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FACILITY LAYOUT DESIGN: A CASE STUDY OF A SOAP MANUFACTURING COMPANY IN NIGERIA

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Abstract

This research paper seeks to reiterate the importance of facility layout design as an inevitable component of business operations, and also to reemphasize its advantage in the elimination of unjustified cost of material handling. A soap manufacturing company was visited and the facilities on ground were observed with the arrangement of activities work centers and the workforce capacity and capability carefully noted. Production routing of the company was observed and the flow process chart, activity-relationship template, activity relationship chart, and degree of closeness of each department was drawn. And it was observed that an intensive study of material handling technique might yield monumental savings and some possible line balancing will combine to reduce downtime and correspondingly cost reduction which gives a very reasonable increase in profit.

1.0 Introduction

The three main types of layouts in manufacturing systems are product layout, process layout, and group layout, which is further categorized into flow line, cell, and centre [1]. The distinction between these types of layouts is made based on system characteristics such as production volume and product variety [2]. Product layout (flow shop) is associated with high volume production and low product variety, while process layout (job shop) is associated with low-volume production and high [3]. Facility layout design determines how to arrange, locate, and distribute the equipment and support services in a manufacturing facility to achieve minimization of overall production time, maximization of operational and arrangement flexibility, maximization of turnover of work-in process (WIP) and maximization of factory output in conformance with production schedules [4].

Among the various aspects of manufacturing management, the facility layout problem is one of the important issues. A good facility layout would contribute to the overall efficiency of operations, and decrease the cost of production. In this paper, a review of literature in the facility layout problem is offered. Various models and approaches for solving this problem are presented. Some important issues related to this problem were also discussed. We hope that our paper will be helpful for researchers/practitioners to identify types of algorithms, the available approaches, and other relevant important facts. This paper's main contribution is not to solve all kinds of layout problems, but to exhibit the practical layout decision requirement for further research [5].

The overall performance of an industrial firm is significantly affected by the design of its manufacturing facility. Facility is an entity that facilitates the performance of any job. It may be a machine tool, a work centre, a manufacturing cell, a machine shop, a department, a warehouse, etc. A facility layout is an arrangement of everything needed for production of goods or delivery of services [6]. A well-designed facility layout results in efficient material handling, small transportation times, and short paths. This, in turn, leads to low work-in-process levels, effective production management, decreased cycle times and manufacturing inventory costs, improved on-time delivery performance, and consequently, higher product quality.

The efficiency of a layout is typically measured in terms of material handling (transportation) cost. The material handling costs are directly influenced by the distances a unit load must travel [7]. Moreover, an efficient layout results in an effective material flow path with no backtracking, congestion, undesirable intersections with other paths, and bypassing. An effective flow within a facility includes the progressive movement of materials, information, or people between departments. The following principles have been observed to frequently result in effective flow: maximize directed flow paths and minimize flow. A directed flow path is an uninterrupted flow path progressing directly from origination to destination. An uninterrupted flow path is a flow path with no backtracking and that does not create congestion, undesirable intersections with other paths, and bypassing.

The design of production facility differs from that of manufacturing layout. The analysis of the capacity of the equipment is done, then by using this analysis a group technology is used to make different type of parts in a layout and identification of a material handling solution for a material flow [8]. A research was conducted to identify and improve the plant layout of pulley’s factory to eliminate obstructions in material flow and thus obtain maximum productivity. The present plant layout and the operation process of each section (i.e., sand mould, core ware house, core making and disassembly, surface finishing, furnace, and inspection sections) was investigated and a new layout was designed [9].

It was estimated that over $250 billion is spent annually in the United States on facilities planning and re-planning. Further, between 20%- 50% of the total costs within manufacturing are related to material handling and effective facility planning can reduce these costs 10-30% [10]. Many researches have been done in facility planning area. However, there are some difficulties and limitation in finding the optimum layout configuration. Anyone who has been involved in facility planning and development understands that errors are common during the planning and development process. The challenge is to complete a facility project with the fewest number of errors. Before becoming too deeply involved in the planning and development process, it is important to review some of the common errors that have been made in the past [11].

It was suggested that these errors include, but are not limited to; failure to provide adequate storage spaces, failure to provide adequate janitorial spaces, failure to observe desirable current professional standards, failure to build the facility large enough to accommodate future uses, failure to provide adequate locker and dressing areas for both male and female users etc. [12].

