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Optimizing Utilization by Using Promodel and Fmea Queue Methods at Toll Gates

Monalisa Eka Febriana [1], Asep Endih Nurhidayat [2]
[1,2] Universitas Indraprasta PGRI
Email: monaliesaf@gmail.com, aennoerhidayat@gmail.com

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ABSTRACT

PT Citra Marga Nusaphala Persada Tbk is a toll road company headquartered in Jakarta, Indonesia. Until the end of 2020, this company holds concessions for five toll roads in Java Island. Looking at the queue report, it can be seen that there are still a large number of vehicle queues on the highest toll roads, namely 65 vehicles at 19.00-20.05 hours. Long queue lengths can affect customer dissatisfaction with the service system on the toll road so that it can be detrimental to the company, moreover the lack of maximum automatic machine work is the main factor in long queues. Of all the problems that occur can be solved using the queuing method and FMEA. The goal is to find out how to deal with queues on toll roads and find out how to deal with automatic machines working optimally. Based on the results that have been obtained, the company only opened 2 automatic substation machines. There are many obstacles that occur, including there are still queues due to the less than optimal machine work. So that this research was carried out to fix the problem that occurred by adding 1 automatic substation machine. The difference in the utilization rate is very large, namely 10.96% to 31.51%, with the result that the number of vehicles waiting is 0, meaning there are no vehicles queuing. The high RPN results from the results of the FMEA method make it the basis for the need for preventive maintenance measures to avoid total engine shutdown which results in long queues at toll exits. This action consists of providing maintenance workers who guard the substation to guard against machine problems by working 3 shifts and periodic checks starting from the system to its components.

1. Introduction

Currently, the demand for transportation has been increasing every year, resulting in a large volume of vehicles passing through toll gates on a daily basis, especially at the toll gates for tourists entering the city. This often causes long queues, especially during peak hours in the morning and evening. The congestion can cause

inconvenience for toll road users as they feel that the service they receive is not worth the money they paid (Nugraha et al., 2019). If no effort is made to reduce traffic congestion on the toll road, it will lead to a decrease in the number of toll road users. The long queues at toll gates can cause financial and time losses for both parties (Lukman & Angriani, 2018).

PT Citra Marga Nusaphala Persada Tbk is a toll road company headquartered in Jakarta, Indonesia. As of the end of 2020, the company held concessions for five toll road sections on Java Island. The automation system is aimed at maximizing service, but in reality, there are still queues due to the less-than-optimal performance of the toll booth machines (Simarmata, 2010). Based on reports, there are still a significant number of vehicle queues at the busiest toll gate, with 65 vehicles queuing between 7:00 PM and 8:05 PM. The long queue can affect customer satisfaction with the toll service, potentially causing losses for the company. Furthermore, the less-than-optimal performance of the toll booth machines is the main factor causing the long queues (Barata, 2003).

All these issues can be addressed by using queuing theory and Failure Mode and Effect Analysis (FMEA). Queuing theory is a situation where people or goods are waiting in line to be served (Heizer & Render, 2015). FMEA is an engineering technique used to identify and eliminate known failures, problems, errors, and the like from a system, design, process, and/or service before it reaches the customer (Yulinda Hanif R, 2015).

2. Materials and Methods

The research method used in this study is action research, a type of research conducted to obtain practical findings for operational decision-making purposes in the observed research object. Then, a study is conducted to make improvements using relevant knowledge, so the results of this research can be used as corrective measures for the company in the future. The data used for this research are from machine downtime and company operational reports (Rangkuti, 2019).

