Fleet Sizing of Automated Material Handling Using Simulation Approach

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FOREWORDS

It is a great honor for Bandung Intitute of Technology (ITB) in collaboration with Universiti Malaya Pahang to host the second joint conference of The **The 4th Asia Pacific Conference on Manufacturing Systems** and **The 3rd International Manufacturing Engineering Conference** (APCOMS-iMEC 2017) at Yogyakarta. The special region that is very important to history of our country, Indonesia. It is also a great honor for ITB to work along with Sebelas Maret University in organizing APCOMS-iMEC 2017 locally in Yogyakarta.

We sincerely express our gratitude to Vice Chancellor of UMP; Dean of Sebelas Maret University; Professor Zahari Taha from the Fakulti Kejuruteraan Pembuatan Universiti Malaysia Pahang; The Head Secretary of The Creative Economy Agency of Indonesia (BEKRAF), Doctor Mesdin Simarmata; Professor Shih-Ming Wang, from Mechanical Engineering Department of Chung-Yuan Christian University, and; All parties, which have been very supportive to holding this conference in Indonesia and being part of our important milestone.

To date, we are witnessing another revolution of industrial development. The internet of things era has lead the change on consumer behavior, innovate production system technology, transform global manufacturing network. All of these may reshape our future. Our conference theme is about "**Taking The Factories to The Next Level**". All technologies which may bring the seamless integration (vertically-horizontally) within or between manufacturers are the hot topics to realize the concept of Industry 4.0. The current requirement analysis and future plan for a country within Asia Pacific will be needed accordingly.

On behalf of Bandung Institute of Technology, I encourage all participants of APCOMS-iMEC to work together and contribute to the future development of Manufacturing Technologies to strengthening and harmonizing as well the competitiveness of Asia Pacific countries and for our better society.

We wish all participants to have an excellent conference, expand our academic network, and enjoy the historical city of Yogyakarta.

Bandung, December 2017

The APCOMS-iMEC 2017 Organizing Committee
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Peer review statement

All papers published in this volume of *IOP Conference Series: Materials Science and Engineering* have been peer reviewed through processes administered by the proceedings Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

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Fleet Sizing of Automated Material Handling Using Simulation Approach

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Abstract. Automated material handling tends to be chosen rather than using human power in material handling activity for production floor in manufacturing company. One critical issue in implementing automated material handling is designing phase to ensure that material handling activity more efficient in term of cost spending. Fleet sizing become one of the topic in designing phase. In this research, simulation approach is being used to solve fleet sizing problem in flow shop production to ensure optimum situation. Optimum situation in this research means minimum flow time and maximum capacity in production floor. Simulation approach is being used because flow shop can be modelled into queuing network and inter-arrival time is not following exponential distribution. Therefore, contribution of this research is solving fleet sizing problem with multi objectives in flow shop production using simulation approach with ARENA Software

Keywords: Automated material handling, Fleet sizing, ARENA Software, Queuing theory, Flow shop, Simulation

1. Introduction

Currently, manufacturing company has to face tight competition with many competitors. Company try to have lower price for their products compared to another competitor but still maintain or even higher profit level. The ultimate way to reach the objective is lower the cost to perform an enterprise in form of manufacturing and administration activity. It is well known that lean principle can be applied to response this issue, i.e. eliminating seven waste in the company [1], including transportation waste.

A case study is presented here, in which a manufacturing company tried to minimize its material handling cost by automating material handling in production floor. Automated Guided Vehicle (AGV) is the most popular solution in automated material handling in manufacturing due to many advantages over human power in material handling activity [2-4]. However, this company decided to implement a simple type AGV, which is called AGV towing vehicles. The principle is actually the same as AGV in term of driverless material handling [5] and consists of many parts, such as: DC Motors, sensors to ensure the safety, wireless communication, and energy sources in form of rechargeable battery [6]. The difference between them, AGV towing vehicle is simplification of common AGV which are not fully automated and not flexible as AGV system. It has only two stop points, one is considered as start point and another is considered as end point. Term usage of start and end point is based on material flow in production. Start point is stop point to load material that ready to be processed to the next station and end point is stop point to unload material in the arrival station.

AGV towing vehicle still needs operator to load and unload container manually. The purpose of AGV towing vehicle is to reduce headcount and prevent human operator fatigue due to far distances and repetitive transportation activity. This objective is driven by the increasing labor cost, so that manufacturing company is forced to reduce workers in production floor and tend to have automated or semi-automated system in the production activity. Another consideration of using AGV towing vehicle rather than common AGV is because cheaper investment. Cheaper investment is caused by not all features in AGV used in AGV towing vehicle system.

