FabTime Newsletter

Volume 23, No. 2 **April 2022**

Information

Publisher: FabTime Inc. FabTime sells cycle time management software for wafer fab managers. FabTime's mission is to help the people who run fabs improve performance by 1) helping them to understand the factors that drive fab performance and giving them the data to identify current improvement opportunities; 2) letting them control that data by setting parameters for their own charts, so they don't have to go back to IT every time they want a different piece of information; and 3) including them in a community of people around the world who are all working to drive better fab operations.

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Contributors: Sanjay Rajguru (Redlen Technologies Inc.)

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Welcome

Welcome to Volume 23, Number 2 of the FabTime Cycle Time Management Newsletter. In this relatively brief issue, we have some highlights from Jennifer's LinkedIn posts, a FabTime software tip of the month about using our new on-chart drill-down capability, and subscriber discussion about defining the components of cycle time and measuring fab linearity.

Our main article this month was inspired by a new subscriber to the newsletter. We always ask people who fill out subscription requests on our website "What is the most urgent cycle time issue occurring in your fab?" This subscriber wrote: "Ramping up starts and maintaining cycle time." We realized that although we've written in the past about what to do to during an industry downturn, we had never written an article about what to do to protect cycle time during a strong upturn. We decided to remedy that omission. We share tips for squeezing additional capacity out of an existing tool set, deciding where to add capacity, and spending money in other areas beyond tools, all with an eye to keeping cycle times under control. We welcome your feedback, as always.

Thanks for reading! – Jennifer, Frank, Lara, and the FabTime Team

Community News/Announcements

A Few Highlights from Jennifer's LinkedIn

Jennifer continues to share articles about business management, the semiconductor industry, and productivity improvement on her LinkedIn feed. Recent posts have included:

- FabTime's 23rd birthday post on March 1st. "When Frank Chance and I started FabTime, I can't say that I expected to still be here working on wafer fab cycle time improvement 23 years later. But here we are. Fabs are still challenging and interesting." (LinkedIn post here.)
- A WSJ piece reporting that: "Almost two years of chip shortages have had an unexpected upside for the semiconductor industry: It is better prepared to manage the turmoil caused by Russia's invasion of Ukraine... Companies have moved to shore up supply chains amid the upheaval, in some cases adding alternative suppliers to gain options. They stocked up on neon and other important chip-making materials, and now typically have a six-week to three-month reserve, said Mark Thirsk, the managing partner of Massachusetts-based Linx Consulting Inc., an electronic materials consultant." (LinkedIn post here.)
- Another WSJ piece reporting Intel's planned fab expansion in Germany: Intel "said it would invest $36 billion in chip production and research across Europe, including a new chip-making complex in Germany, to keep pace with surging demand for semiconductors.... Mr. Gelsinger suggested that the German project was contingent on government support coming through, saying in a webcast Tuesday that there was still work to be done to secure permits and "financial support needed to make the project competitive."" (LinkedIn post here.)
- An announcement by SEMI "that, in partnership with Ignited Education, Foothill College and Krause Center for Innovation, it has won a $1 million California Apprenticeship Initiative (CAI) New and Innovative Grant for the development of a semiconductor pre-apprenticeship and apprenticeship program to expand the pathway to careers in the microelectronics industry." This looks to us like a positive step in confronting the labor shortage in the semiconductor industry. (LinkedIn post here.)

For more industry news, connect with Jennifer on LinkedIn:
http://www.linkedin.com/in/jenniferrobinsonfabtime

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

FabTime® User Tip of the Month

Click Chart Images to Drill Down

New to Patch 114 in FabTime is the ability to click on a chart image to drill down to another chart. The links in the data table are still available for drill-down, but now you can more quickly drill down directly from the chart. In each case, we've selected what we think is the most intuitive choice for drill-down. To drill down in other ways, you'll still need to use the data table.

Here are a few examples:

- Click on a bar in a trend chart to drill down to the corresponding pareto chart (e.g., from Moves Trend to Moves Pareto or from Tool State Trend to Tool State Pareto).
- Click on a bar in a pareto chart to drill down to the corresponding list chart (e.g., from Moves Pareto to Moves Lot List or from Tool State Pareto to Tool State Transaction List).

- Click on a bar in a list chart (where available) to drill down to the corresponding history chart (e.g., from Moves Lot List to Lot History).
- Click on a Lot History bar to drill back to the Lot History Chart, filtered for just that operation (to zoom in to a specific operation).

Our best general advice is to experiment with this functionality. Try clicking on the bar of whatever chart you are working on and see if the drill down takes you to where you want to go. If not, just use the browser's back button. You should still be able to drill down from the data table. We hope you find this tip useful.

