Realizing Throughput Improvement through Machine Rate Modeling – Case Study

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Abstract

The toughest challenge compound semiconductor fabs face during the current ramp cycle is increasing equipment throughput (TPT) faster. Determining the opportunities to increase equipment TPT through machine rate modeling is the necessary first step in this improvement process; therefore, an optimized modeling technique is imperative to meet this challenge.

As this case study was completed it identified the opportunities for increasing TPT and yielded a 40% increase through the implementation of proper batching, eliminating or cascading non-value-added activities performed by the operator (approx. 100sec per wafer) and configuring the stepper to load multiple reticle pods at once. As tools are becoming more and more sophisticated and complex it is imperative to create and maintain a machine modeling infrastructure detailed enough to use as catalyst for TPT improvement. At the same time, it has to be simple and cost effective to maintain. This is what MAX I.E.G. has realized time again!

INTRODUCTION

The toughest challenge compound semiconductor fabs face during the current ramp cycle is increasing equipment throughput (TPT) faster. Determining the opportunities to increase equipment TPT through machine rate modeling is the necessary first step in this improvement process; therefore, an optimized modeling technique is imperative to meet this challenge.

Some Fabs use complex simulation modeling, which in most cases are lengthy to create, cost-ineffective and very difficult to maintain. This case study will demonstrate how we achieved a significant TPT increase on a photolithography tool through employing our simple and accurate technique to model machine rate, which also allowed for what-if scenarios and the verification of the improvement impact.

THE CHALLENGE

The challenge we faced was to determine how to increase an ASML 5500/100D stepper's TPT from a mean of 25 WPH to 35 WPH (+40% TPT) within two weeks. In order to figure out the improvement potential we needed to determine the ultimate speed (WPH) of the tool and evaluate the process changes necessary to increase the tool's TPT. The speed modeling technique followed 4 simple steps:

MAPPING→OBSERVING→ANALYZING→ IMPLEMENTING

The Method

We embarked in a modeling effort as the first step in the improvement process.

1. Map

The first step to create a speed model was to understand the tool and its components, such as load/unload ports, handling mechanisms (robots), hold chambers (buffers) and processing chambers. For some tools, identifying their components is simple, because they are visible from the outside; however, for those tools that are completely enclosed, a good starting point is to get the user manual from the vendor, which usually contains a diagram of the inside of the tool with a description of its functional parts (refer to Figure 1). This first step could be underestimated for it would have allowed the modeler to quickly learn how this stepper operated.

FIGURE 1

MACHINE DIAGRAM

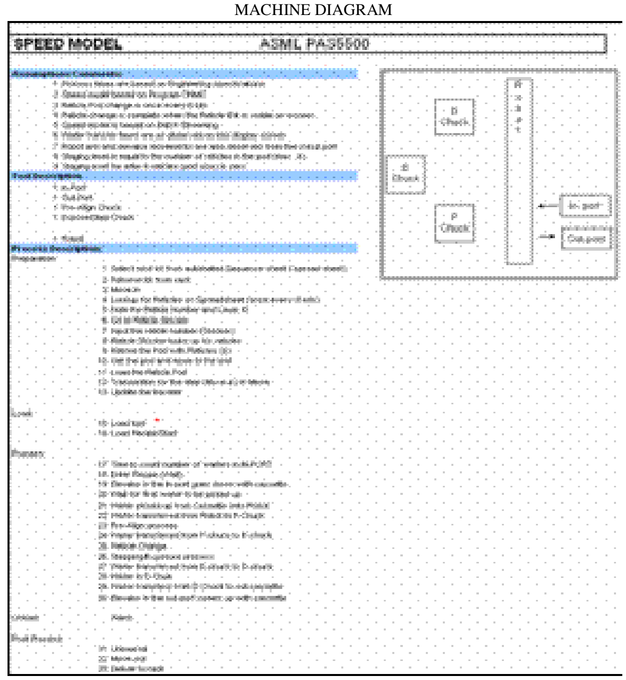


Figure 1 – Machine diagram

2. Observe

Once our data collection form has been approved (refer to Table 1 below) by the process engineer, we started the time study to capture the elapsed time for each activity into the form.

Once we completed the data collection, we convert the elapsed times into time intervals, and their durations.

TABLE 1

DATA COLLECTION SHEET

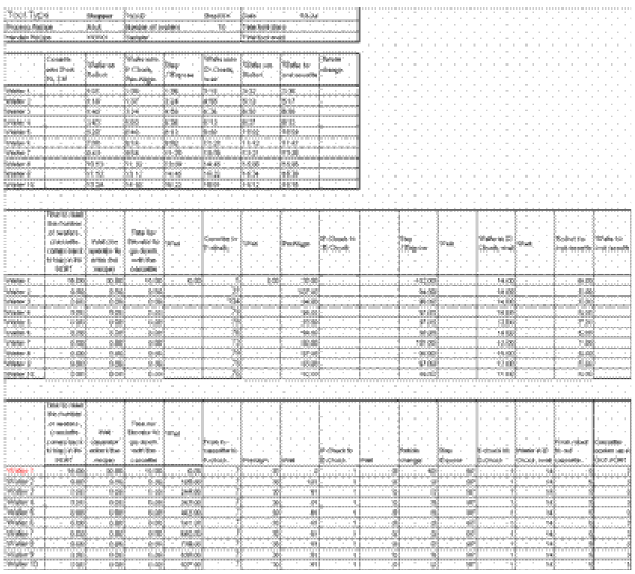


Table 1 – Data Collection sheet

2.1. Creating a Gantt Chart

When we finalized the duration times for each step of the process, we created the Gantt chart for each photo layer modeled. The purpose of the Gantt chart is to determine the overall process time per lot/batch and the critical path that establishes the ultimate TPT.

