Analysis of Waiting Time and Worker Utilization on A Gas Station in Indonesia

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Abstract

Customer satisfaction is strongly influenced by the quality of service provided by the company. The number of requests that exceed the existing capacity can form delay in the system's queue. Henceforth, we made an observation at the 34.xxx.xxx gas station which is located on one of main street of Depok, West Java, Indonesia. The observation is focused on motorist and Pertalite gas refueling. Duration of the observation is 30 minutes for 5 work days during rush hour after working hours are over, which is at 4.30 pm – 5.00 pm where the customer's arrival rate increases rapidly. The purpose of this study is to improve the efficiency of gas station services, especially to minimize waiting time and worker utilization. In this case, the researcher uses Arena Simulation software with discrete event simulations at two servers. This research brings two improvement scenarios, to add one additional server, and add one operator to the existing server. As a result, the average waiting time is decreased to 7.58 for the first server and 19.86 for the second server if the gas station adds another server into the system. The first scenario even brings in an 1,04% increase of system productivity level.

Keywords
Discrete Event Simulation, Worker Utilization, Waiting Time, Gas Station

1. Introduction

Customer satisfaction is one of the main keys in serving customers. Furthermore, to get the optimal level of satisfaction from customers, there are several things that must be considered in analyzing the situation, such as the quality of products or services offered, to various consumer service provision that can support the fulfillment of customer satisfaction. A queue is created whenever there is more demand than the available service (Ebrahim Teimoury et al., 2011). Queues can occur in several places, especially in public facilities that are much needed by the general public, one of which is at the Public Refueling Station (Gas Station/SPBU). The limited number of facilities causes in certain situations customers have to queue to meet the fuel needs of motorists (Manalu &Palandeng, 2019).

As Taha (2003) said in Abel Anthony et al. (2013), There are several elements in a queue system such as Customer, Facility or Server, Inter arrival Time, Service Time, Queue Size and Queuing Discipline. Abel also said that there were several queuing disciplines, including FCFS (First Come First Serve), LCFS (Last Come First Serve) and SIRO

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(Service in Random Order). Identification of the relevant parties is necessary to analyze the queue that occurs, it will be profitable or detrimental. The analysis of the system is used to reduce or minimize the number of queues that occur so that customers are comfortable with the adjustments obtained. Queues at gas stations are one of the things that often happen, such as at Pertamina gas stations 34.xxx.xxx in Depok area. Queue system and time spent at the station are used to calculate Motorist arrival rates, which are the number of customers during this time and can indicate fuel consumption. (Fuzheng Zhang et.al, 2013). During rush hours there are often long queues of motorists to refuel. Queues can be up to 5-10 motorists that make consumers less patient and choose to look elsewhere to refuel. This has an impact on the lack of comfort of consumers in obtaining the expected service. This is because two-wheeled refueling stations have long queues of up to 3 meters. And it causes disruption to other vehicles such as, cars and trucks when it will refuel. Msugh Kembe et. al. (2017) said that queueing in a gas station can be caused by:

1. Faulty fuel pump dispensary (meter).
2. High-cost fuel at the other filling station or inaccurate metering
3. Location of the gas station
4. Inadequate channels and service space in the gas station
5. Scarcity of petroleum product from source

Queues often occur in public facilities that are much needed by the general public, one of which is the queue at gas stations. The queue can be avoided if the relevant parties can identify where the queue will be profitable or detrimental (Kusumaning Tyas, 2018). This study aims to analyze the condition of the fuel queue system at gas stations 34.xxx.xxx that is specialized in two-wheeled vehicles with Pertalite fuel types and to reduce the length of queues at the time of refueling to be more efficient through simulation by using Arena simulation software.

2. Literature Review

In this observation the study observed one entity, it is customer's motorcycle or in this case, we just called it motorist who queued, in refueling Pertalite at gas stations 34.xxx.xxx. Motorist / entities conduct Pertalite refueling assisted by gas station operators 34.xxx.xxx. or it can be called a resource. The relationship between motorists and gas station operators is 1 to 1, that one gas station operator can only serve one consumer's motorist at a time.

