RESEARCH PROGRESS IN MECHANICAL AND MANUFACTURING ENGINEERING VOL. 3 NO. 1
(2022) 68-73

RPMME

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773-4765

ARENA Simulation Training Guideline for Assembly Line

Norsahira Maslazim[1], Sh Salleh Sh Ahmad[1, *],

[1]Faculty of Mechanical and Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rpmme.2022.03.01.007
Received 15 Nov. 2021; Accepted 15 April 2022; Available online 30 July 2022

Abstract: As a beginner for the unfamiliar software such as Arena Simulation, it is very tough when we need to do a simple model by referring to the textbooks or journal articles that contains a lot of difficult words to understand. Therefore, a guideline was created to solve this problem that contains simple wordings, more infographic and the simple step by step procedures that are easy to follow, understand and to help the users. The purpose of the study was to build a training guideline for modeling an assembly line by using Arena Simulation, to build a model representing the assembly process using the training guide, and analyze the simulation result for the assembly line model. The study was conducted using Arena Simulation software. The data was collected based on the actual model to be inserted into the system setting for validation purposes. The model was created with 32 hours replications length to achieve accuracy in the result. The difference between the actual and simulation model must be below 5% percent to said the model is valid. To verify the guideline is applicable we build another example of the model and compared the simulation result with the actual simulation data from the textbook. To validate the model, we calculated the percentage difference between the actual and simulation model results. This simulation finding indicated that the guideline is suitable to be used as a learning tool and reference for users to model an assembly line. To conclude, this project has successfully provide a basic guideline for modelling an assembly line using Arena software and there is still a lot of rooms for future improvement.

Keywords: ARENA Simulation, Training Guideline, Assembly Line

1. Introduction

The simulation has been in the industry since the 1950s and it involves creating a model, building a model or applications that mimic the real scenario in production or assembly line for that industry [1]. Nowadays, business managers are rapidly embracing modelling and simulation as required competencies. So, most organizations required simulation for the best decision, improving the process, and reduce the cost of production. The simulation method is the most powerful tool for deciding for a person that works in designing a process system that difficult to analyze by using the traditional approach [2]. Hence, most companies rely on simulation to test new ideas and options that need to improve in the production or assembly line.

*Corresponding author: saleh@uthm.edu.my

Usually, to grasp this simulation ability such as the Arena software, we need to explore or go through several tools related to the software such as books, paper, posts and so on. As the beginner of this simulation, this common method is not efficient since anyone can easily getting tired and bored because the words in that book or article are so hard to understand. Moreover, the books have many pages to go through the wilful text and insufficient of infographic image to make us misunderstand the topic. Then by providing a clear guide, it can help someone that needs to learn about this ARENA simulation easier and can make it as references.

So in this case study, we created a simple guideline to show how the ARENA simulation software is used in modelling an assembly line. Also, this guideline shows a case study that is commonly involved in assembly lines with a simple flow that does not exceeding ten major processes. It is because, we need to make the beginner users to have more understanding of the concepts and to identify the symbols in ARENA simulation for creating a simple model flows of the systems. Hence, the users can apply this guideline to create a simple model for the system before they can proceed to the advanced version of ARENA simulation.

The simulation is a useful tool that able to communicate to all concerned with the management and operators on exactly how the operations will function and the implications that might happen [3]. With an animated Arena Simulation model, the goals are to design the model, change the model, and “test drive”. It is applied to the actual system or assembly line before the improvements are introduced by referring to the basic guidelines that have been made. Then, by simulation, we can analyze the result of the assembly line model and it is also made the person easily to refer to the guideline.

2. Literature review and Methodology

2.1 Introduction

The simulation modeling can be applied as analysis tools to estimate the changes of existing systems and predict the performances of the new system under a variety set of parameters (Marsudi & Shafeek, 2013). For example, before a company wants to decide to buy or upgrade for a new machine for the production line, the managements need to " test drive" all the parameters until getting the best value or performance. They can then select whether to purchase or enhance the performance of that machine. Hence they can save money by purchasing only the equipment capable of obtaining the characters that they want.

