Jurnal Mekanikal
Dec 2017, Vol 40, 53-60

Redesign and Simulation of Facility Layout in A Manufacturing Company

Xian Fong Low and Kuan Yew Wong*

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia
81310 UTM Johor Bahru
Johor, Malaysia

ABSTRACT

Facility planning involves the organization of departments or machines for improving the work efficiency. A study has been conducted in a jigs-and-fixtures manufacturing company to improve the facility layout of the company. The main objective of the study is to identify the current problem in the existing layout and develop better layouts to minimize the total distance travelled. The main problems in the existing layout are the long distance travelled and unsystematic material flow. A Group Technology approach has been applied to group several products as families. Based on the cells generated using Group Technology, an alternative layout has been developed using MULTI-floor Plant Layout Evaluation (MULTIPLE) method. For comparison purposes, another alternative layout has been generated using the Systematic Layout Planning (SLP) method. The existing layout and its developed alternatives are compared and evaluated through manual calculation and WITNESS simulation. The alternative layout using MULTIPLE method has shown a greater improvement for the facility layout compared to the other two methods. The objective of the study has been successfully accomplished through the problem identification and alternative layouts generation.

Keywords: *Facility layout planning, layout design, simulation*

1.0 INTRODUCTION

In manufacturing sectors, facility layout is an important aspect that should be addressed because it affects the material flow [1]. By properly planning the arrangement of facilities, the excessive movement of materials in a production floor could be reduced. A well-planned facility layout could reduce the losses due to ineffective material flow and material handling. Meanwhile, a good layout arrangement makes the flow of materials in production to be smooth and rapid that reduces the transport handling cost and idle time of man and machine [2].

A case study has been done in a manufacturing company. The existing facility layout of the case study company is not well organized and arranged. By determining the total distance travelled of the worker from one department to another, the ineffectiveness of the existing layout could be identified and investigated. Long distance travelled from department to department causes the worker to take more time to complete a product.

* Corresponding author : wongky@mail.fkm.utm.my

From the material flow of several products, the worker has to walk from one department to another several times before getting the finished goods.

The repetition of long distance movement from a department to another is a sign of poor layout planning. Therefore, a better solution for the layout planning could minimize waste caused by poor layout problem should be proposed.

2.0 LITERATURE REVIEW

Facility planning is the organization of physical facilities in a company for improving the effectiveness of the usage of equipment, people, material and energy [3]. Unnecessary material movement should be minimized by facility planning strategy as it can be considered as a non-value added process in manufacturing [1]. In order to minimize the total distance travelled between departments, Group Technology approach could be applied to group several products as a family and to be produced together in a cell. There are three basic methods to generate the parts family that will be discussed in the following sub-section. Based on the grouping of the products, the layout of the company could be rearranged by applying the method of facility planning.

There are several techniques of facility planning such as Systematic Layout Planning (SLP), Graph Based Method (GBM) and Computerized Relative Allocation of Facilities Technique (CRAFT). The techniques could be divided into two categories which are improvement type and construction type [4]. However, some of the techniques could be applied for both types of layout planning. MULTIPLE and SLP are the methods that have been selected and applied for the facility layout improvement. This is detailed out in the ensuing sub-sections

2.1 Techniques of Group Technology

Group Technology (GT) is a technique used to group the processes into a cell. By forming several cells, production family layout is generated. Basically, this technique involves the identification of two attributes which are design attributes and process attributes. For the family parts generation, there are three basic methods [5].

The first method is visual inspection where the grouping is based on the observation of the production of every single part [5]. The second method is Flow Production Analysis (FPA). This method involves the analysis of process route of component to form group and its associated families [6]. Grouping of the parts to form a cell is always done by clustering methodologies [4]. The third one is the classification and coding system (C&C). This technique requires the details on the similarities and differences of the design of the products and the grouping is done based on the information obtained [5].

2.2 Systematic Layout Planning (SLP)

Muther has developed an organized way for layout planning and it is called Systematic Layout Planning (SLP) [7]. There are always three fundamental aspects at the heart of any layout planning project which are relationship, space and adjustment. SLP could be applied to construct a new layout or improve an existing layout by generating several alternatives. It is an easy to be used technique for layout planning. The relationship chart constructed in SLP shows a clear visualization of the relationships between the departments [7].

