Facility Layout Improvement for Erul Food Industry: A Simulation and Comparison

Nurul Nafisah Abdul Karim, Nurul Ainina Nadhirah Tajurahim, Salwa Mahmood
Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, Pagoh Campus,
KM 1 Jalan Panchor, 86400, Pagoh, Johor
cn180142@siswa.uthm.edu.my
aiaininadhrh@gmail.com
msalwa@uthm.edu.my*

Muhammad Khairul Samat
Erul Food Industry
Lot 3246, Kg Pekan Pedas,
71400 Rembau,
Negeri Sembilan
khairulsamat@gmail.com

Abstract

The simulation analyses numerous situations to discover if the layout would be more effective for the workers to work at the workstations. The main objective of this paper is to design a proper facility layout for the Erul Food Industry according to Makanan Tanggungjawab Industri (MeSTI). A simulation is needed regarding the facility layout designed for optimizing the time and cost by using FlexSim software. This paper was held at Erul Food Industry, a small industry that produces frozen smoked meats located at Rembau, Negeri Sembilan. SketchUp and FlexSim software are the tools used to design and analyze the developed layout for Erul Food Industry. Besides, processor stay time, processor operation, content against time, processor time, and financial analysis data are being gathered and observed. , The total running time for current layout design, Design 1, and Design 2 was recorded in minutes which are 765, 741, and 730 respectively. Meanwhile, the cost analysis recorded for the current layout design, Design 1, and Design 2 are RM22893.68, RM21908.75, and RM21542.81 respectively. The percentage improvement of the time analysis shows the current layout design, Design 1, and Design 2 are 1.9%, 5%, and 6.4% respectively. Finally, a comparison was done to select the developed layout with efficient time and cost analysis. The chosen developed layout: Design 2, is then proposed to Erul Food Industry based on the lowest time and cost. This paper is anticipated to assist Erul Food Industry in developing the real layout to optimize the time and cost analysis at the workstations.

Keywords
Facility layout improvement, FlexSim software, and simulation.

1. Introduction
As an important part of improving the production logistics system, facility planning refers to meet the required restrictions in a specific production environment and identifying the suitable layout form, and position of the equipment by the production goals (Id *et al.,* 2020). The small and medium enterprise (SMEs) food industry grows and changes continuously, re-evaluates product specification changes accordingly with customer needs, technology that quickly keeps growing every day, and workers going in and out of a company. The food industry is experiencing a far more competitive environment and is under pressure as a result of rising market demands and changing client preferences (Ibrahim *et al.,* 2018). The main concept behind this layout design is to minimize costs and ensure workforces finish their work quicker while meeting the expectations and demands of consumers. This paper is a collaboration with the Erul Food Industry as a reference for SMEs' business information sources. Erul Food Industry

is a small business that manufactures frozen smoked foods such as smoked beef, smoked quail, smoked catfish, and smoked duck. Erul Food Industry is a company that is family-owned and located at Pedas, Negeri Sembilan, and has been operating since July 2017. In the beginning, their business only started from the house's backyard, and it has grown with the construction of a work area next to their house. Customers' appetite for the commodity has increased dramatically since their brand became well-known.

Based on past research, (Surianshah, 2020) had proposed several layout designs for process improvement. Erul Food Industry had chosen one of the proposed layout designs as a guide for the layout development of their facility. However, during observation and site visits, Erul Food Industry cannot implement the proposed layout because the facility is no longer arranged, not according to the previous planning, and the workflow that has been proposed. There is an addition of machines related to process due to the high demand from customers. Besides, the extent of the infrastructure does not fully follow the proposed layout design. The construction of the area is not completely done. Hence, their facility area becomes narrow, and their production process is disorganized. As a result of this issue, certain workers are unable to do their tasks efficiently. It takes a long time to accomplish one activity before moving to the next process at another workstation. Aside from that, it might result in a low-quality product and have an impact on the workers' well-being. Therefore, this paper is aimed to assess the current layout and make an improvement by proposing a new layout design for its current facilities. Also, aims to simulate the layout design in the use of FlexSim software for obtaining the time and cost analysis regarding layout assessment. Based on the observation, the workflow process had lack efficiency and effects the time and cost of the production process. In addition, computer-aided modeling software is used to track the progress of the facility layout. One method for observing the improvement of the facility layout is computer-aided simulation. The FlexSim software will be used to simulate regarding on costs and time. FlexSim simulation is a 3D simulation platform that visualizes production systems.

