Cycle Time Reductions for Test Area Bottleneck Equipment

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Biography

Steven Brown is the project manager for Factory Modeling and Simulation, a part of the Manufacturing Science department of Siemens' Semiconductor Division. He has twenty-eight years of management experience in various industries, including nineteen years in semiconductor manufacturing. His formal education includes Bachelor of Science and Master of Science degrees in Business Administration. Mr. Brown is a member of IEEE and INFORMS; his simulation interests are in factory life-cycle analysis and whole factory modeling.

Abstract

Using discrete-event simulation models, a study was conducted to evaluate the current production practices of a high-volume semiconductor assembly and test operation. The specific goal of the study was to find potential areas for productivity improvement that would collectively yield a 60% reduction in manufacturing cycle time for the back-end factory. This paper will present findings and measurable results pertaining to the Burn-In and Tester operations, which are the current factory constraints. The model shows that the cumulative impact of these recommendations is a 32% reduction in average cycle time, a significant contribution to the overall goal. Additional opportunities are being investigated with models of the Assembly area.

Introduction

As yields and efficiencies from wafer fabs continue to increase, more attention is directed towards the ability of semiconductor back-end factories to handle the load with minimum capital expenditures. Throughput, utilization, and cycle time continue to be emphasized as key performance parameters for existing operations and for the complex planning of new facilities.

Siemens' Dresden wafer fab has experienced a quicker-than-expected acceleration up the learning curve, resulting in higher yields than originally planned. This, of course, is what might be classified as a "good" problem. The difficulty, however, is that the back-end equipment set now has a much higher production demand than planned for and has exceeded the original loading plan. The result is a much larger work-in-process inventory than anticipated and, consequently, an unacceptable cycle time. Management's goal is to process the higher volume, within the original cycle time plan, without additional capital expenditures. To assist this effort, members from Siemens' centralized Factory Modeling and Simulation Team [1] constructed a detailed model of the factory and completed a performance analysis of the production operations.

By applying simulation models and analyses, the project team's goal was to identify changes in production operations that could collectively reduce back-end cycle time by 60% while maintaining the current capacity loading levels (see Figure 1).

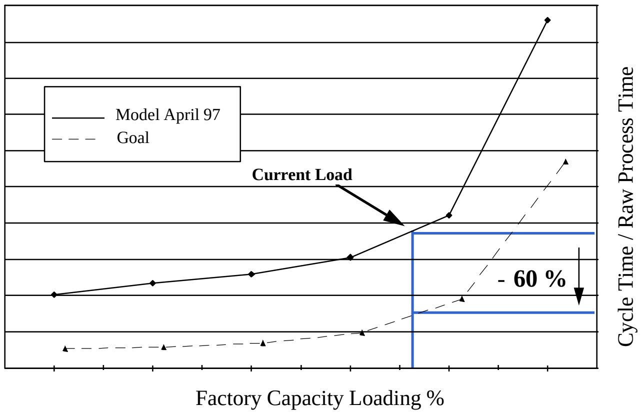

Figure 1. Goal of the Simulation Study

This paper discusses recommendations for the Final Test area, specifically pertaining to the Burn-In and Tester operations. Results are expressed as a percentage decrease in the cycle time of the overall back-end factory. These recommendations show a cumulative 32% reduction in factory cycle time. In addition to this paper, investigations are being done with models in the Assembly area, specifically analyzing the impact of lot release strategies, transport lot sizes, staffing levels, and hot lot strategies [2].

Simulation Methodology

The project began with a problem statement, basically "How can the Dresden back-end factory reach its cycle time goal?" With this in mind, the simulation team worked directly with the production department to determine the project deliverables, schedule, and milestones [3].

This project used the simulation software Factory Explorer™, from Wright Williams and Kelly [4], which proved to be a very effective tool for modeling back-end operations. Within thirty days a top-down model was constructed with available data. From this point, more detail was added to the model to conduct an effective first-pass analysis of the existing factory. Working with key members of the production staff, this analysis and subsequent model were validated against actual factory output data. This process required approximately another two months.

Once the model was deemed by management to be a valid representation of the factory, the simulation team conducted a series of "what-if" analyses and presented the findings and recommendations. Results were expressed, as in Figure 1, via a graph of the operating curve for the factory. The operating curve shows the relationship between cycle time and capacity (or factory utilization). Improvements in cycle time create a shift in factory performance, which results in a new operating curve. The percent cycle time reduction for a given factory is the vertical difference between the two curves at that point.

A key to the success of this (and any other) simulation project was the interactive exchange of ideas and information between the simulation experts and the production group. By working real-time with key production personnel, the simulation team could more easily produce meaningful findings and implementable recommendations. This investment of time and resources by the production personnel allowed effective application of the modeling work.

Four specific recommendations pertaining to the Final Test area are discussed in the following section.

