Evaluation of Warehouse Operation in Power Plant Company Using Discrete Event Simulation

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Abstract

This research was performed at the warehouse of an Indonesian power plant operation and maintenance (O&M) company. This unit controls supply chain activities for non-production materials. Based on initial observations, it was found that the operator has exceeded working time. Thus, operator often worked outside of operational hours. This has an effect on a number of workloads as well as discrepancies in material stock information. The focus of this research is to evaluate the warehouse's operational performance. This study focuses on two main warehouse operations, namely inbound and outbound materials. A discrete event simulation method is used to solve the problem. Performance measurement is carried out using the Arena software. The findings show that RFID technology can improve operational tasks by reducing cycle times, enhancing utility, and increasing productivity.

Keywords
Discrete Event Simulation, Warehouse Operation, Power Plant

1. Introduction

In the supply chain, warehouses play an important role (Dolgui and Proth 2010). Because of the complexity of warehouse management, measuring warehouse performance is a critical topic (Wu and Dong 2007). Warehouse performance measurement has been carried out and explored by many researchers and experts in various ways. In terms of objectives, these performance measurements differ from each other (long or short term decisions), a way of measuring objectives (various performance indicators), warehouse system type (distribution centers, cross-dock platforms, etc.), priority areas in warehouse, (storage , retrieval, etc.), the measurement instruments (statistical tools, mathematical programming, simulation modeling, etc.) (Keebler and Plank 2009).This research was performed at a power plant operation and maintenance (O&M) company located in Pekanbaru, Indonesia. Warehouse operational activities are the primary activity of supply chain management in power plant O&M companies. In this unit, the warehouse functions as a service center and the availability of non-production materials which are generally used for the maintenance process, so that every warehouse operational process needs to be considered in order to meet these needs. Based on initial observations, it was found that the operational working time of the operator had exceeded the standard time which caused the accumulation of work and discrepancies in the material stock information data in the inventory system. The actual time that exceeds the standard time indicates that there is a delay of work so the operator must work overtime. Comparison of actual time and warehouse operational standards and data on material stock information discrepancies can be seen in tables 1 and 2

Table 1. Comparison of Actual Time and Warehouse Operating Standard

Actual Time			**Standard Operating Time**	**Status**
Actual Time Inbound Operations	I	463,9	360	*Overworking Hours*
	II	407	360	*Overworking Hours*
	III	360,8	360	Normal
Actual Time Outbound Operations	I	383,2	360	*Overworking Hours*
	II	372,7	360	*Overworking Hours*
	III	361,2	360	Normal

Table 2. Sample Data Discrepancy of Actual Material Stock and Inventory System

No.	***Item Number***	**Actual Stock**	**Inventory Stock**	***Discrepancy***
1.	100000002	45	37	+8
2.	100000009	4	24	-20
3.	100000010	20	24	-4
4.	100000026	14	16	-2
5.	100000027	16	58	-42
6.	100000028	6	14	-8
8.	100000056	21	41	-20
9.	100000103	5	27	-22
10.	100000130	0	19	-19

In order to meet material needs and gain a competitive advantage. Companies must evaluate warehouse operational activities and see whether the operational processes have been running well and effectively? in order to meet material needs and gain a competitive advantage. A discrete event simulation (DES) was used to evaluate warehouse operations in this study. Discrete event simulation is a method of simulating events that are defined as conditions with variables that can change instantly at different times (Lestari 2018). Discrete event simulation, known as system modeling, is a method for evaluating discrete processes like manufacturing, transportation, queuing, service, and operational systems (Kusnandar and Perdana 2014). Discrete event simulation can be a very useful, time-efficient, and cost-effective tool to evaluate and develop operational processes without having to physically build, change, or damage the system (Karagiannaki 2010). Thus, the aim of this study is to evaluate a set of performance criteria by developing a simulation model that would assist stakeholders in evaluating warehouse operational activities.

1.1 Objectives

This study aims to evaluate the existing warehouse operational system of power plant companies through performance measures with three measurement indicators in the form of cycle time, utility, and productivity. In addition, this study also aims to provide recommendations for alternative solutions in the form of two proposed systems, namely the addition of man power and the application of Radio Frequency Identification technology (RFID). The limitation of the problem in this study is the use of observational data which is time of the operational activities of inbound materials and outbound materials. This research was conducted at a power plant O&M company in Pekanbaru City, Indonesia. In this study, the assumption made is First In First Out service. This study only focuses on the time-based operation process, without considering the layout of the facility.