Besides, facilities improvement is needed for Erul Food Industry by adding a changing room for their employees before entering and leaving the work area for preparing such as suitable cloth during working time. This is to improve the quality of their workstation cleanliness is more guaranteed. Erul Food Industry also intends to apply for a Halal Jabatan Kemajuan Islam Malaysia (JAKIM) certificate for the product. To apply for a Halal JAKIM certificate, industries are required to follow Halal JAKIM requirements which are very important to clean up in terms of raw materials, facilities, and workers. Halal JAKIM certificates are important for helping food industries to convince Muslims of import restrictions. Moreover, the purpose layout design must be analyzed to optimize the time and cost effects that will occur when the facility layout is made. Hence, the results of time and cost will affect the production of Erul Food Industry products.

1.1 Objectives

The main objective of this paper is to design a proper facility layout for the Erul Food Industry according to Makanan Tanggungjawab Industri (MeSTI) needs. Also, this paper aims to simulate the facility layout designed for optimizing the time and cost by using FlexSim software.

2. Literature Review

2.1 Facilities Planning

The most important part of developing a factory in many developed companies is facility layout planning (Bagaskara *et al.,* 2020). The proper arrangement will lead a corporation to an efficient material flow that will benefit the organization. The design, arrangement, and accommodation of people, machines, and system operations are all concerns of facility planning. When developing the facility layout, numerous issues must be considered, including safety, ergonomics, and operator references. Facility layout planning (FLP) is the process of physically organizing all of the production variables that comprise the production system so that it may comply with the organization's strategic objectives suitably and efficiently (Pérez-Gosende *et al.,* 2021). Making the most use of available space through optimal equipment placement, including the human component in workplace design, and properly aligning the workplace with its surroundings are all significant parts of ergonomics (Jiji Thomas, 2016). Improvements can be carried out at any stage of the manufacturing process (Kikolski & Ko, 2018). From the perspective of a manufacturing organization, the productivity of a production line is an essential quality. The arrangement of all equipment, machinery, and furnishings within a building envelope after considering the various performance objectives is referred to as facility layout design (Peron, 2018). While the department-level layout depicts the location, form, and size of each planning department, the machine level reflects and defines a more complete structure in which all equipment,

workbenches, and storage rooms are located within a department (Peron *et al.,* 2020). The allocation design of facilities on a manufacturing shop floor is referred to as facility layout planning (Kovács, 2019).

In today's competitive environment, optimal facility layout has proven to be an effective cost reduction tool for increasing productivity and efficiency. It has become important to have a well-organized layout for all available resources in an optimal manner to maximize returns from facility capacity (Sravan Kumar et al., 2015). There are many kinds of method that are being developed by researchers to achieve the optimization objectives. One of the methods is layout simulation, which allows one to readily modify or improve the current layout area in a short period (Chen et al., 2020; Line, 2020). Besides, there are different simulation software that can assist in evaluating the layout for the optimized time based on the requirements since the facilities layout can influence the process and material flow design in production. The simulation software able to obtain qualitative and quantitative advantages which the data is collected from industry over a specific time and some of necessary decisions had been made with help of experts. Furthermore, an appropriate layout process flow can provide smooth and effectiveness of material movement from the initial stage of material to the end of the process. Optimizing the facilities layout also can help reduce waste or non-value added operations and enhance overall effectiveness (Sugandhi et al., 2017; Sravan Kumar et al., 2015).

2.2 Ergonomics Related to Facility Layout

Companies should estimate the space needs those new technologies will put on them while planning expansion. Because technology is reducing labor intensity while requiring room to function, production spaces should be designed with flexibility in mind. Ergonomics is a branch of study concerned with human behavior and responses in terms of sitting, standing, and mobility (Ravindran, 2019). One of the most important reasons for occupational accidents and injuries in production systems is a poorly designed working environment. Inadequate and inadequate working environments, which disregard ergonomic elements during the planning stage, result in chronic psychological disorders, increased errors and accident rates, and decreased work efficiency Improving worker-worker compliance is one of the most effective techniques for increasing productivity (Özkaya *et al.,* 2018). Improper work designs and uncomfortable posture can lead to decreased productivity and occupational health issues. Ergonomics (or human factors) is a scientific discipline concerned with the understanding of interactions between humans and other system elements, as well as a profession that applies theory, principles, data, and methods to design to optimize human well-being and overall system performance (Matt Middlesworth, 2021). The ergonomic factor is important for assessing the layout design for Erul Food Industry. This is because implementing ergonomic innovations could improve employee health and productivity. The repetition movement has occurred in the production process at Erul Food Industry. If ergonomics were implemented as guidance for layout design, hazard issues can be eliminated, quality work will increase, can produce a high productivity level, and encourage safety in the workplace.

