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# Assembly Line Efficiency Improvement by Using WITNESS Simulation Software

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# Assembly Line Efficiency Improvement by Using WITNESS Simulation Software

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**Abstract.** In the nowadays-competitive world, efficiencies and the productivity of the assembly line are essential in manufacturing company. This paper demonstrates the study of the existing production line performance. The actual cycle time observed and recorded during the working process. The current layout was designed and analysed using Witness simulation software. The productivity and effectiveness for every single operator are measured to determine the operator idle time and busy time. Two new alternatives layout were proposed and analysed by using Witness simulation software to improve the performance of production activities. This research provided valuable and better understanding of production effectiveness by adjusting the line balancing. After analysing the data, simulation result from the current layout and the proposed plan later been tabulated to compare the improved efficiency and productivity. The proposed design plan has shown an increase in yield and productivity compared to the current arrangement. This research has been carried out in company XYZ, which is one of the automotive premises in Pahang, Malaysia.
**Keywords**; Production, Witness software, Line balancing

## 1. Introduction

In brief, it is vital to have an efficient layout arrangement and material flow path design because material handling needs a massive percentage of the product cost [2]. The problem with assembly system gives increase to the assembly line balancing problem (ALBP), which involves of allocating assembly tasks to some workstations in imperative to enhance a given purpose [3].

In some occasion, other methods in assembly sequence can use and another case; there is no adjustability in the assembly sequence. In an assembly line, each station organised in the sequential system along the assembly line. Each workstation performs given the subset of tasks on each product unit arriving at that location at fixed time intervals. This range is known as cycle time. The formula shown in (Eq. 1) is for the cycle time [6].

$$\text{Cycle time} = \frac{\text{available time}}{\text{desired output}} \tag{1}$$

Idle time is also one of the essential components that considered in solving assembly line problem. Idle rate measured as the difference between the cycle time and the workload of each station where the station workload described as the total of operation times of jobs that it performs [7]. Assembly system regarded as a single model line. As for the level of automation, it divides two lines, which are manual lines and automated lines. In assembly line, manual material handling implemented, lot-sizing choices can have a significant influence on workload and human performance, which can have a substantial impact on ergonomic parameters and thus worker [9].

Simulation is one of the methods used to figure out assembly line balancing problem. Simulation is a scientific method to not separate study a system without actually disconcerting it, but also to assess ideas that have not been used in the real world [10]. Simulation is used to predict assembly line performance among other machine layouts and scheduling rules, thus find the best performing layout. Suggest that simulation modelling is mostly used to support decision-making in various commercial tasks [11]. The model simulations offer data about the process results, performance and behaviour with diverse process structures [11]. Mostly, a manufacturing approach is a set of manufacturing policies planned to maximise performance among trade-offs among profit standards to meet the manufacturing job determined by a corporate strategy [12].

## 2. Research background

The XYZ Company was chose after several selection processes has done. Selection of the company is based on permission criteria, which required by the premise before any further research about the company problem addressed. This study was conducted at S-class car assembly line in XYZ Company premise. The existing assembly line is having line-balancing problem, which affected productivity of its output. Total of 10 workstation were involved on S-class car assembly line. This study will collect data of the current design layout, the number of workstation, number of operators, time study and processing time.

## 3. Methodology

The methodology is created to ensure that this research is well organised to get the precise result and data. Figure 1, show the flow chart of this research methodology.