2.0 Methodology and Procedure

An indigenous soap manufacturing company was visited and the facilities on ground were observed with the arrangement of activities work centre carefully noted, also was the workforce capacity and capability. Sufficient data was collected and this formed the tool for the analysis of the existing plant. Sources for data collection are:

(i.) Interview with Key Personnel Officers: Information was gotten through discussions with personnel officers and cost of materials, equipment, company annual profit and the likes was collected.

(ii.) Work measurement of task: Data relating to standard time required to perform each operation was established.

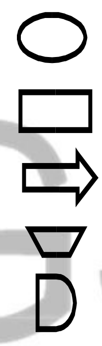
(iii.) Physical study: All information concerning the physical activities and all intricate and complex aspect of the job were obtained.

(iv.) Study of organization past record: Previous records and necessary data were obtained from the past work reports and past work order sheet.

2.1 Data Collection and Analysis

In the process of gathering data concerning the various operation of the firm, there is a large number of detailed information which could generate problems in the analysis of complex long process. For this reason, a system of charts and diagram has been developed to take care of any difficulty, with the use of some set of standard symbols. Some of these symbols are:

Operation
Inspection
Transportation
Storage
Delay



The actual production routing presently employed in this company is as presented in table 1, it is the sequence of all operations involved in the production of soap. And figure 1 shows the operation process chart derived from the combination of the production processes and depicted by standard symbols for each process. A flow process chart (Worker, Material & Equipment type) was designed using the information from the operation process chart and is shown in table 2.

Table 1: Production Routing

Operation No.	Description	Machine
1.	Mixing soap material and conveying.	Mixer and screw conveyor.
2.	Pressing soap material to increase surface area.	Triple roll mill and roll mill conveyor.
3.	Compressing and extruding.	Vacuum plodder.

4.	Cutting soap bars.	Cutter.
5.	Detecting metal particles.	Metal detector.
6.	Stamping of soap names and other accessories on the soap and cutting it to soap cake.	Stamper.
7.	Wrapping of soap cake in its wrapper.	Khosla Wrapping Machine
8.	Printing of information on the soap wrapper.	Coding machine
9.	Packing of soap cakes into carton.	Packing
10.	Sealing the carton by cello tapping machine.	Taping machine