2.3 Simulation

A simulation is a time-lapse simulation of the functioning of a true process or system. The simulation could be used to illustrate the quality effects of various situations and courses of action. Simulation is also utilized when the real system could be linked because it is inaccessible, unsafe, or inappropriate to engage, being created but not yet created, or simply does not exist. Since the beginning of time, humans have utilized simulation to assist in education and learning (Lowther & Armstrong, 2021). Simulation usage necessitates careful preparation to produce relevant, valuable, and realistic case situations that satisfy the learning objectives (Lowther & Armstrong, 2021).

The facility layout of Erul Food Industry needs a simulation to enhance and develop the facility design of the working environment or the goods. It investigates all concepts including ergonomics measurements, such as cycle time, machine set-up, assembly line, bottleneck, and process, utilizing simulation. This simulation makes use of technical data to aid in the evaluation of assembly ergonomics. The simulation is the basis of the digital factory since it can physically analyze not either current system without interfering with operations.

3. Methods

The current facility layout design has been redrawn using SketchUp software to give a clearer picture. Two new layout designs are purpose in this paper which are Design 1 and Design 2. From these two designs, only one of the layout designs will be chosen and it is dependent on the analysis of simulation from FlexSim software.

3.1 Development of Proposed Layout Design

Development is the process of making the necessary improvements and adjustments for a better way of life and existence. In this process, the proposed layout design was prepared for Erul Food Industry workstation uses. After observing the current layout design at Erul Food Industry, the new layout design will develop according to the requirement of the checklist for applying for MesTI and Halal Jakim certification. Sketchup Software is the medium that was used for sketching and design purposes.

3.2 Propose New Layout Design

In this phase, many factors need to be considered to develop a layout design. Among the factor is improving the efficiency of the manufacturing process and satisfying the demands of the workers. It also needs to consider the smoothness of workflow, material handling, and machinery in such a method that they produce a continuous and functional system. These two new layout designs will be compared with the current layout design at Erul Food Industry.

3.3 Simulation of the Proposed Layout

Simulation is an activity that mimics the behavior of a real system (Ishak *et al.,* 2020). Simulation models are sets of numerical conditions addressing the conduct of the framework in an actual area of interest. In the early turn of the development process, ordinarily more basic framework portrayals utilize logical presumptions and confirm the collaboration between a few actual angles on an idea level. By using simulations, we can identify problems in the workspace and perform analysis to avoid any errors during construction that will cause a loss of cost and workflow that does not save time and efficiency. Therefore, the simulation can help in the process of building a layout design for Erul food to get the maximum quality layout design possible.

3.3.1 Time and Cost Analysis

The collected data by the simulation is a time and cost analysis of the established layout, with the time analysis consisting of the stay time of the product at the workstations and the time of content entering and exiting the process. Aside from that, the processor time was monitored utilizing simulation data collection, and in this case, the exact moment each workstation began and stopped operation was recorded. The processor time also represented the time spent idle and processing by workstations during the production process. In addition, the simulation logged the overall running duration of the entire procedure. This data analysis had to be simulated to reduce the time required by workstations for the established layout and to shorten the processing time for the product.

3.3.2 Comparison of Time and Cost Analysis

An efficient layout can help to avoid wasteful material handling, reduce costs, and keep goods flowing through the facility. For the development of the layout, two plans were created for Erul Food Industry. These two plans were recreated utilizing the FlexSim programming to accumulate the time and cost examination. The correlation for the two created formats was to choose constantly the appropriate layout design for Erul Food Industry. This correlation needed to pick based on the base time handling and cost at the workstations.

4. Data Collection

According to the observation during the site's visit at Erul Food Industry, the present workstation arrangement at Erul Food Industry is unsuitable for the food establishments to function and manufacture a product. This is due to the industry's disorganized workstations and there is no suitable arrangement for the workstations, the position of each workstation is incorrect, and not all the workstations are in the same location. Hence, the detailed measurements for each workstation in the development arrangement. as shown in Table 1.

