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Comparison of Transfer Process Layout at Company A using Arena Simulation Software

Muhammad Izzat Hakimi Ramlan[1], Tengku Nur Azila Raja Mamat[2*], Shaiful Rizal Masrol[3]

[1] *Department of Mechanical Engineering Technology*
Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Pagoh, Johor, 84600, MALAYSIA
[2] *Innovative Manufacturing Technology, Universiti Tun Hussein Onn Malaysia, Pagoh, Johor, 84600, MALAYSIA*
Advanced Packaging Technology Research Group (APTReG)
[3] *Universiti Tun Hussein Onn Malaysia, Pagoh, Johor, 84600, MALAYSIA*

*Corresponding Author: nurazila@uthm.edu.my
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Abstract

This study aims to analyze, provide ideas and compare two processes of transporting oil palm fruits from plantations to factories, namely through the use of roads and cableway systems. This study was conducted at Bukit Pasir Palm Oil Mill Sdn. Bhd. Which is a small-scale palm oil production company located in Bukit Pasir, Muar, Johor, the storage size for palm fruit processing at the factory involved is as much as 50 metric tons/hour where the final product for the palm fruit is divided into two, namely crude palm oil and kernel. Among the problems faced is the lack of information on the appropriate way to increase productivity for a factory. This study was done by focusing on the layout of the palm fruit transfer process from the farm to the factory. Using Arena simulation, the results show a comparison of the performance between the two processes. The road approach shows more travel time compared to the use of the cableway because it involves a long journey and involves high road construction costs. Meanwhile, the cableway system shows the potential to reduce construction costs where the difference in construction costs is as much as RM 5754.84 while in terms of time it involves fast and little travel time compared to road use with a reduction of 5.89%. The results of the analysis show that the choice between these two processes requires careful weighing between the time and cost factors. The recomendation that can be given by propose the idea to a large-scale companies or a company that will be built in future where the impact of introducing innovations such as cableways for the transport process may provide benefits in the long term, including cost reduction and increased operational efficiency.

1. Introduction

The manufacturing process refers to the series of steps that are taken to transform raw materials into finished products. It involves a combination of human labor, machinery, and technology to produce goods on a large scale. The specific steps involved in the manufacturing process may vary depending on the industry and the

product being produced. Efficiency through layout study in industry is a process of optimizing the arrangement of equipment, workstations, and resources in a manufacturing or production facility to improve productivity and reduce waste [1]. After more than a century, palm oil sector has significantly benefited the country. In 2021, palm oil revenue surged to RM67.48 billion, with RM44.63 billion from exports. The export volume rose to 11.47 million metric tons in 2022. This growth signifies Malaysia's vital role in the global palm oil market [2].

The palm oil tree, scientifically known as Elaeis Guineensis, originated in West Africa [3]. Its use surged during the British Industrial Revolution and expanded foreign trade. Palm oil became a driving force in industrial production, serving various purposes from candle making to producing lubricating oil. Rich in nutrients, red palm oil became a crucial asset for sustaining long sea voyages. The palm oil industry in Malaysia began in 1917 with the first commercial planting by the French traveler "Henri Fauconnier" in Batang Berjuntai, Bestari Jaya, Selangor [4].

Time is a crucial factor in manufacturing factories, as it directly affects the efficiency and productivity of the production process [5]. In a manufacturing factory, time is a critical resource that must be carefully managed and optimized to ensure that products are produced on time and at a competitive cost. A bad time management may cause bottlenecks and delays.

If the layout is considered, it can be determined that one of the sources of palm fruit that the company will use is located outside the facility in a region with palm oil farms. It is well-known where to find fresh palm fruit, but to bring the fruit to the mill in one piece, trucks are required. One consideration that can be considered is the distance to the destination, the amount of oil fuel required, and the length of time. The higher the distance to the destination, the amount of oil fuel required, and the longer the time, the higher the cost that the manufacturer must bear.

Company A has a factory area of 3 acres, where the factory has been operating since 1981 where the factory's initial capacity was only 20 metric tons per hour, but in 2014 the factory has been improved to 50 metric tons per hour [6], the business carried out at the factory includes the production and sale of crude palm oil, the sale of palm kernel and related products.

