

Simulation of a Wafer Fab Manufacturing Plant

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Abstract. This paper describes a real life factory model that was developed using 'Witness' software. A wafer fabrication manufacturing facility in Singapore was selected for this project. The model was built to enhance understanding on operation parameters with respect to manufacturing cycle time. It also served as a tool for the operation to identify potential opportunities for direct improvement projects.

1 Introduction

With advances in computer technology, computer simulation has been considered a significant factor in improving the productivity and quality of a manufacturing process. Computer simulation is done prior to committing large amounts of time, money and other resources before actual implementation. Management of a system is usually action based on prediction. Rational prediction requires systematic learning and simulation educates people on how an environment operates. Modelling is thus an excellent tool for forecasting outcomes.

The fundamental goal of the simulation is to provide a useful model as simple as possible. This implies capturing the "appropriate level of detail" that can describe the wafer fabrication operation behaviour, predict its performance and control the variable parameters.

2 Model Development

The model was developed with the objective of representing the real world that we function in. To be able to assess whether the model is valid and useful for the operation and management, performance measure *Cycle Time* was selected as a way of model validation. Figure 1 shown the input parameter that has been built in the model.

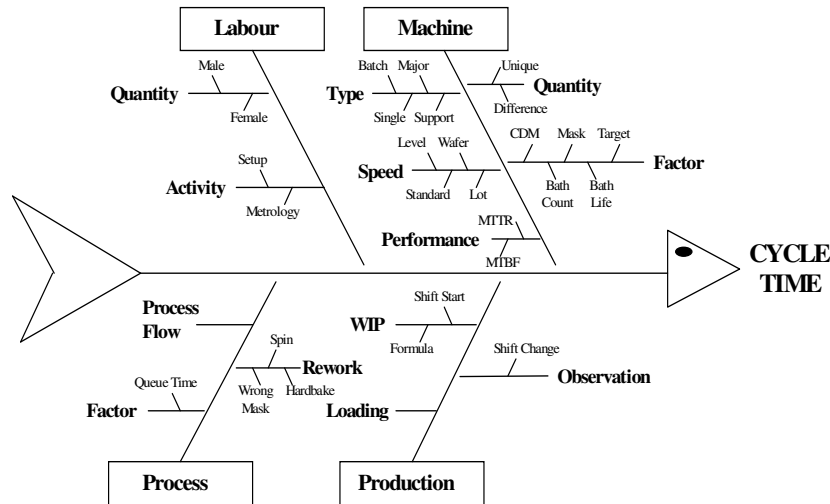


Fig. 1: Model Input Parameter

In general, 4 main areas (i.e. man, machine, method and material) in the operation were considered to be critical factors in the process and would significantly affect the modelling result. Much effort has thus been spent to collect, verify and validate to ensure that sufficient information is being modelled and represented correctly.

The simulated results for 4 weeks in Mar'99 were generated and compared with actual result collected as shown in Figure 2. The discrepancy between both sets of data point was less than 5%. This leads to the conclusion that simulation model is capable for forecasting events as well as other applications.

