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A Simulation of Facility Layout Improvement at Local Food Industry

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Abstract: As Salaiport become well known recently, demand for their product keep increasing. However, no proper layout of the workstation and the manual production process tend to reduce the production process and cause ergonomics problems. Simulation is a problem solving methodology for the solution of many real world problems, including to determine an effective layout for the workers in order to improve the productivity and efficiency of the production. The main aims of this study is to propose a layout for Erul Food Industry that optimize processing time and minimize the cost in view of ergonomics. The Sketchup software is used to design the production line layout and the FlexSim software is used to identify the best design based on time and cost of processing. Based on the simulation results, Design 2 is the best design as it has minimum processing time and cost. It can be concluded that the shorter total running time of production, the lower cost of production.

Keywords: Ergonomics, ergonomics, FlexSim, layout design, simulation, poultry food industry

1. Introduction

Manufacturing facilities design can be explained as the organization of physical facilities to promote the efficient use of the resources such as people, equipment, material and energy. This facilities design includes the plant layout, plant location, building design and material handling [1]. This leads to a requirement of a company to produce a working layout that needs to be considered. This development requires a facility layout of the design which must fulfill the different aspects to achieve the desired production. The facility layout is considered as the way to develop the company especially in small and medium sized enterprises (SMEs). Facilities layout at SMEs is one of the requirements for an industry to work efficiently. Other than that, SMEs require an improvement on the facility layout in order to expand the company and mostly to control ergonomics.

This project is conducted at a selected SME which is Erul Food Industry, or commercially known as Salaiport. The demand for their product has been outstanding since their company became well known. Currently, there is no proper layout at Erul Food Industry because the company operate manually in house. This situation causes inefficient working situation for workers in which a lot of worker movement from one station to another that lead to less productive working hour. In addition, it may lead to bottleneck situation that may slower production and further lower product

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quality and also affect the workers wellbeing. Besides, unsatisfactory workstation may lead to ergonomics problems. The main aim of this project is to propose several layout designs for Erul Food Industry. Hence, the selected layout is expected to optimize the working time and cost for a facility layout that have been improved.

2. Literature Review

2.1 Facility Planning

Facilities planning is one of the most important aspects in the manufacturing industry as it provides support for the development, assessment and justification of facility needs. In facilities planning, it can be facilitating any production tasks which the machines tools, department, production stations and many more [2]. There are many factors that need to be considered when planning the layout of the facilities, such as safety, ergonomics and operator references [2] to ensure the efficiency of the layout planning for the workplace. Workstation consists of different stages, i.e. specified product, inspections, labelling, packaging and storage of final product that influence the production process and quality. Coordination of the designer is needed in the complex process of planning facilities with the quality of the facilities considered to be cost-effective and minimal errors [3]. After all, process flow of facilities planning must match the objectives of the developing facilities planning.

2.2 Facility Layout Design

The layout is the arrangement of the machine and equipment of production, workstations, personnel, materials storage and material handling equipment [4] that enables efficient material flow in order to produce a product with limited space, surrounding areas and legislation that focuses on ergonomics and safety [5]. The layout development consists of two phases, which is conceptual and detailed phases. The conceptual phase deals with a block layout to show the production flow while, the detailed phase involved the physical connections and models [5]. The optimum facility layout is an effective cost-reduction tool by enhancing the productivity of the facility layout. In addition, facility layout affects the production flow. An effective layout will make production flow smoother and steadier. Important aspects that need to be considered when designing the facility layout is flexibility and space utilization to ensure that workers able to work productively and the equipment are located in the right location.

2.3 Ergonomic Related to Facility Layout

Ergonomics is the science of designing the job or task to fit the worker instead of worker to fit into the job [6] to eliminate discomfort and risk of injury due to work [7]. Ergonomics in the workplace may relate to the cost of work related to pain, injury and illness. Improper facility layout may affect workers and cause them to suffer from high risk category injuries, including MSDs, fatigue, etc. [7]. An ergonomic workstation is important because it may affect the workers' performance [8], minimize the risk at workstations and help workers to work in smooth production flow. Ergonomics consideration may lead to change the workstations layout and task time values [9].

2.3.1 Musculoskeletal Disorders (MSDs)

Musculoskeletal Disorders (MSDs) are injuries in human musculoskeletal system including tendons, joints, muscle, ligaments and nerves [10]. MSDs can arise from varies occasion especially the use of human musculoskeletal system, doing a same or repetitive tast without rest, working in an awkward posture or stand for a long period of time. MSDs can be preventing by designing an efficient ergonomic workstation that maintain the neutral posture while doing tasks and reduce distance of the body and the stations to reduce the overload force for a repetitive task [11].

2.3.2 Fatigue

Fatigue is considering as one of an ergonomic problem in the manufacturing industry. Fatigue is a state of feeling tired, exhausted or sleepy due to lack of sleep, stress, and repetitive physical work [12]. Fatigue could reduce the performance of the worker, which would affect the quality of the product, increase the risk of damages and accidents at the workstations. There is two types of fatigue; mental and physical fatigue [13]. Physical fatigue can cause short-term implications such as discomfort, back pain and reduce energy capacity [13], [14], [15], [16]. However, physical fatigue can also cause a long-term implication due to longer working time and further affecting workers' health. In order to reduce fatigue among worker, ergonomic design is important as it is included to shorten the length of time-on-task and work pace [17].