2. Methods

This study is based on a case study at a power plant O&M company in Pekanbaru, Indonesia. The method is used for performance measurement with a discrete event simulation approach. Performance measurement aims to evaluate the model through the performance measurement attributes that have been designed. The model is measured using Arena software which describes warehouse operational activities. There are several steps that must be followed to find the results of simulation modeling, namely problem formulation, conceptual modelling, verification and validation, experimentation and analysis of results.

2.1 Problem Formulation

Warehouse operational evaluation with performance measurement is formulated into three performance attributes including cycle time, waiting time, and productivity. These attributes are measured using a discrete event simulation approach.

A. Cycle Time

Cycle time describes the total time of each operational activity ($\sum Ti$) inbound and outbound materials. The Inbound process starts from unloading materials to update process on inventory system. Meanwhile, the outbound process starts from the material plan process to update process on inventory system. Low cycle time indicates as a good cycle time. Total Cycle time can be calculated following equation:

$$TCT = \sum Ti \qquad (1)$$

Where,
TCT = Total Cycle Time
Ti = Cycle time activity-i

B. Utility

Utility is defined as the ability of resources to complete services both in the material inbound and the material outbound. High utility indicates that resources can provide good benefits in completing services. Utility is calculated by Eq. (2) as follows:

$$\text{Utility} = \frac{\text{Actual Output}}{\text{Maximum Possible Output}} \text{ x } 100\% \qquad (2)$$

Where,
Actual Output = Number out
Maximum Possible Output = 90% x Number In

C. Productivity

Productivity is defined as the ratio of the number of outputs (number out) divided by the number of inputs (number in). Productivity shows the ability of the system to complete services where the higher productivity, the better system. Productivity can be calculated as:

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}} \text{ x } 100\% \qquad (3)$$

2.2 Conceptual Modelling

Conceptual modelling is an initial model that is required to represent a system in developing simulation modelling into software. Arena software was used to convert a conceptual model into a simulation model. Structure, operational, and numerical data are compiled into a simulation model in this simulation model. Figure 1 shows a simulation model of warehouse operations.

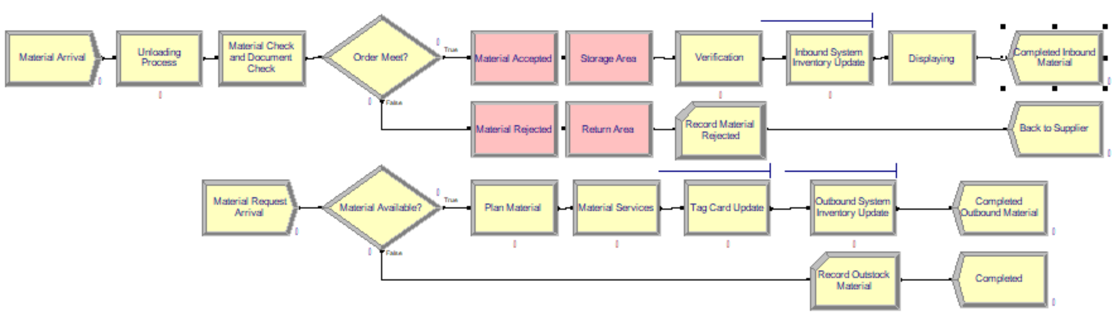


Figure 1. Simulation model of warehouse operations

2.3 Verification and Validation

Verification is used to check whether there are errors in the system and ensure the model works correctly and according to logic. This study is supported by Arena simulation software. Thus, software verification is performed by pressing F4 check model or by selecting the check model command in the run menu and a notification appears. Therefore, verification is a technique for collating data to check whether there are errors in the Arena model. Validation using simulation is carried out to compare the output of the simulation model with the records in the actual system to properly consider the model. Thus, the solution can be applied to a real system. Subsequently, these results were discussed with stakeholders for the validity of the model.

