Systematic Planning Layout and Line Balancing for Improvement in an Armoured Vehicle Manufacturing Plant

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Abstract

The facility layout problem is directly linked with the efficiency of the facility or the manufacturing line, which will give a direct impact to the production performance. The main objective of this project is to design a new optimized plant layout based on current plant layout through methodology experiment and evaluating the proposed alternative layouts using Systematic Layout Planning (SLP) Procedure and Line Balancing. This project is conducted in one of military vehicle manufacturing company in Pekan, Pahang. Currently, the company is having a major delay in production performance and high number of deficiency. Hence, the company needs an optimized plant layout to maximize the product capacity and manufacturing throughput time on a minimum utilization of resources environment. Based on the data analyzed, performance of current layout is very poor. It can be classified in two subjects, which are material flow and assembly sequence. The failure on managing these two subjects has given bad impact to the quality of the vehicle. Total defects found are 188 which the defects included method defect 77.1%, part defect 20.2% and design defect 2.7%. The alternative layout 1 has been proposed to solve this issue which covered 5 criteria; space utilize, flow of material, traffic flow, preferred closeness and safety and working condition. Nevertheless, this research managed to provide better understanding and valuable information on the effectiveness of plant layout can give impact on performance of the production. Recommendations are made to improve the plant layout in order to provide a better performance in production activity and product quality.

Keywords: **Systematic Layout Planning (SLP); Assembly Line Balancing (ALB);Line Balancing(LB); Just in Time (JIT); Production, Planning and Control (PPC)**

1. INTRODUCTION

The manufacturing industry faces numerous challenges in today's market place. The four most significant challenges are dealing with intense global competition, finding and keeping skilled labor, handling cost pressures, and adapting to different consumer needs. Globalization has allowed manufacturers increasing access to developing markets. Companies can move production anywhere in the world in search of materials, expertise, and low labor costs (Abdullah, 2003). The result has been the globalization of supply chains, as firms around the world compete for business. American and European firms have benefited from this arrangement because they are able to purchase materials and labor at lower prices. But it has also opened them up to fierce competition (Chien, 2004).

The plant layout problem, that is, finding the most efficient and effective arrangement of inseparable departments with differing space requirements within a facility, has been a dynamic research subject for several decades (Meller and Gau, 1996; Yang and Hung, 2006). Plant layout problems has also been addressed in researchers in various fields, e.g. industrial engineering, architecture and management science (Lee et al., 2003). Thus, the objective of this paper is to improve an assembly armored vehicle through the new process layout and and line balancing in order to increase the production rate to the optimum level.

Based on Tompkins and White (1994), it has been estimated that effective facility layouts can reduce manufacturing operating expenses by at least 10% to 30%. Moreover, if effective facility layouts were to be implemented throughout all industries, the annual manufacturing productivity in the US would increase approximately three times more than it has in any year in the last decade.

Currently, fixed position layout is implemented in the assembly line. In a fixed product layout, the product stays in one place and the workers, tools and materials come to the product until it is completed. This design layout minimizes the chances the product could become damaged because it is not being moved between workstations. However, the fixed floor plan does pose other disadvantages as following.

In this manufacturing industry sectors, it is important to produce a good quality products and meet customers' demand. This action could be conducted under existing resources such as employees, machines and other facilities. However, plant layout improvement, could be one of the tools to response to increasing industrial productivities. Plant layout can be defined as Plant layout is a mechanism which involves knowledge of the space requirements for the facilities and also involves their proper arrangement so that continuous and steady movement of the production cycle takes place. Plant layout design has become a fundamental basis of today's industrial plants which can influence parts of work efficiency. It is needed to appropriately plan and position employees, materials, machines, equipment, and other manufacturing supports and facilities to create the most effective plant layout. This paper is therefore purposely to determine and study the existing plant layout efficiency for assembly, line balancing to avoid station delay and to improve the plant layout to a new design resulting in increasing the production rate.

2. METHODOLOGY

The objective of this chapter is to evaluate the existing plant layout of manufacturing and improve it using systematic layout planning (SLP) for a better plant space utilization and increased productivity. The analysis of the existing plant layout was conducted first by studying aspects like flow of material and activity relationship resulting in the relationship diagram. The analysis then continued by producing space relationship diagram from gathering the data of space requirement and space available. The last step of the analysis involved a consideration of further modification and practical limitations to develop several alternative plant layouts. The new alternative plant layouts were designed and been evaluated and compared to the existing layout. The final layout was selected after the evaluation, providing a better plant space utilization, higher productivity, better flow of material and traffic flow and better safety and working condition.