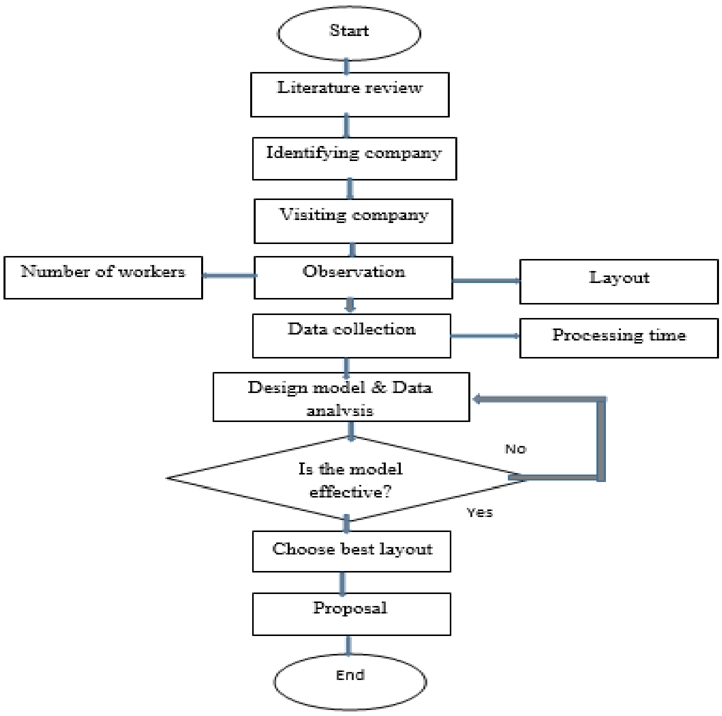


**Figure 1.** Research methodology flow chart.

Firstly, the research is developing based on literature review method to collect data from the previous study. According to the data obtained, there are many studies about assembly line balancing. Thus, many data can be concluded to develop this research. The suitable company need to be identified to do the research. Next, the researcher visiting the premise is to ensure that the company's condition is known. The observation focus the assembled product's processing time and the current layout design. The data collected has then been analysed and developed onto new layout design that will increase the efficiency of the assembly line. The received data were analysed to get the calculation for standard time, current layout, workstation, number of operators and used material handling system. The collected data will be evaluated using Witness simulation software. The software analyses the processes and makes the optimal choice in a short time. Then, selection of the best arrangement selected from the new layouts, will proposed to the company.

## 4. Result and Discussion

### *4.1. Current Layout*

Firstly, before the new layout constructed, the current arrangement was analysed using Witness software as in Figure 2. The existing plan is build up using the multi-cycle process on each workstation. All the processing time for each workstation is being filled carefully to avoid any mistakes during analysis.

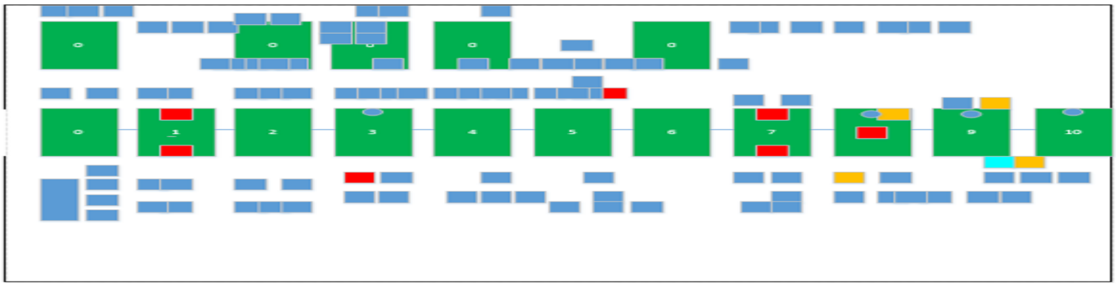

**Figure 2**. The illustration of the current layout of S-class car.

The present layout of S-class car is in a straight line. The green box in the straight line indicates the workstation while the green box at the side of the workstation is the sub-assembly. The blue square indicates the small parts that will be assembled into the car meanwhile the red square show the lifting equipment to lift the part into the car. In addition, the orange square indicates the machines used such as fuel pump while the light blue square shows the setup machines such as brake bleeding and coolant. After the car reaches workstation number 10, the car then transfers to the testing and quality inspection. The layout begins with workstation preparation and finished in workstation 10. There is five sub-assembly in the current production of S-class car. They are front module, centre console, headlining, cockpit, and rear wall assy. The precedence diagrams show how the work for each workstation progress while the processing time indicates the time used to complete the work. Table 1 shows the overview of all workstation in S-class car assembly line. Figure 3 shows the precedence diagram for all workstation for S-class car. By using all inputs required, Witness Simulation shows, the time required for one car to be finished assemble is 8165 minutes. The time was measured from workstation preparation to workstation 10, including with all the sub-assembly. In a month, the labour-hour is 13200 minutes as the workers only work for 22 days per month and 10 hours per day. After the simulation run for six months, the total number of the car produce is 51. The inputs that were used to measure the productivity is work hours. For six months, the overall work hours is 79200 minutes. The productivity for the current layout for six months is calculated to become the benchmarks for the new plans. Eq. (2) shows the equation for productivity. Table 1 shows the summary of all cycle time for each workstation for the current layout.