4. Results and Discussions

Based on the data collection that has been obtained and the exposure of problems that have occurred, data processing is carried out to find out the appropriate improvement proposals. Data processing consists of 2 stages, namely the first based on data processing using the Queue method and the second data processing using the FMEA method (Nurfitria et al., 2015)(Nengsih, 2020). Here are the stages of data processing as follows:

1. Data processing using the Queue method

In actual data processing, the reference data is based on the company's actual data by going through several stages as follows:

a. etermine the P0 value in each service facility (M/M/2)

In this situation, arrivals form a single line to be served by a single station. Data processing at this stage to calculate the probability of queuing to be served. The formula of each result that has been contained in the data analysis technique. Here are the results that have been obtained as follows:

Table 4.2 Results of P0 values in each service facility (M/M/2)

Moon	Arrival (N)	μ	M	PO
1	64	15	2	2,27
2	51	15	2	1,40
3	48	15	2	1,20
4	21	15	2	0,60
5	55	15	2	1,67
6	65	15	2	2,33
Total	304	90	12	8,27

Source : Research

Based on the results that have been obtained, the average vehicle queuing is 2 cars with the highest level in January and June as many as 3 cars. This occurs a buildup of vehicles that want to get out where the exit lane hampers the process of vehicles that want to park as well.

b. Calculate the results of Ws, Ls, Lq and Wq

This stage is the next stage of the PO results that have been obtained to find out more details about the waiting time for the vehicle to come out. The formula of each result that has been contained in the data analysis technique. Here are the results that have been obtained as follows:

Table 4.3 Results Ws,Ls,Lq and Wq

Ls	Ws	Lq	Wq	Wq (Minutes)
273,07	1,77	5,57	0,09	5,22
173,40	1,71	4,82	0,09	5,67
153,60	1,69	4,65	0,10	5,82
29,40	1,29	4,90	0,23	14,00
201,67	1,73	5,04	0,09	5,50
281,67	1,77	5,63	0,09	5,20
1112,80	9,94	30,62	0,69	41,41

Source : Research

Based on the results that have been obtained, the number of vehicles waiting in the system in 6 months is 1113 cars.

c. Calculating Utilization results using Promodel Software

Labor utilization is the ratio of actual working time spent to the total amount of available working time (AS & Shalahuddin, 2015). In the utilization results of this promodel, it is seen to determine the percentage of waiters who can serve customers. Here are the promodel results that have been obtained as follows:

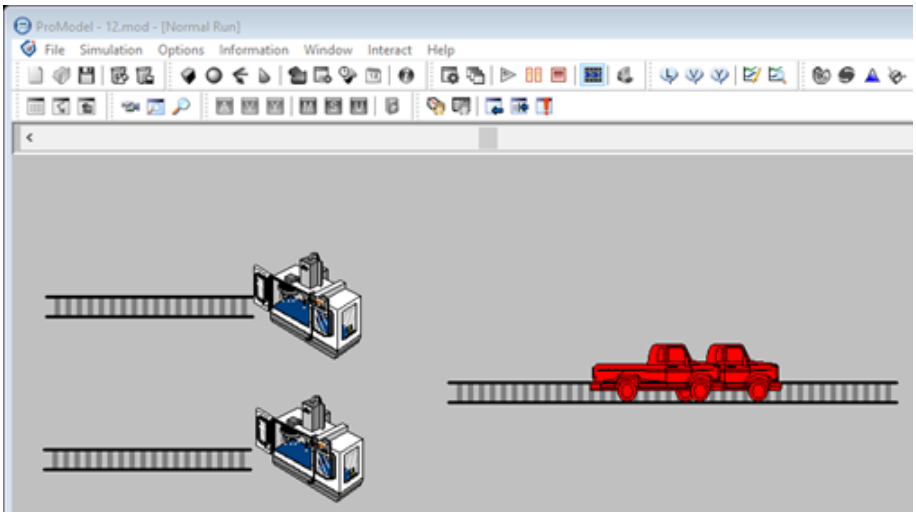
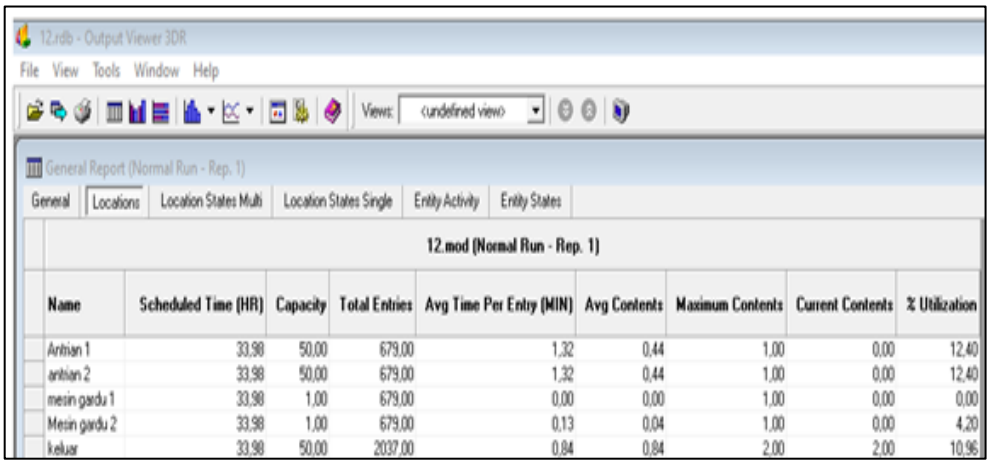