The main attributes to be measured are utilization and waiting time. After both attributes are obtained, the system productivity level will be gained, which will show an increase in the effectiveness and efficiency of the gas station system performance. Msugh Kembe et. al (2017), said that formation that accumulates over a period in a certain queue can causes an increase of customers waiting time, over utilization of available servers, and loss of customer's goodwill.

a. Utilization (r) is the level of performance of a refueling worker to complete the filling of incoming customer's motorist. Utilization is measured by using the customer arrival rate (l) and also the level of service that workers can perform in 1-hour (m) times the number of Workstation (s) (Obar Kinan Arighi, 2017, Fitra Lestari et. al., 2016). According to Gartner analyst Robert Handler, is between 70% – 80% utilization of team member's scheduled time (Kimberlee Meier, 2021).

$$r = l/sm$$

b. Waiting time is one of the major problem encountered in a gas station, and it's being relevant to conduct a study to find a solution for waiting time problem in the workstation (Msugh Kembe et. al, 2017). In this research, waiting time is obtained from the subtraction of final time, arrival time, and processing start time.

Waiting time = Final time – process time – arrival time

c. Productivity can be defined as output that exceeds input, which indicates the efficiency of the production system (Saurav Dixit et. al, 2017). In this case, productivity is calculated by dividing the number of customers who are successfully served by the workers during work hours. Output in the system obtained from number out and the input is from number in.

Productivity = Output / Input = Number Out / Number In

3. Methods

This queue simulation research begins with data retrieval directly through observation methods at 34.xxx.xxx gas stations. Data collection is done at a certain time, specifically in 30 minutes at 4:30 pm to 5:00 pm. The data taken is the customer's arrival time, station entry, service start time, final time, time between arrival, processing time, and queue time. then after the data is collected, the data is collected to then search for the type of data distribution using Arena simulation software. The next step is to design a model of simulated refueling queue using Arena Simulation Software. This queue simulation will describe the actual condition of the queue that occurs, if there is a long queue time then it is necessary to provide an alternative proposal to reduce the queue time of refueling. The existence of an alternative proposal will result in an increase of costs which is then calculated the amount of costs which will appear.

3.1 Structural Data

Structural data is necessary to describe the flow of raw material to be finished product that occurs (Fitra Lestari et. al.,2016). In this case, Pertalite gas can be categorized as raw material that must be given to the customers or motorists. At this stage explain the structure and flow of the gas station 34.xxx.xxx. data, starting from the customer data that goes into the payment process that will be received by the gas station workers. This data contains all the processes available in it so that it can be a reference for observation to analyze from the queue system.

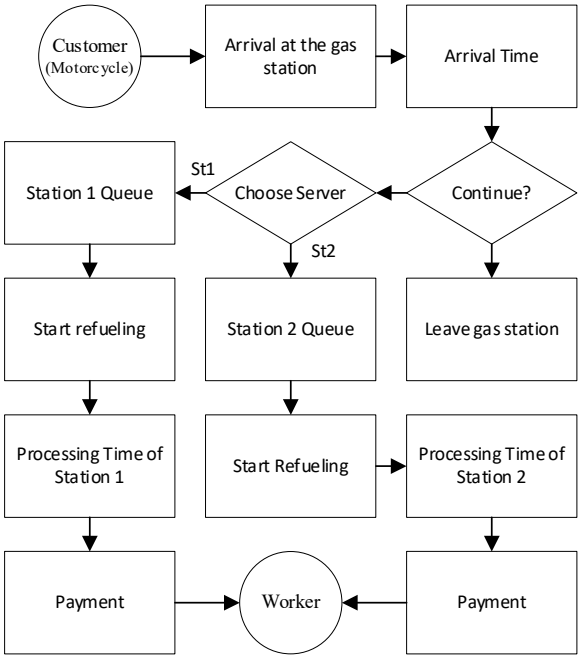

Figure 1. Structure Data of Gas Station 34.xxx.xxx Model

3.2 Operational Data

Operational data is related to the operational strategy among entities (Fitra Lestari et. al.,2016). The first step in measuring performance to change relationships between entities is to make a model that changes structural data in operational data, so that operational data is related to operational strategies between entities. This study categorizes the relationship strategy between motorists and gas station workers using the First Come First Served (FCFS) method where motorists arriving in line early will be served first by the gas station worker.