$$\text{Productivity} = \frac{\text{units produced}}{\text{inputs used}} \tag{2}$$

$$= \frac{51}{79200}$$

$$= 0.0006439 \text{ units per labour hour}$$

The productivity for the current layout is 0.0006439 units per labour-hour. Besides productivity, the aspects that also measure are the usefulness of the labours or the effectiveness of the employees. The value of the workers determined by observing the busy and idle time for each worker.

**Table 1.** The summary of all cycle time for each workstation for current layout

| Workstation | Number of workers | Time (min) |
|---|---|---|
| Preparation | 2 | 63.13 |
| 1 | 3 | 62.07 |
| 2 | 3 | 57.41 |
| 3 | 3 | 103.15 |
| 4 | 3 | 64.24 |
| 5 | 3 | 65.15 |
| 6 | 1 | 39.54 |
| 7 | 4 | 58.33 |
| 8 | 3 | 50.59 |
| 9 | 3 | 56.29 |
| 10 | 2 | 41.20 |

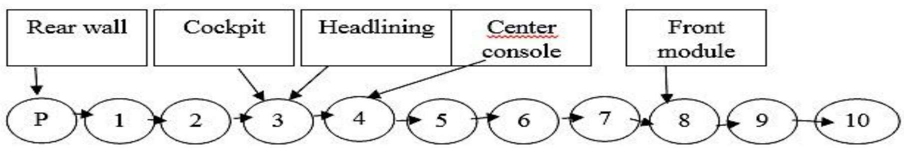


**Figure 3**. The precedence diagram for all workstation for S-class car

In Appendix A, Figure 7 shows the current layout that was constructed in WITNESS software for workstation preparation until workstation 4 while Figure 8 displays the current design that been built in WITNESS software for workstation 5 until workstation 10. Figure 4, indicates the percentage of the idleness shown is high. To avoid the losses due to labours' inactivity in the current layout, the workers that have too many idle times should be reassigned or fired from the factory.

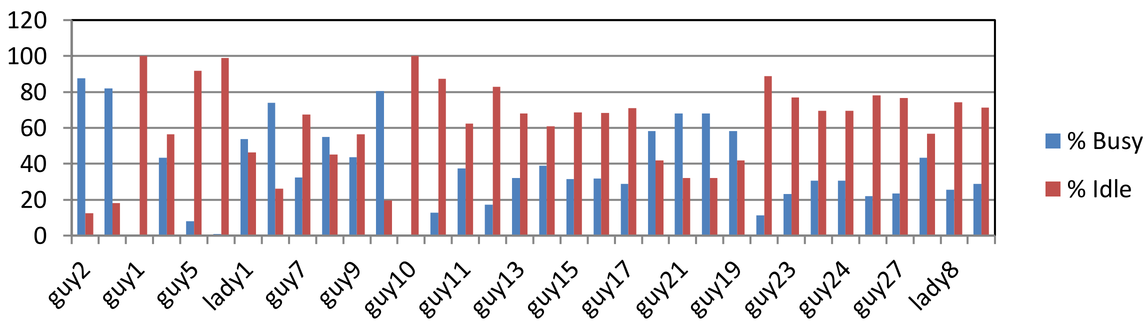


**Figure 4**. The graph of the effectiveness of each labour for current layout.

*4.2. New Layout 1*

Simulation using Witness software take place after the New Layout 1 invented as in Appendix A, Figure 9 and Appendix B, Figure 10. The data from Witness simulation show that time demanded one car to assemble is 8119 minutes. Then, the simulation is continued until six months to see the effectiveness of the New Layout 1. The number of products increased by 1, which made it become 52 units in total production. The productivity is measured and compared with the current layout to see the effectiveness of the new design layout. The Productivity is measured using Eq. (2). The Effectiveness of the New Layout 1 was measured using the busy and idle time of each worker as shown detail in Appendix C, Table 3. Figure 5 verifies the Effectiveness of each labour in the New Layout 1. The guy6, guy14, guy20, and lady9 have been reassigned to other department or fired. The total number of workers left is 30 people. The total number of employees reduce because the level of their idleness is high and it does not affect the line.