2.4 Simulation by FlexSim Simulation

Simulation is an experimental computerization technique used to analyze any real-world problem, compare different alternatives [18] and to analyze the long-term behavior of a system [19], [20]. The advantage of simulation while designing the layout is that it involves ergonomic measures such as cycle time, machine set-up, assembly line, bottleneck and process. In addition, it also considered material flow and machine utilization. FlexSim is a 3D simulation software that able to models, simulates, predicts and visualize system [21] which widely used in manufacturing, material handling, healthcare, warehouse, mining, logistics, etc. Apart from being used as a decision-making tool, it can be used to study the effect and give priority to the option to reduce costs and increase revenue [22].

3. Methodology

3.1 Workstation Measurement

First, the current layout of the facility is being observed and measured using measuring tape to obtain the dimension for proposed workstation. Measuring tape is used to measure every length, width and height of every workstation at Erul Food Industry.

3.2 SketchUp Software

Next, several proposed workstation layout is prepared according to guideline by MeSTI Secure Food Certification Scheme (MeSTI). A 3D modelling computer program, named SketchUp software is used to draw the interior design and developed the workstation layout of the Salaiport and it expected to minimize the risk factors, reduce process time and also production cost at the workstation. Step 1 to 7 listed the steps of developing layout using SketchUp software:

- Step 1: SketchUp software will start with various type of template after opening the software.
- Step 2: After choosing the template, the unit of template is change to feet.
- Step 3: Label the dimension of the layout after designing the layout.
- Step 4: Decorate the developed layout to shows real design of the layout.
- Step 5: Label the developed layout.
- Step 6: Remove the label and dimensions to shows the real developed layout.
- Step 7: Lastly, save the developed layout as .skp file

3.3 FlexSim Software

FlexSim software is a 3D simulation software is used to analyzed the layout and identified a solution to optimize the production by improving the workstation layout hence, reduce the production cost and time. The analysis in this FlexSim involved data of cost and time of the developed layout. The simulator will show the processing time, the idle and the total running time of the whole process for each processor. There are 5 basic steps in developing the model in FlexSim as follows [23].

- Step 1: Develop layout by selecting object, drag and place in the layout windows. Repeat the process until modeler has completed the layout.
- Step 2: Connect object to visualize all possible routing options for the model.
- Step 3: Insert detail of objects such as cycle times, capacities, speeds, routing logic, downtimes, statistics and graphic options in the object GUI.
- Step 4: Run the model after creating the model and assigning the logic to objects. The model can simulate in conditional scenarios based on the target comparison or optimization.
- Step 5: View the output, results of simulation in 2D, 3D or VR animation.

Three proposed workstations were analyzed based on time and cost analysis. The best option based on the minimum processing time and cost at the workstation is chosen as a proper facility layout for Erul Food Industry.

4. Results and Discussion

The developed workstation layout for Erul Food Industry is designed using SketchUp software, while simulation of the proposed layout and time and cost analysis is performed using FlexSim software.

At present, there is no proper layout of the workstation at the Salaiport. Some workstations located in different locations and hilly areas around the premises cause a number of ergonomic problems, including MSDs and fatigue. Handling smoked meat that weighs more than 100 kg from a smoker to a weight table station causes workers with MSDs and back pain because smoked meat needs to be handled with care without using a hand trolley. Moving from one workstation to another caused fatigue on the part of workers due to the location of each workstation that was quite far from each other. Unorganized workstation layout reduces production time and makes the production line less efficient.

4.1 Developed Layout of SketchUp Software

Three proposed workstation layout is designed using SketchUp software. The 3D layout design from the top view of the developed layout for Design 1, Design 2 and Design 3 is shown in Fig. 1, 2 and 3, respectively.

