Lean Management: Reducing Complexity Towards Improving Process Flow Using Arena Simulation in IR4.0

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Abstract

The purpose of this study is to simplify the complexity of process flow in manufacturing company and evaluate the improved process flow using Arena Simulation. Lean is a method for continuous improvement and elimination of wastes, it can be applied in to any process including the processes in manufacturing. This study aimed to simplify the complexity of process flow and examine the improved process flow with Arena Simulation. Qualitative research method is applied in this study and the data will be collected by using observations and surveys. Then, data collected will be analysed by using Arena Simulation. Conclusion, this paper has successfully accomplished the objectives as the improved process flow results in a greater output of 346 compared with 303. And also, the effectiveness and efficiency of productivity increase as the total time used in the process decreases at most 31.61%.

Keywords
Lean, Complexity, Arena Simulation.

1. Introduction
At first, they started Lean Manufacturing with the goal of reducing procedures that don't add value to the end product. Sartal et al. (2017) shows how lean manufacturing may increase industrial performance by leveraging technology-enabled capabilities in their study. It is believed that their production performance will be able to improve and also stabilize the quality of their outputs by implementing lean management in manufacturing industries. Complexity was defined as the state of having many different parts connected or related to each other in a complicated way. "One source of complexity is the interactions among different levels of the system" (Rouse & Serban, 2014). Furthermore, a complex system is made up of interconnected elements that, as a whole, exhibit one or more behaviours that are not obvious from the features of the individual parts. The combination of product, process, and organisation results in a complex system that engineers and managers struggle to comprehend.

The main functions of lean, is to deliver product's value from customers' perspective, to eliminate waste and to improve continuously. Therefore, the process flow will be able to eliminate waste processes by implementing the lean technique. As a result, the production team will be concentrated on tasks that provide value to their customers and the quality of product will be improved indirectly. In conclusion, industries or management that applied lean technique will be far more adaptable and able to respond to customers' requirements much quicker than those industries or management without lean. Lean management concepts will enable system to build a consistent production system with a greater likelihood of enhancing overall performance.

Today, the manufacturing industry is the fastest expanding and has become an important element in the country's economic growth. The manufacturing industry has existed since the colonial era, although its contribution was minimal at the time, accounting for around 8% of national Gross Domestic Product (GDP). Malaysia's manufacturing

sector has grown quickly since the early 1980s, when the country transitioned from an agrarian to an industrial economy. Malaysia then went on to pursue a plan to diversify its economy, with the objective of becoming a country focused on economic activities with greater added value, while also reducing an over-reliance on commodities upstream, notably tin and rubber. Since the Malaysian government launched an industrial policy in the 1980s, there has been extraordinary progress, as evidenced by the National Industrial Policy and the Industrial Master Plan. This fundamental transition occurred when the country realised that it needed to lessen its reliance on imports and build technology-based industries to assure the national economy's prosperity.

Based on the data sourced from Department of Statistics Malaysia, it is very clear to see a dramatic growth of Gross Domestic Product (GDP) from manufacturing in Malaysia from year 2012 to year 2020. Hence, it is very important to maintain and improve the quality of product. In order to overcome the challenge of this growing demands in market, lean management should be applied to reduce the complexity and improve the process flow. Figure 1 shows GDP from manufacturing sector in Malaysia from 2012 t0 2020.

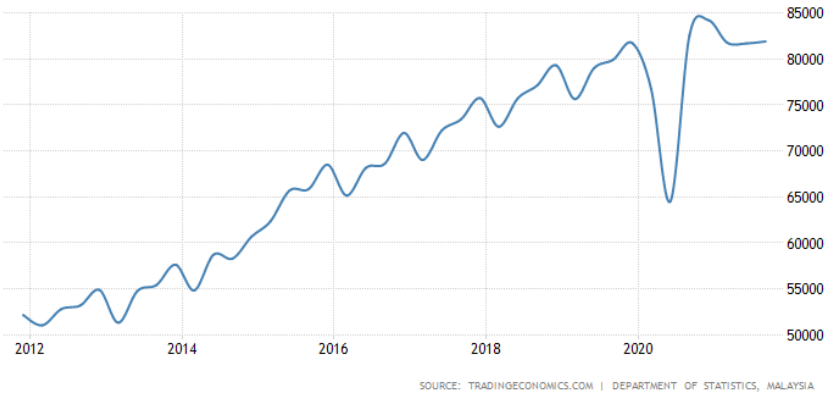


Figure 1: GDP From Manufacturing in Malaysia from year 2012 to 2020 (source: Department of Statistics, Malaysia)