2.4 Experimentation and Result Analysis

At this stage, a simulation model that has been created, as well as other alternatives that may exist, will be run. The simulation runs according to the real conditions of the system, for 26 days and 8 hours of work per day. This study adopts the type of terminating simulation to analyze the simulation output. In addition, to obtain the desired level of accuracy in simulation modeling, this study adopted Paired-t confidence interval to match the sample and determine replication. Result analysis is used to estimate the performance criteria of the system. The estimation results are used to answer the research question. Experiments also consist of two systems, an existing system which is used to evaluate the system and a proposed system as an alternative system that will be the solution to the problem. The proposed system consists of two alternatives. Alternative 1 is an alternative to adding human resources. This alternative uses the logic of adding one resource with one server. Alternative 2 is an alternative technology modification in the form of Radio Frequency Identification (RFID) technology in the inventory update process both at the material inbound or material outbound. This alternative system uses the logic of changing the delay type in both processes to be "constant" in one second.

3. Data Collection

The data is collected for the evaluation of operational activities by measuring performance using a discrete event simulation approach. It is carried out based on structural data, operational data, and numerical data (Lestari et al., 2016).

3.1 Structural Data

Structural data is needed to describe the flow of services until the service is completed for each section. Thus, operational activities are represented by physical flows. In addition, this data is built based on activities in business processes.

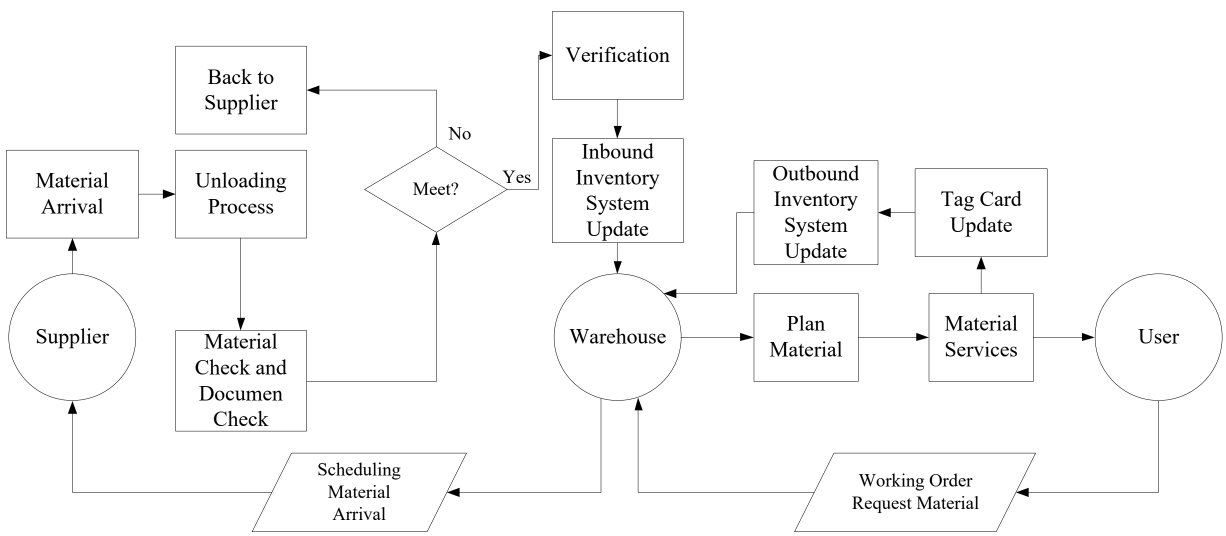


Figure 2. Structural data

3.2 Operational Data

The process of evaluating performance is done by transforming the relationship between entities into a model, which is done by converting structural data into operational data. As a result, operational data is closely linked to entity-to-entity operations. This study shows the operational process of a power plant material warehouse which consists of two main processes, namely Inbound and Outbound of materials. The Inbound process is the process of entering goods into the warehouse, while the Outbound process is the process of meeting material needs by removing goods from the warehouse. Each of these main processes is counted as completed when it has been recorded in the inventory system.

3.3 Numerical Data

The next stage is transforming numerical data in the form of time observation data for the entire process of material Inbound and material Outbound into the form of data distribution obtained from the input analyzer process on the Arena software. Table 3 shows detailed numerical data based on case studies.