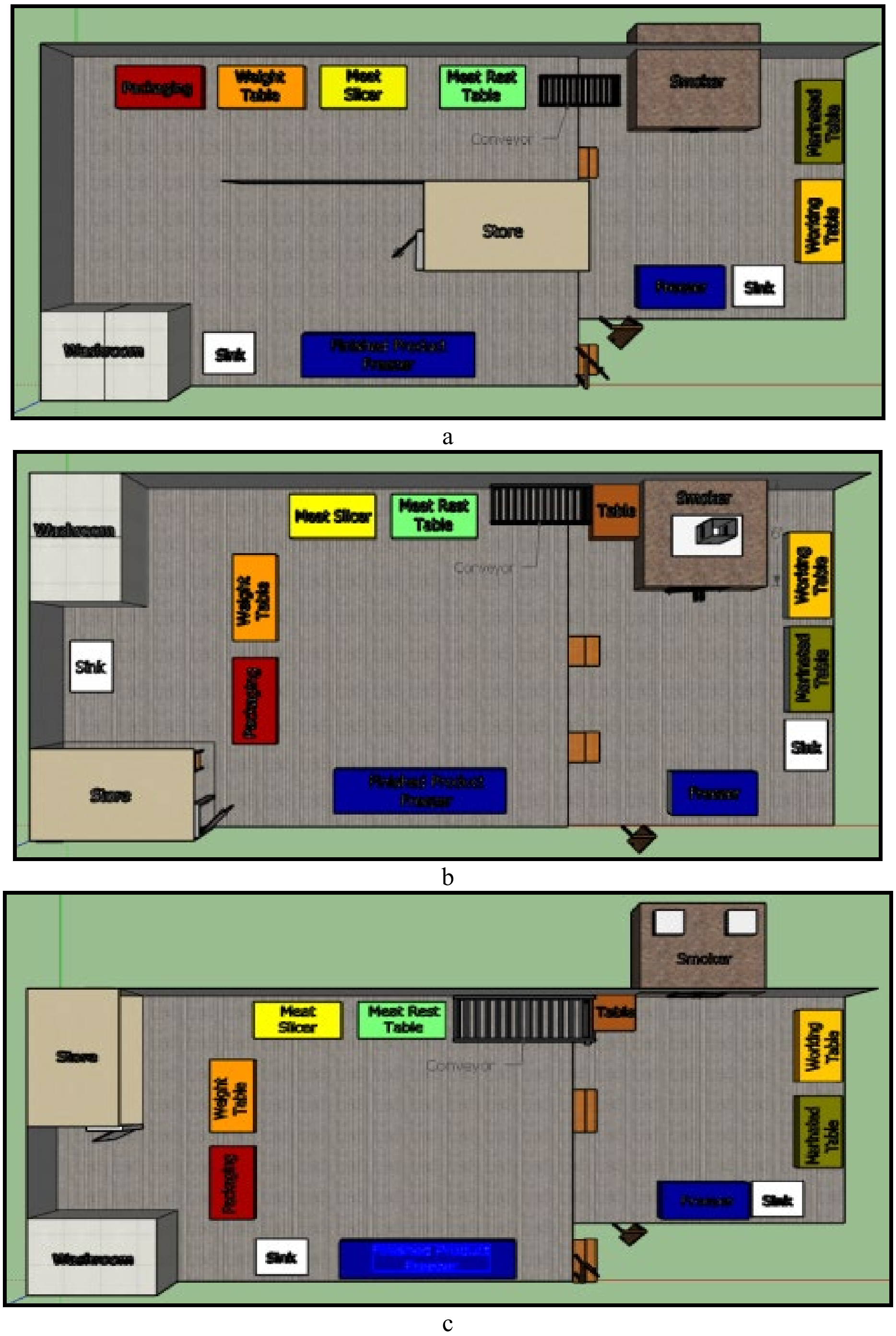


Fig. 1 - Top view of developed layout (a) design 1; (b) design 2; (c) design 3

The difference between Design 1 and Design 2 is the position of workstations and the route of flow product. The position of the workstations in Design 2 is more in order than that of the workstations in Design 1. Next, for this design, it had only one way in and one way out, while Design 1 had two ways out, one for way in and the other for way out. This is because, the production line for this design is smoother and it is easy for workers to carry the product in one way while Design 1 production line is blocked by the store in the middle. The difference between this design from Design 1 and Design 2 is the position of the smoker. For Design 3, the smoker is placed outside the building while in Design 1 and Design 2, it is placed inside the building. The door of the smoker is placed at the wall of the building while the body of the smoker is behind the wall. Similar to Design 1, Design 3 has two ways for in and out from the workstation. For Design 2 and 3, a table is placed between the smoker and the conveyor, making it easy for workers to place the product before the product flows through the conveyor. Besides, Design 1 and Design 3 have a U-shaped production line and Design 2 has a gridline production line. The measurement of the workstations and cost of items located at the workstation are shown in Table 1. The measurement of workstations is in unit of feet (ft).

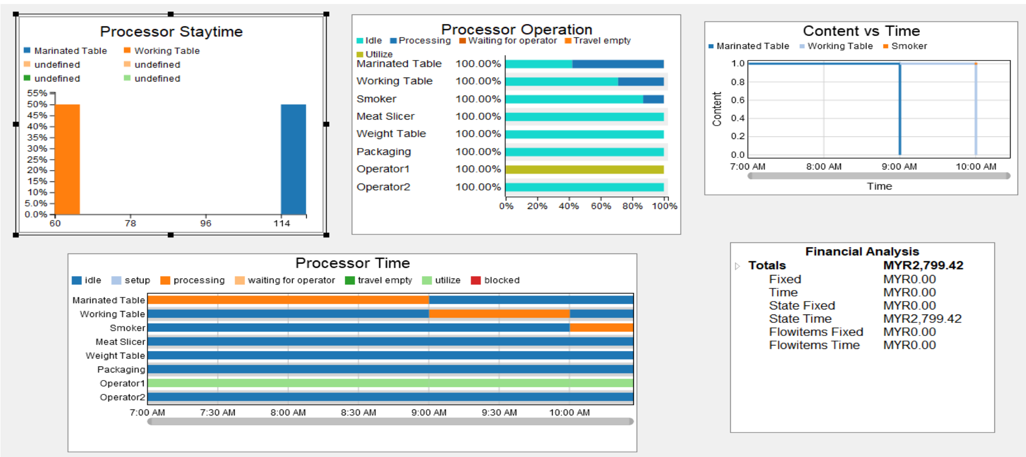
Table 1 - Measurement of stations for the developed layout

No	Stations	Measurement (feet) Length x Width x Height	Units	Cost (RM)
1	Freezer	5 x 2.5 x 2.5	1	1699
2	Sink	3 x 2.5 x 0.3	2	900
3	Marinated table	5 x 2.5 x 1	1	500
4	Working table	5 x 2.5 x 1	1	300
5	Smoker	7 x 6 x 3	1	3000
6	Conveyor	-	1	208
7	Meat rest table	5 x 2.5 x 1	1	300
8	Table	3 x 2.5 x 1	1	150
9	Meat slicer	5 x 2.5 x 1	1	1800
10	Weight table	5 x 2.5 x 1	1	500
11	Packaging	5 x 2.5 x 1	1	4000
12	Finish product freezer	10 x 2.5 x 1.5	1	2199

4.2 Time and Cost Results

4.2.1 Design 1

Fig. 2 shows the initial, intermediate and final data of simulation Design 1. Initial simulation processor operation data Design 1 shows that the marinated table starts working at 57.5%, while the working table and smoker use 28.76% and 13.59%. Operator 1 is fully utilized; on the other hand, operator 2 is idle as operator 1 is responsible for the preparation of raw materials until the product is processed in the smoker. Based on the content versus time graph, one batch of the product needs 120 minutes, which ended at 9:00 a.m. This product continues the process at the working table and ends at 10:00 a.m. For processor time, it shows that the marinated table was running until 09:00:08 am and then idle after finishing the process. The working table is in idle state from 7:00 a.m. to 9:00 a.m. and will start processing for 60 minutes. Meanwhile, the smoker starts working at 10:00 a.m. Finally, the financial analysis shows that the initial cost of the processor is RM 2,799.42.