Figure 4.1 Promodel *Parking System* M/M/1
Source : Research



Name	Scheduled Time (HR)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization
Antrian 1	33,98	50,00	679,00	1,32	0,44	1,00	0,00	12,40
antrian 2	33,98	50,00	679,00	1,32	0,44	1,00	0,00	12,40
mesin gardu 1	33,98	1,00	679,00	0,00	0,00	1,00	0,00	0,00
Mesin gardu 2	33,98	1,00	679,00	0,13	0,04	1,00	0,00	4,20
keluar	33,98	50,00	2037,00	0,84	0,84	2,00	2,00	10,96

Figure 4.2 Utilization Results of Promodel *Parking System* M/M/2
Source : Research

Based on the results that have been obtained for the service system, only 1, namely the result of entrance utilization, which is 12.40% with an obstructed parking exit rate of 10.96%.

2. Data processing using the FMEA method

The FMAE used in this study is the process FMAE where the definition of the system here is a production machine (Pratama, 2019). The FMEA approach is used

to improve the most prioritized policies in order of the largest value to the smallest value from the Risk Priority Analysis (RPN) results (Botutihe et al., 2018). To get the RPN value, you must first know the values of severity, occurrence and detection (Oktaviana et al., 2020). Therefore, to obtain severity, occurrence and detection, a scale or criteria of events must be made according to the FMEA method.
The following table 4.4 is the severity criteria on automatic substation machines, as follows:

Table 4.4. *Severity Criteria*

Effect	*Severity Criteria*	Rank
Dangers Without Warning	Failure is very high, endangering visitors as well as the machine environment but there is no damage warning	10
Danger with Warning	Very high failure, endangering visitors and the machine environment with a damage warning	9
Very High Interference	*The Oven* Machine cannot operating due to the loss of the main functions of the machine	8
Annoyance Tall	*The Oven* Machine cannot Operate	7
Moderate Impairment	*The Oven Machine* can be operated but there are parts that cannot function	6
Low Interference	*Oven machine* can operate but experience performance degradation	5

Source : Research

Table 4.4. *Severity Criteria* (Advanced)

Very Low Interference	*Oven machine* can operate with normal but needs reset	4
Minor Disturbances	*The oven* machine can operate normally but the operator notices a small disturbance	3
Very Minor Interference	*The oven* machine can operate normally and the effects of interference do not interfere with the performance of the machine	2
No Distractions	*The oven* machine can operate normally and there is no effect of any interference	1

Source : Research

Based on failures contained in automatic substation machines. So the rank and scale of occurrence are determined to be Table 4.5 below:

