

SIMULATION TECHNIQUES IMPLEMENTATION TO REDUCE PRODUCTION LEAD TIMES IN SMEs

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Abstract - Simulation is one of the most effective methods in the Design of Manufacturing Systems. Typical reasons for the simulation of a manufacturing system includes evaluating the capacity and equipment utilisation, identifying bottlenecks in the system, comparing the performance of alternative designs [1]. The potential benefits in using simulation are very large. Simulation can help users by contributing in design, in management and in the decision making of production systems. It is also able to model all kinds of company processes: physical, informational and decisional. Simulation models can be built at all hierarchical (operational, tactical, strategic) and detailing levels (machine, cell, shop, etc...). Moreover, the whole manufacturing system life cycle can be modelled and simulated (design, analysis, implementation, operation, etc...). This paper discusses case studies where modelling and simulation were used to evaluate and improve the performance of manufacturing systems. In all cases ProModel simulation package was used.

Keywords: Process simulation; Lead-Time; SMEs; Performance analysis; Utilisation

1. Introduction

Simulation is widely used around the world, and therefore becoming very familiar to many of today's production managers [2]. The most important reasons and advantages of simulation methodology for modelling manufacturing systems are that:

- Realistic models of real manufacturing systems are possible; they are a practical approach to representing the important characteristics of such manufacturing system and may incorporate any complex interactions.
- Options may be considered without direct system experimentation, and alternative designs could be easily evaluated independently.
- The computer simulation models ability to directly address the performance measures that are typically used in a real manufacturing system.
- Visual outputs to help and assist the end users, such as production managers, in the development and validations process.
- Lack of the requirement for advanced mathematical knowledge.
- Analytical methods are perceived to be unhelpful by management, and would require large simplifications.

In recent years, there has been a rapid growth in the interest of applying simulation techniques and other information technology based tools for aiding in the decision making process in a wide range of applications at all levels [3]. This development has been accelerated by the significant reduction in the cost of computer technology and increase in power of such technologies.

The semiconductor industry is at a significant turning point. Since the semiconductor market has reached \$135 billion in revenue, an average annual industry growth rate of 16% will be difficult to sustain. To maintain industry profitability and growth, new ideas for cost effective manufacturing must be aggressively pursued [4]. Reducing manufacturing cost of the entire industry by developing and adopting a new technology has become the only way to remain competitive, however, it is well known that such development is very expensive to built and operate, therefore, it is very critical to understand how to design and operate them efficiently, especially if there is not past experience that could be learned from as in this case. Therefore, software simulation techniques would be desirable at the planning stage in order to estimate the performance of such relatively new production system.

Performance evaluation of discrete parts manufacturing plant design is quite difficult and has to date been tractable mostly through simulation [5]. Object-oriented based simulation is used due to its ability to facilitate links between the analysis and specification of real system and the design and implementation of an action model for that real system where the structure and behaviour of entities are readily modelled as objects. The ability of the object-oriented paradigm to provide a direct representation for real world objects comes with four unique features associated with it. Object-oriented simulations have now been produced in many languages, however, it is important to emphasise that the use of object-oriented methods is not dependent on any particular programming language.

Manufacturing systems are faced with continuously changing market conditions. Due to this fact, enterprises are permanently forced to adapt their organisational and personnel structures to new requirements created by these changing market conditions. In order to fulfil these requirements, it is becoming more and more important to take the cost intensive personnel resources into considerations [6]. The problem of assigning personnel to functions and workplaces is, at least in the case of planning a new workshop, characterised, on the one hand, by a large number of possibilities for varying the abilities of employed persons and, on the other hand, by a large number of different possibilities for allocating these persons to work functions. The simulation software that was used in the case studies discussed in this paper has this capability of assigning personnel to functions.

Simulation also focuses on the formulation and solution of problems by trial and error methods. The simulation process is iterative and often reveals important information and new insight into problems area as a result. During this iterative procedure, the relationship between the system under study and the model are defined and continually redefined. Simulation and modelling are therefore inextricably linked with the steps in the simulation process. Therefore, the more experienced practitioners used intuition and experience. The following section will show the benefits, through industrial case studies, of applying simulation in the analysis and evaluation of various manufacturing systems.