$$\text{Productivity} = \frac{52}{79200} = 0.0006566 \text{ units per labour hour}$$

The productivity for the New Layout 1 is 0.0006566 units per labour hour. The new layout is compared with the existing layout to measure the effectiveness using Eq. (3).

$$\text{Effectiveness of New Layout 1} = \frac{\text{productivity new layout} - \text{productivity current layout}}{\text{productivity current layout}} \times 100 \qquad (3)$$

$$= \frac{0.0006566 - 0.0006439}{0.0006439} = 1.97\%$$

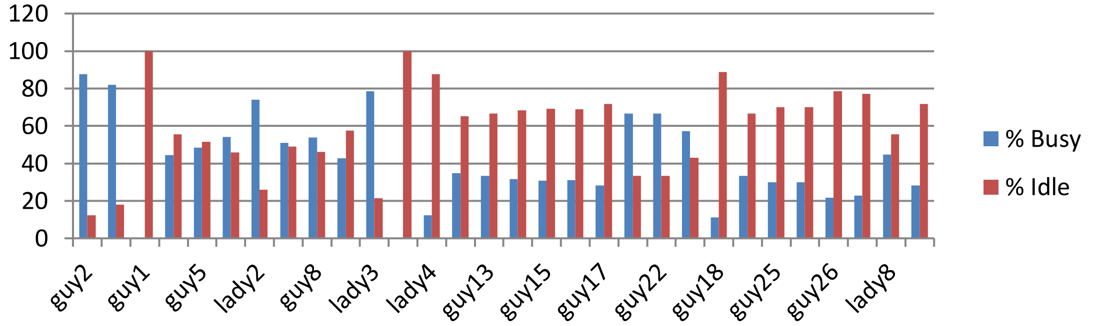


**Figure 5.** The graph of the effectiveness of each labour in the New Layout 1.

*4.3. New Layout 2*

The analysis for New Layout 2 is simulated after the design of the layout is completed. The illustration shows in Appendix B, Figure 11 and Figure 12. The time taken for a car to produce is 8077 minutes. After the simulation run for six months, the car units that produced are 53 units. The productivity is calculated to see the effectiveness of the New Layout 2. The productivity is measured using Eq. (2). An alternative way to measure the effectiveness of the new layout is by calculating the efficiency of the labours. Figure 6 demonstrates the graph of the effectiveness of each worker in the New Layout 2, as well as the details as shown by Table 4 in Appendix D. From the data, we can see that lady6 and guy28 are fired or reassigned to another department. The total number of workers in the new layout 2 is 32 people. The other two people that removed in the New Layout 1 reassigned to the new workstation. They have a new workload that can make them efficient instead of having many idle times. The productivity for the New Layout 2 was 0.0006692 units per labour hour, which is higher than the New Layout 1 by 0.0000126 units per labour hour. The effectiveness of the New Layout 2 is measured using Eq. (3).

$$\text{Productivity} = \frac{53}{7920} = 0.0006692 \text{ units per labour hour}$$

$$\text{The effectiveness of the new layout 2} = \frac{0.0006692 - 0.0006439}{0.0006439} \times 100\% \quad = 3.93\%$$

Table 2 shows the productivity and improved efficiency comparison. Table 2 demonstrated that all new layout shown improvement in efficiency and productivity from the simulation analysis. The New Layout 2 shown the highest productivity of the three layout which is 0.0006692 units/ labour hour. New Layout 2 also improved the efficiency of the current layout by 3.93%.