3.3 Numerical Data

Next is to define numerical data into arena simulation software. There are 4 operations connecting motorist and gas station workers. In this study each operation, covered by the resources that serve the entity of gas station workers. Furthermore, the resource performs operations on its entity, namely motorist to be served. Here's a table showing details of numerical data based on case studies.

Table 1. Numerical Data of Gas Station 34.xxx.xxx Model

Operation	Resource	Expression	Time	Item
Arrival	Motorist	Beta	0.5 + 59 * (0.834, 1.33) second	
Choose Server	Motorist			50% Station1 50% Station2
Station 1	Operator	Beta	35.5 + 15 * (1.43, 1.55) second	
Station 2	Operator	Beta	34.5 + 15 * (1.33, 1.17) second	

3.4 Assumptions of Model

As mentioned by (Masoud Rahiminezhad, 2013) and Msugh Kembe (2017), a few assumptions can be used in this simulation model such as:

1. The system assumed to be in a steady state
2. Arrival of entity is in a random state
3. There is no jockeying in the system
4. The capacity of queue is infinite
5. No customer leaves the system after entering queue.
6. The system uses FCFS basis.
7. The server only represents one product of fuel
8. The service providers are working to their full capacity
9. The average arrival rate is greater than the average service rate
10. Both arrival and departure rates are in dependent state, which means that they depend on the number of customers in the service facility
11. The observation process has been done in several days, and some fluctuations in the gas station is ignored.

4. Data Collection

In the previous research by Fuad Dwi Hanggara and Putra (2020), data collection is done by direct observation at the gas station within a predetermined time. The data taken starts from the beginning of the motorist arrives at the system until the motorist leaves the system. The data taken are arrival time, service start time, and service end time. From those three data, the following data can be obtained such as inter-arrival time, queue time, and processing time.

Table 2. Observation Data from Gas Station 34.xxx.xxx

Num.	Arrival Time	To Station	Service Start Time	Service Finish Time	Inter-arrival Time	Inter-arrival Time (sec)	Process Time	Process Time (sec)	Waiting Time
1	16:31:02	1	16:31:20	16:32:05	-	-	0:00:45	45	0:00:18
2	16:31:04	2	16:31:29	16:32:18	0:00:02	2	0:00:49	49	0:00:25
3	16:31:16	1	16:32:24	16:33:12	0:00:12	12	0:00:48	48	0:01:08
4	16:31:36	2	16:32:39	16:33:19	0:00:20	20	0:00:40	40	0:01:03
5	16:31:38	1	16:33:35	16:34:21	0:00:02	2	0:00:46	46	0:01:57
6	16:31:54	2	16:33:32	16:34:08	0:00:16	16	0:00:36	36	0:01:38
7	16:31:59	1	16:34:31	16:35:11	0:00:05	5	0:00:40	40	0:02:32