In this research, real case study used in manufacturing company which AGV towing vehicle will be implemented and already in prototype phase. AGV towing vehicle will be implemented to transport material consecutively from supermarket to X station and from X station to Y station. The layout map for case study in AGV towing vehicle systems implementation can be seen in Figure 1.

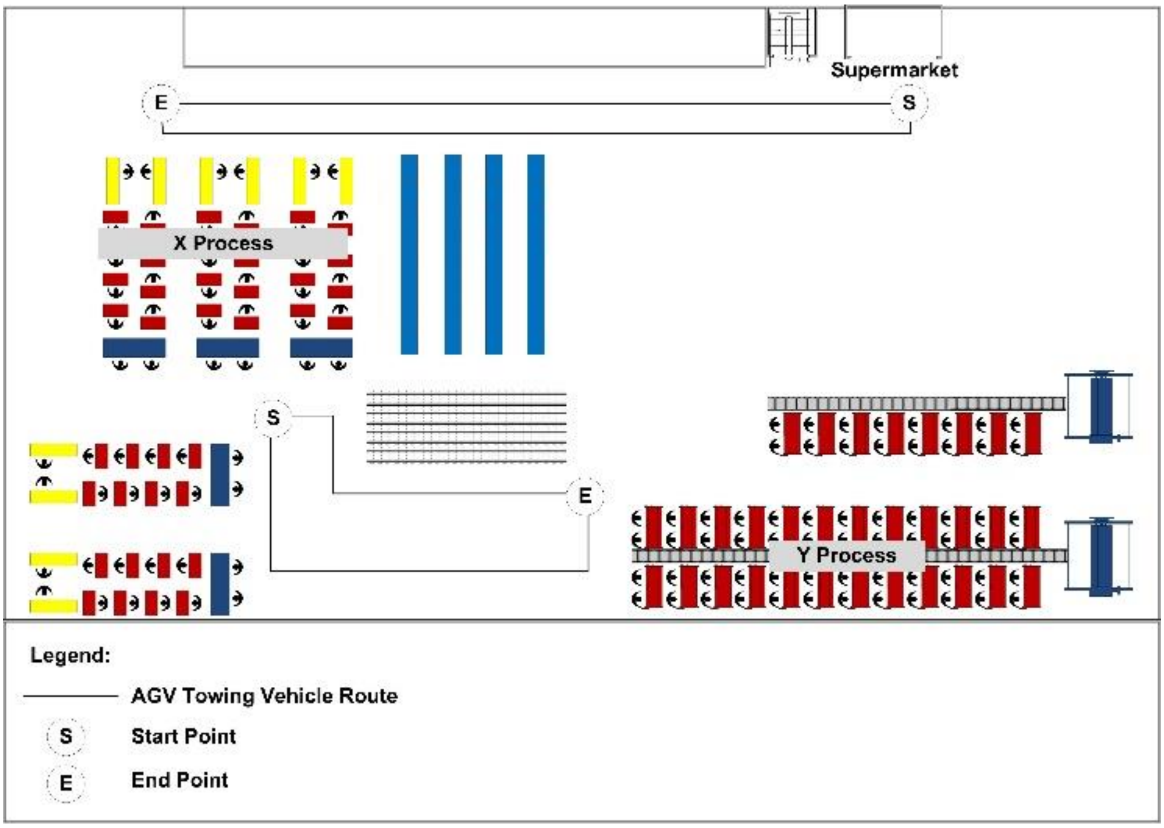

Figure 1. Layout Map

AGV towing vehicle can be said as automation in manufacturing process in term of material handling. As automation, designing the system is a critical phase to ensure that production system is optimized. It is critical because main reason of automation is actually to improve previous process in term of cost spending and ensure that AGV towing vehicle usage is to eliminate and not adding any waste in previous process. AGV towing vehicle also should not become a bottleneck in production or make production capacity reduced. This research is important because appropriate number of AGV towing vehicle can have minimum flow time of material.

2. Simulation Model

In order to imitate how the system works, a simulation model is developed using ARENA software. The description of the model is presented below, while the whole model is available in Figure 2. It is noted that the key decision variables to be taken in this situation are number of AGV towing vehicle to be placed in phase one (between supermarket and X station) and number of AGV towing vehicle to be placed in phase two (between X station and Y station).