3. RESULTS AND DISCUSSIONS

Assembly process for AV8 must obey the sequences of each installation. The step cannot simply bypass by other installation. The assembly technicians are using work instructions that develop to follow the assembly sequence. All operations were conducted at all 6 stations concurrently. Sequences required are nominated as 710, 720, 760, 780, 930 and 991 respectively. PPC department are required to deliver same part to different fixed station layout which will take more time as well as longer distance as shown in figure below.

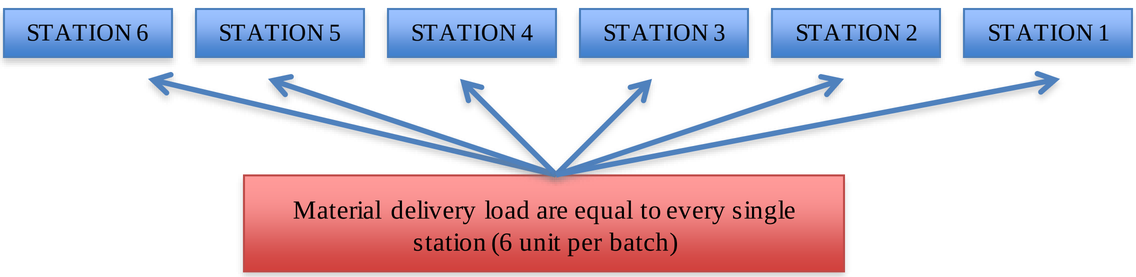

Figure 1.0: Flow of material in current assembly process

Before come out with several alternative layouts, first the practical limitation and modification consideration had to be identified and listed down. The reasons are to come up with the layout that meets the practical limitations and modification consideration.

The practical limitation is a type of constraint that can disturb the flow of process in the plant layout. As a result, it can significantly affect the rate of productivity. According to Inglay (2009), the practical limitation could arise out of the space characteristic. The following are the practical limitation in the plant layout here.

- The weight of the hull that make it harder to move. The empty hull weight is approximately 7 tonnes. It must be handled with care. It needs help of an overhead crane to move from one station to other station until station 760.
- The hull can move after wheel installation is completed at station 760. Then it needed to go through wheel alignment process.
- Special tool is required for some installation. Special tool are the tool specifically designed and used to ease the installation of AV8. The installations that needed the help of special tools are: Suspension System, Transfer Case Installation, Drive Train Installation, Water Propulsion System, Wheel Installation, Armor Installation, Bumper Installation and Turret Installation.
- All stations required the help of overhead crane for certain installation. The installations that used overhead crane are: Suspension System, Transfer Case Installation, Fuel System, Power pack Installation, Self-Recovery Winch, and Winch Cover. Trim Vane, Grill, Ramp, Driver/Personal Hatch and Turret Installation.
- Turret installation in station 930 required overhead crane with minimum height of 6m. The chain that is used to lift the turret must have a distance of 1m from the hook of the overhead crane to the turret.
- Jig crane. There are 3 jig cranes in the plant layout, 1 tan

The modification considerations are:

- Included Substation. There are 3 substations here. Station 630 deals with power pack side assembly installation, station 700 deals with mechanical side assembly and station 731 deals with electrical and electronic side assembly.
- Using Product layout design. This layout is based on the processing sequences for the part being produced on the line.
- Station 710 is the starting point of the assembly sequence. All the installation in this station needed to be installed first before others station's installation or it will cause problem and disturbed the flow of the installation.
- Safety's distance between the hulls must at least 2m.