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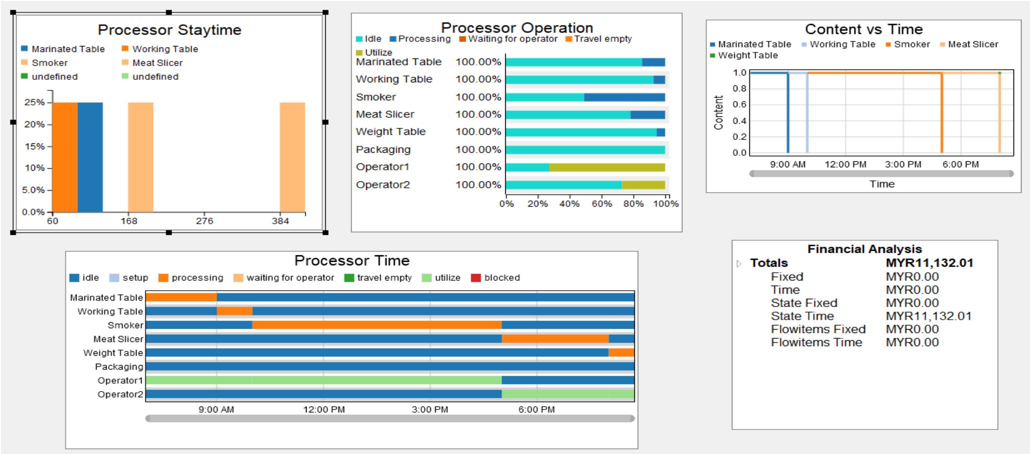

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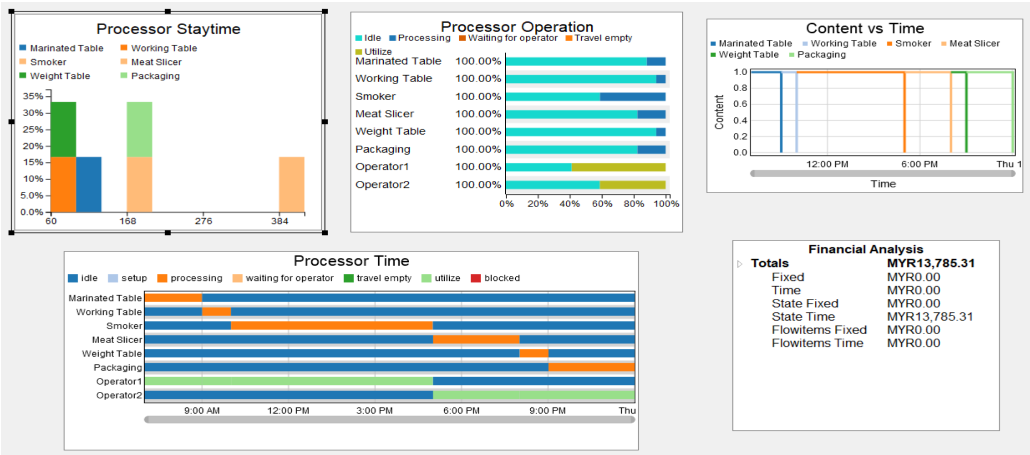

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Fig. 2 - Simulation results design 1 (a) initial data; (b) intermediate data; (c) final data

As a result of the intermediate data, the processor operation for the meat slicer and weight table is 21.82% and 5.32%, respectively. Operator 1 is utilized 72.73% while operator 2 is utilized 27.14%. Content versus time graph shows that the smoker stations finish processing at around 5:00 p.m. for 420 minutes, while the meat slicer finished the process at 8:00 p.m. for 120 minutes. Processor time chart shows that the smoker starts working at 10:00:17 a.m. Processor time also shows the operator 1 started working from 07:00 a.m. to 5:00 p.m. The intermediate data shows that the cost of the processor is RM 11,132.01.

The final data of the Design 1 simulation shows that all the workstations had been operated and performed their work. Graphic content versus time shows that the weighting process takes 60 minutes and the packaging takes 180 minutes before entering the finished product freezer. Processor time chart shows that the smoker is operating from 10:00:17 a.m. to 5:00:17 p.m. and in idle state after 5:00:17 p.m. For the meat slicer, it is in idle condition from the morning until 5:00:58 p.m. and the processing of the meat is continued from 08:01:02p.m. The packaging process starts at 09:00 p.m. In addition, operator 2 started working at 5:00:58 p.m. while operator 1 started working in idle state at 5:00:17p.m. Finally, the financial analysis shows that the overall cost of the Design 1 process is RM 13,785.31 with a total run time of 1021.13 minutes. Fig. 3 illustrates the simulation operation for Design 1.

