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SIMULATION ANALYSIS OF PROCESSING COMPLEXITY AND PRODUCTION VARIETY IN AUTOMATED MANUFACTURING SYSTEM

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ABSTRACT

In this paper, a simulation model for a manufacturing system is developed using Rockwell Software (ARENA 15.7-Platform) running production processes of multi-options product (MOP). There are different types of processes in the system which is either automated or non-automated making the manufacturing system as a partially automated system. Currently four types of products are planning into the productions which are practically coded OP1, OP2, OP3, and OP4. Because of the shortage in capacity of the non-automated processes compare to the automated, and adopting a fully automated production process is not applicable in the system causing OP1 directly goes out of the system to be manufactured later utilizing another plant. The objective of the work is to identify the resources needed to stabilize the system and run the entire product variety utilizing the current plant resources. Therefore, the problem is overcoming trade-offs between two solution scenarios; to find an optimal setup of automated processes that realizes the highest possible level of throughput and working effectively with the capacity of non-automated ones, and find the required setup of the resources running the system responsively. Different allowable cycles of processing time are examined to investigate the impact on the system throughput along with simulation experiments. Results show that there are many of opportunities to improve the MOP production processes using simulation methodology along with low investments. The analysis shows that there is no evidence that necessitates adoption of the full automation to the system improving the production. In other words, the automated section of the system involves the modifiable processes for optimizing the utilization of system resources.

1 INTRODUCTION

Full automated environment of manufacturing systems sensitizes technical problems like inducing the level of the system complexity in terms of destabilizing the flow rate of the processing discrete events. Although the automation; in general, has advantages such as reduction in the number of workers, efficient planning, best possible quality, and the highest level of productivity with the same number of resources. Partially robotizing the manufacturing system provides chances to enhance the flexibility of products variety (Ic, Y. T., Dengiz et al. 2014). Discrete events simulation is a methodology that commonly used in modeling the complex manufacturing system and analyzing the modifications contributing towards the most effective decision of the production plan (Phatak et al. 2014). Industrial companies develop different scenarios simulation base for the current system to differentiate the machines plans of multi-option

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products for the same system and requiring different utilizations during the operating (Biele & Monch. 2015). Heterogeneous discrete events that generated to plan the variety are simulated as homogeneous ones by separately modeling the varied machines (Kang et al. 2014). In this research work, four different types of MOPs have been classified into OP1, OP2, OP3, and OP4 depending on the options list of each product. MOPs are the variety that initiates the processing resources complexity. The demand is always variable which necessitates maintaining the system partially automated and the flexibility at the height level. Two sets of processes in the system; automated processes at the beginning and non-automated processes for the remaining stream. Currently, MOPs pass through the system to be manufactured excluding OP1 that goes after the automated processes to another system. Figure (1) shows the processing stream layout. The transportation between the processes is another non-automated process. The system production rate set as follows: 530,000 MOPs per year (253 workdays), 188,839 OP1; 111,108 OP2; 195,128 OP3, and 34,928 OP4. The main goal is to identify bottleneck stations, improve the production and harmonize the automated facility with the non-automated.