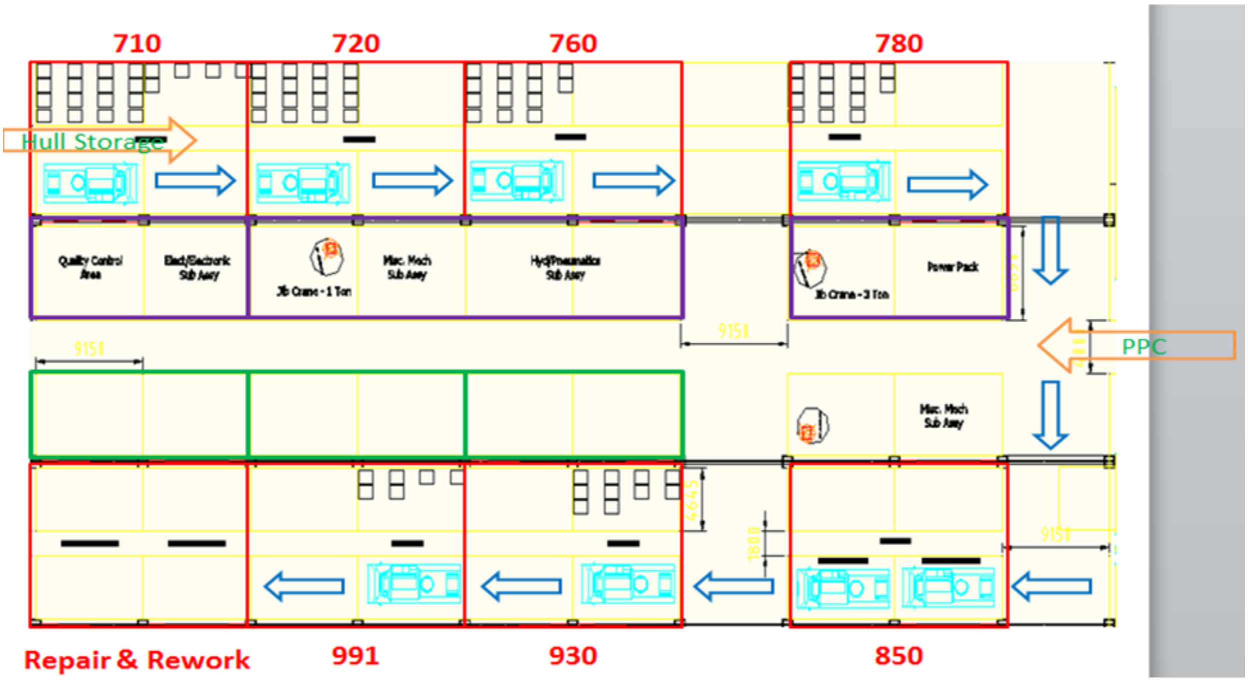

Figure 2.0 Selected Alternative layout

Figure 2.0 shows the selected alternative layout 1. The hull is arranged in a straight line as product layout is assumed to be implemented. The hull will move from first station 710 to the station 780. Upon completion at station 780, the vehicle can move station 850 for verification purposes. The vehicle then moved to station 930 and 991 for final assembly processes. The part storage is placed opposite to the hull, while the working area is provided situated beside the hull for ease of assembly operation. The station 710 is placed at the Entrance 1 due to close to the hull storage area in about 12m. But on the other side station 710 is far from PPC approximately in 140m. Station 850 is located near two entrances, entrance 3 and entrances 4 to ease the test that will be carried out in this station.

The last step in SLP is to evaluate the best layout design among these designs. The best layout is chosen based on 3 methods. The advantages and disadvantages are defined in this step, which will be based on the performance of the assembly itself. There are 5 criteria that being analyze on each layout.

- Space Utilize : The space used by the hull and part storage that used fully and efficiently
- Flow of material : The distance from Production Planning Control or Warehouse to production line
- Traffic flow: The distance from the part storage to the hull
- Preferred Closeness: The Arrangement of station or process that favored
- Safety & working condition: Safety of the worker and the situation that comfortable for the worker

Table 1.0: Summarized of Comparison between existing and alternatives layout

Criteria	Existing layout	Alternative layout 1	Alternative layout 2
Space Utilize	X	√	X
Flow of material	X	√	√
Traffic flow	X	√	X
Preferred closeness	X	√	√
Safety & working condition	X	√	X

The line balancing was conducted after SLP to level the workload across all process in assembly line to remove bottlenecks and excess capacity. Experiment on a new heuristic assembly line balancing in real-life automobile assembly plant case results in shorter physical line length and production space utilization improvement, because the same number of workers can be allocated to fewer workstations. (Kumar & Mahto, 2013). For the systems to be efficient, the line must be balanced, which means that the individual processes must be allocated to workstations in such a way that the total assembly time required at each assembly station is approximately the same. If such balance cannot be achieved, inefficiencies in the form of idle time at stations, or temporary blocking or starving of stations will result. Before conduct the line balancing, Takt Time has been recorded based on current assembly process on every single installation process. The Takt time recorded is not balanced and bottleneck also occurred. Graphs in figure 3.0 and 4.0 can explain briefly comparison between current situation of 6 stations in assembly line before and after conducting the line balancing.

