Improvement of Bottling Production Line Using Simulation Method

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Abstract
In order to demonstrate changes in business, most of today's world multinational companies are using wide spectrum of computer- based technologies to assist them in managing many business data information and performance. Simulation method is one of the ways to help these decision makers. The simulation method in this study was based on ARENA® software. The animated simulation models for comparing the actual and improved line were successfully developed in this study. All related data information regarding to the manufacturing line are collected and analysed. After considering all possible factors, it is found that by the model simulations, the improvement could be done and the efficiency is 99.3% which is better compared to current efficiency that has value of 72%. The number of waiting unit in the filler section which represents the bottleneck in the current line also has been eliminated from 3257 unit to 0 (zero). Both efficiency calculation and number of waiting unit in the line are work as validation indicator in this study. The study also generated cost savings which will give benefit after 3 months of investment.

Keywords: Bottling Production Line, Efficiency, Simulation Method

1.0 Introduction

History of commercial bottling was as early as hundreds year before, where most products were beverage in brewery industry. Now, the product-in-bottle has expanded to other type or product such as paste and sauces, where until today the business still growing rapidly comprises of small backyard up to a multinational organization. Simulation method is used because it has become one of the most powerful tools for decision makers especially for those who involve in designing a process line or system which is complex to observe traditionally. Simulation method is also a tool to determine system performance and weakness that might occur during the process, which may be overlooked during in the actual manufacturing area. Simulation technology has rapidly grown since its early pioneering days in the 1960's. Simulation is a scientifically defined as a process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behaviour of the system and/or evaluating various strategies for the operation of the system (Shahnon, 1998). Simulation makes possible to study, analyse and evaluate the situations that would not to be otherwise possible. Many fields now rely mostly on simulation to test new ideas and options.

2.0 Literature Review

Today, manufacturers have to determine many ways in order to increase the efficiency and improvement at production line. This is because years by years, competition in the industry is tough as consumers have wide variety of choice. The rivalry includes not only the technology and quality driven competitive from another company but also the low cost production driven competition from another countries (Tummala, Lee and Yam, 2000).

A study made by (Bailey and Cheng-Hsin, 1999) to improve an electronic manufacturing line was by changing the layout of the actual production line experimentally in order to gain a better workflow. However, by doing this the researchers had to collect data for four months in order to get a result. However, implementing improvements by changing actual production line experimentally will add cost to the manufacturers, and sometimes if unlucky the first modification made is not quite effective. This requires more changes until the manufacturer gets the right one, which also not only waste money but also time.

Another method to improve production line is by setting the machines at certain speed and record the system performance. The technique is called Method Time Measurement (MTM) (Grabau, Maurer and Ott, 1997). However, this method is may not be economically feasible because it is very time consuming, requires personnel to observe the processes and to record the data. It could somehow result in an inaccurate data collection as well as biasness. Therefore many expensive errors can be avoided if simulation technology is used in this manufacturing sector.

In this study, simulation method is used to improve a production line, by doing experimental designs and to determine ideal operating conditions. Furthermore, it is expected by using the simulation method, the productivity will be increased and all possible bottleneck determined will be solved. By this way, simulation method is one of technique that can assist decision maker to analyse a system performance virtually before making actual changes. Thus, this may help the management to understand better the business process and performance.

2.1 Objective of The Study

The following objectives were identified for achieving the aims:

- To identify activities that causes bottleneck or any problem to the production line
- To develop an animated simulation model consisting of bottling line.
- To improve the efficiency of line.
- To validate the improvement made to the line.

2.2 Simulation Application and Software

This study is using ARENA ® Simulation Software Systems. The ARENA ® modelling systems developed by Systems Modelling Corporation, which based in Pittsburgh, USA. The ARENA ® software is a flexible and powerful tool that allows analysts to create animated simulation models that accurately represent virtually any system (Takus and Profozich, 1997).