2 Applying simulation to assist in improving industrial manufacturing performance

2.1 First Case Study- Knitwear Production Company

This company is one of the leading fashion products' suppliers in the market today. They supply various Garment designs to many high street clients. Due to the high level of competition and the demand for a quicker turn around of new Garment design, the current production facilities would not be satisfactory. The current production system was modelled and simulated in order to evaluate its current performance, and hence highlight the problem areas within it so that improvement actions could be implemented. In order to achieve this the following tasks were carried out:

- Model the current production system using ProModel Simulation Package, as shown in Figure 1.
- Upload the relevant data into the developed model and simulate the production process based the production of 5000 garments in batches of 72s.
- Interpret the results of the simulation, and make appropriate recommendations that would provide improvements in the production system.
- Re-Model and simulation the production system based on the recommended actions to demonstrate the possible improvements that could be achieved.

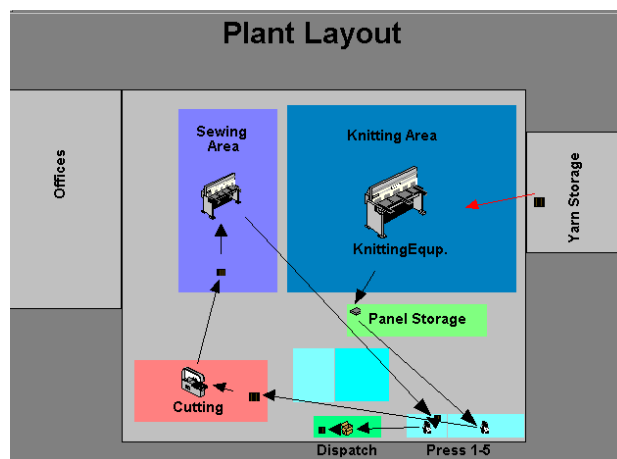


Figure1. - Plant Layout Model using ProModel.

Based on the information provided by the company, the production process was built into the developed model of the plant. All process details, in terms of manufacturing times, were also entered into this process plan. The simulations' results clearly have shown the large variation in performance and capacity of the various departments within the factory. It was clear that the knitting department was working continuously at 98% utilisation, while other departments such as the sewing and cutting were working single shifts at 15-20% utilisation, as shown in Figure 2. It was therefore clear that any improvement in productivity, and hence customer delivery performance, would need to be the result of improving the productivity within the knitting department. Based on these and other recommendations, the company purchased new Knitting machines to compensate for the difference in utilisation levels. This purchase reduced the lead-time from 5-weeks down to 2-weeks, as shown in Figure 3.