8	16:32:18	1	16:35:35	16:36:24	0:00:19	19	0:00:49	49	0:03:17
9	16:32:47	2	16:34:31	16:35:18	0:00:29	29	0:00:47	47	0:01:44
10	16:33:40	1	16:36:48	16:37:30	0:00:53	53	0:00:42	42	0:03:08
11	16:33:45	2	16:33:58	16:34:35	0:00:05	5	0:00:37	37	0:00:13
12	16:34:32	2	16:34:58	16:35:46	0:00:47	47	0:00:48	48	0:00:26
13	16:34:57	1	16:37:48	16:38:35	0:00:25	25	0:00:47	47	0:02:51
14	16:34:59	2	16:36:03	16:36:44	0:00:02	2	0:00:41	41	0:01:04
15	16:35:44	1	16:38:49	16:39:36	0:00:45	45	0:00:47	47	0:03:05
16	16:35:45	2	16:37:03	16:37:46	0:00:01	1	0:00:43	43	0:01:18
17	16:35:55	1	16:36:08	16:36:52	0:00:10	10	0:00:44	44	0:00:13
18	16:36:01	1	16:37:07	16:37:45	0:00:06	6	0:00:38	38	0:01:06
19	16:36:30	2	16:38:02	16:38:47	0:00:29	29	0:00:45	45	0:01:32
20	16:36:44	1	16:38:10	16:38:47	0:00:14	14	0:00:37	37	0:01:26
21	16:37:25	1	16:39:06	16:39:42	0:00:41	41	0:00:36	36	0:01:41
22	16:37:47	2	16:39:12	16:39:57	0:00:22	22	0:00:45	45	0:01:25
23	16:38:20	2	16:40:22	16:41:08	0:00:33	33	0:00:46	46	0:02:02
24	16:38:36	2	16:41:21	16:42:05	0:00:16	16	0:00:44	44	0:02:45
25	16:39:18	1	16:40:02	16:40:45	0:00:42	42	0:00:43	43	0:00:44
26	16:39:46	2	16:42:18	16:43:07	0:00:28	28	0:00:49	49	0:02:32
27	16:39:50	1	16:40:56	16:41:35	0:00:04	4	0:00:39	39	0:01:06
28	16:40:16	2	16:43:20	16:43:55	0:00:26	26	0:00:35	35	0:03:04
29	16:40:38	1	16:41:48	16:42:28	0:00:22	22	0:00:40	40	0:01:10
30	16:40:41	2	16:44:20	16:45:08	0:00:03	3	0:00:48	48	0:03:39
31	16:40:43	2	16:45:29	16:46:10	0:00:02	2	0:00:41	41	0:04:46
32	16:40:47	1	16:42:42	16:43:23	0:00:04	4	0:00:41	41	0:01:55
33	16:41:11	1	16:43:33	16:44:20	0:00:24	24	0:00:47	47	0:02:22
34	16:41:31	2	16:46:21	16:47:00	0:00:20	20	0:00:39	39	0:04:50
35	16:41:54	1	16:42:09	16:42:47	0:00:23	23	0:00:38	38	0:00:15
36	16:41:56	2	16:43:11	16:43:49	0:00:02	2	0:00:38	38	0:01:15
37	16:42:36	1	16:44:00	16:44:46	0:00:40	40	0:00:46	46	0:01:24
38	16:42:37	2	16:42:55	16:43:35	0:00:01	1	0:00:40	40	0:00:18
39	16:42:58	1	16:44:57	16:45:41	0:00:21	21	0:00:44	44	0:01:59
40	16:43:30	2	16:43:45	16:44:28	0:00:32	32	0:00:43	43	0:00:15
41	16:44:01	1	16:46:02	16:46:43	0:00:31	31	0:00:41	41	0:02:01
42	16:44:20	2	16:44:45	16:45:27	0:00:19	19	0:00:42	42	0:00:25
43	16:44:56	2	16:45:41	16:46:23	0:00:36	36	0:00:42	42	0:00:45
44	16:45:31	1	16:45:41	16:46:20	0:00:35	35	0:00:39	39	0:00:10
45	16:45:47	1	16:46:43	16:47:26	0:00:16	16	0:00:43	43	0:00:56
46	16:46:30	2	16:46:39	16:47:25	0:00:43	43	0:00:46	46	0:00:09
47	16:46:43	1	16:47:48	16:48:25	0:00:13	13	0:00:37	37	0:01:05
48	16:47:34	2	16:47:49	16:48:36	0:00:51	51	0:00:47	47	0:00:15