Results

One effective use of simulation is to take a planned improvement at one work station or operation and test the impact of this change on the performance of the overall factory. In this case, the management team was considering a process change at the Burn-In operation that would potentially eliminate the majority of the rework at the P2 Test operation (see Figure 2).

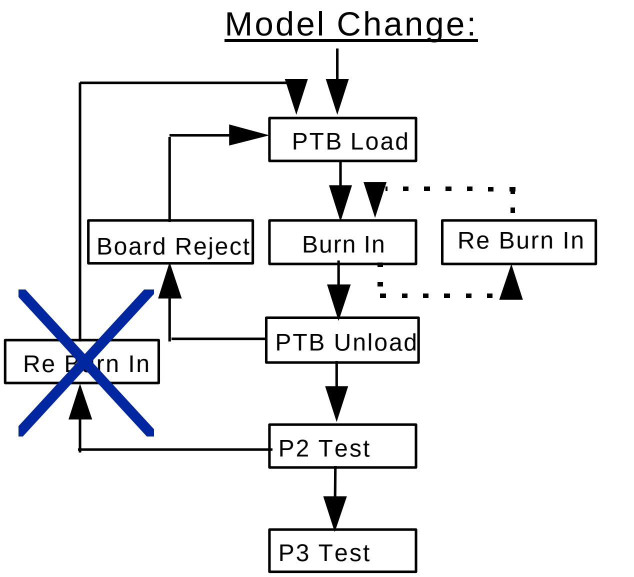

Figure 2. Proposed change to the Test rework process

In effect, the change would move the rework loop away from the testers. Simulation analysis verified that this would indeed be a good strategy, resulting in a 12% decrease in overall back-end cycle time and a subsequent reduction in inventory (see Figure 3). Although this change significantly increases the process time at the burn-in ovens, the overall factory performance is improved because the testers are the bottleneck tools. This change effectively reduces the load at the system constraint, thus permitting the cycle time reduction, and can be implemented without additional capital expenditures.

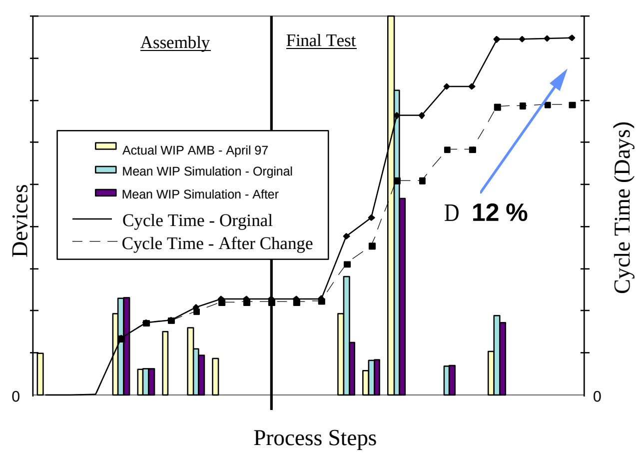

Figure 3. Impact of change in rework process

The Burn-In area currently operates under a full-load batching policy (an oven is left idle until enough inventory is available for a full load). Figure 4 shows the benefit of managing the ovens with a greedy batching policy, a 9% decrease in average cycle time when operating at the same capacity loading. A greedy policy requires each available oven to be immediately loaded with available inventory. The model shows this benefit to exist until the ovens reach 96% utilization, at which point cycle time begins to degrade.

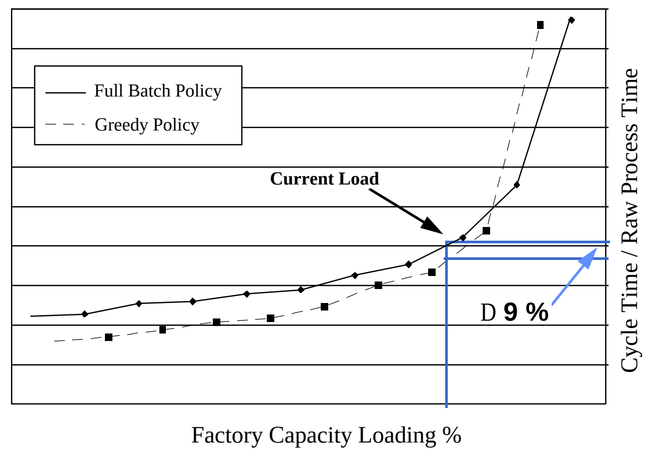

Figure 4. Impact of change to Burn-In batching policy

If these two recommendations are implemented together, the model shows that the Burn-In operation would become the bottleneck of the back-end factory. This highlights a very significant advantage of using simulation analysis to better understand the factory: if incorporating changes to the production floor will cause the system constraint to shift, it is critical to know this in advance so that necessary adjustments can be made to production management strategies. Use of discrete-event simulation tools gives the manager this depth of understanding. In this case, knowing that the bottleneck has shifted to burn-in also suggests a starting point to look for additional cycle time reductions in future studies.