This study has three main objectives. Firstly, it aims to analyze the current transfer layout at Company A using flow process chart. Subsequently, the study seeks to propose new transfer layout to the company. Finally, Arena simulation software will be used to simulate and make a comparison based on time result between the current transfer process and proposed transfer process. These objectives collectively aim to provide valuable insights and recommendations for optimizing Company A's operational layout and processes.

1.1 Palm harvesting process

The main objective of palm harvesting is to get fresh fruit bunches with excellent oil content and quality and can get the maximum profit. Before the fruit being process at the factory there are three process that need to be go through step by step, as stated in Table 1:

Table 1 *Three steps of palm fruit harvesting process*

Fruit harvesting	Weighing	Transportation
• Involves cutting and gathering the ripe fruit to be transported to the factory [7]. • As soon as possible (ideally within 24 hours). • Usually the process of harvesting palm fruit is done once in 7 - 10 days.	• Will be weighed first to obtain the weight value. • To ensure that the production of palm fruit is in good condition.	• Transport fresh bunches of fruit from the farm to the factory as quickly as possible • Will be sent to the factory the same day it is harvested usually not more than 24 hours • The use of lorry is one of the example of transportation for a long distance journey [8] and cableway system being use at surrounding area of the farm for a large scale palm oil factory

1.2 Layout study

Layout study is defined as the practice of coordinating the physical workplace with the people and work of the organization it integrates the principles of business administration, architecture, and behavioral and engineering sciences [9]. Facility management is a multidisciplinary or transdisciplinary profession that utilizes the theories and methods of behavioral science, engineering, architecture, design, and accountancy.

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In a production system, the physical arrangement of components like workstations or machines is known as layout design. The goal of layout design is to ensure efficient movement of personnel, supplies, and information across the system. Layout design is regarded as a crucial issue in developing and manufacturing systems in order to achieve this goal because it entails significant expenditure and any errors made at this point will result in losses for the organization.

1.3 Layout Simulation software

A simulation is an animated model that imitates the functioning of a current or potential system. Nowadays simulation software plays significant role in factory layout design. The ability to swiftly and simply design and modify the layout must be taken into account, but so must the collaborative aspect of layout creation, where all parties must be able to visualize, communicate, and share information [10]. The system should be a collaborative setting that can share and manage data and models from various sources as well as coordinate various layouts created by various disciplines

Simulation has significant advantages in helping users to design, test, and optimize complex systems [11]. In simulation, users can observe how a system behaves in various conditions and different parameters by taking data from the simulation model that has been created. This allows users to predict potential problems or changes that may occur in the system before it is physically implemented. In addition, simulation also allows users to save time and costs in developing and improving the system because testing can be done virtually without the need for expensive physical testing. Some simulation such as Arena Simulation offers a complete range of statistical distribution functions, including discrete, continuous, and empirical distributions that can be used to represent various aspects of the system being modelled. This enables users to generate realistic input data for their simulation models and accurately predict the system's performance. Additionally, the software provides users with performance metrics and dashboards that allow users to measure and compare the system's performance under different scenarios, enabling them to identify opportunities for improvement. Nowadays there are various type of simulation that can be used that able to help the user to build or simulate a layout either in 2D or 3D form, among them are Simul8 simulation software, Flexsim simulation software, AnyLogic simulation software, Arena simulation software and more, the selection of the use of a simulation software depends on the suitability and use of the work to be done.

2. Methodology

In order for a study to be carried out to be successful, it is necessary to meet the objectives that have been listed, where to obtain data with the existing layout of the factory involved either from the layout of the machine or the layout of the palm fruit transfer process, a site visit can be done. While in order to get a clearer exposure of the production, a flow process chart needs to be done to facilitate the detection of improvements that can be made and finally based on the data that has been collected the construction of the layout using simulation is necessary, where the use of Arena Simulation has been used in order to build the existing layout and proposed layout.