Fig 1: The company operation process chart

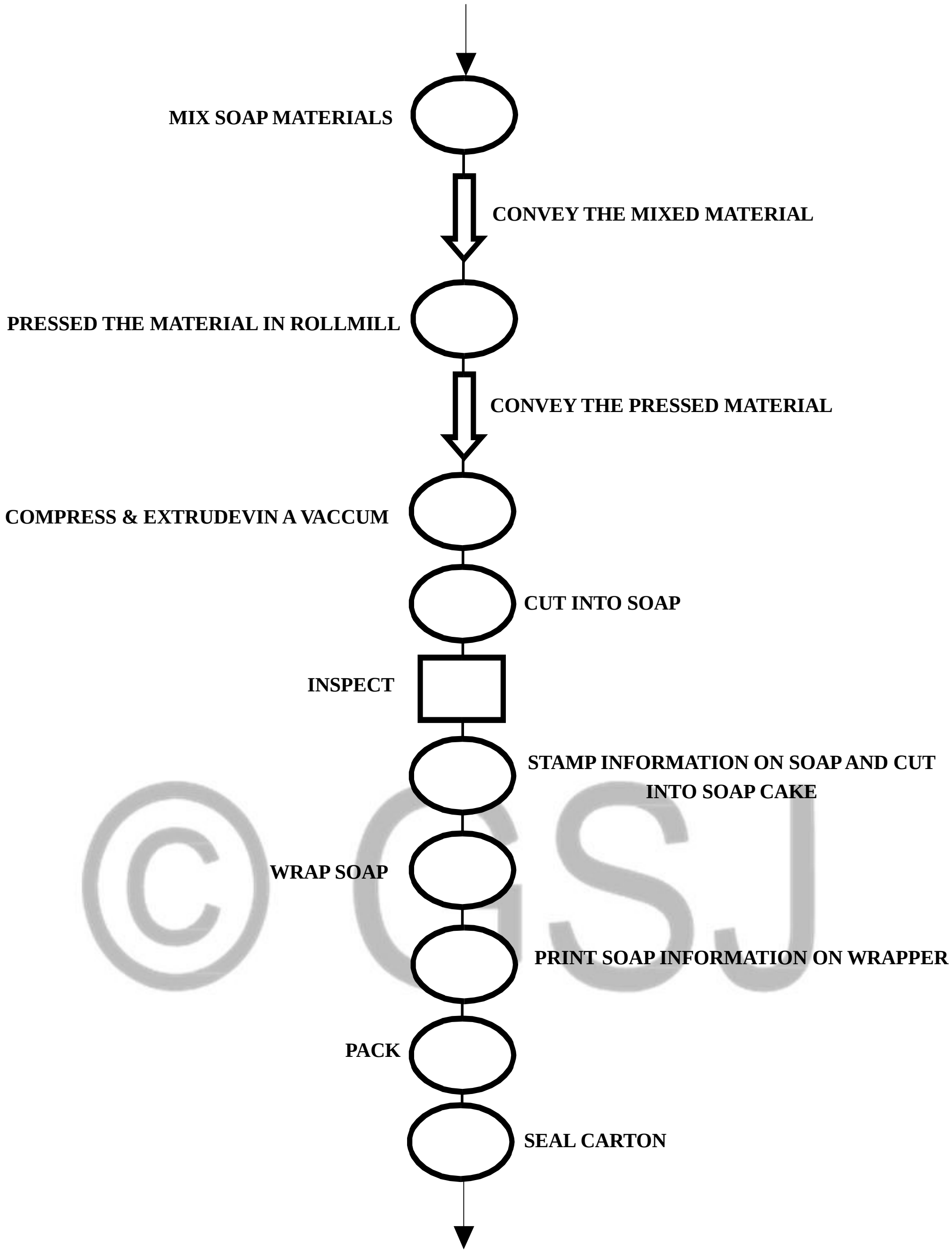


Table 2: Flow Process Chart Worker/Material/Equipment Type

Chart No.1 Sheet No.1 of 1	Summary			
Subject charted: Soap	Activity: Operation ○ Transport ⇨ Delay D Inspection □ Storage ▽	Present	Proposed	Saving
Activity Method: Present/Proposed	Distance(m)			
Location: **a soap manufacturing company in Nigeria**.	Time(Workman)			
Charted by: Olanrele Oladeji .O. Date: MAY 2015 Approved by: Mr. Fowowe .D Date: 01/06/2015				
Description	Total			

	Qty	Distance	Time	○	⇨	D	□	▽	Remarks
MIX SOAP MATERIALS.				●					
CONVEY THE MIXEDMATERIAL.					●				
PRESS THE MATERIAL IN A ROOLMILL.				●					
CONVEY THE PRESS MATERIAL.					●				
COMPRESS & EXTRUDE IN A VACCUM PLODDER.				●					
CUT INTO SOAP BARS.				●					
INSPECT							●		
STAMP INFORMATION ON SOAPAND CUT INTO SOAP CAKE.				●					
WRAP SOAP.				●					
PRINT SOAP INFORMATION ON WRAPPER.				●					
PACK.				●					
SEAL CARTON.				●					

2.2 Activity Relationship

Material handling and plant layout are so interwoven that they cannot be separated. The material handling equipment choice will affect the plant layout design which will reflect in the handling time. A major statement can say that the primary goal in increasing the productivity of this organization is good and proper material handling. Reduction in material in-process time can only be achieved when related activities are situated close to each other, thereby reducing unnecessary movement and activities within the process flow. Other reasons for putting related activities side by side are; to carry out similar task, to improve degree of personnel contact, to reduce noise disturbance, using same work space, proper arrangement of work flow, use of similar records, use of same equipment. The existing production floor layout is presented in figure 2 below.