The growth of Gross Domestic Product (GDP) is very obvious and stable. In January 2020, GDP from manufacturing reached RM81740 million but then dropped to RM76745 million. Yet, GDP from manufacturing did not grow upwards after that and continue to drop dramatically at RM64512 million in July 2020. Even though the Gross Domestic Product (GDP) from manufacturing is having a stable growth, yet, the sources in manufacturing industries must be well planned. Hence the Movement Control Order (MCO) policy for pandemic of COVID-19 increased the burden of costs in the industries, lean management should be implemented in order to reduce any waste of resources so the costs will be decreased.

2. Methods

A research question is a question that you propose to answer through data collection (Monique Hennink et al., 2020). This study applies qualitative research method to collect data. Qualitative research methods collect data at a glance and in real time, where participants are experiencing problem. Researchers collect data in different forms such as interviews, observations and documents. Observations will be conducted on every process conducted in process flow. Also, surveys will be done so the researcher could collect more information about the process flow of the manufacturing company. Lastly, Arena Simulation will be used in analysing the data as it helps in finding the best approach to optimize and improve system performance.

The research methodology section describes all the necessary information that is required to obtain the results of the study. The research methodology consists of detailed information regarding workflow, strategy, and approach. The methodology adopted in carrying out the study should be well explained.

2.1 Research Design

Research design is the framework for the methodologies and approaches used by the researcher in his or her study. Research design usually can be divided into quantitative method, qualitative method and mixed method. Mixed method is easy to understand like how it called, it is a method which combines both quantitative method and qualitative

method. Qualitative research method is applied in this study. Qualitative research may be used to learn how a person subjectively perceives and interprets their social environment. Therefore, this research method may aid in the interpretation and better understanding of the complexity of process flow in the selected manufacturing company which located in Johor, Malaysia.

2.2 Research Process
This research begins with problem identification in the process flow of manufacturing industry. After the problem is identified, research objectives will be set up for this study. Then data will be collected and analyzed from the selected organization.

2.3 Problem Identification
In this study, an organization in Johor, Malaysia is targeted by the researcher. This organization is a manufacturing industry. Problem identification is the process of observing the actual problem and situation before approach to settle it. The process of problem identification includes clearly identifying a problem's main resource and providing a precise problem statement that outlines the problem's impact on the process flow.

2.4 Data Collection
Data collection is a systematic procedure of obtaining observations or measurements. Type of data that need to be collected is based on the research methodology applied in the research. Hence, qualitative data is needed to be collected in this study. There are some methods for the collection of qualitative data, which are observations, interviews, focus groups, surveys and secondary research.

2.5 Analyze Data
In this research, data is analyzed by using Arena simulation. Before the analyzation of data is run with Arena simulation, the researcher should arrange and construct the data collected through observation and surveys. Next, review and examine the collected data about its' pattern. After that, the researcher continues to analyze the data with Arena simulation. Arena simulation also functioned to analyze and solve problems. At the same time, the simulation applied with Arena works to reduce the waste of productions

3. Results and Discussion
3.1 Data Analysis
This section contains an examination of the data from the research era. The statistics represent the workplace's current status map. The deployment of value stream mapping in the company's production area was explored in this section.

3.2 Observation
The researcher observed the current state of process flow in the selected organization. Based on the observation at the selected organization's production process flow, there are 17 processes to go through to produce a DOCOMO adapter. At the same time, the number of operators needed in each process is noted down. And the process time and queue time in seconds are recorded in Table 1.

Table 1: Current process flow of DOCOMO adapter

Operation	Process	Operator	Process Time (seconds)	Queue Time (seconds)	Maximum Time (seconds)
1	Manual Insert 1	1	7.0	7.7	14.7
2	Manual Insert 2	1	6.7	8.0	14.7
3	Manual Insert 3	1	7.3	7.4	14.7
4	Manual Insert 4	1	6.7	8.0	14.7
5	Manual Insert 5	1	6.0	8.7	14.7

6	Manual Insert 6	1	5.7	9.0	14.7
7	Manual Insert 7	1	5.3	9.4	14.7
8	Solder	1	14.7	0.0	14.7
9	PWB App Check/ ICT	1	17.5	5.5	23.0
10	PWB Check Auto	1	17.0	6.0	23.0
11	DC Cod Solder	1	22.0	1.0	23.0
12	CCD Checking	1	23.0	0.0	23.0
13	Apply Grease & Bond	1	11.0	12.0	23.0
14	Case Assembly/ Welding & Aging	1	27.0	3.0	30.0
15	Electrical Check	1	30.0	0.0	30.0
16	Double Check	1	15.0	15.0	30.0
17	Packing	1	11.0	19.0	30.0

3.3 Create ARENA simulation for current process flow

Based on the observation made, the current process flow is simulated using ARENA simulation software and the analysis is done using ARENA Simulation.