Table 1. The measurement of the workstations

No	Station	Measurement (feet), Length x Width x Height	Unit/s	Cost (RM)
1	Freezer	5.0 x 2.5 x 1.5	16	2085
2	Sink	3.0 x 2.5 x 0.3	1	250
3	Marinated table	5.0 x 2.5 x 1.0	1	500
4	Working table	5.0 x 2.5 x 1.0	2	600
5	Smoker	7.0 x 6.0 x 3.0	1	3000

6	Meat slicer	5.0 x 2.5 x 1.0	1	1800
7	Seal machine	3.0 x 2.5 x 1.0	1	300
8	Turmeric machine	5.0 x 2.5 x 1.0	1	8000
9	Lemongrass machine	5.0 x 2.5 x 1.0	1	3000
10	Vacuum machine	5.0 x 2.5 x 1.0	1	2111
11	Chiller	3.0 x 2.5 x 1.5	2	1450
12	Weight table	5.0 x 2.5 x 1.5	1	500
13	Paste Machine	5.0 x 2.5 x 1.0	1	4182

5. Results and Discussion

The proposed layout designs were analyzed to identify the use of time and cost which is better to implement at Erul Food Industry by using simulation of FlexSim software. The criteria that have been requested from Erul Food Industry are to build a changing room for the worker before entering the workstation and rearrange the position of the machine processor for a better workflow. Besides, the arrangement must need to follow by MeSTI and Halal JAKIM checklist to achieve the certification for the SMEs industry. According to Julien Benabes et al. (2013) layout design and planning are given the most importance in industrial sectors to decrease cost and time. The design of facility layout is an influential factor in a company's performance to support the streamlined production process. The design of facility layouts is a priority for the industry to increase productivity (Suhardi et al., 2019).

5.1 Develop Layout of SketchUp Software

The current layout design was designed using SketchUp software based on the real layout at Erul Food Industry. Figure 1 shows the 3D current layout design at Erul Food Industry from the top view. For Design 1, Figure 2 shows the top view of the developed layout Design. the position of the workstation has been rearranged for a better workflow to produce the frozen food product. Figure 3 shows the top view design for developing Design 2. The difference between this design with Design 1 is the arrangement of the processor and the workflow of every station.