One of the most common simulation software used by the industries is Arena Simulation (Kelton, 2015). The Arena Simulation is also known as one of the most sophisticated simulation modeling program for solving industry issues. This simulation helps the user to create, predict and measure the strategies of the system effectively and optimized performance. Arena simulation is quite challenging even to build a simple model because it was hard to understand the words in the textbooks or journals.

Therefore, in this case study, we build a training guideline that contains simple words and more infographic on how to create a simple model step by step to make sure the users can easily understand. As a result of referring to the guidelines, the novice of this simulation is eager to learn more about it. Figure 1.0 shows the front page of the manual in this case study.

Figure 1.0: The front page of the training guideline for Arena Simulation software

2.2 Equations for verification and validation

Every test needs verification and validation to ensure that the simulation model can represent the actual production system. In this case study, we build a model based on the training guidelines and compare it with the example in the textbook. At the same time, we make sure that the step in the manual guideline can easily be understood with simple words used to create a simple model specifically for the beginner in the arena simulation. If the model simulation results show similarity with the existing example in the textbooks, this means model built is validated and verified.

For the verification purpose we conducted the static testing to make sure the model is free of function and logical errors. Validation on the models are defined to ensure the simulation model's accuracy and animation, the data that been used is correct and it also represents the real production system. The difference between the output of simulation and the actual data is calculated using the following formula in Eq.1:

$$Difference\ (\%) \frac{=|Simulation\ manual - simulation\ textbook|}{|simulation\ textbook|}\ x\ 100\% \quad \text{Eq.1}$$

2.3 Methodology

The methodology approach for this case study is comparing the actual model in the Arena textbooks by Kelton (2015) and the modified model based on the guideline. Both models contain two exercises named Exercise 4.1 and Exercise 4.2 which are referred to the textbook. Both exercises have two parts called Part A and Part B. The process for Part A is called Prep A and Part B is Prep B. The same parts were used to create two models that represent the actual model based on the arena textbook~~s~~ and the modified model~~s~~ for the guideline. For both models, the procedure to built them is the same. The replication and base time units are what distinguishes them.

The original model must operate for 32 hours replication with simulation based time unit in minutes with 24 hours per day, but the updated model must run 10 days with a 16-hour operating time each day. After simulating both models, we need to calculate the percentage difference to validate and verify. The percentage difference that we had achieved is below 5 percent. Therefore, our guideline was considered successful and correct in terms of validation and verification. Figure 2 shows the model in the Arena Simulation after running the simulation. Figure 3 and Figure 4 shows the data based on both models for Exercise 4.1 and Exercise 4.2.

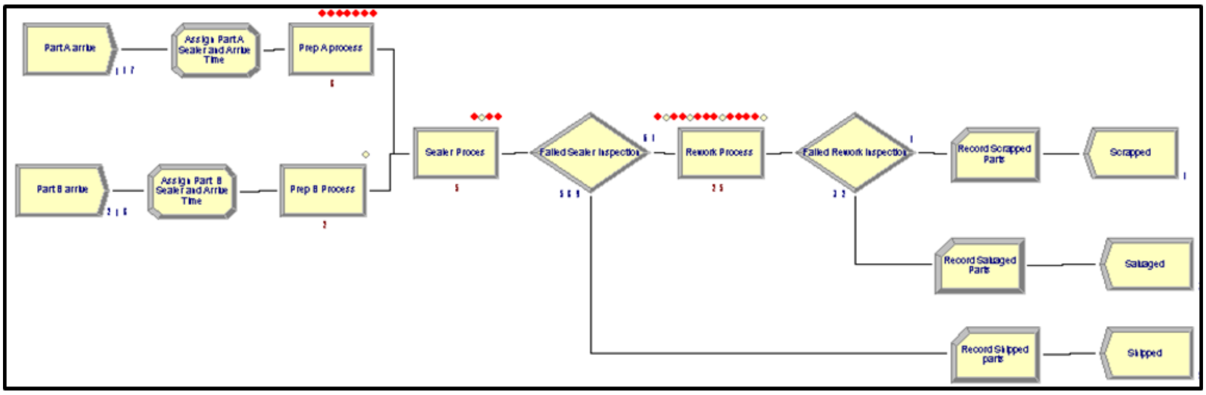

Figure 2: The model for electronic assembly line after running the Arena Simulation