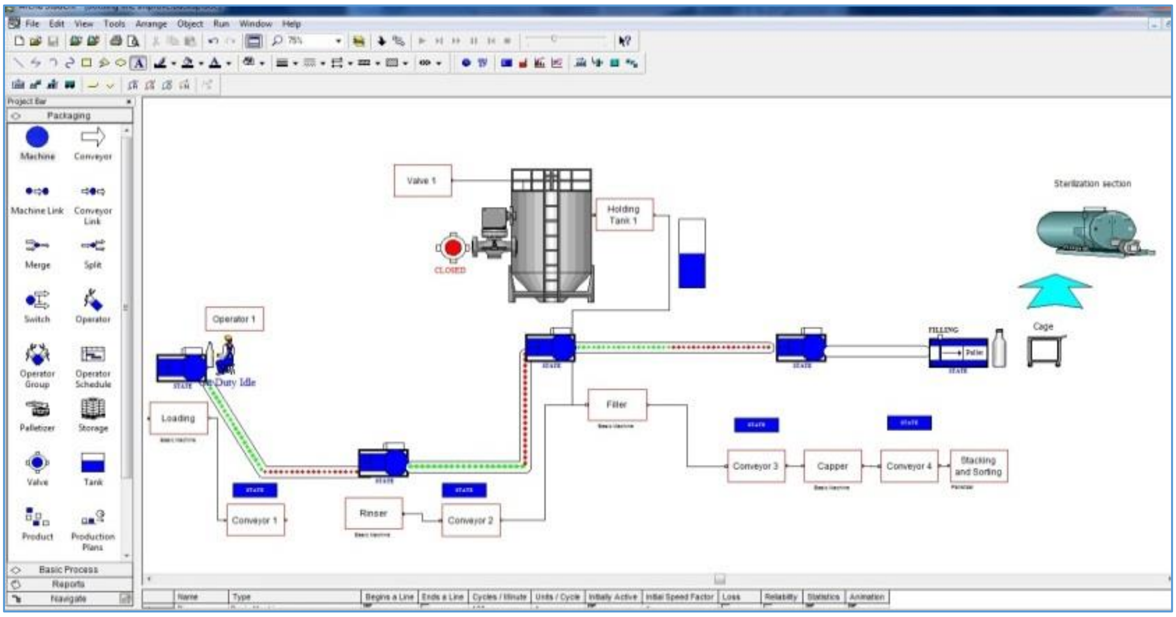

Figure 2.1: ARENA ® in Animated Simulation Mode

3.0 Methodology

In order to accomplish the study, plant layout must be visualized in order to give an overview of the production line. By the data collection, a simulation model will be designed to identify what kind of improvement that could be made in the production line. Observation in the production line is the next step of the project to identify problem and establish objectives. Then, data collection related to the production line is the next stage of the project. Simulation stage is next in order to solve the problem identified. In this stage, if the objective is not achieved, the process will be repeated until achieved. The project will be end after the stage of data presentation with suggestion and recommendation. Overall methodology is shown in Figure 3.1.