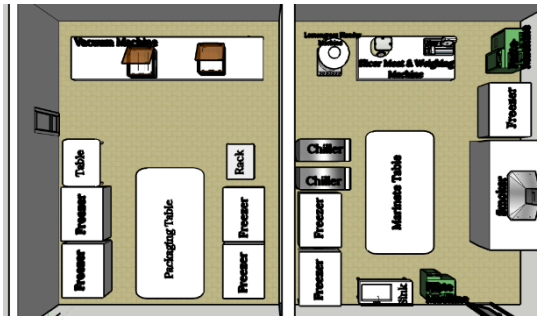

Figure 1. Top view of current layout design

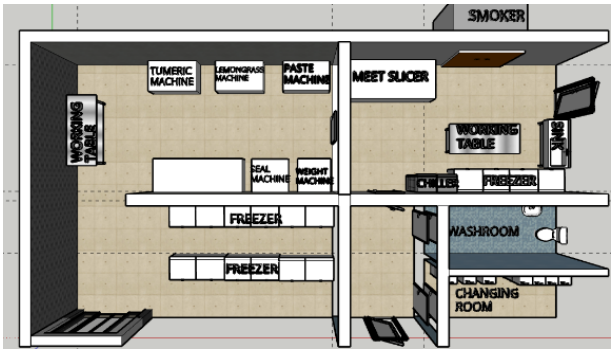

Figure 2. Top view of developing layout Design 1

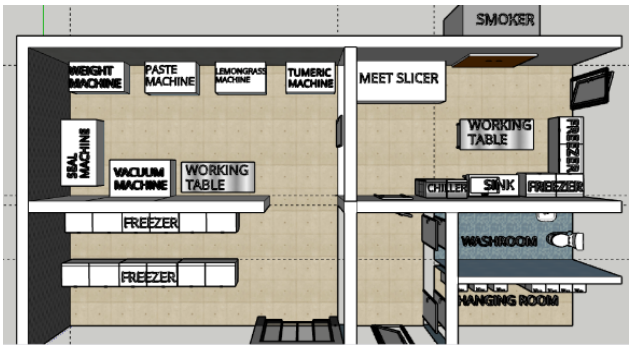

Figure 3. Top view of developed layout Design 2

4.2 Simulation in FlexSim Software

The FlexSim software has been used in many case studies in various industries (Chen et al., 2020). The design of the industry provides a way to analyze layout by using the model to examine the efficiency of layout planning which to improve the production process. Besides, FlexSim can investigate various simulated scenarios by changing the storage space at the workstations, the number of machines, the distances between the workstations, the part and type combination, the service disciplines of the input and output buffer queues at the workstations, the routing sequence of part types, and so on (Line, 2020; Gelenbe & Guennouni, 2017). As a result, FlexSim may also be used to assist the designer of the real Flexible Manufacturing Systems (FMS) database system in determining appropriate database selections in conjunction with performance concerns; further, if the real FMS database already exists, the information it contains may be transposed into FlexSim's database. Previously, several studies had been done for layout improvement using FlexSim software (Surianshah, 2020). Therefore, this study has implemented this software to make a comparison in terms of time and cost for layout design. Also, this study was conducted utilizing the simulation in FlexSim software, which assists in simulation and enables to find a solution as well as improve systems in planning, such as restoring equipment in the workplace production process at a short distance and obtaining minimal production time, and increasing output capacity.

Figure 4 shows the simulation design for the current layout design from Erul Food Industry. This design followed the real arrangement and the data from the simulation was shown in Figure 5. For processor time, it shows the marinated table processing until 09:00 am then goes to an idle time when it is finished processing. Also. shows that smokers started to be processing at 09:00 am until 04:00 pm. For meat slicer, it is being in an idle state from morning until it starts to process at 04:00 pm then the weight processing continues from 05:00 pm. Both paste machines will complete at 07:30 pm after that will proceed with the lemongrass machine until 07:40 pm and the turmeric machine was completed at 07:45 pm. Lastly, the packaging operation will complete at 08:45 pm. The data of the simulation on financial analysis shows that the overall cost of the process in the current layout design is RM 22893.68 with a total run time of 765 minutes.