2.3 MULTIPLE

MULTI-floor Plant Layout Evaluation (MULTIPLE) is an algorithm developed by Bozer, Meller and Erlebacher in 1994. It is an extended version of CRAFT with the use of space-filling curve to facilitate the exchange of departments in the process of layout improvement [8]. Although it is originally developed for multi-floor facilities, it can be

used for single floor layout improvement by setting the number of floors equal to one [4]. By comparing with CRAFT, MULTIPLE is more likely to obtain a lower cost layout if they are started with the same initial layout [8].

3.0 METHODOLOGY

A company has been identified as the main subject of interest to conduct the case study. The company background was first studied through discussion with the employer and employees of the company to have a grip and understanding of the relevant situation in the company. The objectives and scopes of study were subsequently defined to pursue the case study. Based on the observation and discussion with the employer, the identification of the problems in the company was then carried out. For the stage of identifying problem, data collection and analysis were performed to justify the existing problems in the company. From the problems identified, alternatives were developed and proposed to improve the current problem in the existing layout. The improvement is started by applying the Group Technology approach to group the family of products. Based on the cells generated, an alternative layout is developed using the MULTIPLE method. Meanwhile, the SLP method is used to generate another alternative layout for the purpose of comparison between the two alternatives. The alternatives developed were compared with the existing layout through manual calculation as well as simulation. Based on the results of evaluation and comparison, the best alternative layout is further discussed.

4.0 PROBLEMS IDENTIFICATION

Material flow smoothness is one of the main problems in the current layout. The overall flow of material is shown in Figure 1.

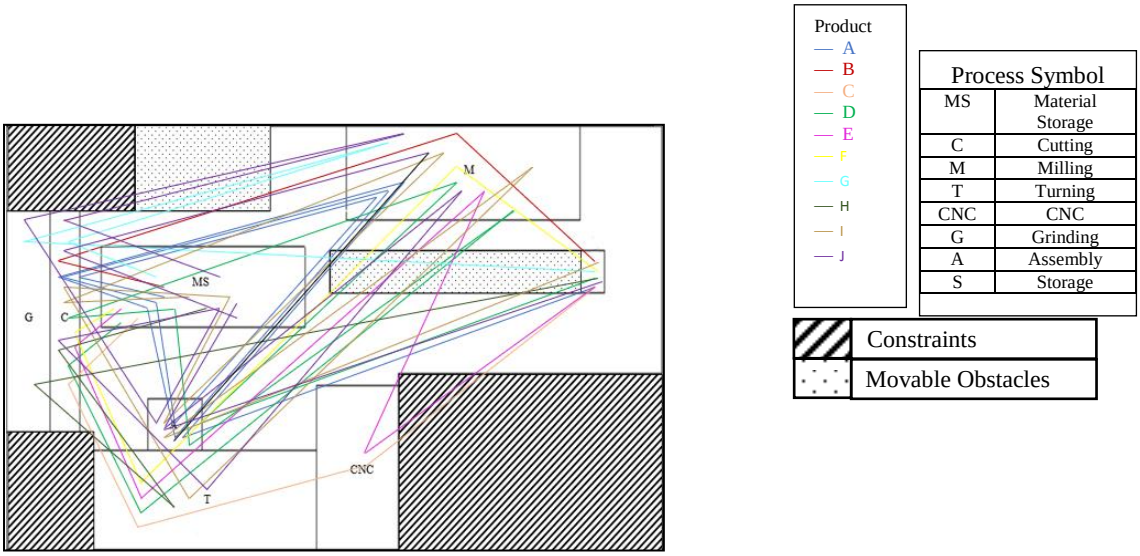

Figure 1: Overall flow of material

It is clearly shown that the process flow of the material is unsmooth and unsystematic. There are numerous backtrackings and cross-traffics along the path of material flow. It is a sign of ineffective material flow which leads to a poor layout. Occurrence of

backtracking and cross-traffic is the main cause of the long distance travelled between the departments in the process flow. Long distance of travelling between the departments will cause more time consumption and could prolong the production time. Therefore, rearrangement of the departments or machines is required to minimize the chances of backtracking and cross-traffic as well as the distance travelled between the departments. In order to achieve this objective, grouping the similar products to be produced at a certain area or group technology concept could be applied.