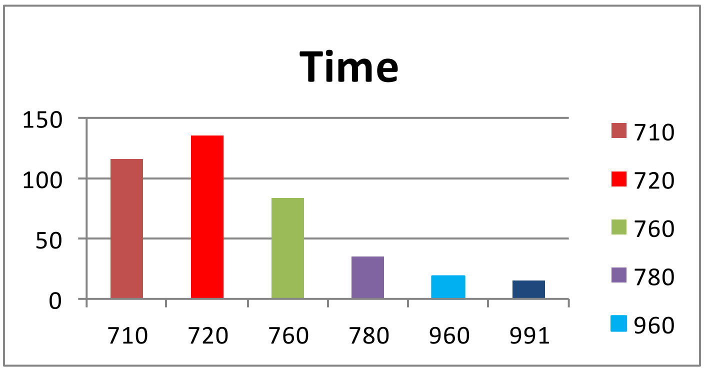

Figure 3.0:Takt time recorded before line balancing

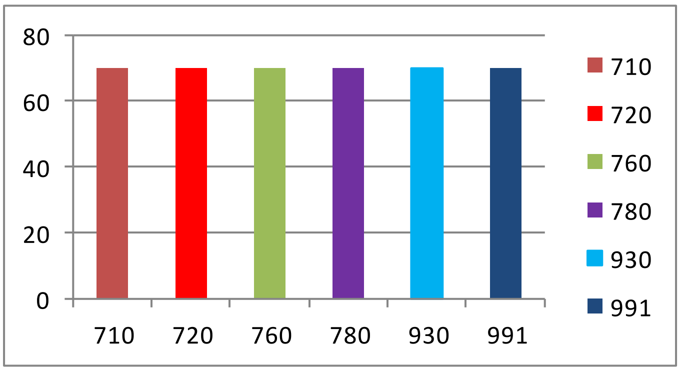

Figure 4.0:Takt time after line balancing

Figure 3.0 shows that station 720 has the highest load followed by station 710,760,780,960 and 991 respectively. This means that assembly technician in this station has overburden which leads to increase the waiting time for the next station. In order to resolve this issue, line balancing is required to be implemented. The graph in figure 4.0 above shows how all the station should be after the line is balanced. The total time taken is 417.78 hours. For the 6 stations to be balanced, the services time taken for each station is 70 hours.

Based on table 2.0, it can be concluded that the existing layout has a very bad workload distribution and very low efficiency. Therefore, 2 Alternative Layouts has come out and alternative layout 1 has been chosen to be implemented in the assembly line because it has the lowest SI and 99% efficiency compared to alternative layout 2.

Table 2.0: Summarize for three layouts line balancing calculation

Layouts' Name	**Smoothness Index(SI)**	**Line balance Efficiency,(E_b)**	**Balance delay,(d)**
Existing Layout	115.67	35%	0.65
Alternative Layout 1 LCR Method	1.12	99%	0.01
Alternative Layout 1 KWM Method	1.82	99%	0.01

4. CONCLUSION

The first objective of this research is to study the performance of existing layout in the company. Second objective is to propose an improved plant layout in the company. Based on SLP and Line balancing Method that has been conducted, existing layout has shown very bad performance. Smoothness Index for existing is 115.67 which is very high and efficiency as low as 35% only. On the other hand, it clearly shows that Alternative Layout 1 is the best layout to be implemented. For SLP Method, 5 criterias were discussed in this research which are; space utilization, flow of material, traffic flow, preferred closeness and safety and working condition. From this alternative layout 1 shows higher similarity with the criteria compared to alternative layout 2. In addition, from Line balancing calculation, proven that alternative layout 1 also performed the best outcome which is SI; 1.12 and 99% efficiency. Furthermore, this study also resulted fixed layout change to product layout.

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BIOGRAPHY

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