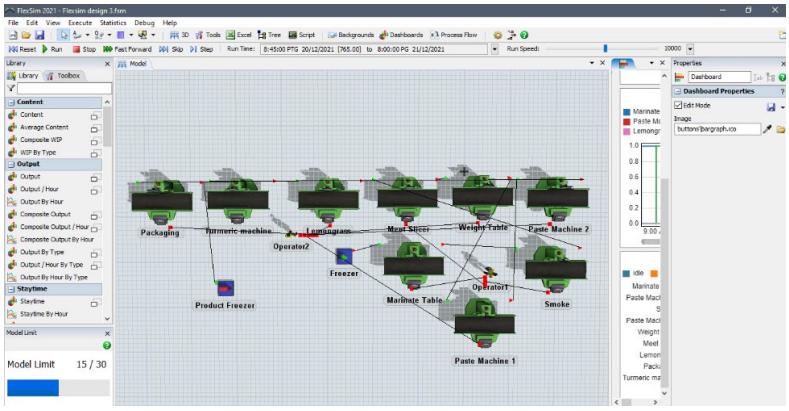

Figure 4. Simulation of current layout design

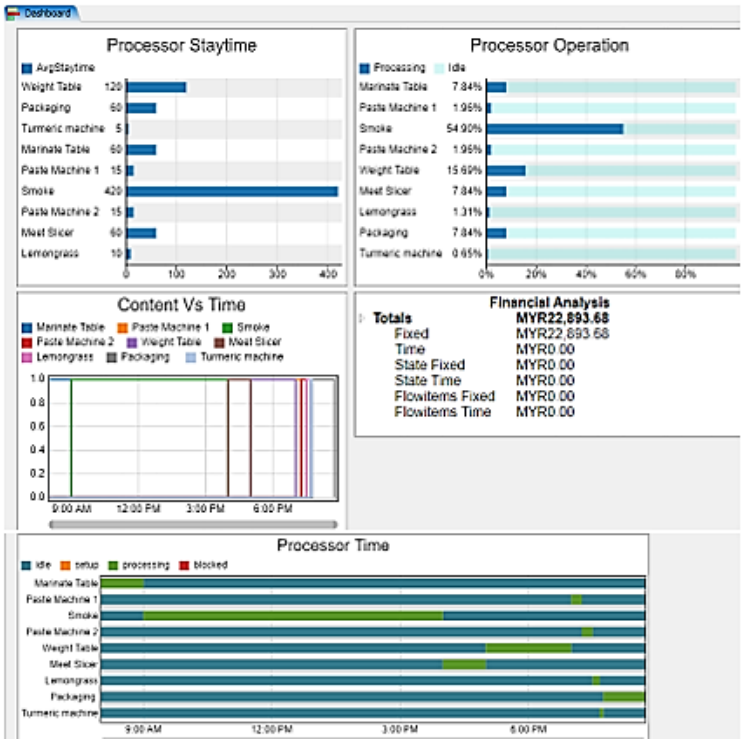

Figure 5. Data from simulation of current layout design

Simulation of Design 1 is shown in Figure 6. This new layout design was created with a new workflow for the production process. The data of the simulation of Design 1 is the first idea of layout improvement for the Erul Food Industry. The data analysis for Design 1 was shown in Figure 7. For processor time, it shows that the marinated table is processing until 09:00 am. The smoker started to be processed from 09:00 am until 04:00 pm. The meat slicer will be complete the process at 05:00 pm then the paste machine was continued until 05:13 pm. After that, the lemongrass machine process proceeded until 05:23 pm and the turmeric machine was complete at 05:28 pm. The weight station will operate until 07:18 pm. Lastly, the packaging operation will complete at 08:21 pm. At the end of the simulation, the cost provide is RM 21908.75 with a total run time of 741 minutes.

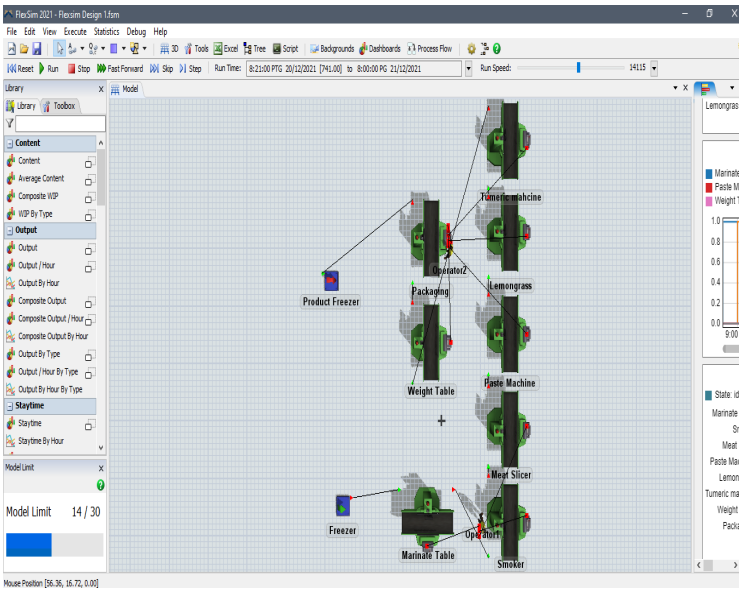

Figure 6. Simulation of Design 1

Figure 7. Data from simulation Design 1

Figure 8 shows the simulation of Design 2. This arrangement of layout is the second idea for layout improvement for Erul Food Industry. The data from the simulation was shown in Figure 9. For processor time, it shows that the marinated table is processing until 09:00 am. The smoker started to be processed at 09:00 am until 04:00 pm. The meat slicer will be complete the process at 05:00 pm then the turmeric machine was continued until 05:05 pm. After that, the lemongrass machine process proceeded until 05:15 pm, and the paste machine was complete at 05:30 pm. The packaging station will operate until 07:20 pm. Lastly, the packaging operation will complete at 08:10 pm. Finally, the data of the simulation on financial analysis shows that the overall cost of the process in Design 2 is RM 21542.81 with a total run time of 730 minutes.