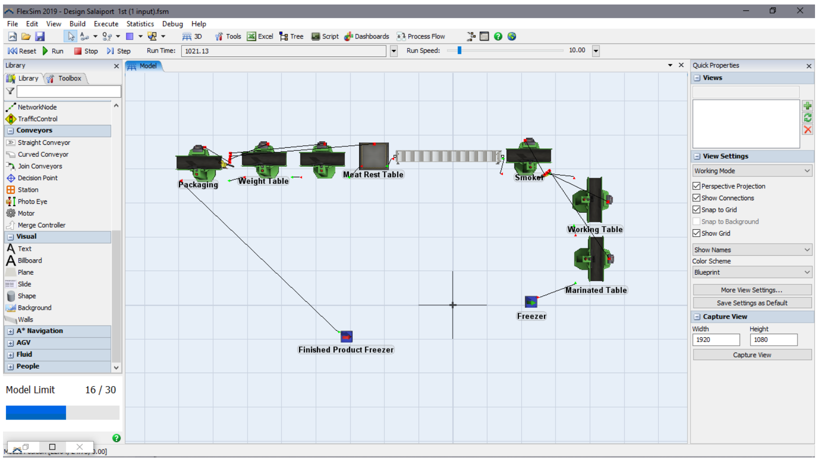
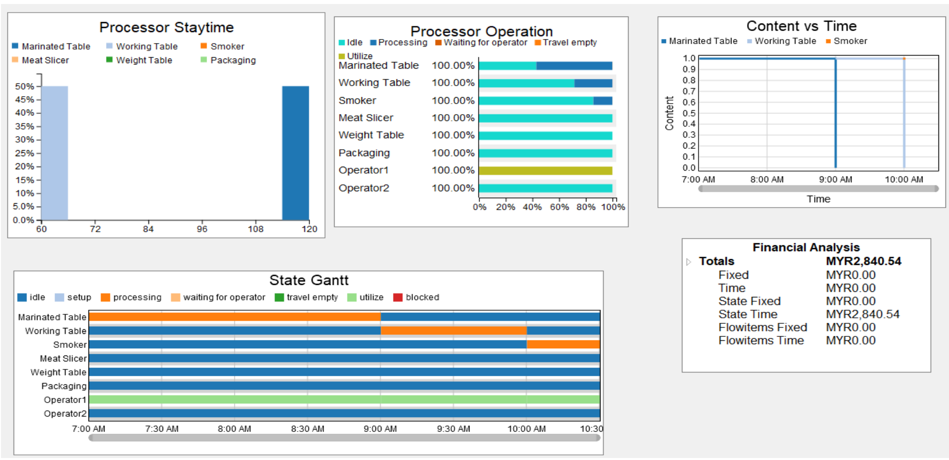


Fig. 3 - Simulation design 1

4.2.2 Design 2

Fig. 4 shows simulation results for initial data, intermediate data and final data for Design 2. The processing operation shows that the marinated table operates at 56.72% while the working table operates at 28.36%. Operator 1 is fully utilized, while operator 2 is in idle condition. Data content versus time shows that the operation starts with the marinated process at 7:00 a.m. and ends at 9:00 a.m., continues with the working table at 9:00 a.m. and finishes at 10:00 a.m. The processor time chart shows the detailed time for each process, that is, the marinated table started to process at 7:00:08 a.m. and ended at 9:00:08 a.m. For the working table, the workstation started to process at 9:00:12 a.m. before being idle since 7:00 a.m. The process at the working table ended at 10:00:12 a.m. with a total duration of 60 minutes. The financial analysis shows that the operating cost in the initial state is RM 2,840.84.



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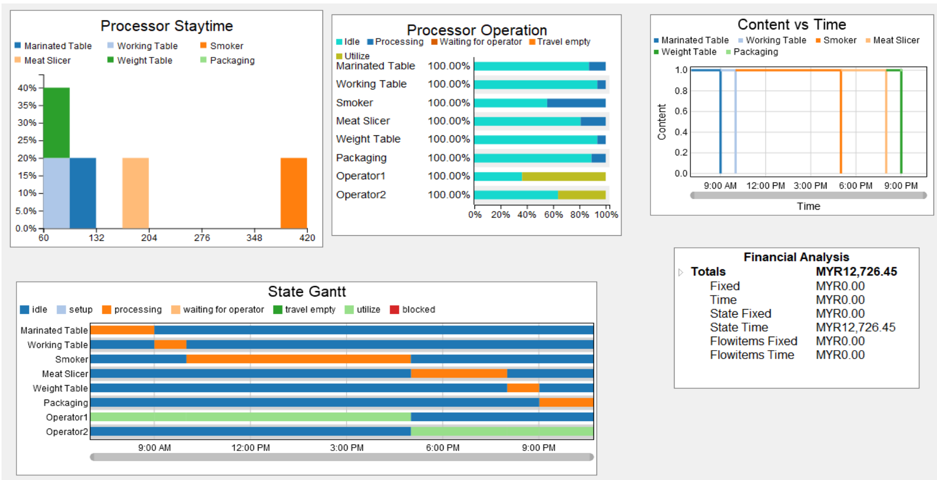

