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FLEXIBLE PROCESSING MIX STRATEGY FOR COMPLEXITY OF AUTOMATED MANUFACTURING SYSTEM

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ABSTRACT

Deciding how to change/expand a production process of an automated system is a critical take for a manufacturer. The decision made as to how best of expanding will have a robust impression, with the potential for gain or loss. In this research work, automated manufacturing system (AMS) has been planned to produce three products: x_1, x_2, and x_3 as the system production variety. x_1 and x_2 are currently running on the manufacturing processes working at maximum capacity. The manufacturer needs to expand the production reaching x_3 of the variety and attempts to adopt the best of alternatives that supports the growth needed and the future market share in terms of enhancing the current capacity or establishing a new independent line of processes. The research focuses on gathering real-world industrial data from the existing stream of manufacturing processes to build an analytical model simulating an improvement methodology using computer simulation proposing an applicable tool of deciding methodology. The approach is a decision-lead strategy modeling whether it is the best to increase the capacity of the current production system or build a second line to have a dedicated production of the third product. Rockwell Software (ARENA 14.7- Platform) has been used to test the alternatives along with a set of experimentations using the full factorial design. Results show that (1) to achieve 50% increase in the throughput of AMS, building the new production system far exceeds the need and (2) the optimal cost of the current line is possible by increasing the resources capacity.

1 INTRODUCTION

The classical objective of AMS is a task of planning the heterogeneous discrete events of processing time to be consistent in producing the variety (Kang et al. 2014). The planning decision that enhances the productivity of AMS to run and adopt the products variety as discrete events arriving/operating at each process in the system is not always available (Akcay, A., & Biller, B. 2014). System simulation is an earlier tool that used in the design phase for the support of production planning model and control-related to the best decisions (Ziarnetzky et al. 2014). Discrete events simulation is commonly used in modeling, analyzing, and modifications of the complex manufacturing systems as an offline method contributing towards the right decision as well as justifying the optimum package of scenarios and the best configuration that results in the optimum performance of the manufacturing system (Phatak et al. 2014). AMS understudy has been adopted by the manufacturer to produce a variety of three different products: x_1, x_2, and x_3. The system is currently running x_1 and x_2 at maximum work capacity of AMS. The manufacturer needs to enhance the throughput producing x_3 and analyze the solutions that support the best growth strategy. This study aims to determine the total throughput and capacity breakeven point at which an expansion of current line comparing to the alternative which planned to add a second line so that the line can be a dedicated for x_3. Under the current manufacturing process, x_1 is an input for the creation of x_2 which serves as an input for the product x_3. Management is trying to determine the most effective cost plan for expansion to ultimately produce x_3. Rockwell-ARENA software has been used modeling two manufacturing system description to determine capacity needs for the most cost-effective strategy of the expansion. Figure (1) shows the proposed simulation model that has been used to experiment the beneficial plan of the expansion. Manufacturing added-values have been loaded to the products in one streaming map along with a diversity of manufacturing stations. The six stations; greenly framed, have been mainly categorized into three groups which are the sequencing-structuring, manufacturing-assembling, and inspecting-releasing the products.

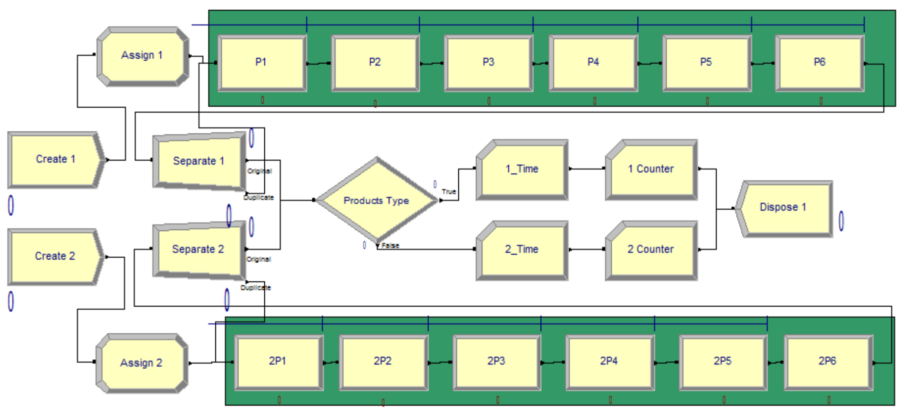

Figure 1: Two ARENA simualtion models for the alternative systems of the experimention

