FabTime Cycle Time Management Newsletter

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Information

Mission: To discuss issues relating to proactive wafer fab cycle time management

Publisher: FabTime Inc. FabTime sells cycle time management software for wafer fab managers. New features in development for FabTime include a short-interval scheduler and a new goal-setting interface.

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Contributors: David Jimenez (WWK); Jeff Potter (Polar Semiconductor, LLC)

Keywords: Financial Impact of Cycle Time; Factory Behavior; Reporting; WIP Turns; Predicted Cycle Time

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Welcome

Welcome to Volume 16, Number 3 of the FabTime Cycle Time Management Newsletter! In this issue we have a call for papers for a joint symposium between eMDC2015 and ISSM2015. Our FabTime software tip of the month is about identifying the tool that experienced the most time waiting for parts. In our subscriber discussion forum we have one response to the previous newsletter main article, and two responses to a subscriber discussion topic about balancing cost and on-time delivery.

In our main article, we take a more short-term look at balancing cost and cycle time in wafer fabs. We start by looking at the strengths and weaknesses of several possible approaches, and then focusing on how one might use actual historical data to help balance cost and cycle time at a tactical level. We welcome additional feedback on this complex and mission-critical topic.

Thanks for reading – Jennifer

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Community News/Announcements

Call for Papers: Joint Symposium 2015 - eMDC2015 & ISSM2015

Conference Date: September 2-3, 2015, in Taipei
Paper Submission Due Date: June 1, 2015

Scope:
In collaboration with ISSM, this joint Symposium focuses on recent technological advancements to align the needs of designers, manufacturers, equipment suppliers, software vendors, solution providers and researchers. It offers a public arena for the exchange of up-to-date experiences among manufacturers for adoption of technological developments. With green notions of supply/engineering/value chains, coverage of the joint symposium includes, but is not limited to, the following topics of interests (list abridged by FabTime):

- Benefits and Justification (ROI, CoO, OEE ...)
- Data Collection/Quality/Storage/Management
- e-Diagnostics, e-Manufacturing, and EEC
- Engineering/Supply/Value Chains
- Fab Management/Scheduling/Dispatching
- Factory Integration/Operations
- Factory Physics & Queueing Operations
- Manufacturing Control and Execution Systems
- Manufacturing Strategy and Operation Management
- Yield Enhancement and WIP Management

For more information (including a complete list of topics), visit this link.

FabTime welcomes the opportunity to publish community announcements, including conference notices and calls for papers. Send them to newsletter@FabTime.com.

FabTime User Tip of the Month

Find the Tool that Spent the Longest Time Waiting for Parts

When looking to improve cycle time in a fab, one area to target is time that tools spend down and waiting for parts. In FabTime, you can easily generate a list of the longest waits for parts (or, the longest waits for techs to come, etc.). To do this does require that you are tracking tool state transactions, and that you have a sub-state in which you log tools as waiting for parts (or techs, or whatever else you would like to measure). If so:

1. Generate the Tool State Transaction list chart.

2. Filter the chart for the tools of interest to you (e.g. all of the tools in a particular production area).

3. Filter for just unscheduled downtime transactions by typing “UNSCH” in the “E10St:” filter. To also include scheduled

downtime transactions, type “UNSCH, SCHED” in that field.

4. In the “SubSt:” filter, enter the name of the sub-state. (That is the state that is logged into your MES, prior to being mapped into the SEMI E10 tool states.) To list multiple sub-states, separate the values with commas. To see the list of available values, click on the name of the filter.

5. Change the “From:” date to look back a full month (or as needed), and hit enter, or press the “Go” button at the bottom of the main set of filters.

6. Sort either the chart image or the chart’s data table (or both) by selecting “Elapsed Time” first in the sort control, and checking the box to sort in descending order. This will bring the long wait transactions to the top. Use the data table (or, if using the JavaScript charting engine, just mouse over the chart column), to see which tools spent the most time waiting for parts.