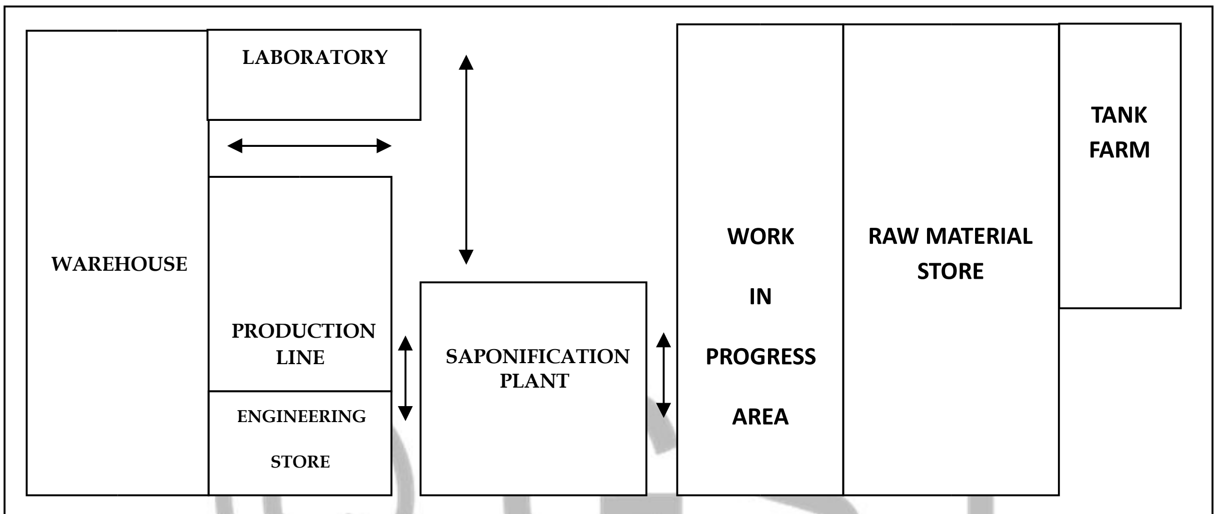


Fig 2: Production floor layout

In other to develop an activity relationship chart, a set of codes representing the degree of closeness as shown in table 3 was used. And a chart showing the relationship between all departments within the organization towards the achievement of the overall goal, that is soap production, was developed and is as shown in figure 3. Also, the degree of closeness of each department was developed and shown in table 4. Activity relationship template showing the closeness of relationship between all the required activities performed in each department was then designed and is shown in figure 4.

Table 3: Closeness Rating Code

CODE	CLOSENESS
A	Absolutely Necessary
E	Essentially Important
I	Important
O	Ordinarily Okay
U	Unimportant
X	Undesirable

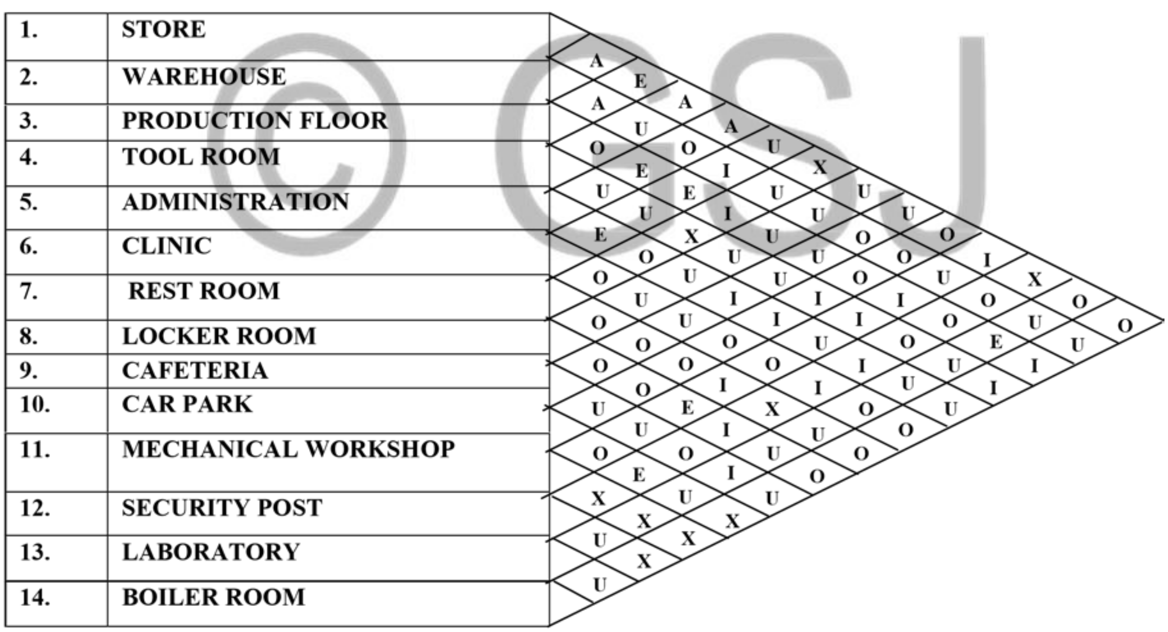


Fig 3: Activity Relationship Chart for new layout

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Table 4: Degree of Closeness.