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49	16:48:15	1	16:48:50	16:49:29	0:00:41	41	0:00:39	39	0:00:35
50	16:48:43	2	16:48:54	16:49:36	0:00:28	28	0:00:42	42	0:00:11
51	16:49:35	1	16:49:50	16:50:28	0:00:52	52	0:00:38	38	0:00:15
52	16:49:37	1	16:50:47	16:51:33	0:00:02	2	0:00:46	46	0:01:10
53	16:49:56	2	16:50:15	16:50:57	0:00:19	19	0:00:42	42	0:00:19
54	16:50:24	1	16:51:52	16:52:31	0:00:28	28	0:00:39	39	0:01:28
55	16:50:47	2	16:51:00	16:51:39	0:00:23	23	0:00:39	39	0:00:13
56	16:50:49	1	16:51:05	16:51:46	0:00:02	2	0:00:41	41	0:00:16
57	16:51:33	2	16:52:00	16:52:35	0:00:44	44	0:00:35	35	0:00:27
58	16:52:14	2	16:52:48	16:53:28	0:00:41	41	0:00:40	40	0:00:34
59	16:52:53	2	16:53:43	16:54:22	0:00:39	39	0:00:39	39	0:00:50
60	16:53:13	1	16:53:26	16:54:08	0:00:20	20	0:00:42	42	0:00:13
61	16:53:37	1	16:54:29	16:55:16	0:00:24	24	0:00:47	47	0:00:52
62	16:54:22	2	16:54:32	16:55:18	0:00:45	45	0:00:46	46	0:00:10
63	16:54:28	1	16:55:36	16:56:19	0:00:06	6	0:00:43	43	0:01:08
64	16:55:03	1	16:56:36	16:57:26	0:00:35	35	0:00:50	50	0:01:33
65	16:55:32	2	16:55:43	16:56:29	0:00:29	29	0:00:46	46	0:00:11
66	16:55:37	2	16:55:53	16:56:38	0:00:05	5	0:00:45	45	0:00:16
67	16:56:17	1	16:57:37	16:58:25	0:00:40	40	0:00:48	48	0:01:20
68	16:57:16	1	16:58:45	16:59:28	0:00:59	59	0:00:43	43	0:01:29

5. Result and Discussion

5.1 Numerical Result

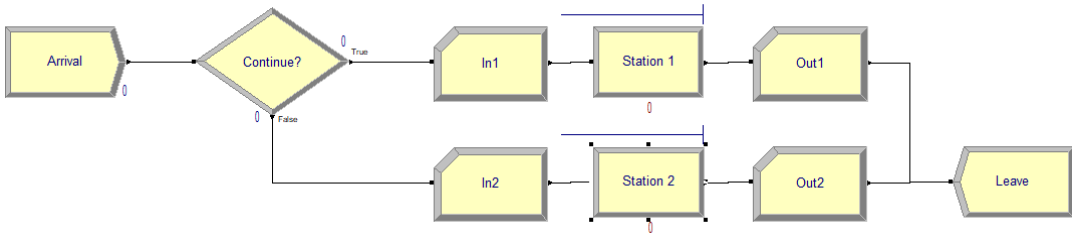

Figure 2. Arena Logical Model of Gas Station 34.xxx.xxx

The simulation runs for 5 days from Monday to Friday during after work rush hour, at 4.30 pm – 5.00 pm at gas station 34.xxx.xxx Depok. This simulation is focused on optimizing the work system so that the excessive waiting time and utilization of the system can be reduced. The existing gas station system as shown in Figure 3 was run with one replication for 30 minutes according to the research time under actual conditions. Based on the results of the report which obtained from the Arena Simulation Modeling, the average waiting time for Station 1 is 33.47 seconds with a maximum value of 106.06 seconds. As for Station 2, the average waiting time value is 62.74 seconds with a maximum value of 204.37 seconds. The arrival rate in 30 minutes is about 77 motorists with an average of processing time of 41.56 seconds and a maximum processing time value of 49.04 seconds.

The number of worker at each refueling station is one person. The average worker utilization rate of Worker 1 at the Station 1 is 90.11% with the same busy rate value. The average worker utilization rate of Worker 2 at the Station 2 is 83.6% with the same busy rate value.