Alternatively, you can use the Tool Hours Pareto Chart, sliced by tool and filtered for the “waiting for parts” sub-state. This will tell you cumulatively how much time each tool spent waiting for parts across the time period.

For either chart, if any of the tools at or near the top of the list are highly loaded, these suggest an opportunity for improvement (e.g. reviewing spare parts contracts or supplies).

Subscribe to the separate Tip of the Month email list (with additional discussion for customers only). Thanks!

Subscriber Discussion Forum

Balancing On-Time Delivery with Cost Pressures

David Jimenez from WWK submitted the following, in response to a topic suggested by Guy Gandenberger in the last newsletter issue: “While WWK doesn’t run a fab, we have been hit by the question of CT vs. cost since 1994. Our first introduction to what is almost always an inverse relationship between CT and cost was in a cost of ownership training session at a fab in Texas. We were hired to focus staff attention on lowering costs and displayed a chart of utilization/factory loading vs. cost.

As soon as we showed that chart, we had to peel the fab manager off the ceiling. His bonus was tied to cycle time reduction and he saw cost reduction as a conflicting requirement (one that was bad for his paycheck). Since that day, our chart has also added CT to show the trade-offs in those factors.

So, how have we seen this addressed? There has to be a high level decision on what is the best balance for the company and its clients and that depends on what business you’re in. Memory fabs tend to focus on reducing cost and maximizing output. ASIC fabs tend to focus on CT. Multi-product fabs are somewhere in the middle.

But how do you arrive at the balance? Our suggestion is to use a discrete-event simulation software package (like our

Factory Explorer product) that also incorporates activity-based costing. Using this type of tool allows a company to look at the trade-offs between cycle time and WIP reduction, on time delivery projections, dispatch rules, overall product costs (margins, profit), etc. With this data, the company is in a better position to make a decision on what is the best operating point."

FabTime Response: We agree that discrete event simulation can be very useful in looking at these types of trade-offs, though there is always a concern regarding the amount of data maintenance required to keep such models relevant in the changing environment of a fab. Queueing models can also give some limited estimates of dynamic fab behavior - they require less data maintenance, but are also less accurate in modeling the complexities of the fab. Incorporating cost modeling in with dynamic modeling is, of course, necessary to fully consider trade-offs like those discussed above.

Jeff Potter from Polar Semiconductor, LLC wrote: "Guy's question is interesting and one that we, and I'm sure others in the fab world, face daily. In my opinion, the following are key concepts that should be considered.

- In any fab, large or small, there exists a volume of wafers that must be produced to achieve the desired financial results.
- If the fab is loaded to a level to meet the financial result, then OTD is no less important than consistently shipping the desired volume. If OTD is low, then it stands to reason that ships have missed plan. If ships have missed plan, then the financial result cannot be achieved. The two are connected, not independent.
- Fab planners must consider all sources of variation in their fab to determine the level of loading the fab is capable of accepting and consistently delivering; availability, product mix, arrival rates, hot lots, number of bottleneck tool areas are key examples to consider.
- The maximum loading should allow for consistent ships which also means there exists sufficient buffer capacity to accommodate the sources of variation. Planning above this line may seem like costs will be lower, but if you can't consistently achieve the output, then the cost targets aren't realistic anyway. The key is consistently shipping the acceptable volume of wafers.
- Once the maximum loading is identified, OTD should be of acceptable levels as well since the consistency is there to meet the customer's demands.
- The real question at this point is what cycle time will result from the fab loading given the OEE requirements on the various tools. Simulation, x-factor tables, historical data can all be used to give the planner an idea of the queues that will result from the loading.
- Each fab has different requirements of cycle time which is typically demanded by their customers or influenced by the competition. If the resulting cycle time from the above approach provides acceptable cycle time, then the current tooling is sufficient. If the cycle time is not acceptable, or there is a push to reduce the level of WIP in the fab while still maintaining the expected output/OTD, then strategic tooling must be added to the key bottleneck areas to reduce the cycle time. There are also lower cost solutions that could reduce cycle time such as improving tool availability, addressing key sources of variation that increase queues, or improving the line yield.
- Obviously adding tooling will increase costs, but each fab must consider the value of reducing the cycle time versus keeping costs in line.