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Prep A Process.Queue	14.6220	(Correlated)	0.00	46.3460
Prep B Process.Queue	26.9037	(Insufficient)	0.00	85.9510
Rework Process.Queue	456.35	(Insufficient)	0.00	810.98
Sealer Process.Queue	2.5153	(Correlated)	0.00	14.0456

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Prep A Process.Queue	3.1680	(Correlated)	0.00	11.0000
Prep B Process.Queue	3.5017	(Insufficient)	0.00	14.0000
Rework Process.Queue	12.9534	(Insufficient)	0.00	26.0000
Sealer Process.Queue	0.8631	0.334935455	0.00	6.0000

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Prep A Process.Queue	19.2028	(Correlated)	0.00	121.70
Prep B Process.Queue	51.4159	(Correlated)	0.00	207.79
Rework Process.Queue	116.25	(Insufficient)	0.00	397.74
Sealer Process.Queue	7.8260	(Correlated)	0.00	68.9696

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Prep A Process.Queue	3.8876	(Correlated)	0.00	27.0000
Prep B Process.Queue	6.8862	(Correlated)	0.00	33.0000
Rework Process.Queue	3.6329	(Correlated)	0.00	15.0000
Sealer Process.Queue	2.6266	(Correlated)	0.00	22.0000

Figure 3: The result of Exercise 4.1 & Exercise 4.2 for the actual model in Arena Simulation

Table 4-1. Selected Results from Model 4-1 and Model 4-2

Result	Model 4-1	Model 4-2
Average Waiting Time in Queue		
Prep A	14.62	19.20
Prep B	26.90	51.42
Sealer	2.52	7.83
Rework	456.35	116.25
Average Number Waiting in Queue		
Prep A	3.17	3.89
Prep B	3.50	6.89
Sealer	0.86	2.63
Rework	12.95	3.63

Figure 4: The result of Exercise 4.1 & Exercise 4.2 for the modified model in Arena Simulation

3. Results and Discussion

3.1 Results

The production line model execution by using arena simulation needs to be verified and validated before further study related to the model could be done (Heshmat et al., 2013). According to Rani, Ismail, and Ishak (2014), the percentage difference between adjusted simulation data and actual data must be less than 10% to be considered as successful verification and validation. The current case study model is considered effective because the percentage discrepancy between the modified simulation and actual data for exercises 4.1 and 4.2 is less than 5%, as indicated in Table 1.0.

We had successfully fulfilled the requirements for the first and second objectives for this case study. The first objectives state to build a training guideline for modeling an assembly line using Arena simulation. And the second objective mentioned creating a model based on the assembling process by referring to the manual guide.

Table 1.0: Summary for the result modified simulation data and actual data for Exercise 4.1 and Exercise 4.2

Parameter	Entities	Simulation data 4.1	Actual data 4.1	% difference	Simulation data 4.2	Actual data 4.2	% difference
Average Waiting time	Prep A	14.6220	14.62	0.014	19.2028	19.20	0.015
	Prep B	26.9037	26.90	0.014	51.4159	51.42	0.008
	Sealer	2.5153	2.52	0.19	7.8250	7.83	0.05
	Rework	456.35	456.53	0	116.25	116.25	0
Average Number of waiting time	Prep A	3.1680	3.17	0.064	3.8876	3.89	0.06
	Prep B	3.5017	3.50	0.05	6.8912	6.89	0.056
	Sealer	0.8631	0.86	0.03	2.6256	2.63	0.13
	Rework	12.9534	12.95	0.04	3.6329	3.63	0.08