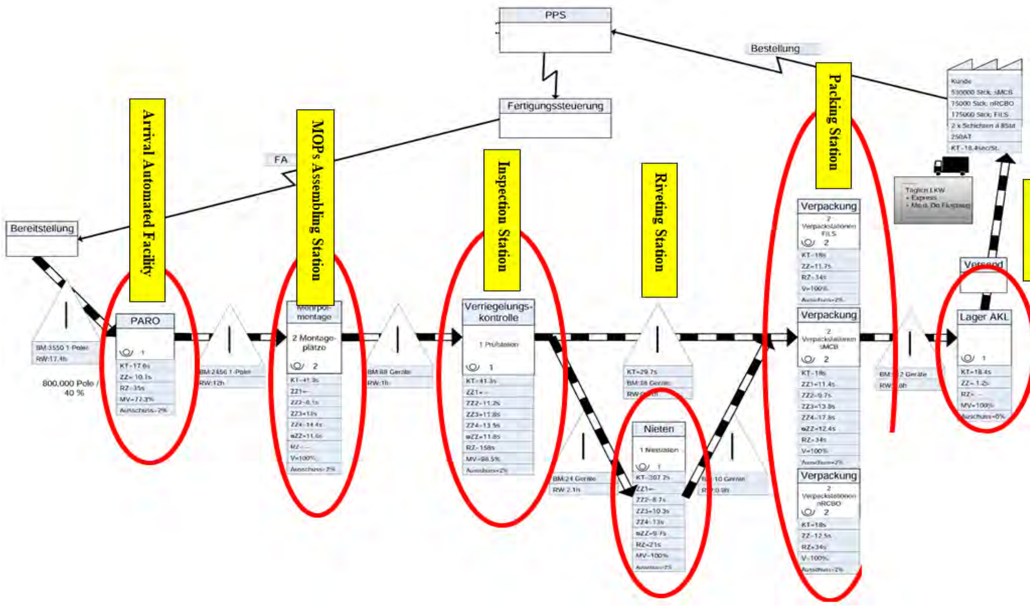

Figure 1: Added-value stream mapping of MOPs production system.

2 SIMULATION MODEL BUILDING

Input data of the simulation model are collected from the real-world plant modeling the value stream mapping that illustrated in Figure (1). The data are the values of products in the production term, cycle times of processes, transportation times between the processes, the availability of the processes and the capacity of the non-automated processes. The cycle times are entered in seconds for each process in the system as a constant expression varying relative to the product type. The processes havw been simulated using four different cycle times modeling MOPs excluding OP1 that simulated by 0.0 second. Experimentally, the cycle times of the transportation have been collected for modeling. Two breaks of 15 min for every non-automated process after two hours and seven hours of the shift and 30 min break after 4.5 hours in each shift.

3 RESULTS ANALYSIS AND DISCUSSION

Table (1) shows the results data that used for validating of the simulation model. Results validate the output of the simulated processes to manufacture 3083 MOPs in total as real-world value (μ_0) that measured per day. The t- statistical test has been applied to test the model within 10 replications; (n=10), tested at value of $\boldsymbol{t}_{(025,\ 5)}$ considering two-sided validation as follows $t_{0.025,\ 5} = 2.262$ with significance level of α=0.05. The results analysis approves the hypothesis of (if $|t_0| < \boldsymbol{t}_{(0025,\ 5)}$ is true, then model is valid).

The result shows that $|t_0|\approx1.53$ which is less than $t_{0.025,\ 5} = 2.262$ approving that $|t_0|$ is located in non-rejection area of (1- α) confidence interval.

Table 1: Data results of the simulation model validation

Output of Productions		
3082	3089	3099
3076	3086	3082
3076	3083	3086
Validation Analysis		
Referenced value (μ_0)		3083
Mean		3083.7
Standard Deviation		6.913

Experimental results analysis illustrates that cycle times of MOPs variety in the non-automated processes are related to the utilizations of the automated facility. The following set of data is used as different cycle times testing the automated facility and has been used to analyze the effect on the production output: 5 s, 7.5 s, 10.1 s, 12.5 s, 15 s, 17.5 s and 20 s. Comparing analysis of the results has been illustrated in Table (2) using the following variables for the performance adequacy: output MOPs of production processes, processing utilization of automated facility, processing utilization of non-automated, number MOPs in the progressing, number in the buffer of automated facility, waiting time in the buffer of automated facility, number in the buffer of non-automated facility, waiting time in the buffer non-automated facility, resource utilization of transportation process. The analysis concludes that improvements are possible by rising the cycle time to 15 s, instead of 10.1 s at the automated facility without new investments for the non-automated processes. In other words, slowing down the run of the automated facility harmonizes the entire processes and increases the throughput by 21.2 %.

Table 2: Simulation results with different cycle times (sec.) of the automated facility

Variable of Analysis	5	7.5	10.1	12.5	15	17.5	20
Output MOP Production System	2010	2673	3082	3480	3910	3851	3493
Process Utilization / Automated Facility	0.7731	0.773	0.7731	0.7731	0.7731	0.7731	0.7731
Process Utilization / Non-automated Facility	0.4984	0.39	0.3207	0.2591	0.2139	0.1869	0.1639
MOPs In-Progress	6004	3535	2172	1385	809	406	218
Number In-Queue / Automated Facility	333	222	165	133	111	95	83
Waiting Time In-Queue / Automated Facility	0	0	0	0	0	0	0
Waiting In-Queue / After Automated Facility	2264	1044	514	271	136	61	26
Waiting In-Queue - Non-automated Facility	12748.81	9296.73	6719.97	4385.95	2653.78	1395.29	694.92
Transportation Utilization	1.0002	1.0001	0.9999	0.9999	0.9997	0.9322	0.8443

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