On the other hand, the total distance travelled between the departments has been calculated using *from-to* chart. Two *from-to* charts are required to investigate the total distance travelled between departments. The first one is the *from-to* chart of distance between the departments while the second one is the *from-to* chart of total flow of material between the departments. By multiplying both *from-to* charts, the total distance travelled between the departments could be obtained. The calculation was done using the following formula:

$$\text{Total Distance} = \sum_{i=1}^{m} \sum_{j=1}^{m} f_{ij} d_{ij} \quad (1)$$

where

f_{ij} : flow from department *i* to *j*
d_{ij} : rectilinear distance from department *i* to *j*

Based on the *from-to* chart constructed, the total distance travelled between the departments is 4851.84 m per week. Long distance travelled between the departments indicates the ineffectiveness of the current layout. Rearrangement is thus required to minimize the distance travelled between the departments in the process flow.

5.0 ALTERNATIVE LAYOUT

The alternative layouts are generated to improve the existing one in the company. Before the development of alternatives, the products were grouped to be produced in a cell using GT technique. The coding of the machine is shown in Table 1 while the grouping is shown in Figure 2. The grouping is based on the machine required to produce the products.

Table 1: Coding of machine

Coding	Machine
M	Milling
T	Turning
CNC	CNC
G	Grinding
A	Assembly

Part	Machine				
	G	A	M	T	CNC
J	1	1	1	1	
G	1		1		
H	1			1	
D		1	1	1	
I		1	1	1	
A		1	1		
F			1	1	
B			1		
C				1	1
E			1	1	1

Cell A
Cell B
Cell C

Figure 2: Grouping of products

5.1 Alternative Development

There are two alternatives developed in this study. The first alternative layout is generated using MULTIPLE method while the second alternative layout is developed using SLP method. The alternative layout generated using SLP is for comparison purposes. The details of the departments are summarized in Table 2. Figures 3 and 4 show the alternatives developed using MULTIPLE and SLP methods, respectively. The alternative layouts shown in Figures 3 and 4 are drawn based on the grid layout with the dimension of 1 x 1 m^2 each.

Table 2: Details of departments

Types	Departments	Room Number	Min. Space (m^2)	Min. Grid needed	Grid used
Non-productive	Tool Rack	-	2 x 18	36	36
	Broken Machine	7	4 x 10	40	50
	Material Storage	1	4 x 15	60	150
Productive	Cutting	2	3 x 10	30	70
	Cell A	3	-	46	120
	Cell B	4	-	38	120
	Cell C	5	-	48	120
	Shipping Storage	6	2 x 2	4	30

