‘NO COST’ APPLICATIONS FOR ASSEMBLY CYCLE TIME REDUCTION

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ABSTRACT

This paper focuses on cycle time reduction strategies that can be applied to the Assembly area of semiconductor manufacturing facilities. Using discrete-event simulation models, a study was conducted to evaluate the current production practices of a high-volume semiconductor back-end operation. The overall goal was to find potential areas for productivity improvement that would collectively yield a 60% reduction in manufacturing cycle time. The simulation analysis resulted in a series of recommendations for the Assembly area that would require no additional capital expenditure. The model showed that the cumulative impact of these Assembly recommendations would be a 20% reduction in average cycle time, a significant contribution to the overall goal.

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.

The application of modeling and simulation for factory performance analysis is in the beginning stages in this industry, relative to device and process modeling [Moore 1997]. However, the National Technology Roadmap for Semiconductors [1997] now identifies modeling and simulation as critical needs in the area of factory integration. The Next-Generation Manufacturing Project Team goes even further in their discussion of ‘pervasive modeling and simulation’, predicting that all future production decisions will be made on the basis of modeling and simulation methods [The Agility Forum 1997].

Siemens Semiconductor Division has used such an approach to address a classic capacity issue. 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 [Brown, *et al.* 1997] 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).

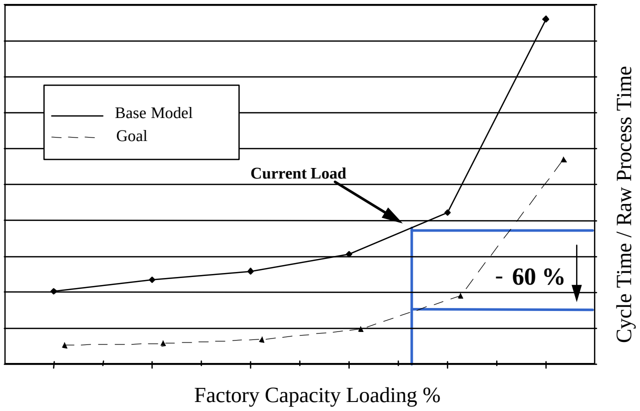

Figure 1. Goal of the Simulation Study

Attempting such a dramatic cycle time reduction was a formidable assignment and required reviewing many different aspects of factory operations. Figure 2 is a summary of the primary areas of investigation done for this project.

Parameters for Analysis

- Handler Dedication
- Rework and Retest
- Unscheduled Downtime
- Preventive Maintenance
- Operator Training
- Operator Staffing
- Dispatch Rules
- Hot Lots
- Changing Process Flow
- Lot Size
- Batch Size
- Lot Release
- Process Speed Improvements

Figure 2. Areas of Investigation

This paper discusses recommendations for the Assembly area. Results are expressed as a percentage decrease in the cycle time of the overall back-end factory. These Assembly recommendations show a cumulative 20% reduction in factory cycle time. In addition to the results described in this paper, investigations have been done with models in the Final Test area. These analyzed the impact of rework procedures, test handler dedication strategies, operator staffing levels, and material batching policies for the burn-in ovens [Brown *et al*. 1998].

SIMULATION METHODOLOGY

The project began with the problem statement: '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 deliverables, schedule, and milestones, using a previously-demonstrated project management technique [Chance *et al*. 1996].

This project used the performance analysis software Factory Explorer™, from Wright Williams and Kelly [Chance 1996], 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 as needed to conduct an effective first-pass analysis of the existing factory. Working with key members of the production staff, this analysis and a subsequent, more detailed 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 the targeted capacity loading.

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.

Three specific recommendations pertaining to the Assembly area are discussed in the following section. Figure 3 shows the process flow for this area. While we recognize that no productivity improvement effort can be achieved without expending some resources, these changes can be implemented in the factory without adding capital equipment or incurring significant additional expenses.