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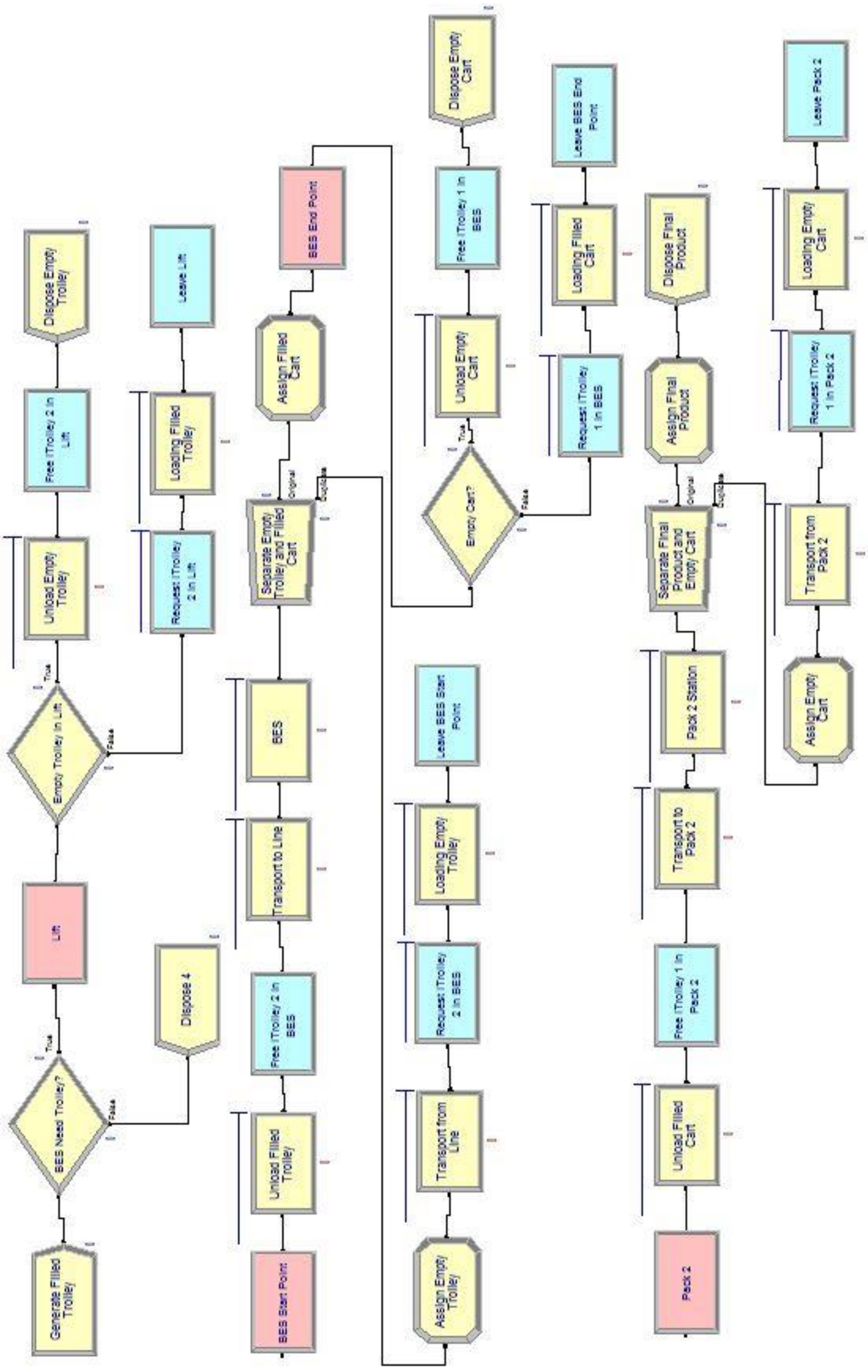

Figure 2. Complete Model in ARENA Software

In the phase one, start point is supermarket and end point is X station. There will be two entities involved in start point, which are empty entities and filled entities. If entity that arrived is empty, operator should unload it first from AGV towing vehicle before it ready to transport another entity. After that empty entities will disposed or exit the system. If it is filled entities arrived, AGV towing vehicle will be requested first before operator can load entities. Filled entities will be departing to X station. End point in phase one is X station. Filled entities will come first from supermarket to X start station and operator need to unload filled entities before AGV towing vehicle ready to use again. After filled entities being unloaded, it will be transported to X station and processed in the station. If filled entities already processed, two entities will be occurred which are empty entities to reuse in previous process and filled entities to be transported to Y station. Empty entities will be transported to X station start point. After that, AGV towing vehicle is requested and operator load it to AGV towing vehicle after it is available. In the end, empty entities leave X station start point and go to supermarket. Another model made in phase one is to generate filled entities to the system. Assumption of supermarket concept in lift should be considered because systems only generate new filled entities when X station needs it. Unfortunately, create module in ARENA Software cannot generate new entities based on conditions. It is only based on schedule or expression of time distribution. Therefore, decide module is placed after create module to create appropriate model to represent pull system between supermarket to X station.