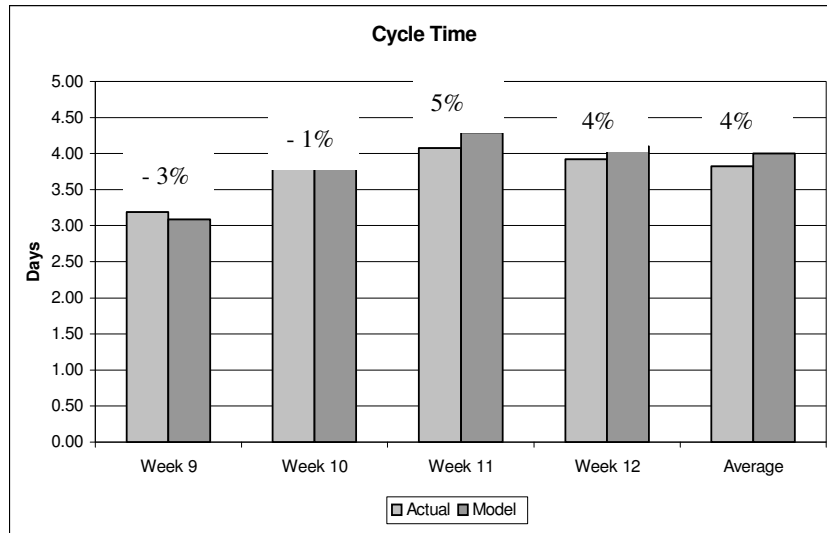


Fig. 2: Model Validation Result

3 Result & Discussion

Upon the successful validation of the simulation model, it was put to application by analysing the relationship between cycle time and work-in-process and varying loading. This study would enable management to extend from what they know into what they want to know pertaining to cycle time.

3.1 Relationship – Cycle Time Versus Work-In-Process (WIP)

From Figure 3, it can be observed that at any given loading and equipment capacity, the cycle time is directly proportional to the amount of inventory. In order to meet output target, there is a minimum amount of WIP that needs to be maintained. Anything below this point as shown would result in missing output target. Similarly, having more inventory than this point would mean more shipment assurance at the expense of cycle time performance.

This important relationship has provided the fab operation a guideline on what level of inventory should the production hold through better understanding of the trade-off. It forms a basis for the management to make better decision through more informed knowledge.

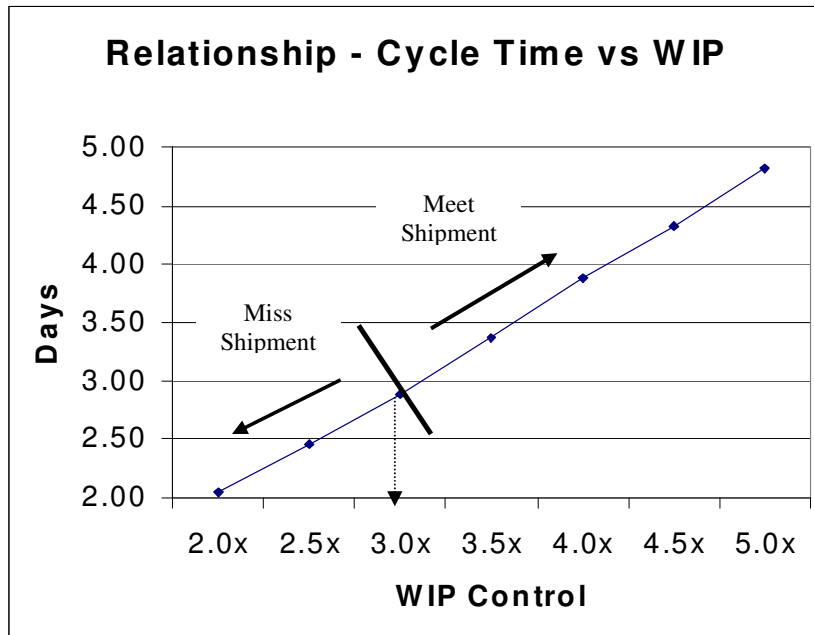


Fig. 3: Relationship Cycle time versus WIP

3.2 Relationship – Cycle Time with varying Loading

Figure 4 highlights a case whereby at low loading causes the cycle to be on the high side in the opposite direction than expected. Further analysis revealed that default operating batch size started to affect the production rate due to the characteristic of machines and thus, created an impact on the cycle time performance.