5.2 Graphical Result

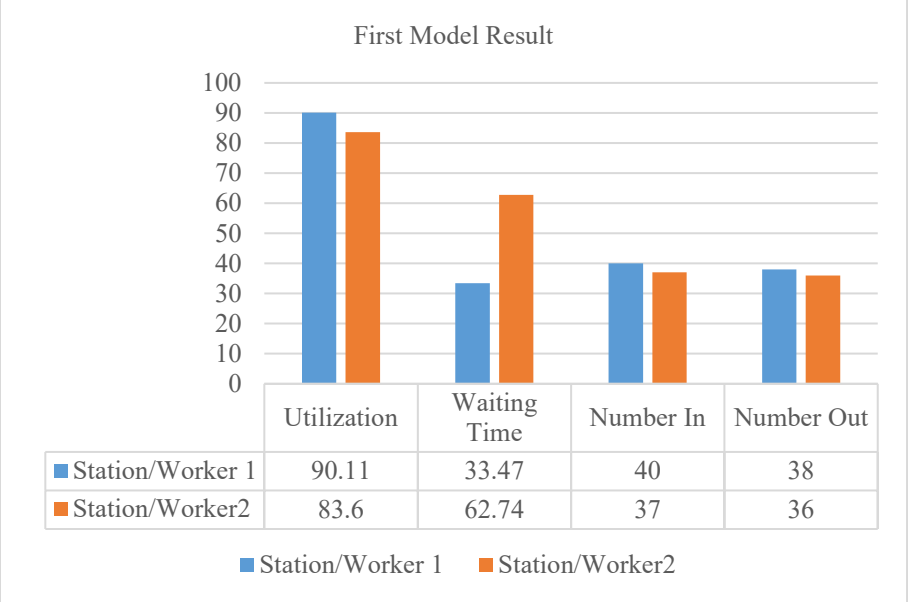

Figure 3. Report Result From Arena Simulation of First Model

As shown in Figure 3, the utilization value for both workers are more more than 80% and almost nearly 100% which is a high enough number that can cause workers to experience excessive fatigue. Waiting time value for Station 2 is twice as high as the waiting time value for Station 1. The number of motorists that enters Station 1 is higher than Station 2.

5.3 Proposed Improvement

The simulation results in a fairly high level of waiting time and utilization, so improvements are needed to make the system runs optimally. Improvement proposals are given in two improvement scenarios.

a. Scenario 1
The number of Refuel Station is added to one more station along with one additional operator to reduce the level of busy work and waiting time of each Refuel Station as shown in Figure 4. As a result, average waiting time of Station 1 is decreased to 7.58 seconds with maximum value of 32.69 seconds and Station 2 is deacreased to 19.86 with maximum value of 108.45 seconds. And for the main problem of busy work and over-utilization of workers, the additional worker at Station 3 will have 50.53% utilization while the worker on Station 1 will have 49.25% and the worker on Station 2 will have 62.38%.

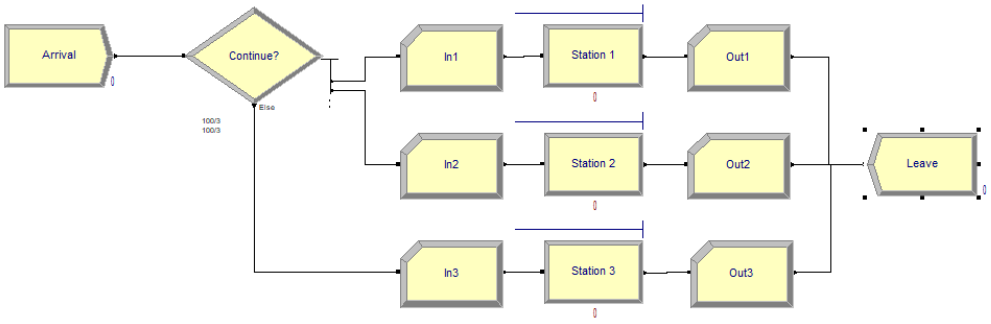

Figure 4. Scenario 1 Logical Model

b. Scenario 2

As there was a large waiting time value at Station 2, then one more operator is added at Station 2 as shown in Figure 5. As a result, the average waiting time of Station 1 is increased to 45.23 second with maximum value of 123.81 seconds, even though its main purpose of reducing waiting time on Station 2 has been successfully with the average value of 4.88 seconds and with maximum value of 53.11 seconds. Worker utilization value of both worker at Station 1 is splitted into two, the first worker have 59.64% while the second have 31.79%. The worker's utilization at Station 2 is also decreased only for a little bit to 83.12%.