So based on the above I don't believe OTD vs. Cost is the issue; it is Cost vs. Cycle Time that is the issue to consider.

Low OTD means revenue isn't being generated to the plan which must also mean that cost targets aren't being met, assuming that there exists a high component of fixed costs which is typical of most fabs."

FabTime Response: We especially liked Jeff's point "Planning above this line may seem like costs will be lower, but if you can't consistently achieve the output, then the cost targets aren't realistic anyway."

We do think that the issue to which Guy was really referring lies not so much in being unrealistic in setting the maximum loading, but rather, yielding to corporate pressures to push loadings to unacceptable levels (or otherwise hinder performance through cost-cutting measures, such as reducing staffing). Then a consequence may be poor OTD values (and, as you say, not even meeting shipment targets anyway).

In a perfect world, everyone would figure out what is the acceptable loading for their fab to make money, figure out what cycle time can be achieved at that loading, set delivery targets from there, and thus have no problem meeting the (realistic) targets. The problem comes when the cycle time that can be achieved is not the same one that the company wants to have (or, more likely, that customers are willing to accept). And then you have some decisions to make. Reducing cycle time, at a given throughput rate, via the methods that you mentioned (by improving availability, etc.) is the win-win answer every time.

So yes, we do think that you're right that it's an issue of the trade-off between fab capacity and cycle time. We will discuss this trade-off more in our main article below.

Issue 16.02: Using WIP Turns to Project Cycle Time

An anonymous subscriber wrote in response to the last newsletter issue: "WIP Turns and Cycle time are directly connected through Little law. At my former company, we used the formula for cycle time prediction (given the throughput of course).

The definition of "moves" is tricky, since there are activities that do not directly add value to the wafer.

The way to deal with it is separation: Some moves are taken in consideration and are named "activities" and others don't (non-activities)."

FabTime Response: We are certainly aware of the relationship between WIP and Cycle Time via Little's Law, and agree that you can use Little's Law to calculate average cycle time from WIP and throughput rate. However, this calculation gives you a current or historic look at cycle time, rather than a forward look at cycle time.

The metric discussed in the newsletter issue takes today's WIP Turns rate and uses that, together with the number of steps, to say: "If we continue performing the way we are performing today, this is what the cycle time is going to be for the WIP that is currently in the fab." In steady state, this is the same as calculating Cycle Time = WIP / Throughput via Little's Law. However, if things are changing in the fab (as they usually are), then the calculation method described in the newsletter will give a more forward-looking estimate. But you are of course correct that this estimate is more difficult to calculate, because of difficulties in defining the number of steps per flow.

Thanks for giving us the opportunity to clarify this.

FabTime welcomes the opportunity to publish subscriber discussion questions and responses. Simply send your contributions to Jennifer.Robinson@FabTime.com.

Balancing Fab Cost and Cycle Time

Introduction

In our subscriber discussion forum above, we shared two responses to a question from Guy Gandenberger of Micrel that was posted in the last newsletter issue: "How do you balance on-time delivery with cost pressure in practice in your fab? For example, running with fewer operators or pushing utilization higher can help with cost, but hurt delivery performance."

The first response recommended using simulation. The second response suggested that in fact, the core issue lies in the balancing of cycle time and cost, with on-time delivery more of a consequence of operating policies. These responses gave us considerable food for thought, but both took a fairly strategic view of the question of balancing cycle times and costs in a fab. And certainly, the decisions you make at the strategic level when planning a fab have a considerable impact on the resulting cost and cycle time that will be achieved.

In this article, however, we would like to discuss balancing cost vs. cycle time on a more short-term, tactical basis. There are frequently decisions to be made in fabs that directly impact cost and cycle time. For example:

- How many operators should we have in each area? How many technicians?
- What spare parts should we keep in stock, and which should we only send for when needed?
- Can we increase the start rate of the fab to push a bit more out?
- Can we idle some lower utilization tools, to reduce the need to staff them?
- Should we force full batches on this tool, to reduce consumables costs?