Looking at the present bottleneck equipment group, the testers, current manufacturing strategy involves a high level of dedication due to production-imposed restrictions and to test handler restrictions. Figure 5 shows that elimination of tool dedication at the factory bottleneck operation will yield a potential 11%

reduction in cycle time (this result is heavily dependent upon the product mix). The cost to upgrade a test handler is equal to 8% of the tester's original capital expenditure.

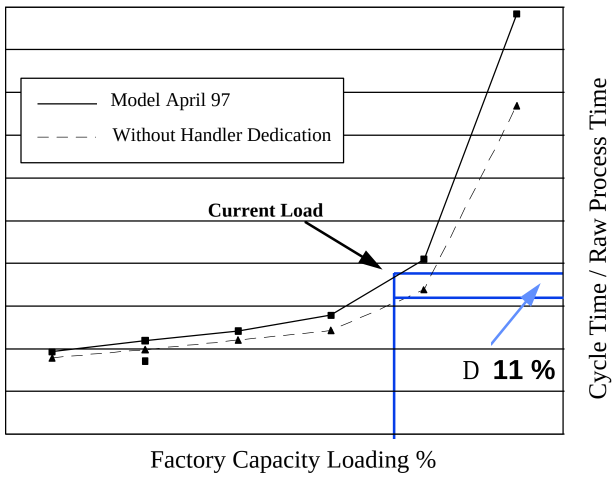

Figure 5. Impact of elimination of handler dedication

The project model is very sensitive to staffing levels. This is not only an accurate representation of the Dresden factory but, the project team believes, also correctly depicts the typical back-end operation. Figure 6 indicates that by adding one operator per shift, and assigning "split" responsibilities between the Burn-In and Test areas (in effect, a "floater"), the average cycle time is decreased 8%. Simulation runs indicate that there is great potential in a detailed analysis of operator levels and qualifications throughout the factory.

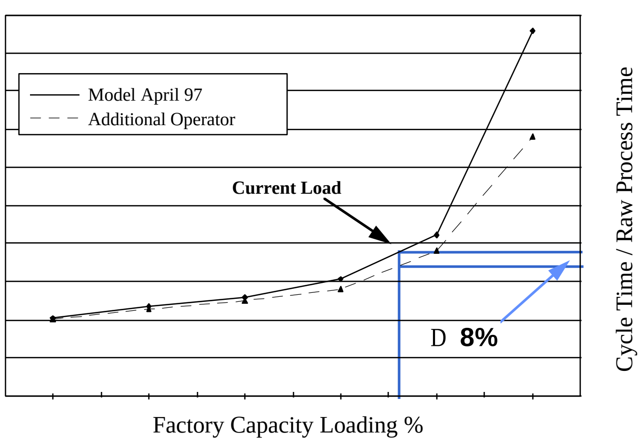

Figure 6. Impact of adding one operator per shift

Conclusion

The final graph, Figure 7, shows the cumulative effect of implementing these four recommendations for the Final Test area. Since there are interaction effects present among the four factors, the total impact is less than the sum of its parts. In this case, the overall factory cycle time is decreased by 32% from the current levels, approximately half the established goal, with a minimum requirement for additional expenditures.

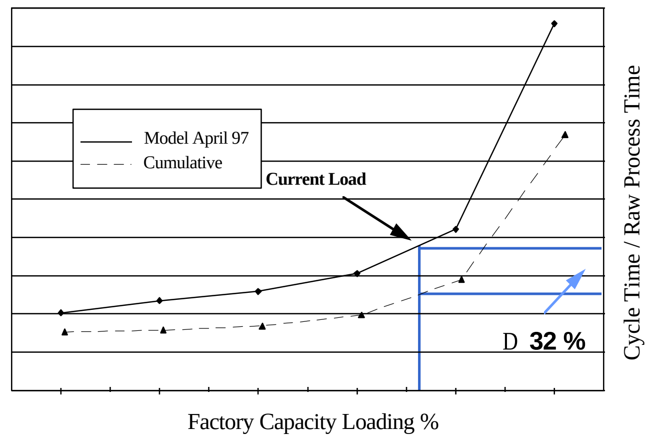

Figure 7. Cumulative impact of the recommendations

This case study shows the benefit of applying simulation modeling to performance analysis of the semiconductor back-end factory. Many aspects of the findings and recommendations for this facility apply to semiconductor manufacturing sites in general. There is agreement among Dresden management that this analysis was very beneficial and that this work will continue at the site. Implementation of these ideas into the actual factory is in process and data is being collected to quantify the impact on actual factory performance.

References

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