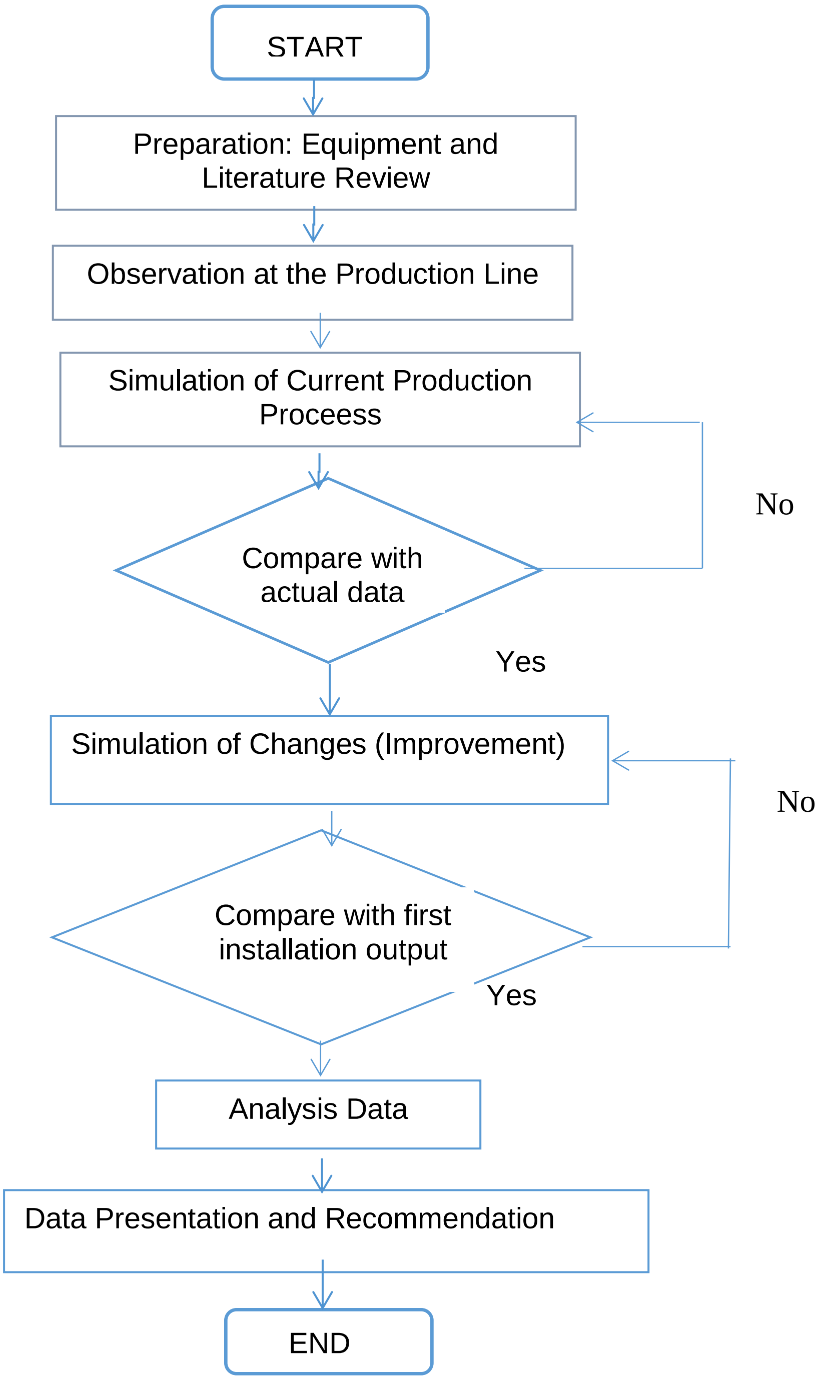

Figure 3.1: Methodology

3.1 Plant Layout

Area of the study is in a factory production line, situated in Bandar Baru Bangi. The study is specifically focus to the operation of bottling line only, which consists of 5 main stations, namely Loading, Rinser, Filler, Capper, Sorting and stacking. Plant layout must be identified in order to gather the right data and information to be used in the simulation design.

All the followings are need to be done in order to have correct result:

i) Daily activity records
It is the main data collection of the study. Possible past historical data of the bottling line will be obtained. This is also include the total number or bottling products produced, defects, timeline of operation and number of workers.

ii) System Observation
It is done during actual operation. All possible bottlenecks, hiccup or problematic area will be define during observations. Observations will be done in each station stated.

iii) Interviews
According to Law and McComas (2001), there will never be a single person that knows all the information necessary to build a simulation model. Thus, it is a necessary for the modellers or the simulation designers to talk as many subjects as they can to gain complete understanding of the system to be modelled.

4.0 Result and Discussion

4.1 Current Production Line for Bottling (Before)

Output produced for the current production line is 7940 pcs in simulation model (in actual current output is 7920). The number of workers and number of waiting unit in current production line is shown in Table 4.1.

Table 4.1: Parameters in the Current Production Line

Station	**Number of workers**	**Number of waiting unit (pcs)**
Loading (Station 1)	2	0
Rinser (Station 2)	1	0
Filler (Station 3)	3	3257
Capper (Station 4)	1	0
Sorting and Stacking (Station 5)	2	0

By the summary of table presented, it can be determined that the bottleneck that occur in the production line that resulting a problem in the bottling line is at filler station.

4.2 Simulation Changes (Improvement) at Filler Section (After).

Five additional fillers are installed instead of only have one filler at the filler section. Number of waiting unit and number of workers in each station is shown in Table 4.2. Take a look that all each station has zero value in number of waiting unit.

Table 4.2: Simulation Changes (Changes Made at the Filler Section)

Station	Number of workers	Number of waiting unit (pcs)
Loading (Station 1)	2	0
Rinser (Station 2)	1	0
Filler (Station 3)	1	0
Capper (Station 4)	1	0
Sorting and Stacking (Station 5)	2	0

In the simulation, the time for filler process is increased five times to cover the input from rinser section. Then after simulation, the number of waiting unit is reduced to zero value, where the changes are made in simulation mode. The *reason* of using six fillers is because if the fillers is less than six, there will be a number of waiting unit at the filler section. After the simulation made, the elimination of two workers at filler section is done, because the filler section can catch up with the input given to the section.