In all of these cases, estimating the financial impact of a change is fairly straightforward. It's estimating the cycle time impact that is more difficult.

Some Potential Approaches

Simulation can be helpful in assessing the potential impact of a change, of course. Simulation models allow you to run scenarios, and (if sufficiently detailed) perform any sort of "what-if" analysis you might be interested in. However, using a simulation model for these types of short-term decisions requires that your fab maintains a detailed, up-to-date model of the fab. This can be an expensive undertaking, potentially requiring a full-time person dedicated to maintaining the model, and responding to changes. In some cases it may be possible to build smaller, standalone simulation models that look in detail at one particular tool group. But these types of smaller models will not generally allow you to look at interactions between tool groups.

Queueing models may be helpful in some cases to understand the likely impact of a change on cycle time. Queueing models are fast and the results are easy to understand. They can readily be included in spreadsheets. FabTime's operating curve spreadsheet uses queueing models to allow you to look at the impact of several variables (including downtime percentage and downtime distribution) on the operating curve of a particular tool group. But queueing models can only handle a limited amount of detail, and hence are more useful in giving relative than exact answers.

Education about the likely cycle time impact of operational changes can also be helpful in knowing what general type of outcome to expect when making a change. In our cycle time management class, for example, we discuss how going from a dual path to a single path for an operation can be expected to roughly double cycle time through that step (at the same utilization). But here again, the answers are generally going to be relative, rather than exact. For instance, we know that imposing a full batch policy on a tool that is not heavily loaded will tend to increase cycle time. But without creating a simulation model, it's difficult to say by exactly how much the cycle time will increase. And even if we knew that, we would still need to determine whether that increase might be a worthwhile trade-off given some reduction in consumables cost.

What Can We Do With Actual Fab Data?

Here at FabTime, of course, we are big believers in using actual data from the fab to help you make decisions. But how do you do use historical data to help you to understand trade-offs between cost and cycle time? If you have made some change for cost-reduction, you may be able to see the impact of that change in your data. However, because a fab is such a complex environment, with many changes occurring at one time, it can be difficult to isolate the impact of some particular change on the fab's cycle time. Unlike when using a simulation model, we can't easily run controlled experiments in the fab.

But there are some things we can do with historical data. We can:

I. Look at where cycle time problems are now, and consider whether a change that we made to cut costs might have affected that cycle time;

II. Use actual data to see where additional spending would be likely to have a large impact on reducing cycle time; and

III. Use actual data to see where we are NOT having cycle time problems, and thus might be most able to absorb cost-cutting measures.

For example, suppose that we learn that a particular highly loaded tool group is experiencing high per-visit cycle times because of long downtimes. If this is a new problem and we recently cut the number of technicians serving that tool group, we may be able to infer that we're paying a cycle time cost for that change. If this is not a new problem, we may be able to look into the data in more detail, and discover that tools in this group regularly spend extended time waiting for parts. We can then consider whether changes to our spare parts planning for this tool group might be worth incurring some additional cost.