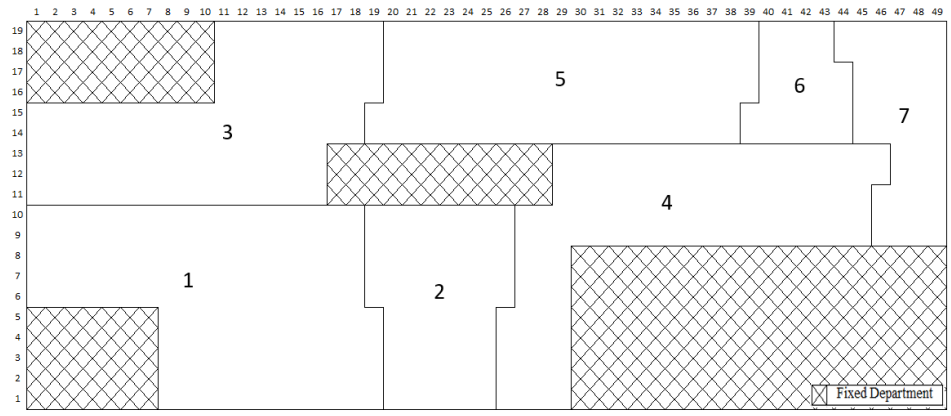

Figure 3: Alternative layout generated using MULTIPLE

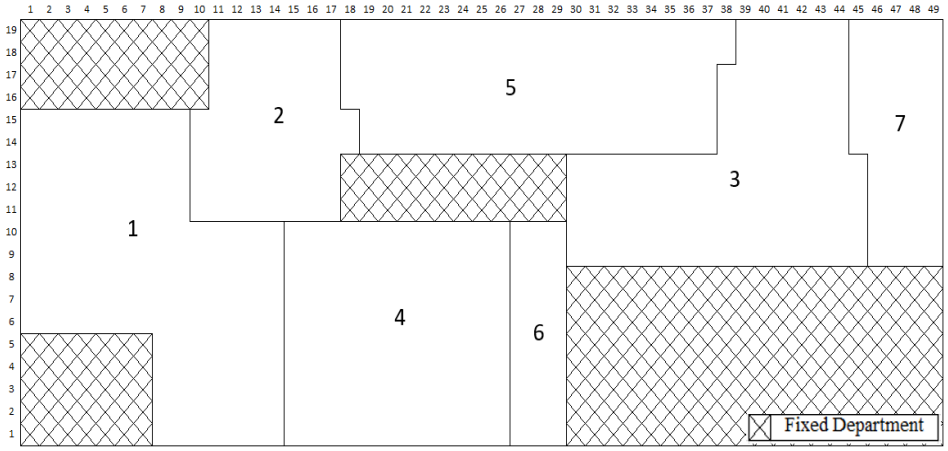

Figure 4: Alternative layout generated using SLP

6.0 EVALUATION OF THE ALTERNATIVES

The existing layout and its developed alternatives are compared and evaluated through manual calculation and simulation to show the improvement of facility layout. Simulation models have been built for the existing layout and the alternatives generated using the WITNESS software to evaluate the layouts. Figures 5, 6 and 7 show the simulation models for the existing, alternative (MULTIPLE) and alternative (SLP) layouts, respectively. The summary of the results of the comparison is tabulated in Table 3.

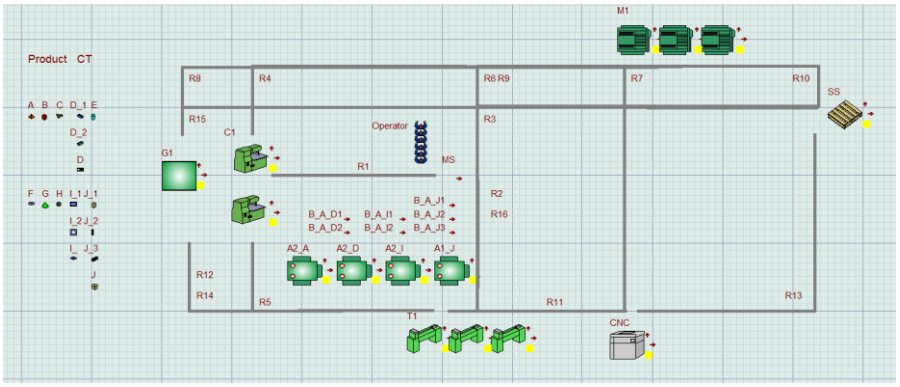

Figure 5: Simulation model of existing layout

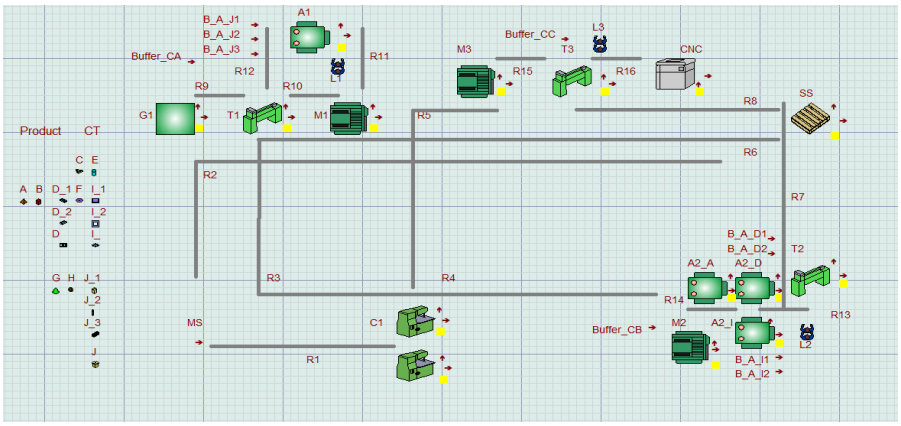

Figure 6: Simulation model of alternative layout (MULTIPLE)