(a) Simulation result for the current process flow

i. Entities result

Number Out can be also knowns as output. While the number in can be also known as input. The number of inputs and outputs of current process flow is shown in Figure 2.

Process Flow of DOCOMO adapter Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 86,400.00 Time Units: Seconds

Entity Detail Summary

Time

	NVA Time	Other Time	Total Time	Transfer Time	VA Time
Materials	0.00	0.00	274.22	0.00	272.22
Total	0.00	0.00	274.22	0.00	272.22

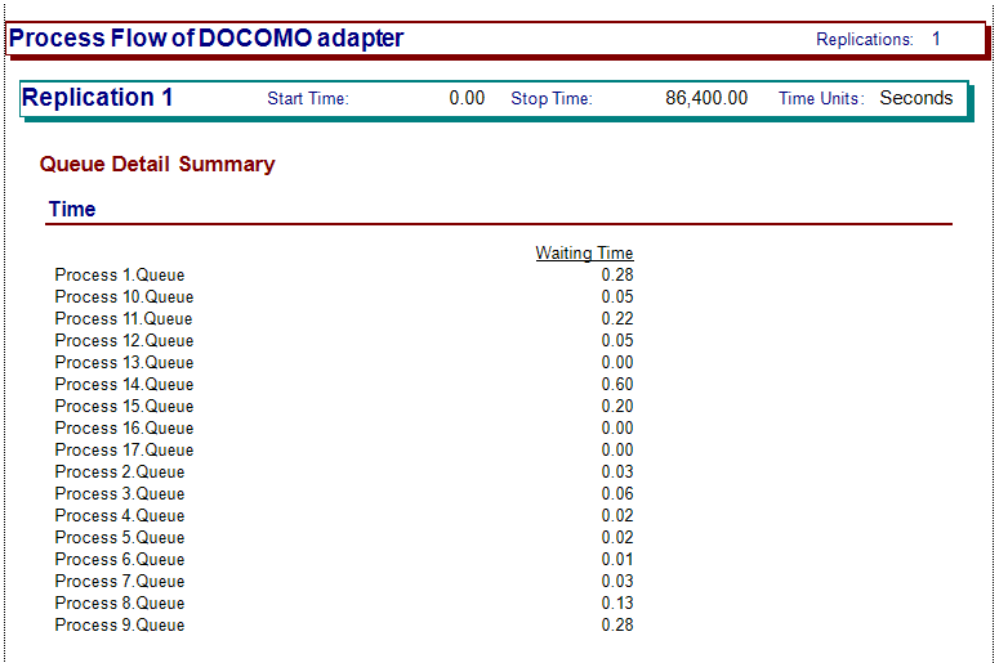
Other

	Number In	Number Out
Materials	305	303
Total	305	303

Figure 2: Entity detail summary of current process flow

ii. Queue result

Queue result shows the waiting time calculated in current process flow in the Figure 3.



Process Flow of DOCOMO adapter Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 86,400.00 Time Units: Seconds

Queue Detail Summary

Time

	Waiting Time
Process 1.Queue	0.28
Process 10.Queue	0.05
Process 11.Queue	0.22
Process 12.Queue	0.05
Process 13.Queue	0.00
Process 14.Queue	0.60
Process 15.Queue	0.20
Process 16.Queue	0.00
Process 17.Queue	0.00
Process 2.Queue	0.03
Process 3.Queue	0.06
Process 4.Queue	0.02
Process 5.Queue	0.02
Process 6.Queue	0.01
Process 7.Queue	0.03
Process 8.Queue	0.13
Process 9.Queue	0.28

Figure 3: Queue detail summary of waiting time in current process flow

3.4 Process improvement

Based on the collected data, improvement of process would be made to reduce and eliminate the waste to improve the efficiency and effectiveness of the production process flow of DOCOMO adapter. Some of the waste such as waste of waiting time and motion should be reduced as well.