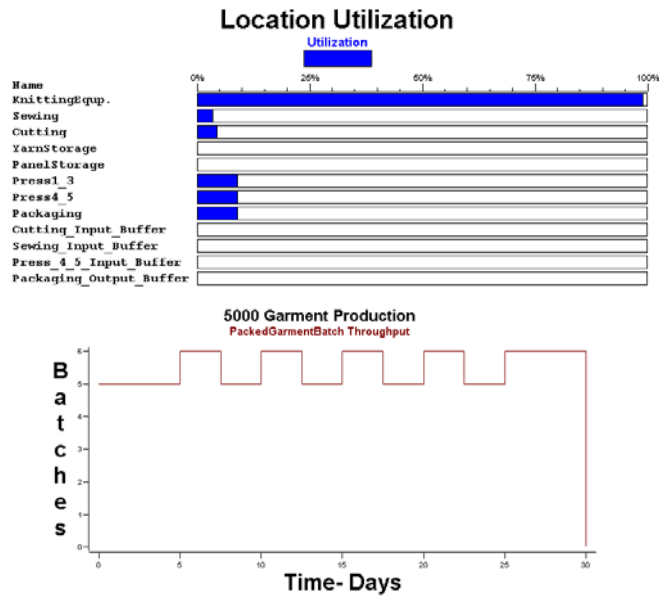


Figure2 – Simulation Results of Plant in its current Status

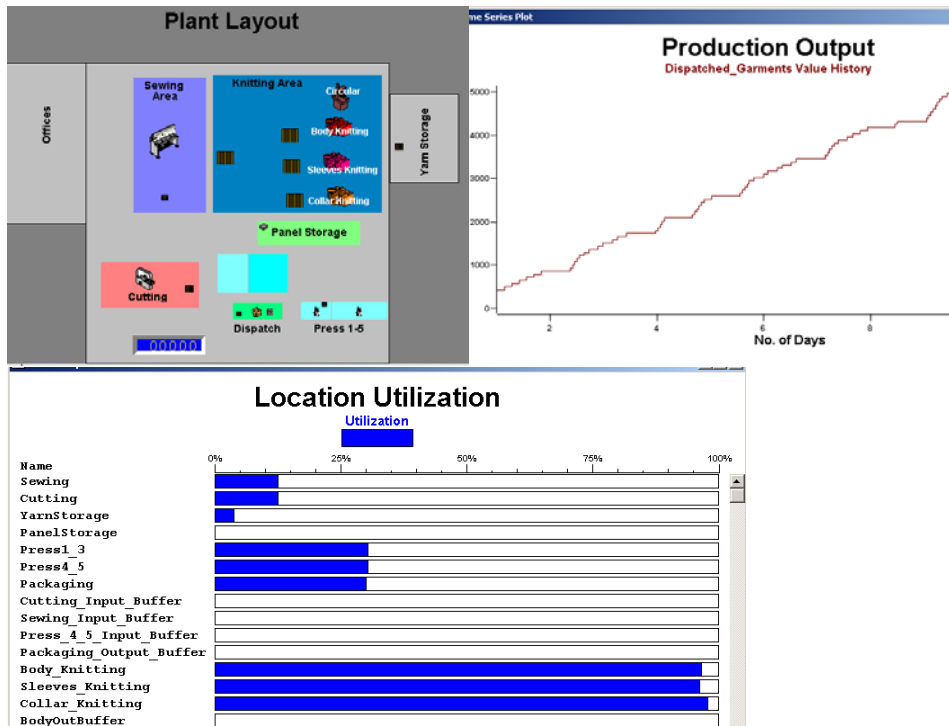


Figure 3. - New Plant Layout including new Machines & Corresponding Simulation Results

2.2 Second Case Study- Forging Company

The company is considering the investment in two possible automation systems. Therefore, the company requires some tangible data in terms of manufacturing performance and utilisation. It is therefore thought to be appropriate to model and simulate the existing factory layout and its manufacturing system, and then if possible simulate the two proposed solutions in order to be able to compare performance. Based on the information provided by the company, the production process modelled using ProModel, and all process parameters were built into the developed model of the plant. The current plant layout is shown in Figure4.

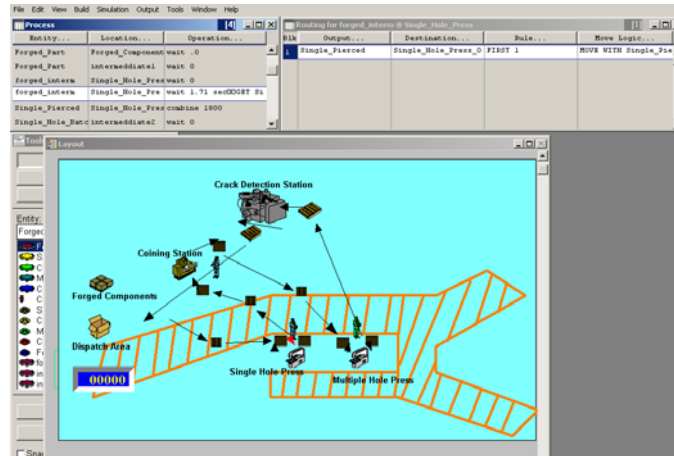


Figure 4. - Current Plant Layout

A number of charts and graphs were presented showing the results of simulating the production system based on different scenarios. The following is a summary of the results:

