing movement 4 – 6. Movement 1 – 5 can be replaced by movement 1 – 6, the double movement being reduced to a single movement. The layout is shown in figure 8.

The saving in cost is ₦4000.00 + ₦5500.00 = 9500.00

∴ Cost of using layout 4 is now

₦98600.00 - ₦9500.00 = ₦89100.00 (Justifying rejection of matrix 3 and 8. Also see table 4)



Department 5: Mechanism Assembly Department 6: Final Assembly

Figure 8: Assembly Departments.

5.0 CONCLUSION AND RECOMMENDATION

A small scale industry planned for the manufacture of automatic sliding door was successfully designed. The design took details of layout needed for the complete manufacturing of the door. A process chart, a travel chart and a work flow diagram was designed. Design was also made of each production department. It is recommended that:

1. A multiproduct layout to manufacture automatic sliding door and other products should be an area in further research.
2. Research into devising the number of movements for different categories of standard engineering materials and if possible, values tabulated.
3. Write software to design and choose the best layout from a given set of data prompted and fed into the software.

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Appendix A

Table 2:Machine Requirement Summary and Manufacturing Area Space Requirement.

Machine no	Machine name	No of machines	Time spent	Floor space By Machine (m^2)		Floor space by department (m^2)
				Per machine	Total	
1	Power saw	1	60	1	1	14
2	Lathe	2	97 (48.5)	6	12	
3	Hydraulic press	1	14	1	1	
4	Drilling machine	1	18	5	5	10
5	Welding machine	1	45	1	1	
6	Guillotine	2	65 (32.5)	1	2	
7	Bending machine	1	30	2	2	
8	Milling machine	1	9	5	5	15
9	Cutting machine	1	12	5	5	
10	Punching machine	1	13	5	5	