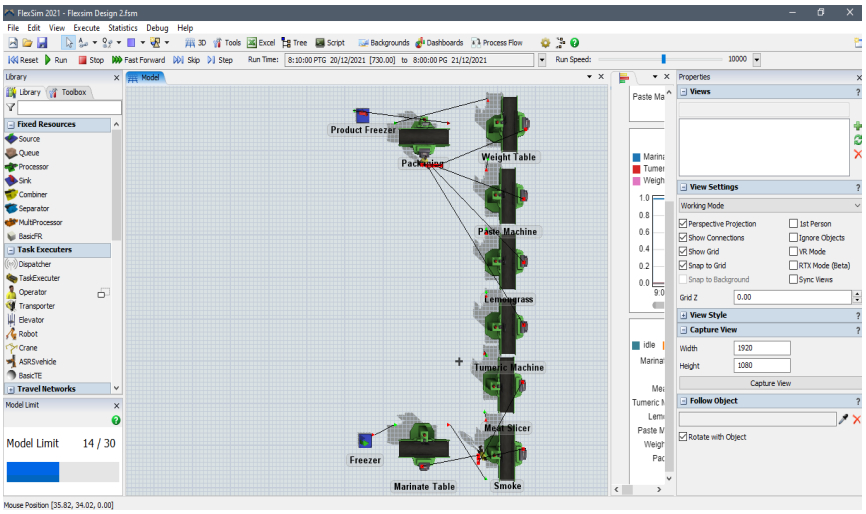

Figure 8. Simulation of Design 2

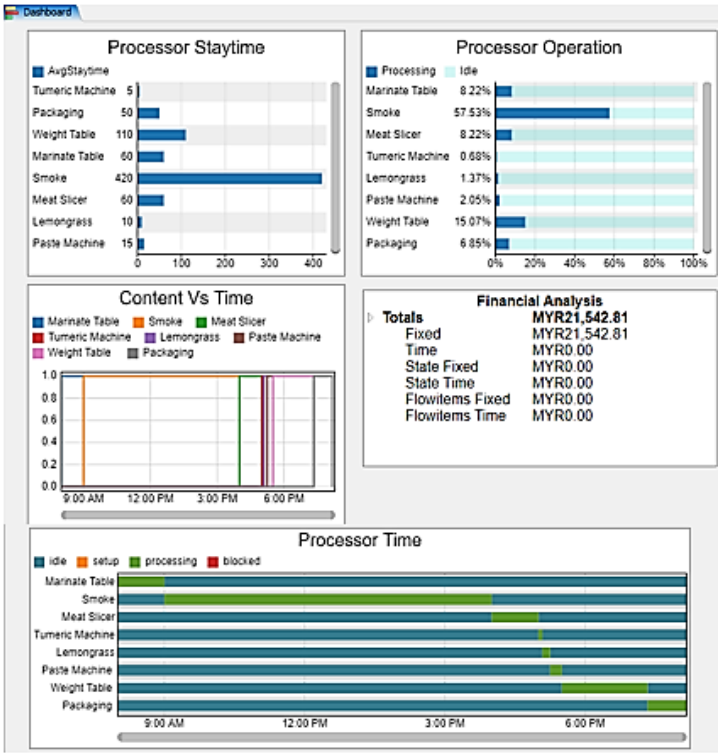

Figure 9. Data from simulation Design 2

4.3 Comparison between Current Layout Design and New Design Idea

When the development facility design is compared to the actual production setup, it is clear that there are improvements to be made, particularly in terms of time analysis. The reduction in time may be considered a success because the time for each layout is less than the initial time for producing a single batch of products. the application of efficiency-improving methods is essential for the industry. Facility layout design or redesign is one of the most important and frequently used methods which can improve efficiency and reduce the operational costs of companies to a significant extent (Kovács, 2019). The processing time difference between the three layout designs was barely a

millisecond. The processing time between the designs is impacted by the shaped line manufacturing in the three layout designs. However, based on the overall production time, the best design for Erul Food Industry might well be chosen for implementation. Based on the analysis and result of the two developed layouts, it shows that the cost for layout Design 2 is lower than others which is according to the financial analysis of the simulation.

Besides, according to the simulation's financial analysis, the cost analysis demonstrating that it flows through the workstations by state time that is in this workstation is RM 29.92 per time for each workstation. This state time represented the overall cost of all processors during the duration of the product flow. The overall cost includes the price of each processor in the workstation. This financial estimate was also influenced by the form of the workstation manufacturing line and the time it took for the product to be completed. It is reasonable to deduce that the shorter the entire running time of manufacturing, the cheaper the production cost. Table 2 shows the simulation data and percentage of efficiency of layout design. The time duration to complete the frozen food product in minutes for the current layout design, Design 1, and Design 2 are 765, 741, and 730 respectively. The cost for the complete one cycle of the process for the current layout design, Design 1, and Design 2 are RM 22893.68, RM 21908.75, and RM 21542.81 respectively. Based on Table 2, the percentage improvement in time analysis demonstrates that the facility layout has been successfully designed and enhanced over the current production setup and Design 2 is a higher percentage of efficiency.