2.1 Site visit and data collection

Make a site visit and face-to-face observation of the production and process in the company involved. Through the visit, student was able to be exposed more clearly and able to make an observation more clearly with the help of the representative of the company. Students are also able to identify the best way to improve the productivity and efficiency of the process. It also will provide an opportunity to see in real-life the manufacturing process of the product and identify issues related to production. By observing, the representative able to help in understanding the principles, especially in the layout management system to optimize the production of a crude palm oil and palm kernel.

Data collection for the simulation involves observing and recording key metrics such as process time and employee count at each station. The primary focus is on recording actual delivery process times to determine cycle times for transporting fruit from the farm to the factory and fruit collection center. These cycle time values will serve as raw data for constructing simulation models in Arena software. The collected data will be incorporated into a flow process chart for a detailed overview of the entire process. Additionally, assumptions are made for the cableway system process, given its conceptual nature. These assumptions, derived from related studies, provide an alternative to facilitate the simulation construction process.

2.2 Existing process analysis using flow process chart

A flow process chart is a concise visual representation of the sequential order of processes or activities in a given operation. Using symbols and arrows, it illustrates the flow from one phase or action to another, offering a clear

overview of the entire process. These charts are valuable for evaluating and improving process efficiency, identifying bottlenecks, and enhancing overall process understanding. Fig. 1 is Company A mill layout plan and top view of the factory where can be seen that the surrounding area of the factory is one of the resources of raw material that will be collected and be transfer to the collection center before finally be transfer to the factory.

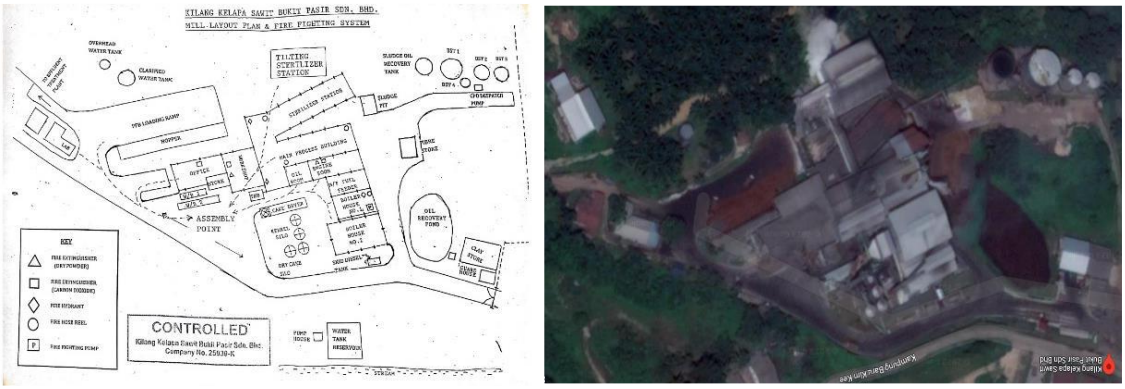

Fig. 1 *Company A mill layout plant*

Improvement ideas for palm oil production include innovative solutions such as a cableway system for transporting palm fruit from surrounding plantations to the factory. This aims to enhance efficiency, reduce costs associated with vehicle transportation, and streamline the collection process. The proposed cableway aims to speed up and simplify the process of collecting palm fruit from the farm to the processing place. With the cableway, workers can easily transport and deliver palm fruit in a shorter and without need to stay at collection center.

2.3 Arena simulation software

Arena modeling employs modules selected from template panels such as Basic Process, Advanced Process, and Advanced Transfer. These modules, comprised of simulation analysis (SIMAN) blocks, are assembled on a canvas during model creation, using a mix of textual and visual programming [12]. Typical tasks involve selecting and placing icons, establishing graphical connections between modules to represent flow pathways, parameterizing elements, and writing case-insensitive code fragments in a text editor. Arena's module-oriented simulation environment facilitates modeling diverse scenarios involving transaction flow through processes.