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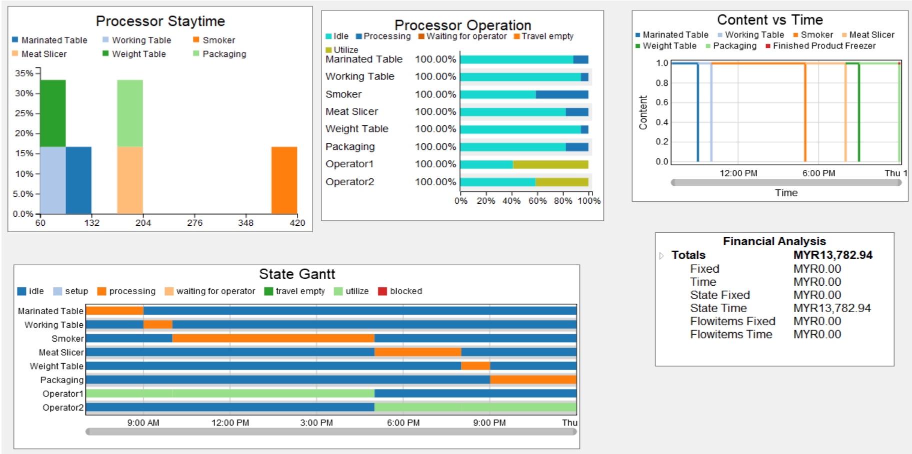

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Fig. 4 - Simulation result design 2 (a) initial data; (b) intermediate data; (c) final data

The intermediate data shows that the processor operation of marinated table, working table, smoker and meat slicer is 12.71%, 6.36%, 44.50% and 18.07%, respectively. In the meantime, weight processing and packaging processors are 6.36% and 10.91% individually. At this stage, operator 1 starts to be idle at 5:00 p.m. while operator 2 is working at 36.33%. Based on the content versus time graph, the product continues the process at the smoker's workstations and ends the process at 5:00 p.m. The product enters the meat slicer station at 5:00 p.m. and continues at work stations for 180 minutes and 60 minutes. The time graph of the processor shows the smoker starting to process at 12:00:17 p.m. and idle from 5:00:17 p.m. The weight workstation started at 08:00:52 p.m. while the packaging started process of product at 09:00:57 p.m. The financial analysis shows that the running cost for this state is RM 12,726.45. Final simulation data Design 2 shows that all processors have operated and finished one batch of the product. The packaging process started at 09:00 p.m. and ended after 180 minutes. The entire production ended at 12:00:52 a.m. The final cost of operation is RM 13,782.94 and will run for 1020.96 minutes. Fig. 5 shows the simulation flow of Design 2.

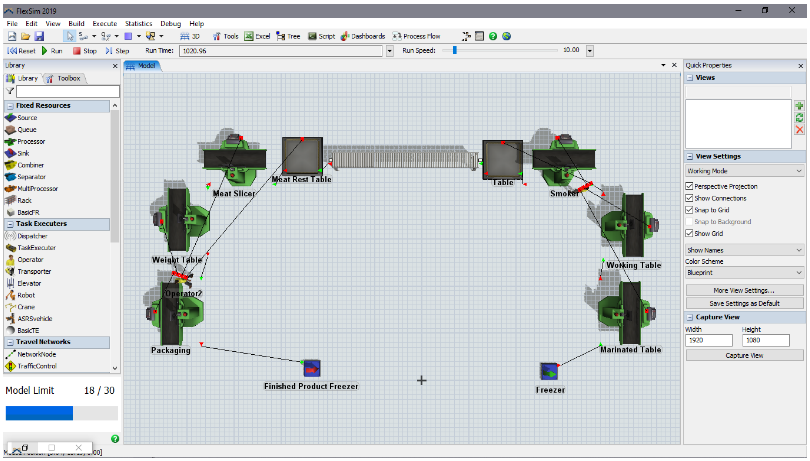
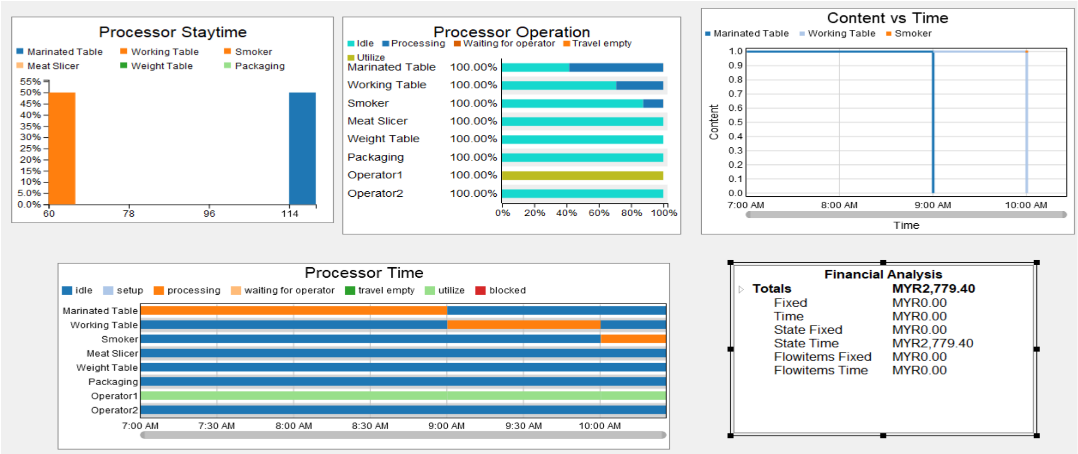


Fig. 5 - Simulation design 2

4.2.3 Design 3

Fig. 6 shows the initial data, intermediate data and final data of simulation results of Design 3. Initial data of processor operation shows, marinated table used for 58.09%, meanwhile working table used for 28.09%. The smoker idles for 87.23% and uses only 12.72%. Content versus time graph shows the marinated table started at 7:00 a.m. and it ended at 9:00 a.m. Next, the product will continue the process at the working table. The financial analysis shows that the operating costs of the initial data are RM 2,779.40.