Table 2. Simulation data and percentage of efficiency of layout design

No.	Design	Times (minutes)	Cost (RM)	Efficiency (%)
1	Current layout design	765	22893.68	1.9%
2	Design 1	741	21908.75	5%
3	Design 2	730	21542.81	6.4%

6. Conclusion

Hence, the facility layout design for Erul Food Industry was successfully developed utilizing the SketchUp software. To develop the required facility layout, measurements for workstations were taken to ensure the design was appropriate for the layout. Two development layouts were designed to be submitted to Erul Food Industry. These facility layouts were designed by adhering to the MeSTI and Halal JAKIM checklist requirements for SMEs while building layouts.

The current layout has been observed in terms of additional machines and the workflow is disorganized which results in certain workers being unable to do their tasks efficiently. Two proposed layouts are being prepared and analyzed. The reduction in time may be considered an achievement when the time for each layout is less than the starting time for producing a single batch of products. A comparison of the proposed and current layouts is presented to optimize the time, cost, and efficiency of the production process. Significant improvement is predicted based on data from the simulation by using FlexSim software for time and cost comparison with the current layout. The simulation of the proposed layout is projected to reduce time and cost for Erul Food Industry's workstations. According to the analysis, altering the layout percentage of efficiency improvement for the time analysis showed Design 2 had the highest percentage improvement which is 6.4% compared to other designs. Therefore, it was demonstrated that the objectives were met by lowering the time and expenses. Based on the current design and the two proposed designs, Design 2 is more appropriate since it takes the least amount of time and costs the least amount of money. Design 2 layout will be recommended to Erul Food Industry for consideration to ensure that Erul Food Industry has a good facility layout to improve work efficiency. Besides, an appropriate layout is required to provide a smooth and consistent flow of manufacturing. The layout of the facility is designed to ensure that workers operate in a productive workflow and that the equipment is in the proper location.

In addition, improvements in the quality of facilities layout and increasing productivity are critical in today's global competition. This could be accomplished by resolving constraints in both the production process and the layout. It was discovered that the proposed layout improved both cycle time and expenses while enabling significant capacity for the production and helping to avoid any repetition movement in the production process which could improve employee health and productivity. Also, a well-organized of facilities layout helps to eliminate the bottleneck which are allowing employees to work faster, reduce idle time, increase production rates, increase efficiency in the production process, and reduce the injury risk of workers or any other damage. However, it should be emphasized that

this study has limitations, including: (1) the measurements of workstations may be inaccurate and imprecise owing to a variety of unforeseeable issues. The instrument uncertainty measurement is one of the factors that contribute to workstation measurements that are not precise. (2) The research scope of facilities does not include multiple production levels.

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Biography

Nurul Nafisah Abdul Karim is currently a fourth-year undergraduate student pursuing a degree in Bachelor of Mechanical Engineering Technology (Manufacturing) with Honours from Universiti Tun Hussein Onn Malaysia (UTHM). She is currently doing an internship program at VS Industry Berhad.

N**urul Ainina Nadhirah Tajurahim** received the Bachelor of Mechanical Engineering Technology (Manufacturing) with Honours from Universiti Tun Hussien Onn Malaysia (UTHM). She is currently pursuing a Ph.D. in engineering technology in the Department of Mechanical Engineering Technology, Faculty of Engineering Technology, UTHM, Campus Pagoh.

Salwa Mahmood received a Ph.D. degree in mechanical engineering from UTM, Malaysia, in 2016. She is currently a Lecturer with the Department of Mechanical Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussien Onn Malaysia (UTHM), Pagoh Campus, Malaysia. Her research interests include industrial engineering, life cycle assessment (LCA), sustainability assessment, sustainable product design, and ergonomics risk assessment.

Muhammad Khairul Samat is the founder of Erul Food Industry, a small industry that produces frozen smoked meats located at Rembau, Negeri Sembilan which is a company family-owned since July 2017. He is a very flexible entrepreneur and always open-minded to collaborating with research academics to expand and improve their business**.**

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