- The existing Plant with production batch of 1800, providing a throughput of 700 components per hour. The existing Plant was then simulated with a production batch of 500, providing a throughput of 730 components per hour.
- Automating the Unloading process only, which then frees the operator to load the press as soon as the component is forged and ejected. This provided a throughput rate of 1200 components/hr.
- Automating both the Loading and Unloading operations with a loading/unloading time of 1Sec. This provided a throughput rate of 1300 components per hour. However, such automation will be at high cost, especially if the 1Sec Loading/Unloading time is to be achieved.
- Applying cellular approach, and devising two identical cells for the Piercing and Coining operations employing press operators, as being done currently, and the output of both cells being the input for the Crack Detection Station. This will provide a throughput rate of 1400 components per hour with minimum investment in new equipment or handling devices, but would require three more press operators.
- Based on the simulation results, and the data provided, the company decided on investing in cellular automation. A sample of the simulation results is shown in Figure 5.

2.3 Third Case Study- Boat Trailers Manufacturing Company

This company designs, manufactures and supplies boat trailers to a number of clients. Due to increase competition and higher customers demand there was a need to review and improve its manufacturing facilities. This would increase productivity by improving workflow as a result of the current factory layout analysis, and hence new layout recommendation. In order to achieve this the current factory layout was modelled, and simulated as shown in Figure 6. The results highlighted current problems. These results were then used to develop a new layout. The proposed layout was then modelled and simulated in order to evaluate the performance of the production system. This was carried as follow:

- Modelled the proposed production system layout using ProModel Simulation Package.
- Uploaded the relevant data into the developed model and simulated the production process based on batches of 20 until preparation, then based on working using a batch of one. The operation of the manufacturing process was based on 8hrs shift per day apart from subcontracting which was based on 24hrs. Result of the simulation shown in Figure 7.
- Interpreted the results of the simulation, and provided possible improvements in the production system.