(a) Improvement process flow through rearrange the process flow

From observation been done, the result found that the space arrangement of process flow could be improved in order to reduce the waste of waiting the product to reach another section. Researcher analysed there are many unnecessary stations that should be changed to improve the effectiveness and efficiency of current process flow.

(b) Eliminate waste in term of transportation through reallocate the operators

Based on the Table 2, researcher found that process time of production should be improved in order to reduce the waste of waiting the product to be done. In other words, process time of some processes should be balanced in order to reach a more balancing process time in the process flow.

3.5 Improved process flow

The research has proposed an improved process flow based on the data collected form the observation on the current process flow of DOCOMO adapter. 17 processes of the current process flow has now been combined become 13 processes in the improved current process flow as shown in the Table 2 in below.

Table 2: Improved process flow of DOCOMO adapter

Operation	Process	Operator	Process Time (seconds)	Queue Time (seconds)	Maximum Time (seconds)
1	Manual Insert 1	1	13.7	3.8	17.5
2	Manual Insert 2	1	14.0	3.5	17.5
3	Manual Insert 3	1	17.0	0.5	17.5

4	Solder	1	14.7	2.8	17.5
5	PWB App Check/ ICT	1	17.5	0.0	17.5
6	PWB Check Auto	1	17.0	0.5	17.5
7	DC Cod Solder	2	11.0	0.5	11.5
8	CCD Checking	2	11.5	0.0	11.5
9	Apply Grease & Bond	1	11.0	0.5	11.5
10	Case Assembly/ Welding & aging	2	13.5	1.5	15.0
11	Electrical Check	2	15.0	0.0	15.0
12	Double Check	1	15.0	0.0	15.0
13	Packing	1	11.0	4.0	15.0

(a) Create ARENA simulation for improved process flow

Based on the observation made, the improved process flow is simulated using ARENA simulation software and the simulation is shown in the Figure 4.

(b) Simulation result for the improved process flow

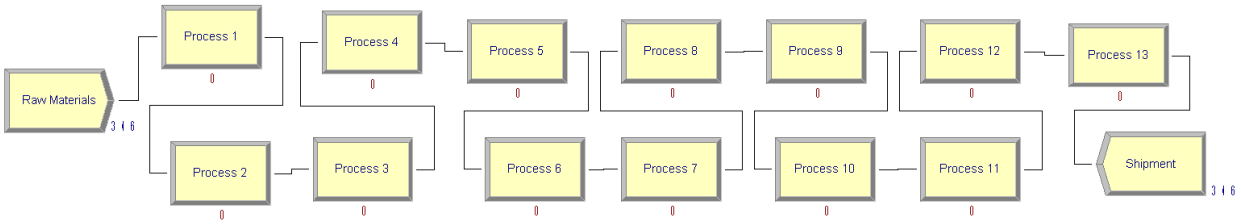


Figure 4: The simulation of improved process flow of DOCOMO adapter in Arena simulation

Lean management is based on the Toyota Production System (TPS) established in the 1940s centered around five principles:

i. Entities result

Number Out can be also knowns as output. While the number in can be also known as input. The number of inputs and outputs of current process flow is shown in Figure 5.

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Improved Process Flow of DOCOMO adapter Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 86,400.00 Time Units: Seconds

Entity Detail Summary

Time

	NVA Time	Other Time	Total Time	Transfer Time	VA Time
Materials	0.00	0.00	187.55	0.00	187.04
Total	0.00	0.00	187.55	0.00	187.04

Other

	Number In	Number Out
Materials	346	346
Total	346	346

Figure 5: Entity detail summary of improved process flow

ii. Queue result

Queue result shows the waiting time calculated in current process flow in the Figure 6.

Improved Process Flow of DOCOMO adapter Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 86,400.00 Time Units: Seconds

Queue Detail Summary

Time

	Waiting Time
Process 1.Queue	0.33
Process 10.Queue	0.00
Process 11.Queue	0.00
Process 12.Queue	0.00
Process 13.Queue	0.00
Process 2.Queue	0.05
Process 3.Queue	0.10
Process 4.Queue	0.00
Process 5.Queue	0.04
Process 6.Queue	0.00
Process 7.Queue	0.00
Process 8.Queue	0.00
Process 9.Queue	0.00

Figure 6: Queue detail summary of waiting time in improved process flow

3.6 Comparison among number in and number out

The result of the comparison among the number in (input) and number out (output) between current process flow and improved process flow is stated in the table below. Then the growth of input and output are shown in the figure 7. Table 3 shows the comparison of number in and number out between current and improved process flow.