4.3 Different between Simulation Output and Current Production Line

Model verification and validation also can be done by calculating the different between the simulation output and the actual data is computed using the formula stated below:

Different (%) = [(Simulation Output – Actual Data) / Actual Data] x 100

According to Shahnon (1998), the differences value between simulation output and actual data must be around ± 10 % or less, in order to satisfy the validity level of the built model to the actual system. The simulation validation is done for the first one, which is the current production line. The other simulation (improvement simulation is just a replication of the first simulation, with changes made on filler process time.

Different (%) = [(Simulation Output – Actual Data) / Actual Data] x 100

= [(7940 - 7920) / 7920] x 100

= 0.25%

Hence, the model used and the replication made by the model can be used and acceptable (value = 0.25% < 10%).

4.4 Improvement Verification & Validation

In order to determine either the improvement to the line is reliable, two parameters can be used. The parameters are the efficiency of the line and number of waiting unit.

4.4.1 Efficiency

According to Stephens (2005), efficiency is an indicator of the equipment performance. With this way, it also can be calculated based on scenarios of simulation modelled for the production line. There are two cases in determine production line efficiency:

i) Efficiency in current production line (before)

ii) Efficiency after changes of production line (after)

Output for first installation of bottling line is given by machine vendor/ supplier. This was when machines were demonstrated at the first time installation, which is in year 2000. The output for first installation of the line is *assumed* as the 100% efficiency of the equipment.

In this case, calculated efficiencies for the production line can be determined as follows:

Calculations related to efficiency can be shown as the following below:

$$Efficiency_{\text{current}} = \frac{Output\ for\ current\ production\ line}{Output\ for\ first\ installation\ of\ line} \times 100$$

$$= \frac{7920}{11000} \times 100$$

$$= \underline{72\ \%}$$

$$Efficiency_{\text{simulation}} = \frac{Output\ for\ simulation\ changes\ (filler)}{Output\ for\ first\ installation\ of\ line} \times 100$$

$$= \frac{10923}{11000} \times 100$$

$$= \underline{99.3\%}$$

The comparison of output, efficiency and percentage of efficiency between current production line and after simulation changes are shown in Figure 4.3.

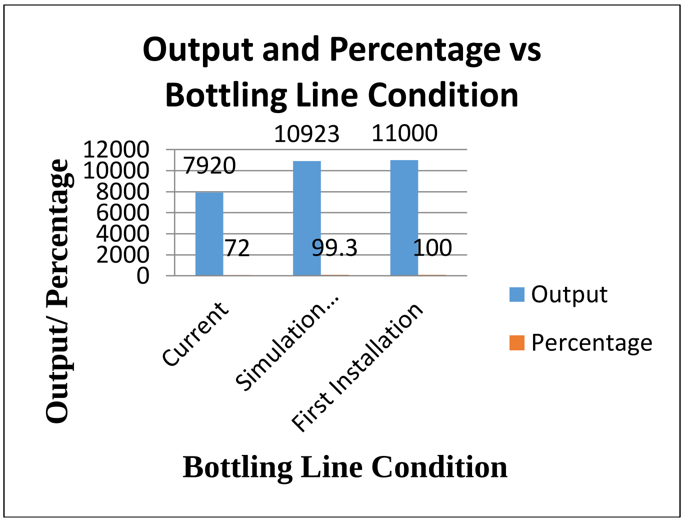

Figure 4.3: Output and Percentage (Current and Simulation Changes) in Bottling Line

4.4.2 Number of Waiting Unit

Number of unit waiting is also the way to measure bottleneck in order to determine improvement in a production. The more the number of waiting unit, the flow of a production line will be slower; hence the improvement made in a production line is less effective. In this study, the bottleneck in current production line is at the filler section. When a bottleneck happens at filler section, the capper section has to wait in order to let filler section complete. Output produced and number of waiting unit in a current production line and changes made at the filler section is shown in Figure 4.4.