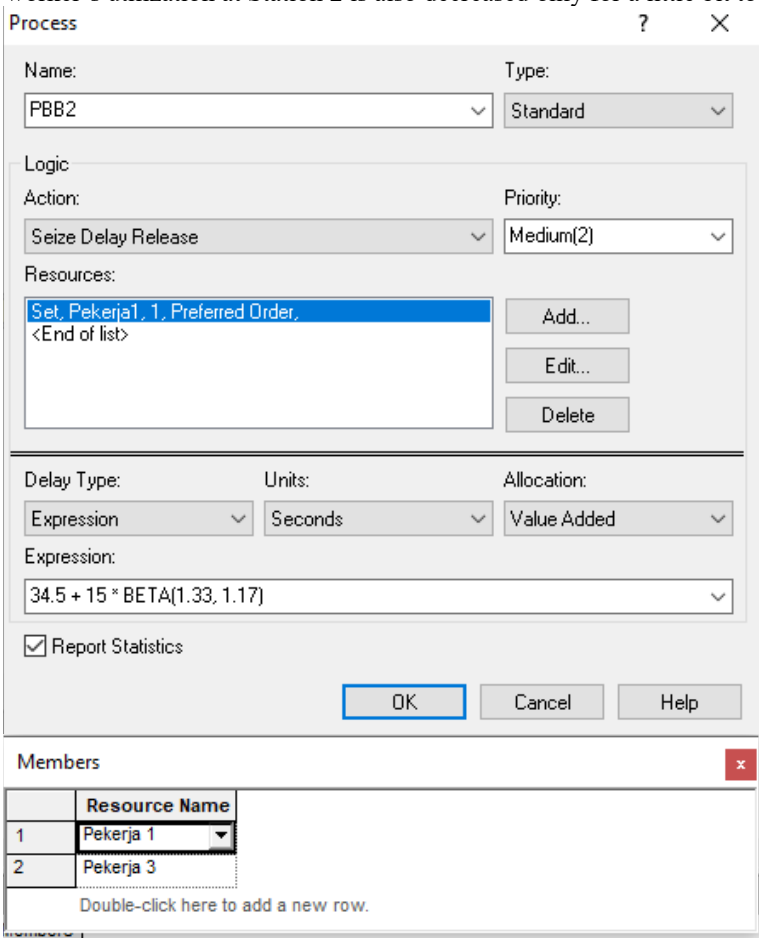

Figure 5. Scenario 2 Process Input Data and Resource Input Data

5.4 Validation

Validation step is used to compare output from simulation with a record within the actual system and proposed scenario to consider the model correctly and ensure the simulation model perform as reality (Masoud Rahiminezhad, 2013). In this case, validation is done by comparing the waiting time, worker utilization, number in, number out, and productivity level of the first model and both of the proposed improvements. Both proposals brought a good improvement to the system as shown in Figure 5 to Figure 8.