Table 3: Comparison of number in and number out between current and improved process flow

	Current Process Flow	Improved Process Flow	Comparison (%)
Number In	305	346	↑ 13.44
Number Out	303	346	↑ 14.19

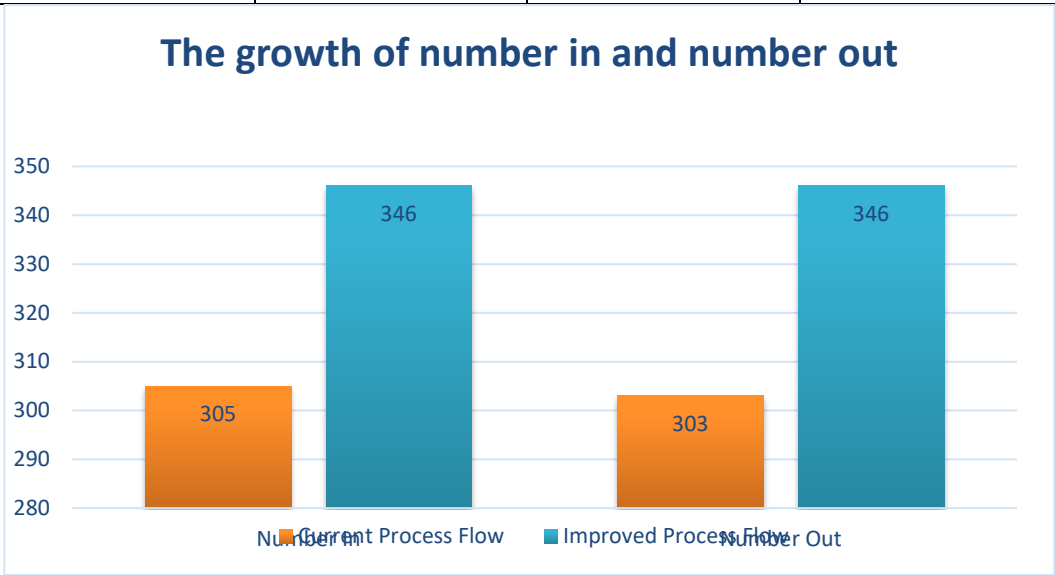

Figure 7: The growth of number in and number out

3.7 Comparison among processes in current process flow and improved process flow

The comparison has been made in the Table 4 below for the processes among the current and improved process flow.

Table 4: Comparison and combination of current process flow and improved process flow

CURRENT PROCESS	PROCESS NAME	IMPROVED PROCESS
1	Manual Insert 1	1
2	Manual Insert 2	
3	Manual Insert 3	2
4	Manual Insert 4	
5	Manual Insert 5	3
6	Manual Insert 6	
7	Manual Insert 7	
8	Solder	4
9	PWB App Check/ ICT	5
10	PWB Check Auto	6
11	DC Cod Solder	7
12	CCD Checking	8

13	Apply Grease & Bond	9
14	Case Assembly/ Welding & Aging	10
15	Electrical Check	11
16	Double Check	12
17	Packing	13

3.8 Comparison among the allocation of operators in current process flow and improved process flow

The comparison has been made in the Table 5 for the allocation of operators among the current and improved process flow.

Table 5: Comparison of allocation of operators in current process flow and improved process flow

CURRENT PROCESS	OPERATOR	PROCESS NAME	OPERATOR	IMPROVED PROCESS
1	1	Manual Insert 1	1	1
2	1	Manual Insert 2		
3	1	Manual Insert 3	1	2
4	1	Manual Insert 4		
5	1	Manual Insert 5	1	3
6	1	Manual Insert 6		
7	1	Manual Insert 7		
8	1	Solder	1	4
9	1	PWB App Check/ ICT	1	5
10	1	PWB Check Auto	1	6
11	1	DC Cod Solder	2	7
12	1	CCD Checking	2	8
13	1	Apply Grease & Bond	1	9
14	1	Case Assembly/ Welding & Aging	2	10
15	1	Electrical Check	2	11
16	1	Double Check	1	12
17	1	Packing	1	13

3.9 Comparison among the total time and value added time in current process flow and improved process flow

The result of the comparison among the total time and value added time between current process flow and improved process flow is stated in the Table 6. Then the growth of input and output are shown in the Figure 8.