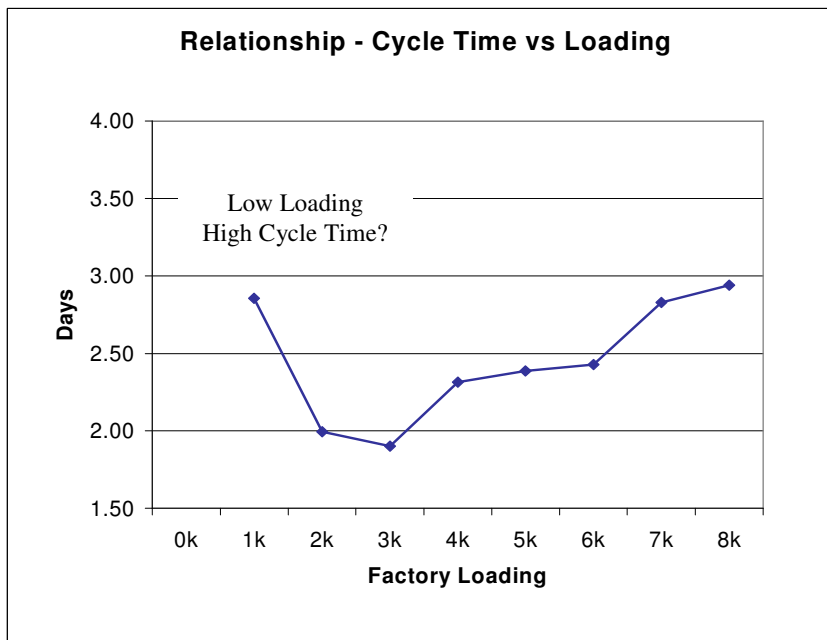


Fig. 4: Relationship Cycle time vs varying Loading (default batch size)

This result has provided some insight to the management on the influence of batch size with respect to factory loading. Through simulation modelling and experimentation, the operation became aware of the level at which running low volume without changing the old practice, the immediate impact to the performance would be cycle time.

Figure 5 highlights a case whereby the batch size is adjusted to low from default. From the result below, at high loading the cycle time performance is extremely high. Both cases illustrated cycle time as a function of batch size on top of the work-in-process.

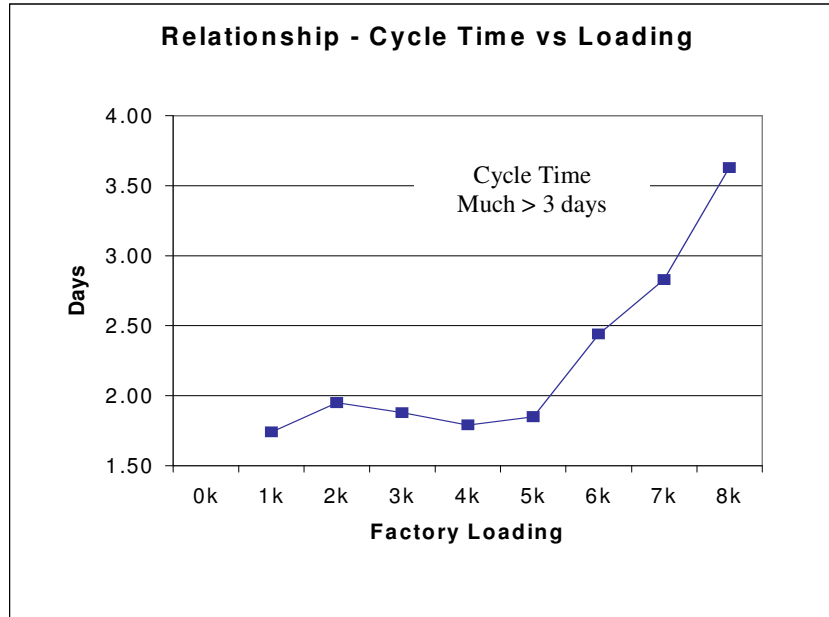


Fig. 5: Relationship Cycle time vs varying Loading (low batch size)

The relationship of cycle time versus varying loading has provided a new understanding to management on the dynamic effect of batch size on the performance factor. It provides a choice for the operation to choose either adjusting batch size or factory loading in order to operate the plant efficiently.

From the result in Figure 6, it is observed that batch size began to interfere with the performance of cycle time at the 6K wafers loading. For loading above 6K, the default batch size would yield a better cycle time. Similarly for loading below 6K, a small batch size would return a preferable cycle time performance.