3. Result and discussion

Identifying the parameters that must be captured or recorded, such as the time parameters for each operation, the work network's layout, and the parameters for palm fruit entry at the beginning of the process, is the observation component that must be completed. The most crucial information to gather throughout the observation is the delivery time and distance. For fruit that is entered before the oil-making process is completed. Fig. 2 is the flow process chart for the palm oil production, it shown the results based on the site visit made while in the factory, where the production to get crude palm oil starts from the process of harvesting the fruit at the plantation until the fruit is delivered to the factory to get the final product which is crude palm oil.

	Palm Oil production.			
	Distance	**Time**	**Symbol**	**Description**
		245 min		Fresh fruit bunch (FFB) harvesting process
		30min		Loading into the Vehicle
	2.5KM	18.52 min		Transportation to the Collection Center
		843 min		Inspection at the Collection Center
	2KM	19.42 min		Transport to Factory (Lorry, Treler and others)
	84.9M	90 min		Fruit goes into the sterilization machine
	42M	16.8min		The cooked fruit is taken to the next machine which is the stripping/threshing process
	59.28M	15 min		Digestion process
		15 min		Pressing process
	56.66M	300 min		The crude oil goes into a clarification tank to be purified
		720 min		Drying process
TOTAL	4747.84 METER	1469.74 MINUTES		

Fig. 2 flow process chart for the palm oil production

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3.1 Layout for transfer process

The oil palm delivery process traditionally involves transporting fruits from the farm to a collection center before reaching the factory. Data collection around factory environments indicates a similar detour. Introducing a cableway system eliminates this detour, eliminates the route to a collection center, and makes it straight to the factory, as shown in Fig. 3 and Fig. 4 (b). This innovation streamlines the delivery of palm fruit directly to the factory, enhancing overall efficiency.

3.1.1 Current layout transfer process

As shown on Fig. 3 it is the current transfer process after harvesting, fresh fruit bunches are collected manually or with mechanical harvesters and loaded onto vehicles. The collection center serves as an intermediate point for multiple farms, conducting preliminary inspections, sorting, and weighing. Once sorted, the fruit bunches are transported to the processing factory using suitable means such as trucks, with the transportation mode determined by the distance to the factory.

Current Transfer Process			
Distance	**Time**	**Symbol**	**Description**
	245 min		Fresh fruit bunch (FFB) harvesting process
	30min		Loading into the Vehicle
2 KM	18.52 min		Transportation to the Collection Center
	843 min		Inspection at the Collection Center
2KM	19.42 min		Transport to Factory (Lorry, Treler and others)
Total	1155.94 min		

Fig. 3 *Process flow chart for current transfer process*

3.1.2 Proposed layout improvement cableway system

The cableway system in palm oil transport efficiently moves fresh fruit bunches (FFB) from the field to the loading area or directly to the extractor [13]. It uses a hauling cable attached to a drum on a prime mover, located either at the top or base of the system. Capable of operating on slopes up to 60 degrees, the system ensures smooth movement. In hilly terrains, like terraced plantations, the cableway is a practical solution for transporting FFB to the factory. Fig. 4 illustrates the time for each process, showcasing the direct transfer of FFB from the farm to the factory using the cableway system. As shown at Fig. 4 (a) is the example of the cableway system and Fig. 4 (b) is the process flow chart for cableway system.

(a)