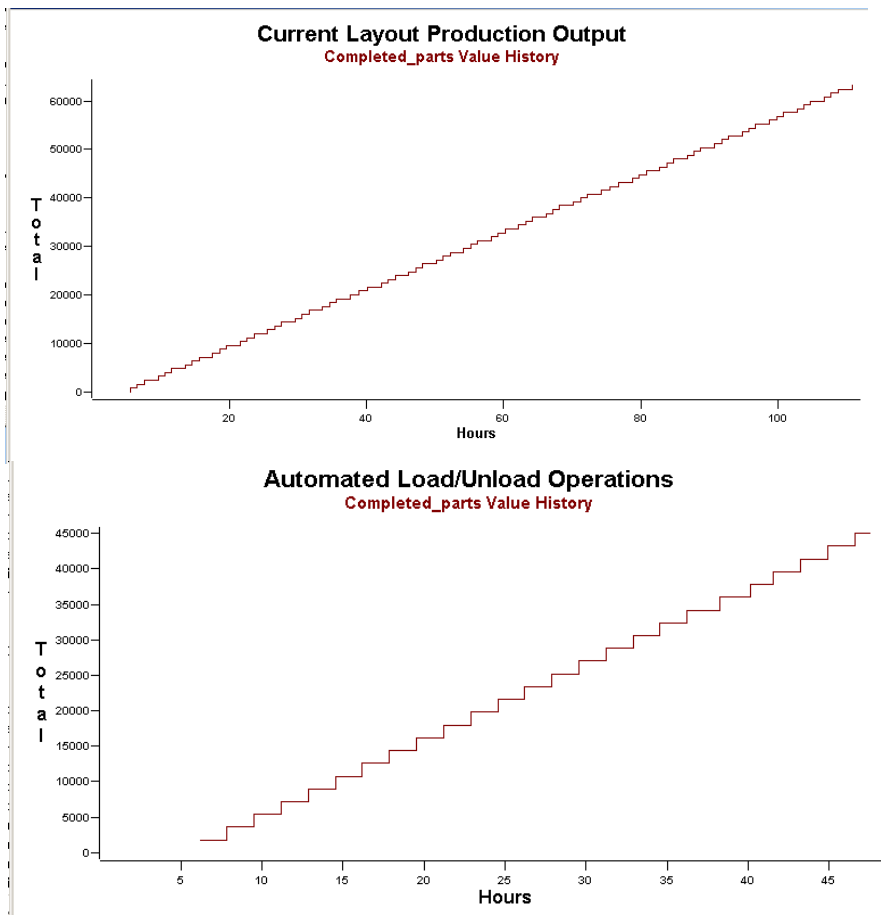


Figure 5. - Sample of Simulation Results before and after Automation



Figure 6 – Current Plant Layout

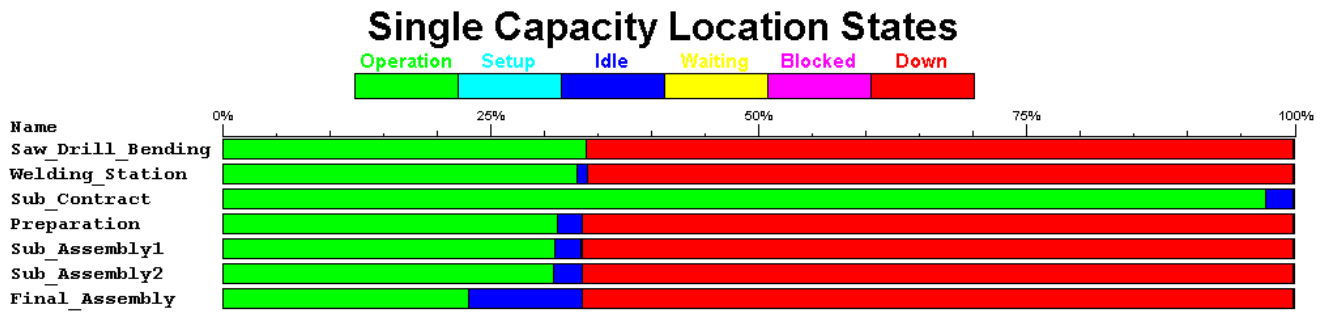


Figure 7. – Simulation Results Based on Current Operational Parameters

The results of the simulation had shown that based on current manufacturing parameters, the factory should be able to produce an average of 20 trailers per week. The simulation results also provided visual representations of the level at which individual departments within the company are performing at. This level of performance and utilisation would be the key elements in terms of production improvement procedures. Figure 8 shows the simulation results based on the new parameters regarding personnel operational activities that were recommended.

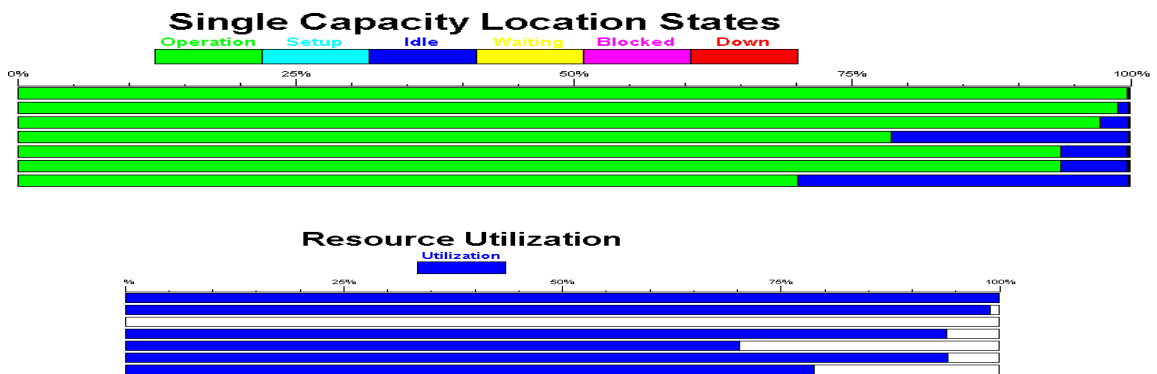


Figure 8. – Simulation Results Based on the Recommended Double Shift Production

2.4 Fourth Case Study- Injection Moulding Company

This company supplies injection-moulding parts to the automotive industry. The company has no details on its manufacturing process efficiency, and therefore required a detailed study in order to evaluate the current production system performance, and hence identify if its current performance could be improved. Based on the information provided by the company, the production process was modelled using ProModel, and all the process parameters including human resources were embedded into the model. All process details, in terms of manufacturing times, were also entered into this process plan. Figure 9 shows the model of the manufacturing system as well as the simulation results in terms of resources utilisation.