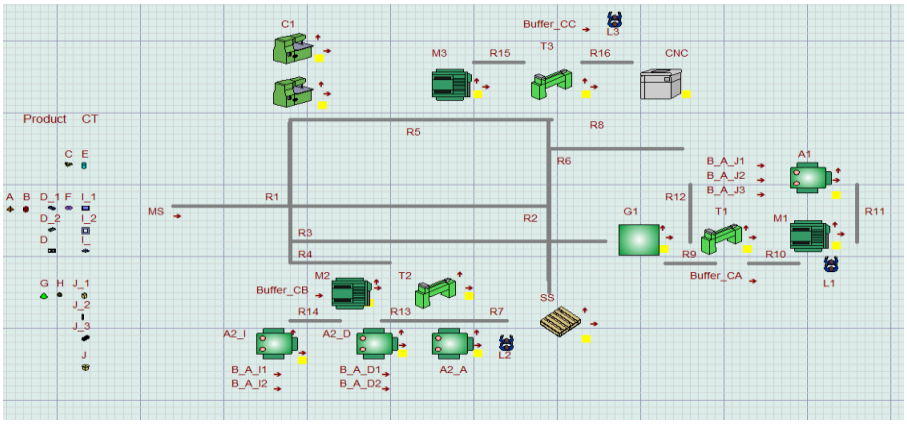

Figure 7: Simulation model of alternative layout (SLP)

Table 3: Summary of results

Layout	Manual Calculation	Simulation	
	Total Distance Travelled (m/week)	Average Total Output	Average Work in Progress (AWIP)
Existing	4851.84	847.4	52.838
Alternative (MULTIPLE)	2152.76	1153.0	36.995
Alternative (SLP)	2164.32	1138.0	38.009

The results for the total distance travelled are calculated manually using Equation (1). Based on the results, the alternative generated using MULTIPLE method has a lower value of total distance travelled between the departments as 2152.76 m per week in comparison to the alternative layout developed using SLP method that is accumulating, 2164.32 m per week. By comparing the alternative layout (MULTIPLE) with the existing layout, the reduction of total distance travelled between the departments is 55.63%. In the aspect of reduction of total distance travelled between the departments, alternative layout (MULTIPLE) is better than that produced using SLP.

On the other hand, simulation models have been built to further evaluate the existing layout and its developed alternatives. In this study, only two response data were selected to evaluate the alternatives, including the average total output and average work in progress (AWIP). The results of the simulation have shown that the alternative layout developed using MULTIPLE method is better than those generated using SLP and the existing one as it has a higher value of the average total output and lower AWIP value.

Hence, the alternative layout generated using MULTIPLE method is the best among the three layouts. In comparison with the alternative solution developed using SLP, the alternative one using MULTIPLE has slightly better results. Meanwhile, when the alternative layout (MULTIPLE) is compared with the existing counterpart, it has shown a great improvement.

7.0 CONCLUSION

The main objective of the study is to identify the current problem in the existing layout of the company and develop a better layout to minimize the total distance travelled. The main problem identified is the long distance travelled caused by poor facility planning in the company. Group Technology has been applied to group a family of products together and form three cells that could produce the products together in certain regions. MULTIPLE method has been used to generate one alternative layout and it is compared with the one developed using SLP method. WITNESS simulation models are built for the existing layout and the alternatives developed. The three layouts are compared and evaluated through manual calculation and simulation. Based on the analysis and

comparison conducted, the alternative layout generated using MULTIPLE method has shown the best result and provided a greater improvement for the company compared to the other two counterparts.

REFERENCES

1. Wong K.Y. and Komarudin, 2010. Solving Facility Layout Problems Using Flexible Bay Structure Representation and Ant System Algorithm, *Expert Systems with Applications*, 37(7): 5523–5527.
2. Patil S.B. and Kuber S.S., 2014. Productivity Improvement in Plant By Using Systematic Layout Planning (SLP) - A Case Study of Medium Scale Industry, *International Journal of Research in Engineering and Technology (IJRET)*, 770–775.
3. Meyers F.E., 1993. *Plant Layout and Material Handling*, Regents/Prentice Hall.
4. Tompkins J.A., White J.A., Bozer Y.A. and Tanchoco J.M.A., 2010. *Facilities Planning*, 4th ed., John Wiley & Sons, Inc.
5. Halevi G., 2017. Expectations and Disappointments of Industrial Innovations, 15–33. https://doi.org/10.1007/978-3-319-50702-6
6. Burbidge J.L., 1991. Production Flow Analysis for Planning Group Technology, *Journal of Operations Management*, 10(1): 5–27.
7. Muther R. and Hales L., 2015. *Sytematic Layout Planning*, 4th ed., Management & Industrial Research Publications.
8. Bozer Y.A., Meller R.D. and Erlebacher S.J., 1994. An Improvement-type Layout algorithm for Single and Mulitple-Floor Facilities, *Management Science*, 40(7): 918–932.