Table 3. Numerical Data

Operation	*Resource*	*Distribution*	*Expression*	*Square Error*	*Item*
Material Arrived	Inbound	Triangular	TRIA(-0.001, 36.8, 368)	0.039383	
Unloading Material	Inbound	Poisson	POIS(16.1)	0.039778	
Material and Document Checking	Inbound	Triangular	TRIA(9.5, 28.1, 33.5)	0.026760	
Material and Document Checking fulfill?					Yes : 95% No : 5%
Verification	Inbound	Beta	181 + 119 * BETA(0.57, 0.741)	0.036271	
Update System Inventory Inbound	Inbound	Beta	40.5 + 32 * BETA(0.477, 0.597)	0.146512	
Material Request	Outbound	Beta	-0.5 + 54 * BETA(0.946, 2.48)	0.011424	
Material available?					Yes : 90% No : 10%
Plan Material	Outbound	Beta	14.5 + 16 * BETA(1.29, 0.983)	0.019762	
Services Material	Outbound	Beta	14.5 + 17 * BETA(1.06, 1.16)	0.015618	
Hanging Card Update	Outbound	Beta	9.5 + 6 * BETA(1.4, 1.35)	0.014030	
Update System Inventory Outbound	Outbound	Beta	16.5 + 44 * BETA(0.725, 0.582)	0.147223	

4. Result and Discussion

Two models were created based on the experimental process: the existing system and the suggested system. The existing system shows the system that is currently being implemented in warehouse operations, while the proposed system has two alternative systems that can be used as a solution for this case. The following simulation results are shown in table 4.

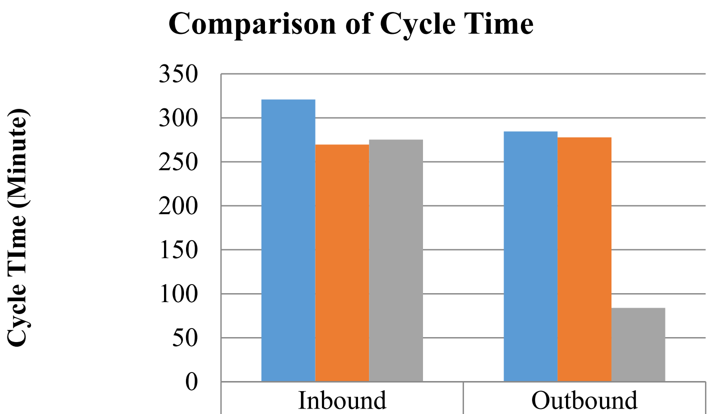
Table 4. Comparison of the Existing System and proposed System

Operation	**Resource**	**Cycle Time (Minute)**			**Number In**			**Number Out**		
		I	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
Unloading Material	Inbound	16,67	16,37	16,30	4	5	5	2	3	3
Material and Document Checking		23,40	23,68	23,03						
Verification		228,70	184,32	235,97						
Update System Inventory Inbound		52,05	45,28	0,03						

Plan Material		23,24	23,29	23,00						
Services Material		22,71	22,47	22,37						
Hanging Card Update	Outbound	112,86	106,38	23,47	35	36	35	10	10	28
Update System Inventory Outbound		125,67	125,59	15,16						

Note: (I) Eksisting, (II) Alternative 1, (III) Alternative 2

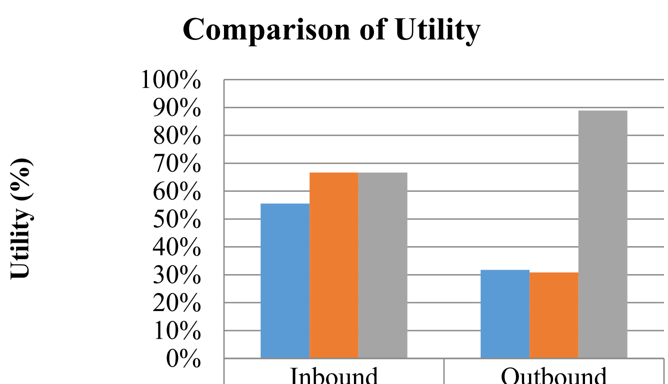
The simulation results in table 4 are interpreted into performance measures such as cycle time, utility, and productivity. Cycle time describes the overall time necessary for each part to process the service from start to finish. A comparison of cycle times is shown in Figure 3.