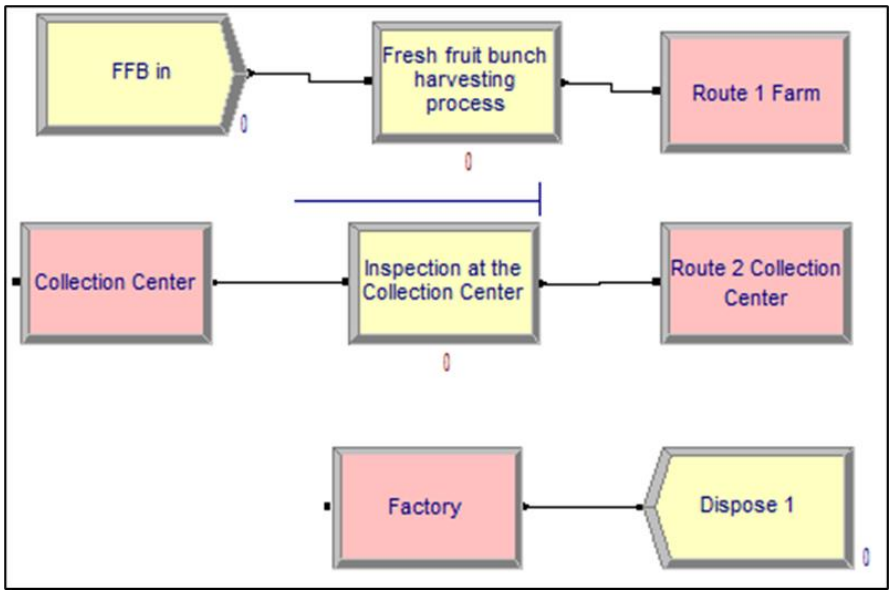
Cable way transfer process			
Distance	**Time**	**Symbol**	**Description**
	245 min		Fresh fruit bunch (FFB) harvesting process
	30min		Loading into the cableway bucket
100m	15min		Transportation to the Factory
	843 min		Inspection at the Factory
Total	1133 min		

(b)

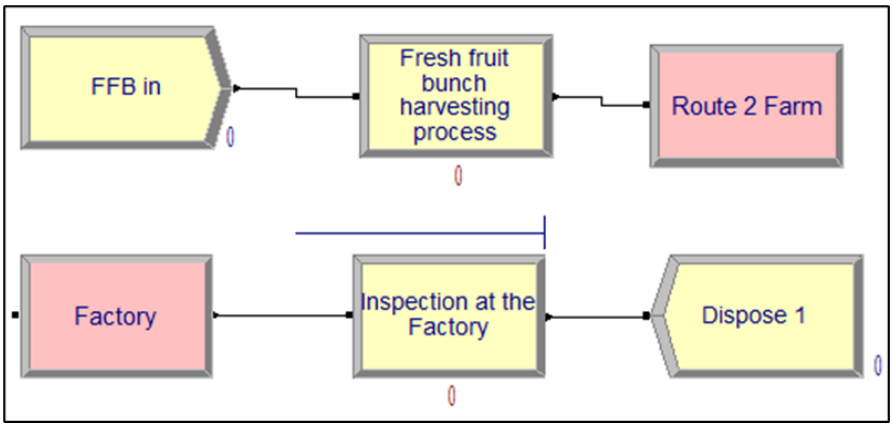
Fig. 4 (a) Cableway system (b) *Process flow chart for proposed transfer process*

3.2 Arena Simulation

The model is created based on the flow of the transfer process of palm fruit from the farm to the factory. The module that has been use in Arena simulation software include the Create, Station Route, Process and Dispose. The simulation shown two different types of simulation but have the same goal which is to bring FFB taken from the farm to be sent to the factory. The construction of the simulation begins when the entity used is entered in the first station and ends when the entity that has exited the last station. The entity that comes out is the number of fruits that will enter the factory to continue the next process, which is the palm oil production process.



(a)



(b)

Fig. 5 *(a) Current layout in Arena Simulation; (b) Propose layout in Arena Simulation*

Based on Fig. 5(a), which depicts the current configuration of the fruit delivery process constructed using Arena simulation, it is possible to understand how fruit is delivered to the collection center following its harvest from the farm at the surrounding area of the factory and then to the factory itself. The fruit can be sent straight to the factory with the production of cable systems like Fig. 5(b), which can eliminate the need to make the trip to the collection center and optimize the delivery process, particularly in terms of time.

3.2.1 Simulation parameter

These parameters are intended to ensure that the modeling to be built is based on the actual process in the parameter network [14]. All the parameter was taken based on the Arena Simulation as tabulated in Table 2:

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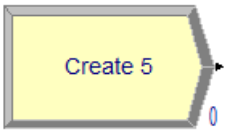
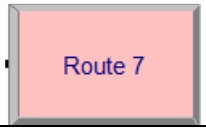
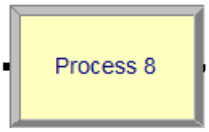
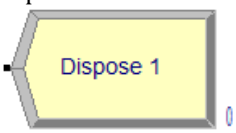
Table 2 *Arena simulation parameter*