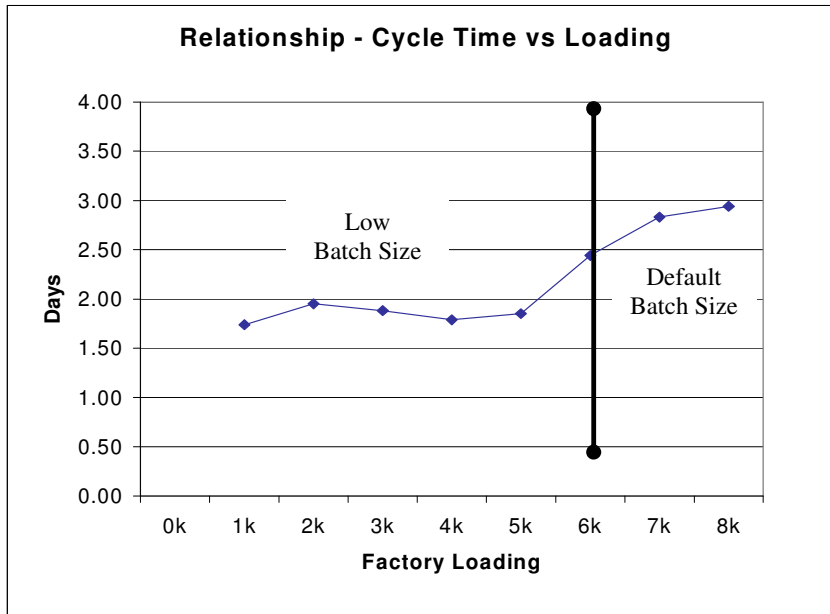


Fig. 6: Relationship Cycle time vs varying Loading

In Figure 7, a curve measuring the loading efficiency ratio was plotted to assess at which loading point would return the optimum output and cycle time. It was found that for loading below 6K wafers with low batch size mode, operating at 5K wafers yield high ratio. For loading above 6K wafers and default batch size mode, operating at 8K wafers yield similarly high ratio.

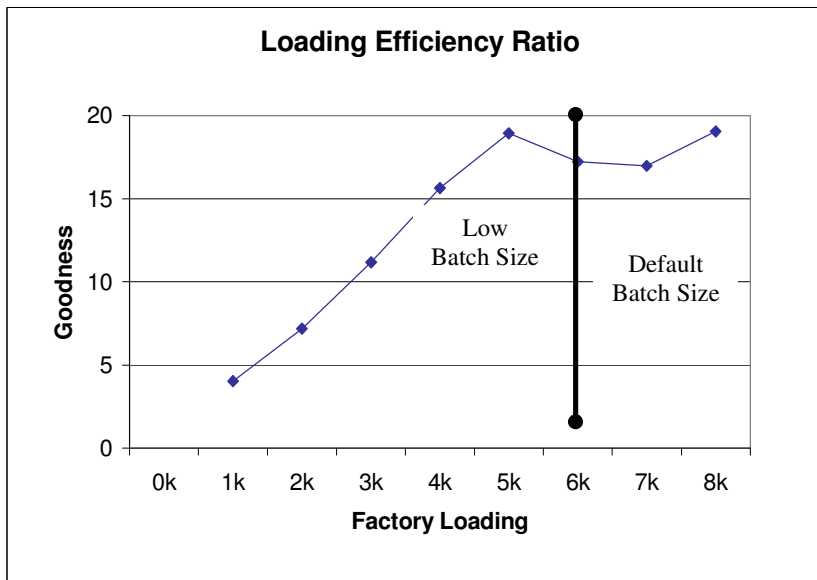


Fig. 7: Loading Efficiency Ratio

4 Conclusion

In this project, a simulation model on the Wafer Fab manufacturing plant was built in the Witness environment. The main objective of this project is to create a tool that enables better understanding on operation parameters and at the same time, a tool for scenario planning in near future. Cycle time was selected as the key performance measure in this case. In addition to using cycle time as a model validation, it also serve as an index to enhance understanding with respect to work-in-process as well as varying loading with a given set of equipment capacity.

From the result, it has been found true that at any loading, cycle time is directly proportional to WIP before batch size begins to interfere. To meet the output, there is also a need to balance between cycle time and WIP. Insufficient or excessive inventory would result in missing output target or high cycle time respectively. Result has also suggested that at loading below 6K wafers, batch size need to be reduced in order to yield low cycle time. The default batch size is only good for loading above 6K wafers. Furthermore, to operate the factory at high loading efficiency, the recommended loading is found to be at 5K and 8K wafers respectively.

5 Acknowledgements

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6 References

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