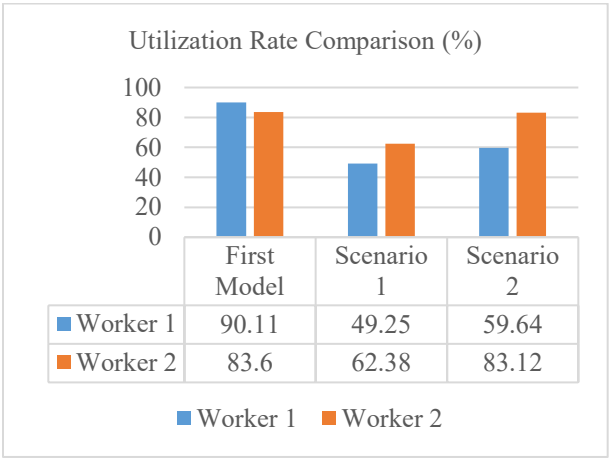

Figure 6. Utilization Rate Comparison

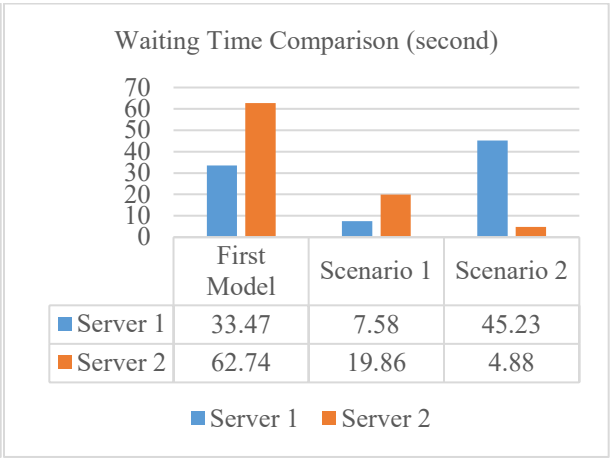

Figure 7. Waiting Time Comparison

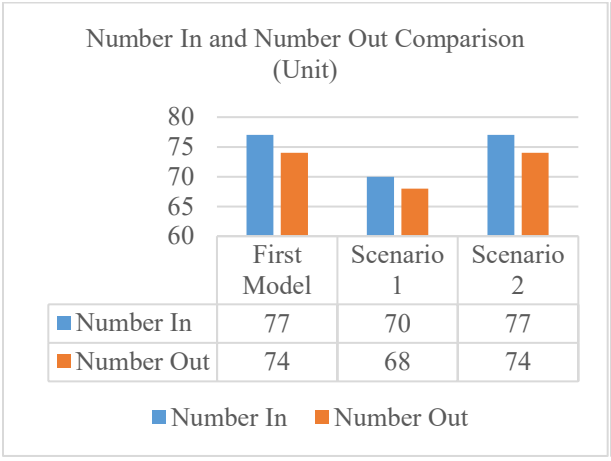

Figure 8. Number In and Number Out Comparison

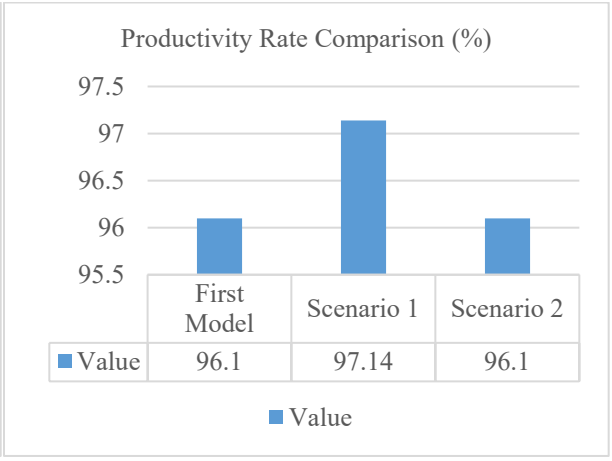

Figure 9. Productivity Rate Comparison

If Scenario 1 is applied to the system, the utilization rate of worker 1 will significantly drop to 49.25% and worker 2 to 62.38%. This will increase the idle time of each worker, but it is also good to maintain the performance of workers and also avoid workers from excessive fatigue. The waiting time of Station 1 was also drastically reduced to 7.58 seconds and Station 2 to 19.86 seconds so that queues on the Workstation will decreased gradually and prevent queues from piled on a single Station. And the last, productivity level will increase by 1.04% if you apply scenario 1 to the system.

If Scenario 2 is applied to the system, the utilization rate of worker 1 will drop to 59.64%, but worker 2 will not have large decrease so that the rate of busy is only felt by worker 1. Waiting time from Station 1 increases to 45.23 seconds and on Station 2 decreases to 4.88 seconds where there will still be a sum of motorist in Station 1 and busy rate will be distributed to Station 2 which is certainly related to the utilization rate on Station 2. Finally, the productivity level will remain the same as the initial simulation model of 96.1%.

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6. Conclusion

From this research and simulations, it was found that the results of Scenario 1 is better than the results of the First Model simulation as well as the results of scenario 2. This means that the most optimal solution is to add one more Workstation along with one worker who becomes the operator in the added Workstation. This research can only apply to rush hour time after work so it can't represent the overall performance of a gas station system. For further research, it is expected to increase research time and observation so that the variation of data can be more visible and the data obtained can be more valid. Furthermore, it is also expected to obtain worker data on a whole shift so that data distribution can be obtained thoroughly.

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