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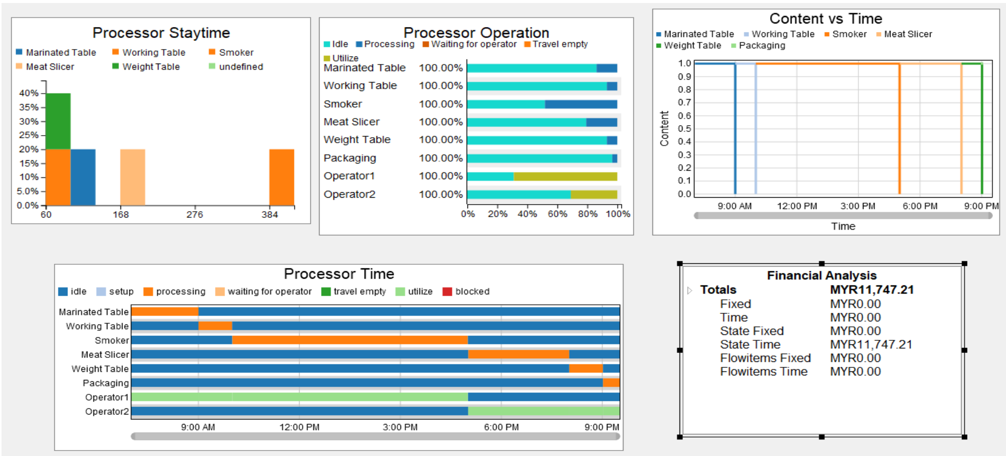

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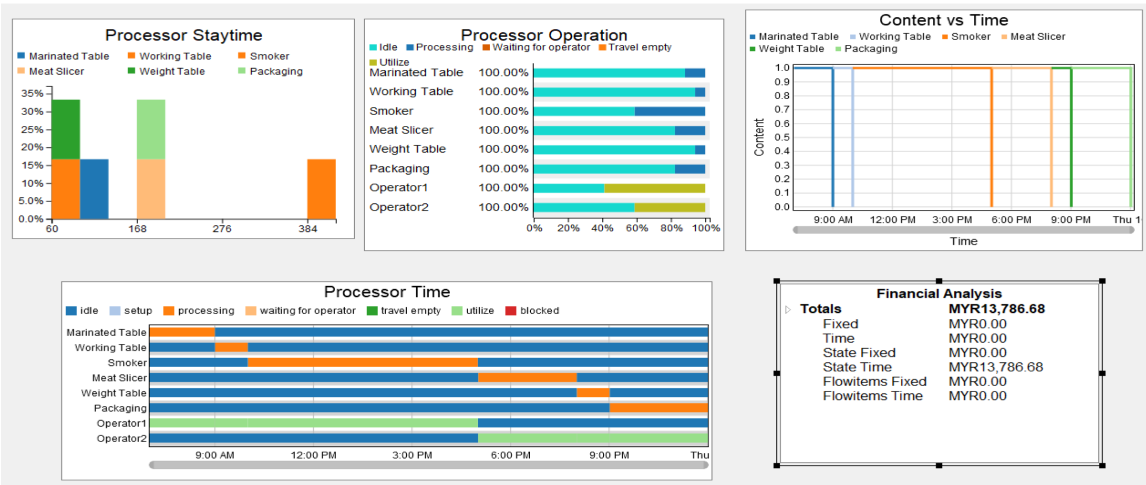

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Fig. 6 - Simulation results design 3 (a) initial data; (b) intermediate data; (c) final data

Intermediate data shows the processor utilization of smoker, meat slicer and weight workstation is 48.27%, 20.69% and 6.09% individually. The smoker starts working at 10:00 am, continues with the meat slicer at 05:00 pm and the weighting station at 08:00 pm. The time chart of the processor shows the starting time for the smoker, the meat slicer and the weight station for the design3, i.e. from 10:00:18 am, 05:01:04 pm,08:01:09 pm, respectively. The total working time is 60 minutes, while the smoker is 420 minutes. Financial analysis of these processes costs RM 11,747.21. The final data shows that the packaging operates for 17.63%. The operator 1 is utilized for 58.75% while operator 2 for 41.13%. Graphic content versus time, the process packaging started at 09:00 p.m. until the process was completed for 180 minutes. The product continues to be processed in the packaging process for a duration of 180 minutes, starting at 09:01:14 p.m. before the product is stored in the finished product freezer. Operator 1 started to operate from 07:00:08 a.m. to 5:00:18 p.m. and then continued to idle. Operator 2 was idle from 07:00:00 a.m. and started to operate from 05:01:04p.m. Finally, the financial analysis shows that the cost of one batch product running through the process is RM 13,786.86 with a total running time of 1021.24 minutes, as shown in Fig. 7.