Department	Absolutely Necessary (A)	Essentially Important (E)	Important (I)	Ordinarily Okay (O)	Unimportant (U)	Undesireable (X)
1.	2, 3, 5	3	11	10, 13, 14	8, 9	7, 12
2.	3	1	6	5, 9, 10, 12	4, 7, 8, 11, 13, 14	-
3.	1	5, 6, 13	7, 11, 14	4, 10, 12	2, 8, 9	-
4.	1	3	10, 11, 14	2, 12	5, 6, 8, 9, 13	7
5.	-	3, 6	2, 9, 10, 12	7	4, 8, 11, 13	-
6.	-	-	3, 12	5, 7, 10, 11, 13, 14	2, 8, 9	1, 4
7.	-	-	11	8, 9, 10, 14	1, 2, 3, 4, 5, 6, 13	12
8.	-	11	5, 12	2, 7, 9, 10, 14	1, 3, 4, 6, 13	-
9.	-	-	4, 5, 13	1, 2, 3, 6, 7, 8, 12	10, 11, 14	-
10.	-	8, 12	1, 3, 4, 7	6, 11	2, 5, 9, 13	14
11.	-	10	5, 6, 8	2, 3, 4, 9	-	1, 7, 12, 13, 14
12.	-	3	9	1, 6	2, 4, 5, 7, 8, 10, 13	11, 14
13.	-	3	9	6	2, 4, 5, 7, 8, 10, 12	11, 14
14.	-	-	3, 4	1, 6, 7, 8	2, 5, 9, 13	10, 11, 12

A - 2,3,5 E - 3 I - 11 O - 10,13,14 U – 8,9 X – 7,12 1	A - 3 E - 1 I – 6 O – 5,9,10,12 U – 4,7,8,11,13,14 2	A - 1 E – 5,6,13 I – 7,11,14 O – 4,10,12 U – 2,8,9 3	A - 1 E – 3 I – 10,11,14 O – 2,12 U – 5,6,8,9,13 X – 7 4	E – 5,6,13 I – 7,11,14 O – 4,10,12 U – 2,8,9 5	I – 3,12 O – 5,7,10,11,13,14 U – 2,8,9 X – 1,4 6	I – 11 O – 8,9,10,14 U – 1,2,3,4,5,6,13 X - 12 7
E – 11 I – 5,12 O – 2,7,9,10,14 U – 1,3,4,6,13 8	I – 4,5,13 O – 1,2,3,6,7,8,12 U – 10,11,14 9	E – 8,12 I – 1,3,4,7 O – 6,11 U – 2,5,9,13 X – 14 10	E – 10 I – 5,6,8 O – 2,3,4,9 X – 1,7,12,13,14 11	E – 3 I – 9 O – 1,6 U – 2,4,5,7,8,10,13 X – 11,14 12	E – 3 I – 9 O – 6 U – 2,4,5,7,8,10,12 X – 11,14 13	I – 3,4 O – 1,6,7,8 U – 2,5,9,13 X – 10,11,12 14

Fig 4: Activity Relationship Template

2.3 Observations

It was observed that there was not sufficient equipment like pallet and hand trucks for conveying finished soaps. After it has been packed into the inner carton, packed in cellophane and sealed in oven, it is then packed into an outer carton and sealed by a sealing machine. The factory has just one forklift truck which makes operation stagnant if the truck is in use in another line. A suggestion of re-equipping the factory with at least a standby forklift truck with increased tone carrying capacity and some more pallets since the noted functional few is not sufficient for the factory.

2.3.1 Quality Issue

It was also observed that in process of collecting saponified and dried soap noodles from the silo into the bag, there are usually an overflow and the factory workers collect everything on the ground together with the soap noodles, thereby contaminating the noodles, leaving the left over which also constitute a nuisance as it makes the factory floor slippery and untidy. Some solutions were provided in form of advice to the company;

Put a basin under each silo, into which soap noodles could fall into since the soap noodles always overflow.

Enlighten the factory workers on the reason for the basin, and inform them that it should be clean at all time in other to avoid contamination.

Instead of using bag to collect soap noodles, install a conveyor that leads directly from the silo into the weighing unit of the amalgamator (mixer), thereby reducing the number of workers working in the section from eight (8) workers to two (2) in each of the three shifts.