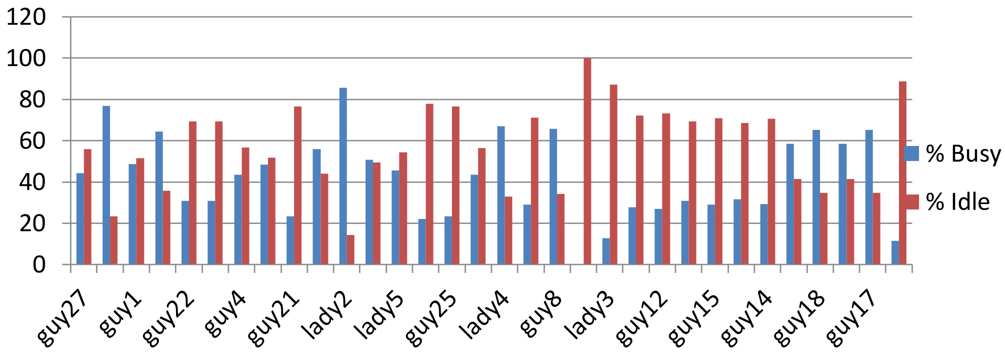


**Figure 6.** The graph of the effectiveness of each labour in the New Layout 2.

**Table 2.** Productivity and improved efficiency comparison

| Layout | Productivity | Improved efficiency |
|---|---|---|
| Current layout | 0.0006439 units / labour hour | - |
| New layout 1 | 0.0006566 units / labour hour | 1.97% |
| New layout 2 | 0.0006692 units / labour hour | 3.93% |

## 5. Conclusion

The study of assembly lines generates when the contextual analysis arises. The first objective accomplished as the data collected concerning time study, the layout for workstation and number of workers were analysed using Witness software.

The statistic for the current layout examines by identifying the rate of productivity and the effectiveness of each employee. Besides, the second objective also achieved which, the two new layouts are designed to improve the amount of productivity and the efficiency of each worker. After the design of the layouts, the simulation conducted to analyse the effectiveness of the new layout and the productivity of each employee.

The data analysis simulated using Witness software, New Layout 2 is better than the New Layout 1 and the current company layout. The productivity rate and the effectiveness of the New Layout 2 are higher than the New Layout 1. Layout 2 produce efficiency of 3.93% in contrast with New Layout 1 that only provide 1.97% efficiency. New Layout 2 production rate is 0.0006692 units per labour hour also better than current layout which only produce 0.0006439 units per labour hour. By comparison of the improved effectiveness, New Layout 2 is more efficient as it has higher efficiency rate. As a result, it is better to choose the New Layout 2 to increase the production of the product. The result shows that the New Layout 2 is better than the New Layout 1 and the present layout. The simulation was run using Witness software proven to be useful in analysing the assembly lines problems because it helps improve the efficiency of the assembly line and increase the productivity of the operators. After the current layout is analysed, weakness and strength of each workstation is determined. Due to condition in the factory, the workstation cannot be redesigned. That is because the plant does not have big enough spaces mainly due to company produce C-class car and E-class car in the same time. Thus by changing layout for workstation, it will consume more money. This generally because company have to reinstall the machines according to the new layout. It is not recommended to redesign the workstation. As a result, the only option in designing the new layout is by reassigning the labours or terminate the employees.

## Appendix A

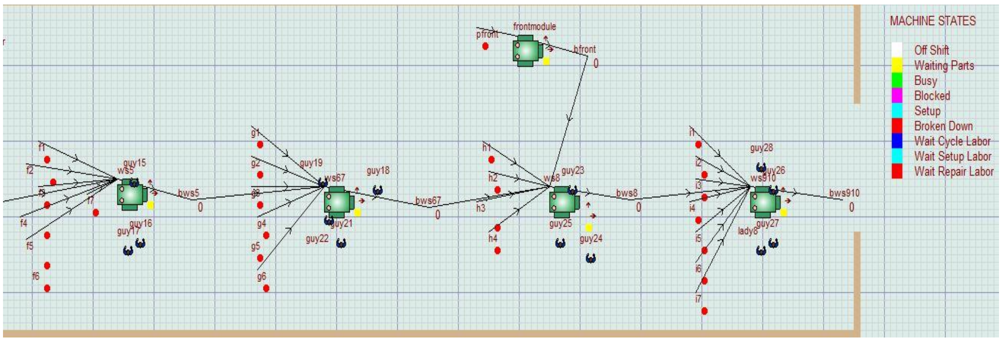


**Figure 7.** The current layout that been constructed in WITNESS software for workstation preparation until workstation 4