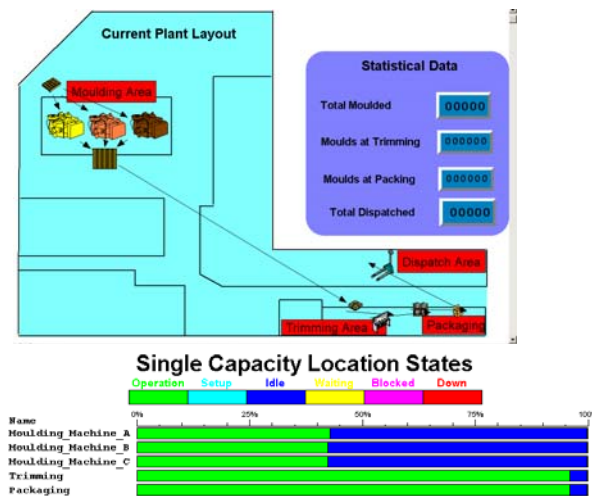


Figure 9. – Production Layout and Simulation Results

The simulations' results clearly have shown the large variation in performance and capacity of the various departments within the factory. It is clear that the Trimming and Packaging departments are currently working continuously at 95% utilisation, while other departments are currently working at 40-45% utilisation. It is therefore clear that any improvement in productivity, and hence customer delivery performance, will need to be the result of improving the productivity within the Trimming and packaging departments. A second simulation was then carried out based on doubling the number of people in the Trimming and Packaging, and the results show that the overall production time for the 304 parts was halved. New Utilisation results are shown in Figure 10.

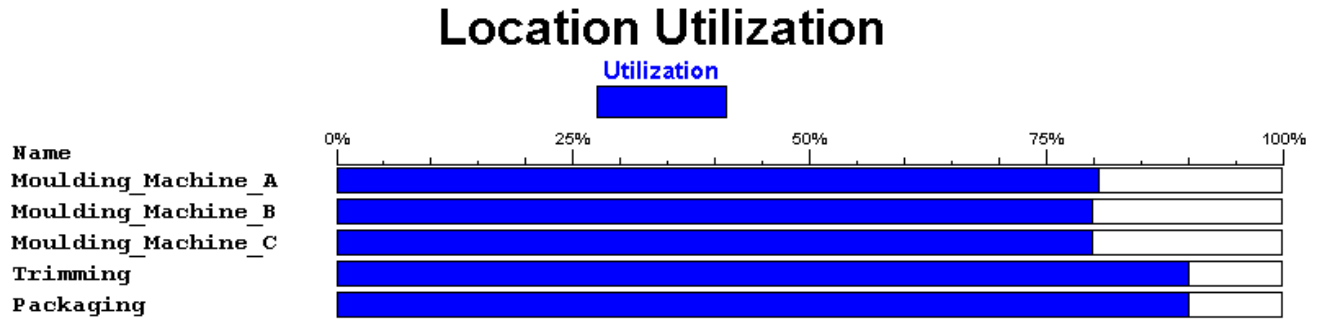


Figure 10. – Simulation Results based on New Recommendations

3. Conclusion

This paper has presented a number of actual industrial case studies where simulation was used to evaluate their current production facilities, and provide appropriate recommendations leading to improved performance.

The use of such simulation technique not only presents tangible data of such production facilities, but also provides their managers with visual representations of the level at which individual departments and personnel are performing. Such key elements and information proves very critical in enhancing the overall utilisation performance of such production facility.

4. Acknowledgements

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