Entity/Element	Parameter
Create 	i. The starting point for the entity (FFB) to start the fruit delivery process. ii. Entity (objects that represent objects in the simulated system). iii. The incoming FFB value is 1 and the maximum value is 50.
Route 	i. Determines how the entity moves through the simulation ii. From one station to the next iii. "Route time" the time required to travel
Process 	i. Representing the station and process for the station involved ii. Set a time for each process iii. Determine wheatear the action of the process is delay, seize delay, seize delay release or delay release. iv. Determine the delay type for this simulation triangular and constant have been used.
Dispose 	i. The last process where the palm fruit that has been sent to the factory will go to the next process which is the process of producing crude palm oil and palm kernel. ii. The factory is able to accommodate as much as 50 metric tons for an hour or more.
Run setup	i. Determining the time taken in a day which is the working period, the total time for all of them for 12 hours a day for the delivery process from one station to another station.

3.2.2 Simulation result and recommendation

As stated at Table 3 the proposed layout demonstrates notable improvements compared to the current layout [14]. With a significant reduction in input, streamlined processing, and a considerable decrease in average building cost per 100 meters, the proposed layout showcases enhanced efficiency and cost-effectiveness [15]. Although there is a decrease in number out, the overall positive impact on transfer time and total production time suggests a more optimized workflow. The data reveals a significant enhancement in operational efficiency with the proposed cableway transfer process, clocking in at 25.251 hours compared to the 26.8345 hours required by the current method a remarkable 5.89% reduction in total time. This improvement points towards a more streamlined workflow, likely achieved through faster transportation mechanisms and optimized processes. These findings highlight the potential benefits of adopting the proposed layout for a more streamlined and cost-efficient production process. The idea using the cableway system can be applied to a large-scale palm oil processing companies or for a new company that may be built in the future, by applying the system to a larger company, the cableway system will be able to be applied as much as possible and can increase productivity for an oil palm factory.

Table 3 *Summary of the results*

Layout / Data	Current layout	Propose layout
Number in *1:10	50	5
Number out *1:10	4	4
Value added (Hrs)	18.9456	18.1501
Wait time (Hrs)	7.2566	6.8509
Transfer time (Hrs)	0.6323	0.25
Total time (Hrs)	26.8345	25.251
Average building cost (100 meter)	RM 17 000.00	RM 11 245.16

4. Conclusion

In summary, the study was successful in accomplishing its goals; the site visit allowed for the proper identification, timing recording, and inclusion of the palm fruit delivery procedure in the flow process chart. Following data collecting, the concept to use the cableway system was put forth as a way to optimize the distribution process. Arena software simulation was used to implement the notion. Following the development of the simulation for both the suggested delivery process and the current one, a comparison is shown, with the suggested delivery procedure demonstrating a clear improvement of 5.89% over the current one. This demonstrates unequivocally that the way the suggested delivery procedure is laid out can be very significant.

In addition, the cost of construction is also one of the comparisons that have been taken into account where the construction of roads to deliver palm fruit can reach up to RM 17K while the construction of the cableway system only takes around RM 11K. In summary, the analysis reveals the pros and cons of the current and proposed layout for oil palm delivery. The existing layout accommodates more fruit, while the proposed layout increases productivity by reducing delivery time. Arena Simulation helps in construction, emphasizing the need for in-depth research to optimize improvements and increase productivity, especially in the palm oil sector.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Muhammad Izzat Hakimi, Tengku Nur Azila;* ***data collection:*** *Muhammad Izzat Hakimi;* ***software simulation:*** *Muhammad Izzat Hakimi, Shaiful Rizal* ***analysis and interpretation of results:*** *Muhammad Izzat Hakimi, Tengku Nur Azila, Shaiful Rizal;* ***draft manuscript preparation:*** *Muhammad Izzat Hakimi, Tengku Nur Azila. All authors reviewed the results and approved the final version of the manuscript.*

The author confirms sole responsibility for the following: study conception and design, data collection, software simulation, analysis and interpretation of results and draft manuscript preparation.

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