This stage of the machine rate model is the most critical to develop depending on how complicated the machine is; multi-chamber or cluster tools are especially complex. On the other hand, this is the most rewarding part of this exercise, as it forces the modeler to fully understand the logic/sequence of the machine and pose the questions that will enable throughput improvements.

This exercise highlighted the inter-dependencies internal to the machine, and exposed the sequential activities that make up the critical path. In turn, the critical path dictates the maximum throughput of the tool.

The Gantt chart example below exemplifies all activities every wafer goes through for a 25-wafer lot; additionally, the white dotted line represents the critical path for this tool. As mentioned before, the critical path will lead you to understand the opportunities for throughput improvement.

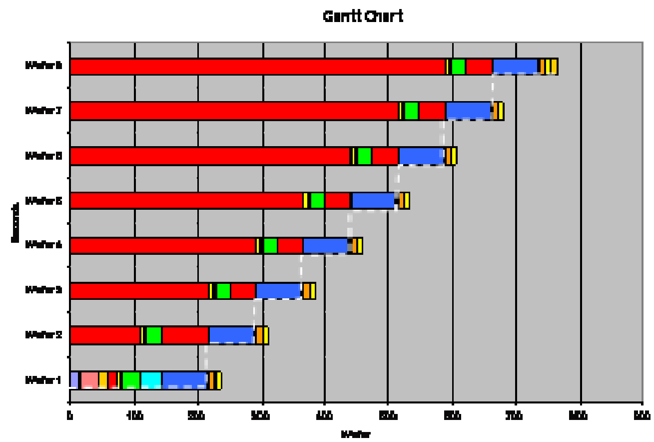


Figure 2 – Gantt Chart

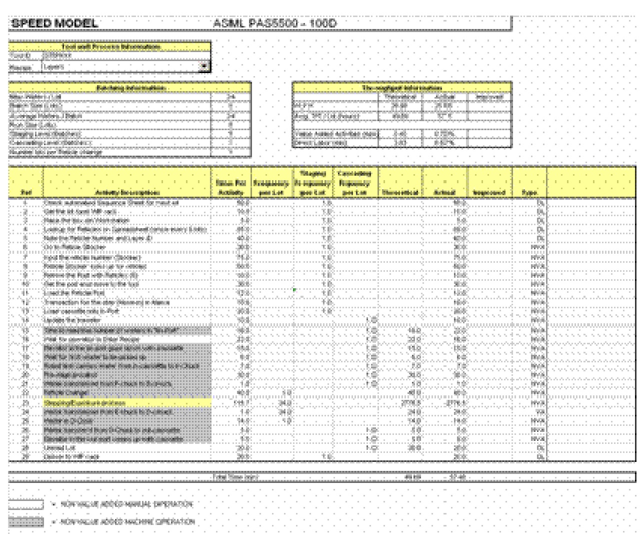
2.2. Creating the Machine Model

When the critical path was establish from the Gantt chart, we then determined the frequency of each activity to generate the actual model (refer to Table 2).

As seen above, there are many parameters that feed this model which can affect throughput, such as lot size, batch size, run size, staging levels (staging is defined as preparing the next lot run in parallel to the previous run) and cascading levels (the machine is fed continuously so it doesn't go idle between lots) – this model provides theoretical and actual throughput results and the reasons for the gap between them. Most importantly, the improved column can be used to calculate improved speeds from what-if scenarios. Example: how does decreasing the time for one process affect the speed of the machine – if the pertaining processing module is not part of the critical path, then the speed won't get improved.

TABLE 2

MACHINE MODEL



3. Analyze

The next stage of this process was to run sensitivity analyses from the model, such as lot staging and cascading levels (batching), and process improvements. We performed this analysis to determine the optimum number of lots needed to be staged to minimize setup activities such as Reticle pod changes. The finding from this model included a detailed analysis of non-value-added activities (machine and operators), reticle loading optimization and reticle layout design modifications. Figure 3 below provides a visual representation of the optimum speed for this stepper under certain staging or cascading conditions

FIGURE 3
BATCHING EFFECT ANALYSIS

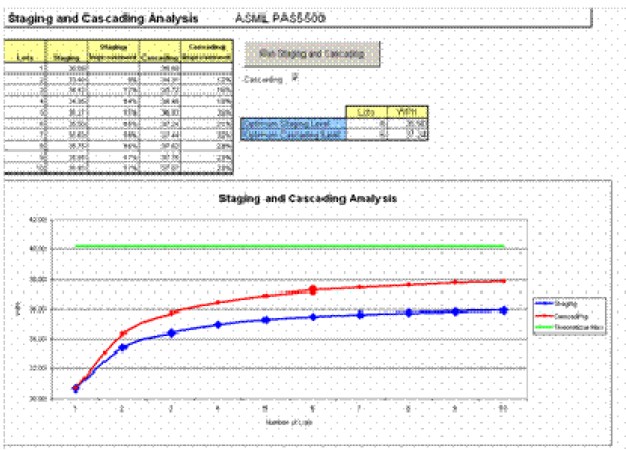


Figure 3 – Batching effect analysis

CONCLUSIONS

As this model was completed it identified the opportunities for increasing TPT and yielded a 40% increase through the implementation of proper batching, eliminating or cascading non-value-added activities performed by the operator (approx. 100sec per wafer) and configuring the stepper to load multiple reticle pods at once. As tools are becoming more and more sophisticated and complex it is imperative to create and maintain a machine modeling infrastructure detailed enough to use as catalyst for TPT improvement. At the same time, it has to be simple and cost effective to maintain. This is what MAX I.E.G. has realized time again!

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ACRONYMS

TPT: Throughput Time