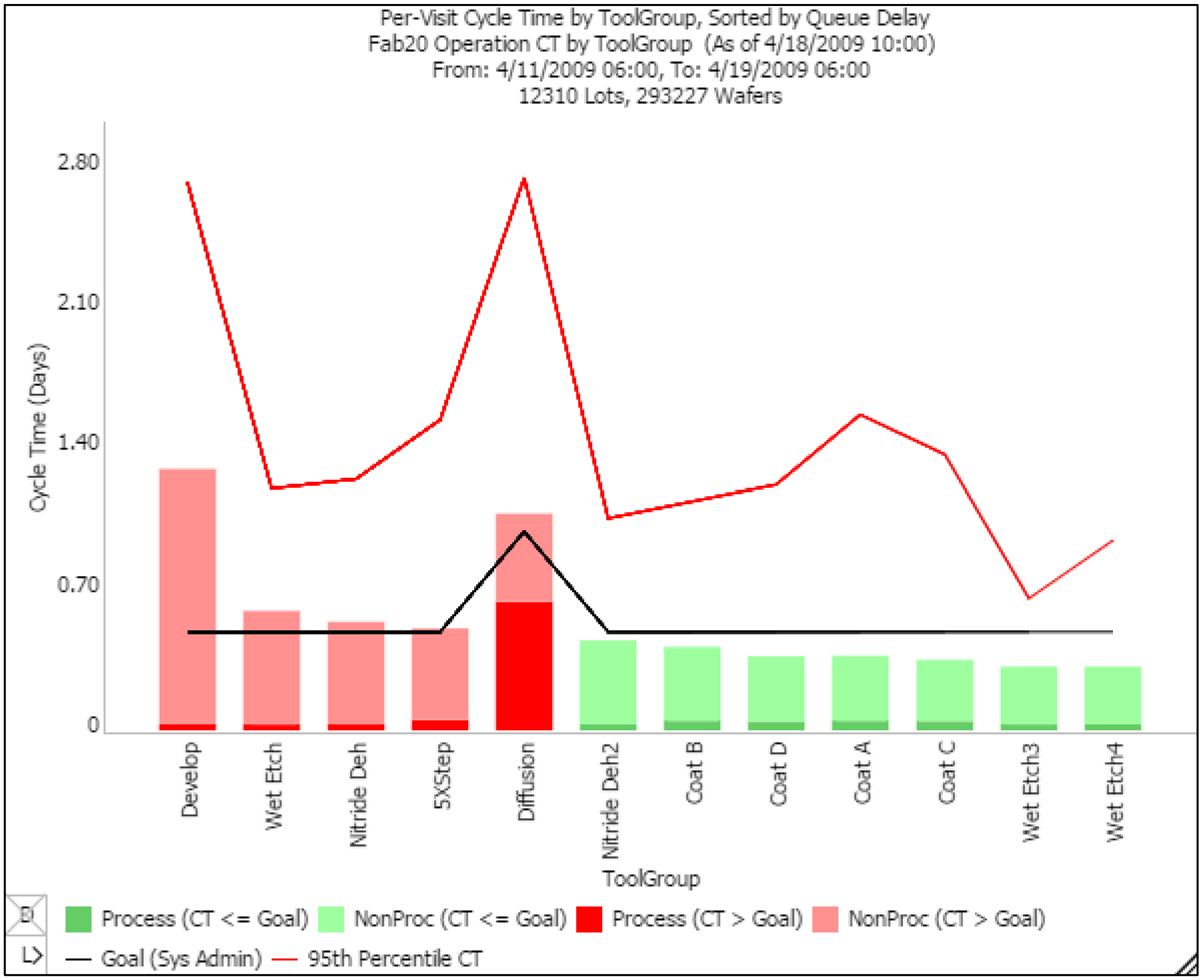
Similarly, if we observe that a bottleneck tool is spending a significant amount of time idle even when there is WIP available, this may be an indication of insufficient operators for that tool. If we recently re-assigned operators elsewhere, we may want to consider rolling back that change. If we recently laid off operators, we may have to accept the cycle time penalty as a trade-off for the cost savings. But we can also look for tool groups that have particularly low utilization rates and cycle times, and consider re-assigning operators from there over to the problem area, at least temporarily.

A Procedure for Using Historical Data to Balance Cost and Cycle Time

Here's a sample procedure for doing this type of trade-off analysis using historical data.

1. Find someplace where you are having cycle time problems. For example, look at operation cycle time by tool group for the current week or month, and sort for tool groups that have a significant amount of queue delay. An example is shown at the top of the next page. Look in detail at the one with the longest queue delay. Dig into the data to get an idea of what is causing the problem (downtime, engineering time, operator delays, arrival variability, etc.).