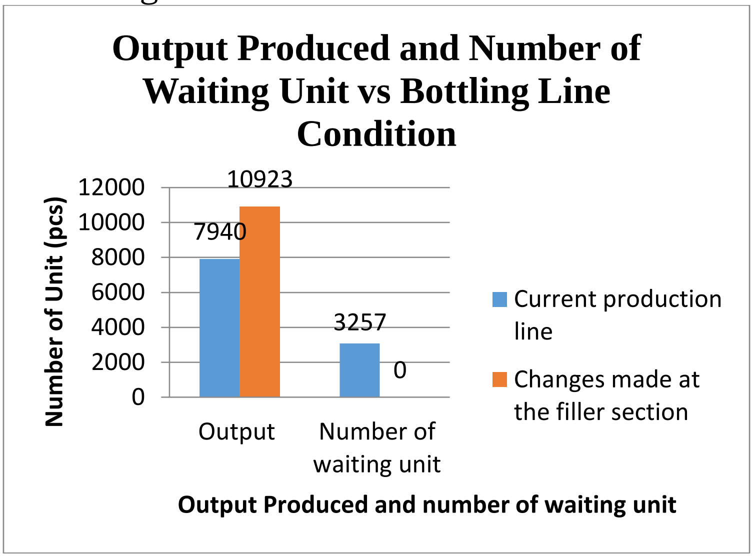

Figure 4.4: Summarization of Output and Number of Waiting Unit between Bottling Line

4.5 Estimated of Cost Saving In Changes Made

When the changes are done, it is believed that the improvement will give benefit which is cost savings of the operation. Cost savings are involved with are Overtime, Electricity, Water and Working hours.The cost savings in overtime, electricity and water is shown in Table 4.5.

Table 4.5: Cost Savings after Improvement

Description	**Savings**				
	Month 1	**Month 2**	**Month 3**	**Month 4**	**Month 5**
Savings (in RM): Overtime	1,523	1,523	1,523	1,523	1,523
Electricity	5,127	5,127	5,127	5,127	5,127
Water	3,528	3,528	3,328	3,328	3,328
TOTAL SAVINGS, (RM)	**10,178**	**10,178**	**10,178**	**10,178**	**10,178**

Overtime for a bottling line is done to meet current customer demand. From reducing the waiting time generated by the filler, the additional working hours (overtime) can be eliminated. In the addition, the saving that could be done by this improvement is not only in cost but also time. Table 4.6 shows that value of expenses for installation of additional five unit fillers.

Table 4.6: Expenses after Improvement (Simulation Changes)

Description	**Expenses**				
	Month 1	**Month 2**	**Month 3**	**Month 4**	**Month 5**
Expenses: Filler (5 units) 1 unit: RM 5,000	25,000 (first instalment)	N/A	N/A	N/A	N/A

Cost Savings:

Cost savings = Overtime + Electricity Bill + Water Bill
= RM 10,178

Hence,

Return of Investment Period = Month 1 + Month 2 + Month 3
= RM 10,178 + RM 10,178 + RM 10,178
= RM 30,534

The cost savings will be effectively implemented started from month 3, where the amount is exceeding RM 25,000 (Savings for 3 months = RM30,534 > Expenses = RM25,000) which is invested for the fillers.

5.0 Conclusion and Suggestion

The outcome of the project is the achievement of improvement by simulation. The improvement made has not only enhances process to produce more output and reduce waiting time or delay, but also give profit from the cost savings made. However, the changes made show that the factory has to invest in order to achieve optimum production line. From this study, it can be concluded that the objectives of the study are achieved. Simulation can facilitate and assist manufacturers (specifically to executives and managers) in order to make manufacturing decisions and improves efficiency in a production. The model built can be used to investigate bottle necks, then alarm managers or executive to look forward on the matter and seek solutions.

5.1 Recommendation for Future Studies

From this study it can be said that there are some extensions that could be made for future studies. Based on the discussion made, there are several factors that contributed efficiency to a production line such as maintenance and age of machine. Poor of maintenance is a main factor of a machine fail to achieve effectiveness. Poor of maintenance also is a factor that contribute to product defects in a production line. For further study, a simulation can be run to find possible situation that might happen if one of the machine is breakdown or delay; or running a production line where high defect products are produced from a poor maintenance machines.

Age of machine is also an important factor that can affect production line. A production line output depends on the machine used. If the machine could not catch up with the input given, the output rate will be reduced. Old machine can create high rate of breakdown and need more care or maintenance compared to new machines. However, if the age of machine is too old, sometimes the cost will be beyond of repair (wear and tear) and such activity as repair or placing additional part is not relevant anymore. By this way, it can be concluded that there are many possible further studies in analysing and improving a manufacturing line that can be researched in the future.

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