In phase two, start point is X station and end point is Y station. There will be two entities in X station which are filled entities that ready to be transported to Y station and empty entities that will be reuse in X station. If empty entities arrived to X station, operator will unload the empty entities so AGV towing vehicle will be ready to transport again. Empty entities will be disposed so X station can reuse it again. If it is filled entities arrived, AGV towing vehicle will be requested. After AGV towing vehicle requested, operator load filled entities and AGV towing vehicle will leave to Y station. End point in phase two is Y station. There are three entities involved in end point, which are empty entities, filled entities, and final product. Filled entity is arrived in Y station and operator should unload from AGV towing vehicle first before it is ready to transport another entity. After filled entities being unloaded, operator transports it to Y station line and being processed in Y station. The outputs are final product and empty entities. Final product will exit the system or disposed and empty entities will be transported first to end point of AGV towing vehicle system. Empty entities will be transported to X station again for reuse. Therefore, AGV towing vehicle will be requested first and operator load empty entities to AGV towing vehicle before it leave Y station to X station.

Time data are collected from the system in order to qualitatively model the system, which are the operator time to: (1) load AGV towing vehicle, (2) unload AGV towing vehicle, (3) transport to Y station, (4) transport from Y station, (5) transport to X station, (6) transport from X station. The mean of these times are (1) 6.60 seconds, (2) 5.56 seconds, (3) 20.94 seconds, (4) 20.15 seconds, (5) 32.46 seconds, and (6) 30.00 seconds, respectively. Moreover, the processing cycle time at X and Y stations are also being observed. It is statistically proven that the distribution of processing cycle time at X station is triangular distribution with minimum value is 5 seconds, mode is 5.12 seconds, and maximum value is 136 seconds. While, the distribution of processing cycle time at Y station is beta distribution with parameter $\alpha = 0.655$ and $\beta = 1.48$. Experiment from the AGV towing vehicle prototype is showed that the cycle time for AGV towing vehicle for phase one and two are 315 seconds and 220 seconds, respectively. For the AGV towing vehicle, cycle time means time needed for the vehicle departs from start point and arrives again in start point.

3. Result and Discussion

Preliminary simulation runs indicate that 80 replications are required for fulfilling desired precision. The alternative of number of AGV towing vehicle to be placed in phase one is 6 – 9 vehicles and number of AGV towing vehicle to be placed in phase two is 8 – 9 vehicles. Therefore, 8 combination of scenario are tested. Flow time and daily production volume are recorded as the system performances. Average performances of each scenario from all replications are presented in Table 1.

Table 1. Simulation Results

Scenario	Phase One Vehicles	Phase Two Vehicles	Flow Time (minutes)	Production Volumes (units)
1	6	8	18.8	1676
2	6	9	17.9	1671
3	7	8	18.8	1674
4	7	9	18.5	1677
5	8	8	18.7	1678
6	8	9	18.0	1676
7	9	8	18.1	1680
8	9	9	17.9	1676

It is shown in Table 1 that the results are quite similar among scenarios, i.e. increasing number of AGV towing vehicles is not having any significance difference in flow time and production volume. Therefore, statistical analysis is required in order to ensure that the performance among scenarios can be considered as statistically same. One-way ANOVA is applied here, with the null hypothesis: all the mean flow time (or the mean production volume) are similar, versus the alternate hypothesis: at least one mean is different. The results of the ANOVA test for flow time and production volume in MINITAB software are presented in Figure 3 and 4, respectively. Since the p-value is greater than α (i.e. α=0.05), therefore, in both hypothesis testing we failed to reject null hypothesis. In other words, there are no statistical evidence that the flow time and production volume are different among scenarios.

Based on these performance analysis, it is recommended that the company use only 6 vehicles in the phase one and 8 vehicles in the phase two. By using this recommendation, the company can save the investment for acquiring the vehicles, while the performance of the system is not significantly different with the system at higher number of vehicles.

Results for: Flow Time.MTW

One-way ANOVA: Scenario 1, Scenario 2, Scena

```
Source   DF       SS     MS     F      P
Factor    7    85.00  12.14  1.85  0.075
Error   632  4138.50   6.55
Total   639  4223.50

S = 2.559   R-Sq = 2.01%   R-Sq(adj) = 0.93%
```

Figure 3. ANOVA Results on Flow Time

Results for: Production Volume.MTW

One-way ANOVA: Scenario 1, Scenario 2, Scenario 3

```
Source   DF      SS   MS     F      P
Factor    7    4573  653  1.64  0.122
Error   632  252081  399
Total   639  256654

S = 19.97   R-Sq = 1.78%   R-Sq(adj) = 0.69%
```

Figure 4. ANOVA Results on Production Volume

4. Conclusion

In order to solve the optimization problem for determining optimum number of AGV towing vehicle used in production floor, a simulation model is developed using ARENA software. Using standard simulation methodology, i.e. input analysis, experiment, and output analysis, the situation of smaller

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material flow time and higher production volume is reached with six AGV towing vehicles in the phase one and eight AGV towing vehicles in the phase two.

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