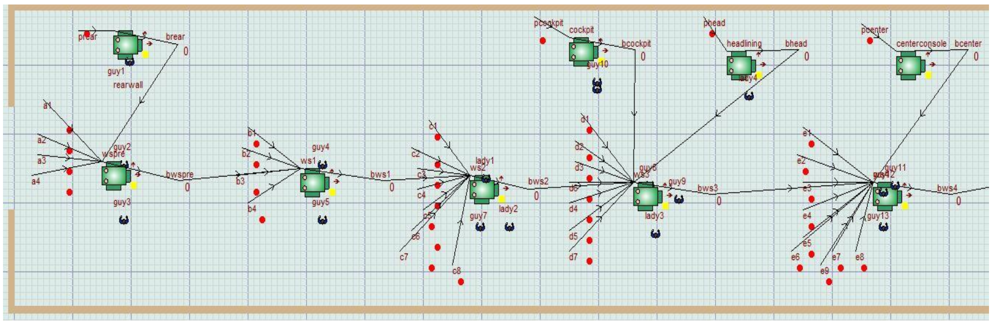

**Figure 8.** The current layout that built in WITNESS software for workstation 5 until workstation 10

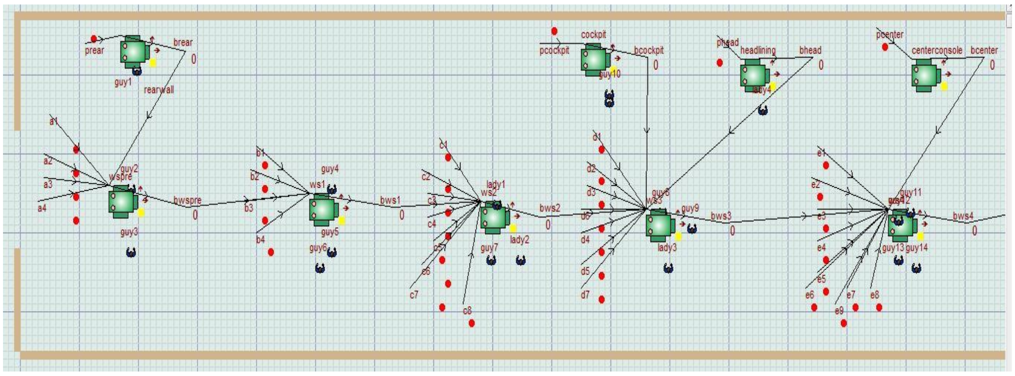

**Figure 9.** The New Layout 1 of workstation preparation to workstation 4

## Appendix B

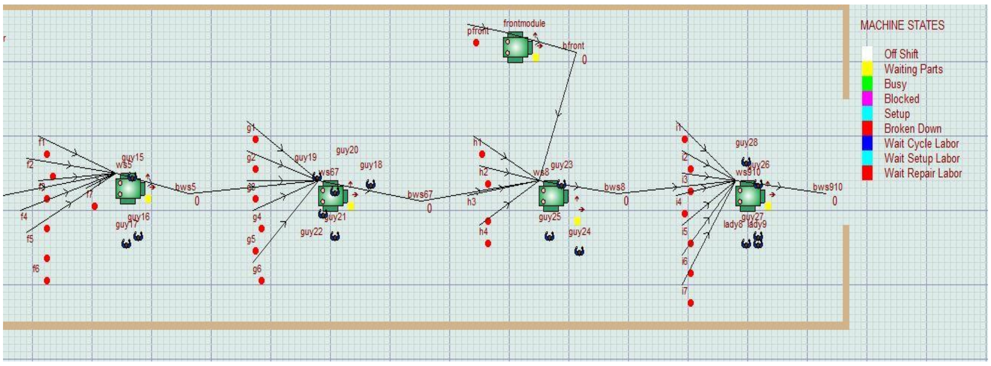


**Figure 10.** The New Layout 1 of workstation 5 to workstation 10

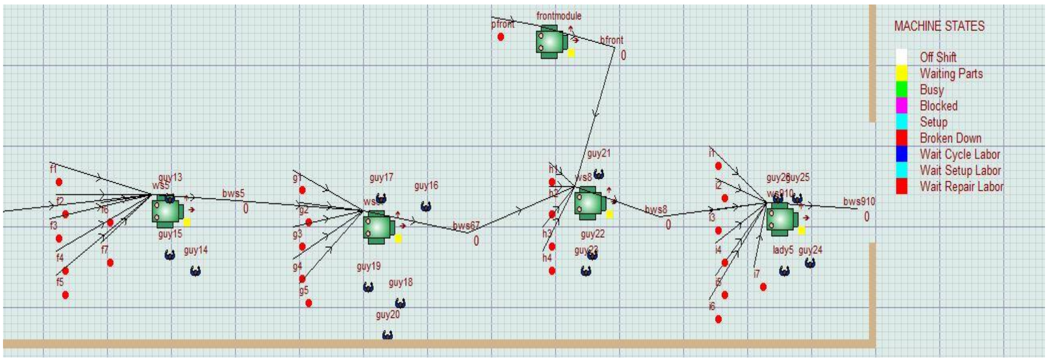


**Figure 11.** The workstation preparation until workstation 4 for the New Layout 2

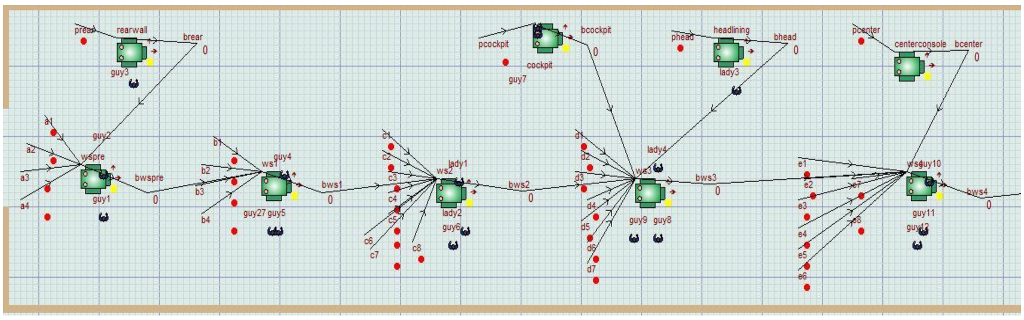


**Figure 12.** The workstation 5 until workstation 10 for the New Layout 2

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**Appendix C**

**Table 3.** The busy and idle time of busy and idle time of each job in the New Layout 1

| Name | % busy | % idle |