2. Determine whether the problem is new or ongoing by looking at the trend in cycle time over time for this tool group.



a. If the problem is new, consider whether you changed something that might have caused this tool group to start being a problem? (e.g. staffing assignment change)

b. If the cycle time problems at this tool group are ongoing, or due to some external cause, is there something you could change that would cause this not to be a problem anymore? (e.g. purchasing additional spare parts)

3. Assess whether or not it is worthwhile to make some change (either rolling back a previous measure, or making some new change). If so, go ahead and make the change. If not, continue to the next step.

4. Go to the next problem.

This procedure can be used for both I and II from above (looking at the impact of previous changes, and identifying potential areas in which to make future changes.) It will be less helpful for III (looking for places where you may be able to reduce costs). However, you can develop a similar procedure in which you instead look for tool groups with low utilization and cycle time, in lieu of those with high cycle time.

Naturally, a method like this requires a fair degree of subjective decision-making. Unlike an integrated simulation and cost model (as described in the subscriber discussion section above), an analysis of historical data can only give you an idea of what might have happened, and where it might be worth making a change. It's a guide, rather than a known, set quantity.

But we feel that there is value to be had in the attempt.

Conclusions

Balancing cost and cycle time is a mission-critical exercise in semiconductor fabs (as in other manufacturing industries). In general (though not always), the more you spend, the better your cycle time will be. But competitive forces exert downward pressure on both cost AND cycle time, leading to complex decisions.

At the strategic level, decisions about purchasing tools, setting target utilization levels, and planning for product mix all set broad parameters around what cycle time will be achievable for the fab. At a more tactical level, however, there are many smaller decisions to be made on a day-to-day or week-to-week basis that affect both cycle time and cost. Insight into these decisions may come from simulation models, queueing models, or education about factory behavior, with each of these approaches having strengths and weaknesses.

At FabTime, we believe in the power of using actual historical data to help in understanding the cycle time impact of changes made for cost reduction. We also believe that historical data can be used to identify opportunities in which additional spending may yield valuable cycle time improvements, as well as areas in which costs might perhaps be cut with little cycle time penalty. While such historical analysis does not allow you to run controlled experiments, or perform detailed what-if scenarios, it can yield useful information with which to make short-term decisions. And given how frequently things change in a fab, short-term decisions loom large.

Questions for FabTime Subscribers

How do you balance cost and cycle time on a tactical basis in your fab? Do you have a full fab simulation model?

Acknowledgements

We would like to thank Guy Gandenberger of Micrel Semiconductor for launching the discussion that led to this article. Our thanks also go to David Jimenez of WWK and Jeff Potter of Polar Semiconductor for their contributions to this discussion.

Subscriber List

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- Does your factory lack real-time reporting?

FabTime can help. FabTime saves your management team time daily by turning MES data into information, via a real-time web-based dashboard that includes lot dispatching. FabTime saves your IT staff time by breaking the cycle of custom-developed reports. Most importantly, FabTime can help your company to increase revenue by reducing cycle times up to 20% for regular lots, and even more for high-priority lots.

Although FabTime was originally designed for front-end manufacturing, you can use FabTime for your assembly or test facility. You simply need to have a transaction-based manufacturing execution system. FabTime can link to all commercial systems commonly used in the industry (e.g. WorkStream, Promis, Eyelit, Mesa, FactoryWorks) or can link to internally developed systems. FabTime can pull data from multiple databases if needed (e.g. WIP transactions from the MES, tool transactions from another system). FabTime is currently being implemented in two assembly and test facilities, with no major technical hurdles.

FabTime Applicability for Back-End Factories

- FabTime handles lot merging and splitting, with full tracking of overall cycle times.
- All chart quantities (moves, WIP, etc.) can be displayed as die, with data tables formatted for readability of large quantity values.
- Custom assembly and test parameters (applicable to WIP or tool state transactions) can be mapped.
- Custom site-specific reports for wire bond area have been developed for customers (die and component placements, etc.).
- Custom dispatch factors allow for incorporation of back-end-specific data used in dispatch decisions (e.g. availability of boards, and minimization of sequence-dependent setups).