3.2 Discussions

Based on Table 1.0, in Exercise 4.1, the modified simulation data for average waiting time for Prep A is 14.6220, whereas Prep A textbook is 14.62. As a result, the percentage difference is 0.014 percent. For Exercise 4.2, there is a 0.015 percent percentage difference between Prep A and Prep A textbook~~s~~. These steps are carried out again for Prep B, the Rework process, and the Sealer process. The percentage difference between Part B Exercises 4.1 and 4.2 is 0.014 percent and 0.008 percent, respectively. The difference in the rework process queue is the same for both manual and textbook. While the sealer process in Exercise 4.1 differs by 0.19 percent percentage point from the sealer process in Exercise 4.2 by 0.05 percent percentage point. Following that, the amount of waiting period~~s~~ for manual Exercise 4.1 is 3.1680 for Prep A, 3.5017 for Prep B, 12.9534 for rework, and 0.8631 for Sealer. The textbook answers for this Exercise 4.1 are 3.17 for Prep A, 3.50 for Prep B, 0.86 for Sealer, and 12.95 for waiting for rework. As a result, the percentage difference between this procedure in Exercise 4.1 ranged from 0.03 to 0.06. These also are exhibited for Exercise 4.2 for the % difference number of waiting time Part A Prep, Part B Prep, Sealer, and Rework Process are 0.06,0.056,013 and 0.08 correspondingly.

Looking at the table, we can see no percentage difference in average waiting time for the Rework process for both Exercises. However, in terms of average waiting time, they obtain only 0.04 percent for Exercise 4.1 and 0.08 percent for Exercise 4.2. Overall, the percentage difference between the simulation and actual data collected achieved less than 5 %. So, our system mimics the textbook simulation of the production line due to the comparison between these data.

4. Conclusion

Lastly, this case studies is considered successful because we had achieved all the objectives of the study. First, we build a training guideline for modeling an assembly line by using Arena simulation. With the guide, we need to create a model representing the assembly process in the Arena Simulation. Then, we had to analyze the simulation result of both assembly line models. The guideline is the approach for the users to learn and understand more about Arena simulation easily compared to read the advanced word in the textbooks. The steps by steps on creating a simple model in the training guide make the users able to come out with the other simple example in the future.

In the future, this guideline needs to be improved by adding different case studies and visual animation. The training guideline can make the users feel interested to learn more about this simulation. Arena simulation is famous in the manufacturing company because this simulation can mimic the actual scenario in the production line. This simulation approach provides great flexibility to change the parameter without intervening with the actual production process.

Acknowledgement

The authors would also like to thank the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] Andradóttir, S., Healy, K. J., Withers, D. H., Nelson, B. L., Law, A. M., McCommas, M. G., Law, A. M., & Box, P. O. (1997). *Proceedings of the 1997 Winter Simulation Conference Simulation of Manufacturing Systems*: 86–89.

[2] Azhar, A. (2008). *Modelling, Simulation and Analysis of an Automotive Manufacturing System Using ARENA Software*: 42-43

[3] Bon, A. T., & Shahrin, N. N. (2016). Assembly line optimization using arena simulation. *Proceedings of the International Conference on Industrial Engineering and Operations Management, 8-10 March*: 2225–2232.

[4] Heshmat, M, and M G El- Sebaie. 2013. "Simulation Modeling Of Production Lines : A Case Study Of Cement Production Line," 1045–53.

[5] Kelton, W. D. (2015). *Sixth Edition Arena Simulation* 4(2): 41-46.

[6] Marsudi, M., & Shafeek, H. (2013). *The Evaluation of Production Line Performance by Using ARENA – A Case Study*. *7*(9): 1831–1835.

[7] Rani, Ruzanita Mat, Wan Rosmanira Ismail, and Izzaamirah Ishak. 2014. "An Integrated Simulation and Data Envelopment Analysis in Improving Production System." *World Journal of Modelling and Simulation* 10 (2): 136