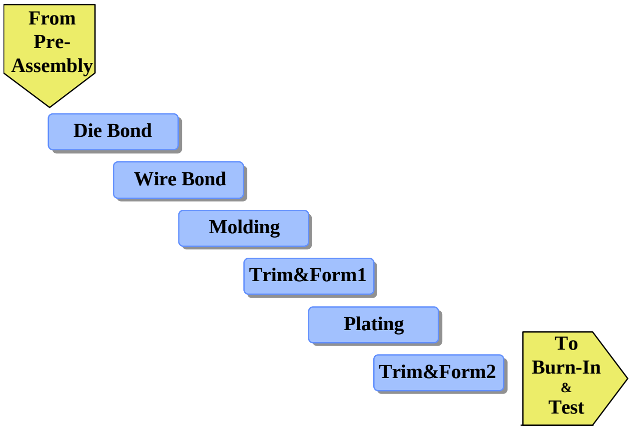

Figure 3. Assembly Process Flow

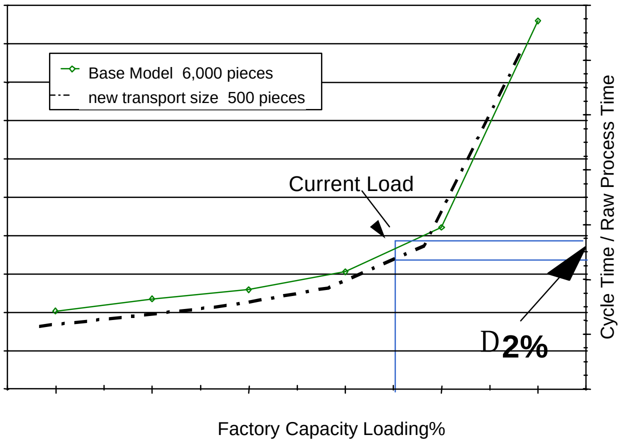

Figure 4. Transport Size Change

RESULTS

When the Assembly area was originally designed, it was expected that the production material would be transported from machine to machine in batches of 4,000 units. When inventory began to build due to increased production volumes, factory managers increased the transport lot size to 6,000 units. This meant that material was not moved to the next work station until all 6,000 units (12 magazines) were finished. Intuitively, the simulation team felt that this might be creating idle time as downstream equipment waited for the entire batch to be delivered. This idle time could reduce the available capacity of the downstream equipment. Further, having 12 magazines arrive at once to a downstream workstation that could only process one magazine at a time would lead to increased cycle times. A model of this actual scenario was compared to a second scenario in which the material was transported in batches of 500 pieces (one magazine) from the die bonders. The smaller batches were then recombined prior to leaving the Assembly area. The result was a 7% decrease in cycle time for the Assembly model and a 2% reduction for the complete factory model (see Figure 4).

In effect, this change eliminated the routine idle time, and subsequent queueing, caused by waiting for material from machine to machine. The increased performance within the Assembly area delivered a smoother flow of material into the Test area and achieved the slight (2%) improvement in overall cycle time by decreasing the variability of the arrival rate to the system constraint. Even though the system constraint for this factory is not in the Assembly area, but rather is in Final Test, the impact is significant. This is because the factory sends material to additional sites for final test operations, and also sells some untested product to customers. Cycle time improvements at non-contraint work centers, as well as those at bottleneck machines, improve overall performance. This modeling recommendation has recently been implemented into the factory with expected results.

The second significant result of this case study pertains to the galvanic, or electroplating, operation. The available capacity of this operation exceeds the capability of the overall factory by a large margin. Therefore, this operation has been run only on two shifts and remains idle at night. This, of course, greatly impacts the manner in which material arrives at the next production area. Again, the team was concerned that this variability might be creating idle time for critical downstream equipment. A scenario was modeled in which the same daily volume was spread linearly across three shifts, as compared to the current two-shift operation. This change allowed a smoother production flow through the factory. The model showed an 8% decrease in overall cycle time (see Figure 5). Factory personnel have been cross-trained so that this recommendation has been implemented without requiring additional operators.

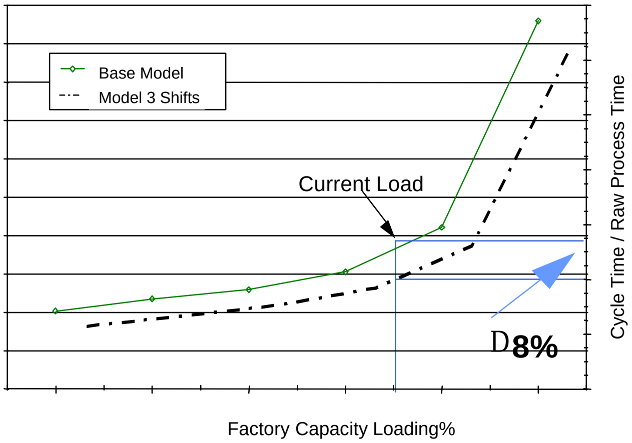

Figure 5. Additional Shift Coverage

A very effective use of performance analysis software is in evaluating alternative scenarios of product mix and lot release strategies. Often such intricate changes to factory operations are cumbersome to initiate and impossible to track over the production cycle. They certainly can degrade factory performance. The way material is introduced into the factory (the mix of products, batching, and timing) determines downstream arrival distributions and greatly impacts the time a machine is idle due to material unavailability. In this third analysis, the team simulated the current material release approach and compared it to various alternative combinations. The result was a recommendation for a new lot release strategy that has less variability and achieves a 12% reduction in modeled cycle time (see Figure 6). The specific lot release strategy that is 'best' is, of course, dependent upon the attributes of the given equipment set. Thus there is no universal application of an 'optimized' rule. However, this analysis supports the general observation that actions to lower variability in a factory tend to reduce cycle times [Hopp and Spearman 1996].