	Inbound	Outbound
Existing System	320.82	284.48
Altenative 1	269.65	277.73
Alternative 2	275.33	84

Fugure 3. Comparison of Cycle Time

Based on the comparison of cycle times, Alternative 1 is preferable to alternative 2 in terms of revenue, whereas alternative 3 is superior in terms of spending. Shorter cycle times imply that the service can be done rapidly.



	Inbound	Outbound
Existing System	56%	32%
Altenative 1	67%	31%
Alternative 2	67%	89%

Figure 4. comparison of Utility

Figure 4 shows a comparison of the utility for each section. On the Inbound side, there is no most superior alternative, but both alternatives can increase utility up to 67%. While in the Outbound section, utility in the existing system shows a low number, namely 32%, so that the most superior alternative is alternative 2, which can increase utility up to 89%.

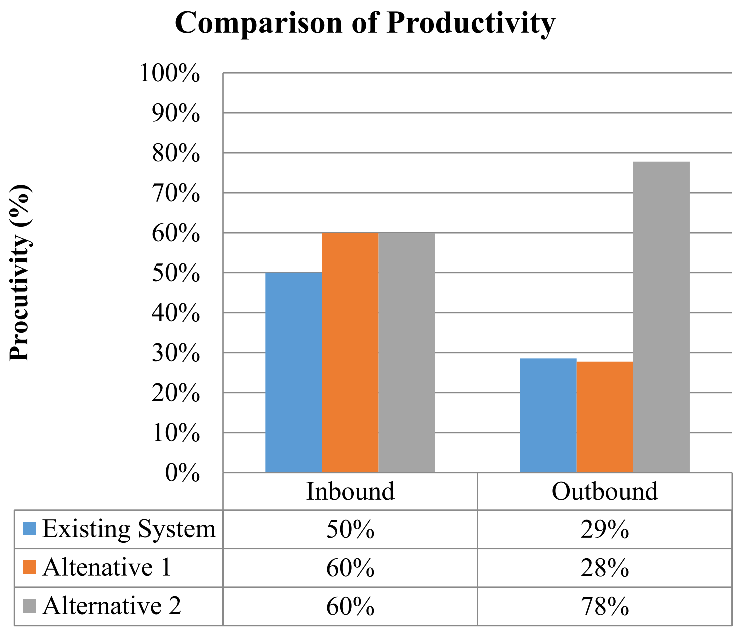


Figure 5. Comparison of Productivity

In Figure 5 can be seen the comparison of productivity. The results in the graph illustrate that there is no superior alternative in the Inbound area, although both alternatives can enhance productivity by up to 60%. In the Outbound area, productivity shows a low figure of 29%, so that the most appropriate solution is found in alternative 2 with an increase in value of up to 78%.

Table 5. Summary of The Result

	System	Cycle Time	Utilitas	Produktivitas
Inbound Section	Eksisting	320,82	56%	50%
	Alternative 1	269,65	67%	60%
	Alternative 2	275,33	67%	60%
Optimization		Alternative 1	Alternative 1 & 2	Alternative 1 & 2
Outbound Section	Eksisting	284,48	32%	29%
	Alternative 1	277,73	31%	28%
	Alternative 2	84	89%	78%
Optimization		Alternative 2	Alternative 2	Alternative 2

Performance measurement with a discrete event simulation approach using Arena shows that alternative 2 is better than alternative 1. The use of technology in the form of RFID is believed to be able to provide convenience in warehouse operational activities both in the inbound materials and outbound materials.

5. Conclusion

Evaluation of warehouse operational activities at O&M power plant companies can be done with a discrete event simulation approach using Arena software. This study shows a comparison of performance measurements on three systems, namely the existing one, alternative 1 is the addition of man power, and alternative 2 is the application of RFID technology. Performance measurement is measured through three indicators, namely cycle time, utility, and productivity. The results showed that in the inbound section, the optimization of cycle time was achieved by alternative 1 with a time of 269.65 minutes, while for utility and productivity optimization was achieved by alternatives 1 and 2 with a percentage of 67% and 60%. In the outbound section, the optimization of cycle time, utility, and productivity is achieved by alternative 2 with the respective results of 84 minutes cycle time, 89% utility, and 78% productivity. Overall, this study shows that the application of RFID technology in warehouse operations is very helpful for each process of its activities. This research can also assist stakeholders in the decision-making process.

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