The goal of the study is to create information regarding the two scenarios for increasing the throughput and enhancing the current variety of x_1 and x_2. The capacity of the existing line and the new line are examined modeling the baseline for comparison and verified to meet the current output specification of the existing line. In the first set of model iteration, the current manufacturing line is expanded to meet the desired process output increase of x_1 and x_2; this is considered the first alternative. The bottleneck processes have been examined to determine if the expansion can sufficiently increase product output; if not sufficient further expansion to be made until the output increase meets requirements. The second alternative is to model the new line to produce x_3 and the existing line for producing $x_1$and x_2.

2 SIMULATION MODEL BUILDING

AMS's processes are controlled by computer and constantly monitored by the system. The data required for the study has been automatically collected by the computer control software of the real-world system. The records of the past year have been pulled from the computer archive for the time of each process, the amount of materials added to each batch, the reaction/ processing time for each step in the manufacturing process, and annual throughput. AMS's processes are a continuous running of 24 hours 7 day a week. Therefore, the simulation model has been run for one continuous year or 8700 hours with for every 720 hours (roughly one month), 8 hours of downtime is included as a preventative maintenance. To reflect the actual manufacturing process as closely as possible, the start time of the x_1 and x_2 are set to be off by the completion of the other. Therefore, x_2 only begins to be manufactured once an entire x_1 process has run from beginning to end. ARENA's input analyzer function used to mathematically create the process time distributions. Table 1 illustrates the input data into the system model which basically consists of six automated manufacturing processes. Two types of expressions for the variability distributions which are the triangles (TRIA) and exponentials (EXPO) have been used to simulate the operation cycles of the major six processes in the system as illustrated in the Table (1).

Table 1: processing time matrix for the mathematical expressions of the simulation (hours)

Basic Variety	P1	P 2	P 3	P 4	P 5	P 6
x_1	TRIA (10, 12, 14)	TRIA (1, 3, 5)	TRIA (1, 2, 3)	TRIA (1, 3, 5)	EXPO (1)	EXPO (2)
x_2	TRIA (11, 13, 15)	TRIA (4, 6, 8)	TRIA (2, 4, 6)	TRIA (4, 6, 8)	EXPO (1)	EXPO (2)

3 RESULTS AND DISCUSSION

Result analysis of the regression model; equation (1) describes the impact of processing time as dependent variables on the throughput of the automated system. The equation is experimentally developed and the judgmental parametric have been validated for adequate prediction of the process capacities as shown in Figure (2). The behavior analysis of the equation results that the fourth process ($P4$) has the greatest impact on throughput.

$$Throughput = 316.25 - 25\,P1 - 22.25\,P2 - 17.88\,P3 - 25.62\,P4 - 0.62\,P5 - 0.5\,P6 \quad (1)$$

Capacities analysis shows that processes of the existing line should be maintained and the dual-line far exceeds the need to achieve 50% increasing in the throughput. Moreover, the dual line approach is not only required investments but also the entire capacity of the existing line decreases. The results conclude that increasing the capacity for the single line is only required to achieve the improvements, and identifying the optimal cost of the current line is possible relying on this strategy.

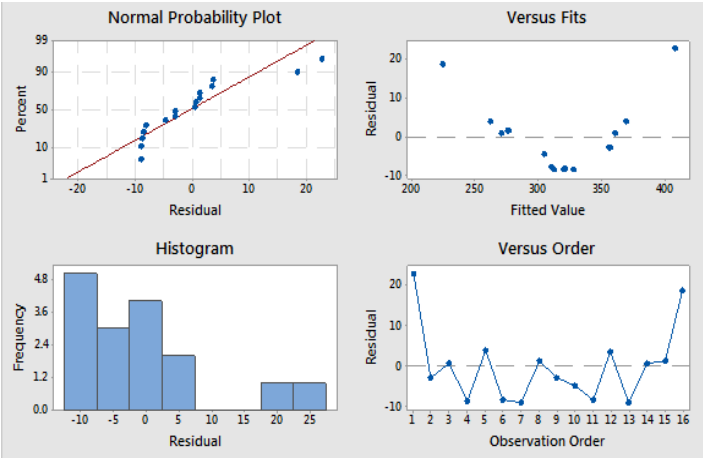

Figure 2: Residual plots analysis of the regression model for the system capacities

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