|---|---|---|
| guy2 | 87.61 | 12.39 |
| guy3 | 81.95 | 18.05 |
| guy1 | 0 | 100 |
| guy4 | 44.34 | 55.66 |
| guy5 | 48.41 | 51.59 |
| lady1 | 54.03 | 45.97 |
| lady2 | 74.03 | 25.97 |
| guy7 | 50.92 | 49.08 |
| guy8 | 53.91 | 46.09 |
| guy9 | 42.6 | 57.4 |
| lady3 | 78.63 | 21.37 |
| guy10 | 0 | 100 |
| lady4 | 12.42 | 87.58 |
| guy11 | 34.79 | 65.21 |
| guy13 | 33.34 | 66.66 |
| guy12 | 31.56 | 68.44 |
| guy15 | 30.77 | 69.23 |
| guy16 | 31.05 | 68.95 |
| guy17 | 28.34 | 71.66 |
| guy21 | 66.7 | 33.3 |
| guy22 | 66.7 | 33.3 |
| guy19 | 57.13 | 42.87 |
| guy18 | 11.11 | 88.89 |
| guy23 | 33.47 | 66.53 |
| guy25 | 29.96 | 70.04 |
| guy24 | 29.96 | 70.04 |
| guy26 | 21.55 | 78.45 |
| guy27 | 22.93 | 77.07 |
| lady8 | 44.59 | 55.41 |
| guy28 | 28.18 | 71.82 |