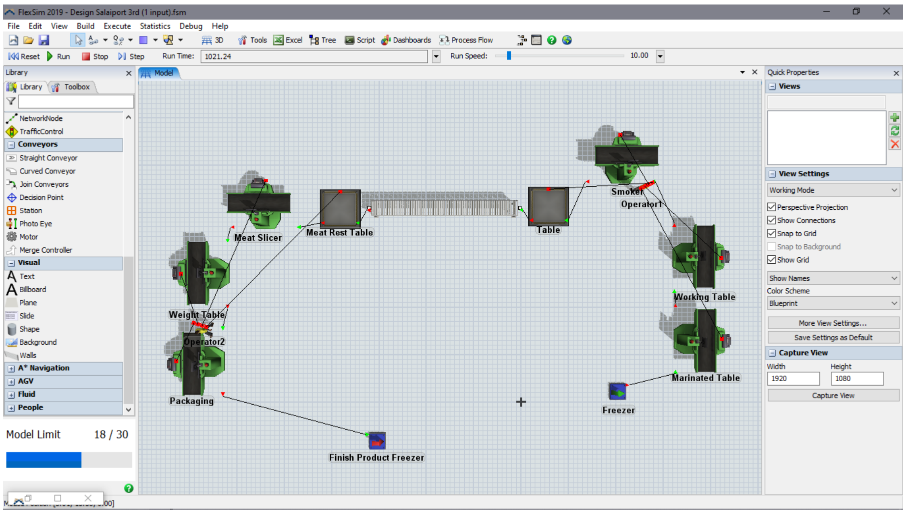

Fig. 7 - Simulation design 3

4.3 Comparisons of Time and Cost Analysis

Three layout designs have been prepared for the development of the workstation layout at the Erul Food Industry, namely Design 1, Design 2 and Design 3. These three designs were simulated using the FlexSim software to perform time and cost analysis. The time-and cost-based comparison of the three developed layouts was conducted to determine the best facility layout for the Erul Food Industry. The best layout is to choose based on the minimum processing time and the cost of the workstations.

The total running time of the simulation design is the difference which layout Design 2 had the lowest running time compared to two other layout designs. The total run time for Design 2 layout is 1020.96 minutes, while the total run time for Design 1 is 1021.13 minutes, while Design 3 layout is 1021.24 minutes. The processor time between the three layout designs differed only by millisecond. Due to the shaped line production in the three layout designs, the time between the designs of the processor is affected. Design 2 has a grid-line production line while another design uses a U-shape production line. It can conclude that the production line of the grid line has a lower processing time compared to the U-shape production line. Design 2 is therefore chosen as the best design to be implemented at Erul Food Industry from the total running time of production.

Based on the financial results and analysis of the three layouts, Design 2 has the cheapest cost than Design 1 and Design 3. According to the financial analysis of the simulation, layout Design 3 has the highest cost between the three designs, which is RM13,786.68, while Design 1 costs RM 13,785.31 and, lastly, Design 2 costs RM 13,782.94. The cost analysis shows that the cost of product flow through the workstations is RM 13.50 per time for each workstation. The financial analysis also affected the shape of the production line and the overall duration of the product. Overall, the shorter the total running time of production, the lower the cost of production. Fig. 8 illustrated the comparison of time and cost for each proposed design layout for Salapiport. Overall, design 2 is chosen to be implemented at Erul Food Industry on the basis of cost and time of production.

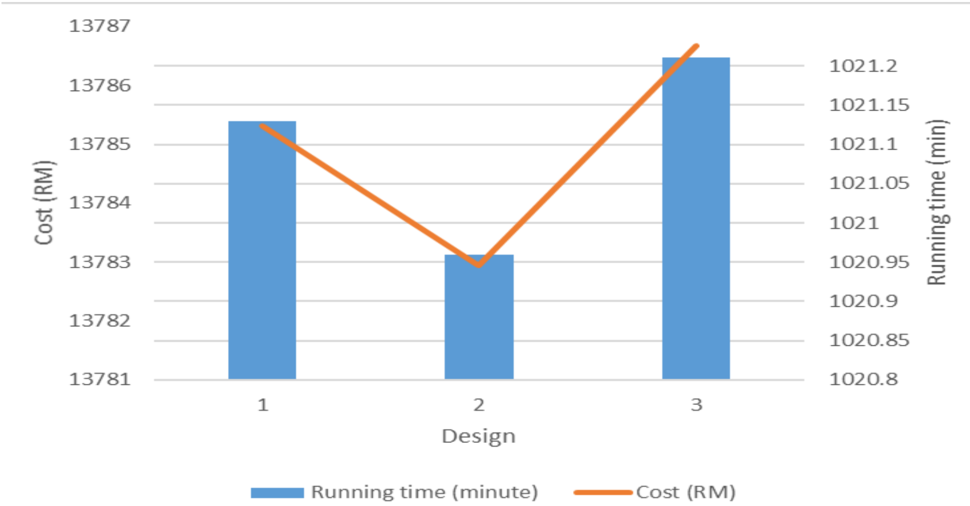

Fig. 8 - Comparison time and cost for each proposed layout design

5. Conclusion

The objective of this study had been achieved by proposing an ergonomics layout for Erul Food Industry that has optimum processing time and cost. Having an ergonomics layout is important to take care of workers health and safety as working at poultry food industry deals with many manual works with minimum helps of machines. Hence, ergonomics layout may help to maintain workers wellbeing and also ensure that the company able to have a productive operation to fulfil customers demands. Three proposed layouts, named Design 1, Design 2 and Design 3 is drawn using SketchUp software and those layouts had examined the time and cost using FlexSim simulation. Results from the simulation show that Design 2 is more suitable as a Salaiport layout because it has the minimum time and the cheapest cost. This developed layout will be proposed for consideration by Erul Food Industry. Proper facility layout at Erul Food Industry is important to ensure that production is efficient and that the working environment for workers is improved. This study demonstrations that, evaluating the proposed layout is important even the difference between those layouts is small because it may affect the overall operation time and cost. However, this study is limited to developing the layout without performing a details ergonomics analysis for each workstation in the factory.

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