Table 6: Comparison of total time and value added time between current and improved process flow

	Current Process Flow	Improved Process Flow	Comparison (%)
Total Time	274.22 seconds	187.55 seconds	↑ 31.61
Value Added Time	272.22 seconds	187.04 seconds	↑ 31.10

3.10 Comparison among the waiting time in current process flow and improved process flow

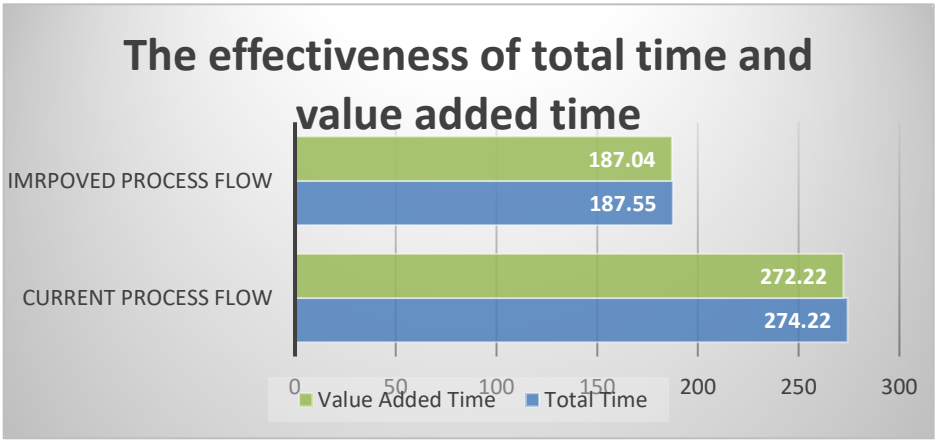

Figure 8: The effectiveness of total time and value added time between current and improved process flow

The comparison has been made in the Table 7 for waiting time among the current and improved process flow.

Table 7: Comparison of waiting time of each process between current process flow and improved process flow.

CURRENT PROCESS	WAITING TIME (seconds)	IMPROVED PROCESS	WAITING TIME (seconds)
Process 1	0.28	**Process 1**	0.33
Process 10	0.05	**Process 10**	0.00
Process 11	0.22	**Process 11**	0.00
Process 12	0.05	**Process 12**	0.00
Process 13	0.0	**Process 13**	0.00
Process 14	0.60	**Process 2**	0.05
Process 15	0.20	**Process 3**	0.10
Process 16	0.00	**Process 4**	0.00
Process 17	0.00	**Process 5**	0.04
Process 2	0.03	**Process 6**	0.00
Process 3	0.06	**Process 7**	0.00

Process 4	0.02	**Process 8**	0.00
Process 5	0.02	**Process 9**	0.00
Process 6	0.01		
Process 7	0.03		
Process 8	0.13		
Process 9	0.28		

4. Conclusion

As conclusion, three objectives of this study have been achieved by implementing lean management, existing problems and all the non-value added processes are identified. Three of the objectives in this research are accomplished in Chapter 4 by implementing the lean management and simulation by using Arena simulation. Lean management helps to eliminate the waste in process flow and also increases the efficiency and effectiveness of productivity in daily schedule. While ARENA simulation software helps in simulating the improved process flow, make sure the improved process flow is functionable and applicable to the process flow. The purpose of this study is to simplify the complexity of process flow in manufacturing company and evaluate the improved process flow using Arena Simulation. Lean is a method for continuous improvement and elimination of wastes, it can be applied in to any process including the processes in manufacturing. This study aimed to simplify the complexity of process flow and examine the improved process flow with Arena Simulation. Qualitative research method is applied in this study and the data will be collected by using observations and surveys. Then, data collected will be analysed by using Arena Simulation. Conclusion, this paper has successfully accomplished the objectives as the improved process flow results in a greater outputs of 346 compared with 303. And also, the effectiveness and efficiency of productivity increase as the total time used in the process decreases at most 31.61%.

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Biography

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Identification of these pathways may allow improvement to be implemented. Ahmad Nur Aizat also works and collaborates with industry and the small medium enterprise sector on various aspects of learning, projects and collaborations. He has published a number of articles in related topics in various publishers indexed by SCOPUS. Before joining UTHM, he was a lean expert in the international aerospace company and gained lots of knowledge regarding manufacturing aspects. He aims to expand knowledge and inspire others to explore multidisciplinary fields with passion to address and solve problems and challenges. He is also a Principal Researcher at Universiti Tun Hussein Onn Malaysia's at the Manufacturing Technology Management Focus Group (MTM FG). Dr. Ahmad Nur Aizat can be contacted via email, aizat@uthm.edu.my.