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**Appendix D**

**Table 4.** The busy and idle time for each worker in the new layout 2

| Name | % busy | % idle |
|---|---|---|
| Guy27 | 44.2 | 55.8 |
| Guy2 | 76.73 | 23.27 |
| Guy1 | 48.61 | 51.39 |
| Guy3 | 64.32 | 35.68 |
| Guy22 | 30.72 | 69.28 |
| Guy23 | 30.72 | 69.28 |
| Guy4 | 43.38 | 56.62 |
| Guy5 | 48.31 | 51.69 |
| Guy21 | 23.29 | 76.71 |
| Lady1 | 55.97 | 44.03 |
| Lady2 | 85.66 | 14.34 |
| Guy6 | 50.64 | 49.36 |
| Lady5 | 45.59 | 54.41 |
| Guy24 | 22.08 | 77.92 |
| Guy25 | 23.45 | 76.55 |
| Guy9 | 43.61 | 56.39 |
| Lady4 | 66.98 | 33.02 |
| Guy26 | 28.92 | 71.08 |
| Guy8 | 65.8 | 34.2 |
| Guy7 | 0 | 100 |
| Lady3 | 12.7 | 87.3 |
| Guy11 | 27.78 | 72.22 |
| Guy12 | 26.83 | 73.17 |
| Guy10 | 30.73 | 69.27 |
| Guy15 | 29.04 | 70.96 |
| Guy13 | 31.53 | 68.47 |
| Guy14 | 29.3 | 70.7 |
| Guy19 | 58.45 | 41.55 |
| Guy18 | 65.26 | 34.74 |
| Guy20 | 58.45 | 41.55 |
| Guy17 | 65.26 | 34.74 |
| Guy16 | 11.38 | 88.62 |

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**References**

[1] Fleszar, *A new MILP model for the accessibility windows assembly line balancing problem level 2 (AWALBP-L2)*. European Journal of Operational Research, 2017. **259**(1): p. 169-174.
[2] Mohamed, N.M.Z.N., et al., *Production Layout Improvement for Steel Fabrication Works.* Journal of Industrial and Intelligent Information, 2014. **3**(2).
[3] Akpinar, S., A. Elmi, and T. Bektaş, *Combinatorial Benders cuts for assembly line balancing problems with setups.* European Journal of Operational Research, 2017. **259**(2): p. 527-537.
[4] Shaaban, S., T. McNamara, and S. Hudson, *Mean time imbalance effects on unreliable unpaced serial flow lines.* Journal of Manufacturing Systems, 2014. **33**(3): p. 357-365.
[5] Riggs, R.J., O. Battaïa, and S.J. Hu, *Disassembly line balancing under high variety of end of life states using a joint precedence graph approach.* Journal of Manufacturing Systems, 2015. **37**: p. 638-648.
[6] Sungur, B. and Y. Yavuz, Assembly line balancing with hierarchical worker assignment. Journal of Manufacturing Systems, 2015. 37: p. 290-298.
[7] Vilà, M. and J. Pereira, A branch-and-bound algorithm for assembly line worker assignment and balancing problems. Computers & Operations Research, 2014. 44: p. 105-114.
[8] Pacauz-Lemoine, M.-P. and P. Millot, *Adaptive Level of Automation fo risk management* 2016: p. 48-53.
[9] Battini, D., et al., *Ergo-lot-sizing: An approach to integrate ergonomic and economic objectives in manual materials handling.* International Journal of Production Economics, 2017. **185**: p. 230-239.
[10] Kavakeb, S., et al., *Green vehicle technology to enhance the performance of a European port: A simulation model with a cost-benefit approach.* Transportation Research Part C: Emerging Technologies, 2015. **60**: p. 169-188.
[11] Orta, E., et al., Decision-making in IT service management: a simulation based approach. Decision Support Systems, 2014. 66: p. 36-51.
[12] Mohamed, N.M.Z.N., et al., Production Layout Improvement for Steel Fabrication Works. Journal of Industrial and Intelligent Information, 2014. 3(2).