Table 4.5. Occurrence criteria

Failure Whistle	Scale of Failure occurrence	Rank
Very High	1 per 30 days	10
	1 per 50 days	9
Tall	1 per 100 days	8
	1 per 6 months	7
Keep	1 per 1 year	6
	1 per 2 years	5
Low	1 per 3 years	4
	1 per 5 years	3
	1 per 10 years	2
Controlled	never at all (1 failure more than 10 years)	1

Research Resources

Based on the failure contained in the substation machine. So the rating and detection scale are set as follows:

Table 4.6. *Detection Criteria*

Detection	*Detection Criteria*	Rank
Not Detected	The failure could not be detected and inflict severe damage	10
Little	*Failure mode* is not easily detected	9
Very Low	Very low detection, machine *The oven* cannot operate but is visible to the operator	8
Low	Low detection, *oven* machine malfunctions	7
Small	Very low detection with replacement of existing parts does not work	6
Keep	Checking and Repair because a component has malfunctioned	5
Quite High	Detection is quite high, machine *oven* must undergo reset	4
Tall	High detection due to warning from *oven machine*	3
Very Tall	Very high detection with Routine inspections	2
Certainly	A definite failure was detected	1

Source : Research

Once known the scale or rank on each RPN variable such as *severity, occurrence and detection*. Below is a table of FMEA results on substation machine operating systems as Table 4.7 below:

Table 4.7. FMEA Results

FMEA *Worksheet*			**PT Citra Marga Nusaphala Persada Tbk**										
			Subsystem : Automatic Substation Machine										
No	**Component**	***Function***	***Failure Modes***		***Causes***		***Failure Effect***		**S**	**O**	**D**	**RPN**	Rank
1	Optical beam sensor	knowing whether the vehicle exists or does not exist, in addition to being a sign of separation between the vehicle in front and the one behind it	1	Faulty sensor	1	The exit bar can not	1	It is difficult to manage vehicles that have been queuing at the substation machine	5	4	5	100	3
2	*Loop coil*	detect if there is a vehicle on it (vehicle height)	1	Cannot be used	1	system illegibility	1	engine off	7	4	1	28	6
3	Treadle axel counting	Counts the number of axles owned by a vehicle.	1	Error	1	does not match the count	1	Non-specific data	5	4	5	100	4

Source : Research

Advanced Table 4.7 FMEA Results

FMEA *Worksheet*			**PT Citra Marga Nusaphala Persada Tbk**										
			Subsystem : Automatic Substation Machine										
No	**Component**	***Function***	***Failure Modes***		***Causes***		***Failure Effect***		**S**	**O**	**D**	**RPN**	Rank
4	Ultrasonic Sensor	Find out whether the bus vehicle is or not.	1	broken	1	Not according to rates	1	Less rates	3	4	4	48	5
5	Height sensor	Detecting the height of the vehicle (in the specification this time the result of this sensor not yet used).	1	faulty sensor	1	disruption of system performance	1	System not saved	5	4	5	100	2
6	AVC controller	To conclude what class of vehicles go through toll gates .ini.	1	Error	1	unusable	1	engine completely shut down	5	5	5	125	1

Source : Research

Based on the results of Table 4.7, the results of the RPN value of each component obtained the results of rank 1, namely in the avc controller and rank 2, namely the height sensor and rank 3, namely the optical beam sensor.

5. Conclusion

Based on the results obtained, the company only opened 2 automatic substation machines. Many obstacles occur including there are still queues due to the lack of maximum machine work. So this study was carried out to fix the problems that occurred by adding 1 automatic substation machine. The difference in utilization rate is very large, which is 10.96% to 31.51%, with the result that the number of vehicles waiting is 0 meaning there are no vehicles waiting in line. The high RPN result from the results of the FMEA method makes it necessary to carry out preventive maintenance measures to avoid complete engine shutdown which results in long queues at toll exits. The action consists of providing maintenance workers who maintain the substation to guard the machine by working 3 shifts and periodic checks starting from the system to its components.

Based on the data processing that has been carried out, appropriate improvement proposals are obtained, namely by adding substation machines and manpower, especially to repair problematic substation machines.

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