Productivity improvement using discrete events simulation

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Abstract. The increasing in complexity of the manufacturing systems has increased the cost of investment in many industries. Furthermore, the theoretical feasibility studies are not enough to take the decision in investing for that particular area. Therefore, the development of the new advanced software is protecting the manufacturer from investing money in production lines that may not be sufficient and effective with their requirement in terms of machine utilization and productivity issue. By conducting a simulation, using accurate model will reduce and eliminate the risk associated with their new investment. The aim of this research is to prove and highlight the importance of simulation in decision-making process. Delmia quest software was used as a simulation program to run a simulation for the production line. A simulation was first done for the existing production line and show that the estimated production rate is 261 units/day. The results have been analysed based on utilization percentage and idle time. Two different scenarios have been proposed based on different objectives. The first scenario is by focusing on low utilization machines and their idle time, this was resulted in minimizing the number of machines used by three with the addition of the works who maintain them without having an effect on the production rate. The second scenario is to increase the production rate by upgrading the curing machine which lead to the increase in the daily productivity by 7% from 261 units to 281 units.

1. Introduction
The high competition in the market forced the manufacturer to search for new methods and procedures to speed up the production rate and reduce the time to market. Traditional methods of planning and development are no longer sufficient to reach targets and survive in the global market. The increasing in complexity of the new technology was increased the cost of investment as well. In many cases, the theoretical calculation is not consistent with the real environment. However, the development of the new advanced software is protecting the manufacturer from investing money in production lines that may not be sufficient and effective with their requirement in terms of machine utilization and productivity issue. By conducting a simulation, using accurate model will reduce and eliminate the risk associated with their new investment. Many of researchers [1-6] try to use different simulation approaches to support this claim. Most of the industries based on discrete events nature. In discrete events processes, each event occurs at a particular instant in time and adds value to the product. Therefore, discrete event simulation (DES) arises as one of the effective tools in production planning. DES is the process of codifying the behavior of a complex system as an ordered sequence of well-defined events [7-8]. However, discrete event simulation technologies have been extensively used by industry and academia to deal with various industrial problems [9]. Different softwares have been
developed recently such as promodel, Sim event, delmia quest and many others. In this research, Delmia Quest will be used for real case study to highlight the importance of simulation approach in protecting manufacturers in unutilized equipment and reduce the risk of wrong decisions.

2. Methodology
Delmia Quest software has been used to analyses the production line of concrete poles in local industry. Most of stages in the production line are shared for the three different sizes of poles produced in the factory. A standard operating procedure (SOP) have been developed as basis to develop the simulation model. To develop the model and then simulating the model, few steps have been conducted.

1. Analyze the product design to determine the main components of the final product to create main sources in the system.
2. Seven main sources have been defined: Caging Part, Spiral Wire, Concrete source, PC wire, Mould A, Mould B and Mould C.
3. The processing time for each individual process has been estimated using direct measurement as well as company resources.

Finally, the model of the production line have been created and ready for simulation as shown in figure 1.

![Figure 1](original design)

Based on original design, two different scenarios have been proposed: the first scenario is focusing on improving productivity and the second scenario is to improve the production rate. However, selecting one of these designs depends on the company objectives. In the following sections, the result of the two scenarios is presented.

2.1 Proposed Design
2.1.1 Scenario 1
The first scenario focuses on the utilization percentage and unused resources. Based on the results in original design, the following assumptions are realised in scenario 1:

1. Stretch and Plug Set Ring process in the original design used two machines with utilization of 44% for each. Therefore, by logic and simple calculation, the company can replace one machine to cut the cost and still can achieve the production rate of 261 parts per day
2. Tighten Bolt Accessories process as in the previous process used as well two machines with utilization of about 12% for each machine. The same calculation can be done and expected that the production rate will not be changed but with advantage of reducing the operational cost of workers and capital.
3. Spinning process have four equipment with utilization of about 71%, thus by assuming full utilization of three machines instead of four machines, the production rate will remain the same.
4. Curing process in the original design have five machines with utilization is between 44% up to 65% based on simulation results. Therefore, the researcher assumes that four curing machines can fulfil the production rate of the company.
5. The Straighten PC Wire process have almost 100% of utilization. This may cause a bottleneck and may affect the whole production line. However, the researcher assumed an additional machine for this process to improve the flow of the production line.
6. Finally, additional handling equipment has been added to improve the flow of the products.

2.1.2 Scenario 2
The second scenario is focuses on improving the production rate per day. However, after different try by focusing on the bottleneck points with high percentage of utilization with different assumption, it was found that the production rate cannot be change by this approach. Therefore, the researches tried another approach by focusing on the longest processing time and try to improve. The research assume that the company upgrade the curing rooms and reduce the total processing time by 10% even though that the curing is not the highest utilization with the average of 52%.

3. Result
The results of the simulation for original design are concluded in figure 2.

![Utilization For Original Design](image_url)

**Figure 2.** Utilization bar chart for original design

To get the whole picture, the analysis of the handling equipment utilization is concluded in figure 3.
One of the most important factors to detect the bottlenecks is the utilization for each machine and handling equipment. The simulation was done for 2 days (8 hour/day) in order to determine the accurate number of products daily after subtracting the products produced in the first day: The has been done to the include the work in progress (WIP) parts that is in reality available in the production system. However, the results show there are 99 products. In the first day, while the second day the average products was 262 products. The second day shows the accurate number of product that should be produced if the system runs smoothly without any interruption or any unexpected breakdown.

3.1 Result on the proposed design

3.1.1 Scenario 1

This scenario was focused on maintain the production rate, on the other hand to cut the cost by reducing the capital investment and the labour cost. The utilization for the different machine was concluded in Figure 4 and 5.

Figure 3. Analysis of the handling equipment utilization of original design

Figure 4. Utilization for the different handling equipment for scenario 1.
A comparison between the original and proposed design based on utilization percentage for selected machine is concluded in figure 6.

Based on the simulation results, it can be concluded that the production rate will be the same of 261 parts per day. On the other hand, the advantages of this design are by saving in capital investments as well as in the workers that should be assigned to each machine. With simple calculations the company can save four works with maintaining the same production rate which means that the productivity is increased based on the basic productivity equation: Total output/total input = productivity.

### 3.1.2 Scenario 2

The second scenario is focuses on improving the production rate per day. Therefore, below is the result of the simulation after the processing time of the curing room has been minimized.
The results show that the production rate was increased by 20 parts per day. However, there is no much difference in the utilization of the machines compared to the original design as shown in figure 8.

As a conclusion, the second scenario shows an improvement in the production rate with need to invest to upgrade the curing system in order to reduce the processing time base on improving the heating system or the capacity of accommodate more than the 40 piece in each curing room. Finally, the researcher analysed the effect of the three designs on the handling system in term of utilization percentage and the idle time without processing. Figure 9 shows a comparison between the handling system for the original and the second scenario in terms of utilization percentage. The figure shows an increasing of the utilization in parts of the handling system. This is due to the increasing of the production rate.
From the results above, it can be concluded that the company have two alternatives based on their strategy and objectives. The first alternative can improve the productivity by selecting scenario 1. The productivity will improve by reducing the number of machines and workers with maintain the production rate per day on the level of 261 products. On the other hand, the company can select the second alternative by focusing on the production rate per day. However, this alternative needs an additional investment and technology experts to upgrade and improve the curing system in the company.

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