2.4 Economic justification

Material handling and plant layout are so interwoven that they cannot be separated. The material handling equipment choice will affect the plant layout design. A major statement can say that the primary goal in increasing the productivity of this particular soap company is good and proper material handling techniques. And the following objectives agree with the primary goal;

(i.) Minimization of unit cost.

(ii.) Reduction in accident rates.

(iii.) Achieving miscellaneous goals.

(iv.) Provision of employee convenience, safety and comfort.

(v.) Improved work efficiency.

(vi.) Reduction of in-process inventory.

(vii.) And reduction of in-process time.

2.4.1 Estimation of saving

Each of the workers on the amalgamator has some sort of training and they are been paid Fifteen Thousand Naira Monthly (₦ 15, 000.00), which means the company pays nothing less than One Hundred and Twenty Thousand Naira (₦ 120, 000.00) monthly for each shift and Three Hundred and Sixty Thousand Naira (₦ 360, 000.00) for the three shifts. But if the conveyor system is installed, they will only need to pay Thirty Thousand Naira monthly ₦ 30, 000.00) for the two workers which work will be reduced to mere inspection. There by having a saving of Ninety Thousand Naira ₦ 90, 000.00) in each of the shifts and Two Hundred and Seventy Thousand Naira (₦ 70, 000.00) in all the three shifts.

3.0 Conclusions

The soap company under study has a well-planned factory with most of the activity areas relatively well placed within the factory. However, based on Industrial Engineering view of developing/improving to a better operation pattern, this has brought about some modifications to the layout and also some suggestions to the administration, believing that the management will favourably receive these recommendations. An intensive study of material handling technique might yield monumental savings and some possible line balancing will combine to reduce downtime and correspondingly cost reduction which gives a very reasonable increase in profit. This I believe is the ultimate goal of all individual and organizations at large.

References

[1] Khusna, D., Siti, Z., Jamasri, and Hideki, A. 2010. A Proposed Study on Facility Planning and Design in Manufacturing Process. Proceedings of the International Multi Conference of Engineers and Computer Scientists 2010 Vol III, IMEC 2010, March 17-19, 2010, Hong Kong.

[2] Tompkins, J. A. 2003. Facilities planning. New York: John Willey and Son.

[3] Hesen, P. M. C., Renders, P. J. J. and Rooda, J. E.2001.Application of a Layout/Material Handling Design Method to a Furnace Area in a 300 mm Wafer Fab.Springerlink International journal of Advanced Manufacturing Technology 17: pp 216–220.

[4] Huang, H. 2003. Facility layout using layout modules, Ph.D. Thesis, The Ohio State University.

[5] Chen, Cand Sha, D. Y. 2001. A Literature Review and Analysis to The Facility Layout Problem. Journal of the Chinese Institute of Industrial Engineers, Volume 18, Issue 1, 2001.

[6] Drira, A., Pierreval, H., and Hajri-Gabouj, S. 2007. Facility Layout Problems: A survey. Annual reviews in control, Elsevier.

[7] Golmohammadi, V.R., Jaafari, A.A., Baygi, M.B., Esfanji, E and Rahimi, M. 2010. An Approach for Facility Layout Problem, Proceedings of the International Multi-Conference of Engineers and Computer Scientists 2010 Vol III, IMECS 2010, March 17-19, Hong Kong.

[8] Thomas, L. 2010. Facilities Layout Optimization Method Combining Human Factors and SLP, International Conference on Information Management, Innovation Management and Industrial Engineering, Vol 1, pp. 608611.

[9] Anucha, W. 2011.Analysis Plant Layout Design for Effective Production, Proceeding of the International Multi Conference of Engineers and Computer Scientists, Vol.2, pp. 543-559.

[10] Balakrishnan. J and Cheng, C.H. 2007. Multi-period planning and uncertainty issues in cellular manufacturing: A review and future directions, European Journal of Operational Research. Ed.177. page 281–309.

[11] Thomas, H. S and Michael, G.H. 2009.Planning Facilities: Master Plan, Site Selection, and Development Phases.Sagamore Publishing, Champaign Illinois.

[12] Horine, L and Stotlar, D.K. 2002. Facility Planning and Design for Health, Fitness, Physical Activity, Recreation, and Sports Facility Development. Sagamore Publishing, Champaign Illinois.