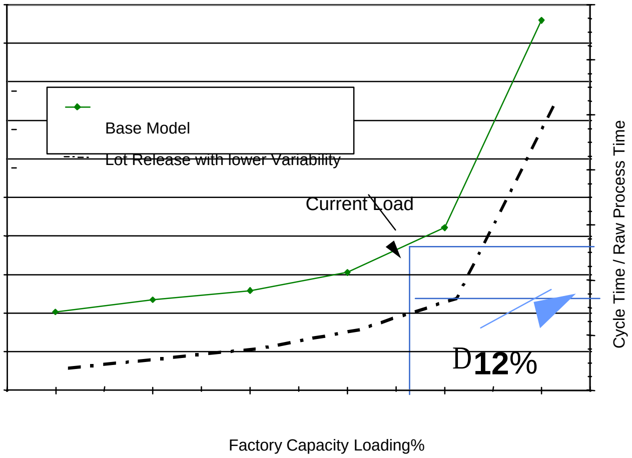

Figure 6. Lot Release

CONCLUSION

The final graph, Figure 7, shows the cumulative effect on the model of implementing these three recommendations for the Assembly area. Since there are interaction effects present among the factors, the total impact is less than the sum of the individual effects. In this case, the overall factory cycle time is decreased by 20% from the current levels. This significant contribution to the established goal required no additional capital expenditures or other expenses.

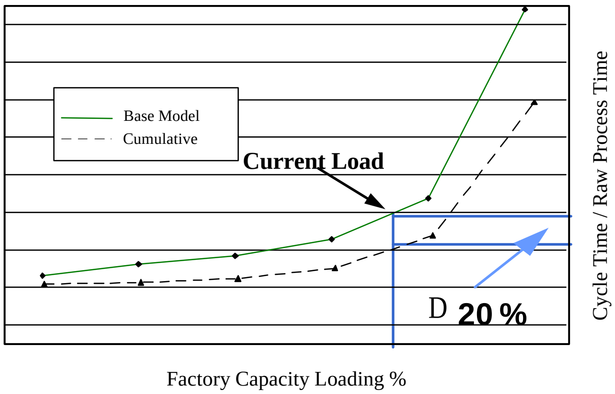

Figure 7. Cumulative impact of the recommendations

By treating the entire factory as a unified system, discrete-event simulation allowed the team to show the positive impact of effectively managing both constraint and non-constraint operations and equipment. Between this study and the results for the Final Test area [Brown *et al.* 1998], the team made recommendations that had a combined potential to reduce the factory's cycle time by 41%.

Since this study began, the average cycle time for the Dresden back-end has decreased by 32%. Measuring the impact of implementing these specific recommendations is difficult because an aggressive fab production ramp and a change in product mix have created a factory of constant change over this time period. In general, however, the simulation team feels that the implementation of this work significantly contributed to this cycle-time decrease.

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 complex manufacturing sites in general. For example:

- Using smaller transport lot sizes reduces cycle times.
- Operating non-constraint equipment such that material flows smoothly to the constraint equipment is important.
- Lower variability in lot releases reduces cycle times.

There is agreement among Dresden management that this analysis was very beneficial and that this work will continue at the site. Implementation of simulation-based recommendations into the actual factory continues.

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BIOGRAPHIES

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-nine years of management experience in various industries, including twenty years in computer chip manufacturing. For the past five years, Mr. Brown has specialized in the modeling and analysis of semiconductor factories, focusing on cycle time and throughput improvements. His formal education includes Bachelor of Science and Master of Science degrees in Business Management. Mr. Brown is a member of IEEE.

Joerg Domaschke is a Simulation Engineer for Factory Modeling and Simulation, a part of the Manufacturing Science department of the Siemens Semiconductor Division. He has two years experience conducting performance analyses for wafer fab and back-end factories. Graduating with distinction in 1996, he earned a Master of Science in Computer Science from the University of Wuerzburg. Queueing theory and simulation were his major subjects of study. His previous experience includes neuronal-network research for Mercedes Benz. Mr. Domaschke’s current simulation interests are in performance analysis of semiconductor factory systems.

Franz Leibl is the Director of Backend Operations for the Siemens Microelectronics Center in Dresden, Germany. He has been with Siemens for eleven years, with extensive experience in photolithography production management, having supported both pilot line and wafer fab operations. His recent work includes international advanced-technology programs.