Subscribe to the separate Tip of the Month email list (with additional discussion for customers only) here: http://www.fabtime.com/tip-of-the-month.php. Thanks!

Subscriber Discussion Forum

Cycle Time Component Definitions

Sanjay Rajguru from Redlen Technologies Inc. asked us: Do you know of any document that defines things like--cycle time/process time/machine time/touch time/travel/non-value time etc?

FabTime Response: We haven't seen a formal industry definition of most of these terms, though we do define many of them in our software and our cycle time management course. Here are the definitions that we use to break down wafer fab cycle time. Perhaps subscribers would like to discuss further.

Factory Cycle Time: Factory cycle time for a lot is the elapsed time from the lot's start to the lot's shipment, unless time spent in specified states (for example crib, or customer-hold) is excluded. In that case, factory cycle time excludes time in these specified states. If there is no start transaction for a lot, factory cycle time is elapsed time from first transaction to lot ship. Ancestor cycle time may also be included for child lots if available.

Operation Cycle Time is the time from move-out of the previous operation to move-out of the current operation.

Cycle Time is broken down in our software into the following sub-categories:

- **Queue:** Time from arrival transaction to move-in transaction.
- **Pre-Process:** Time from move-in transaction to begin-run transaction.
- **Process:** Time from begin-run to end-run.
- **Post-Process:** Time from end-run to move-out.
- **Transport:** Time from move-out transaction to arrival transaction at the next step.
- **Hold:** Time between hold time in to hold time out transactions.
- **Other:** Any time not covered by the above categories.

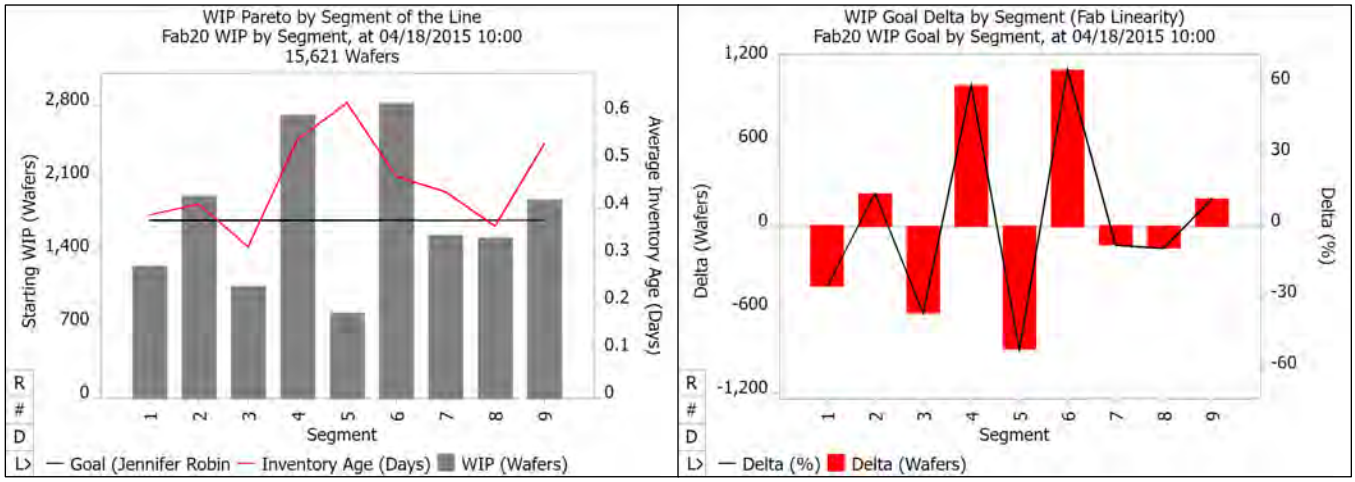
Not all MES systems track all these transactions, of course. What typically happens with less granular tracking is that transport and other time end up lumped together with queue time, post-process time ends up lumped in with process time, and pre-process time ends up either grouped with queue time or process time, depending on whether move-in or begin-run transactions are logged.

We also report **Average Non-Process Time**, which is the sum of everything except Process Time for a lot and is equivalent to Non-Value-Added Time. These sub-categories are further broken down according to whether a lot is in a rework state or not for each time interval. We don't report Machine Time or Touch Time in our software. Do any other subscribers use those terms in their wafer fabs? Are our definitions above consistent with what you use?

Measuring Line Linearity

An anonymous subscriber wrote: "I have been a regular subscriber of FabTime and wanted to reach out to you on any recommendations you may have to measure line linearity. I have been toying with the idea of using a linearity factor and measuring ideal (100% linear matching daily starts) to current deviation. If you are aware of any industry best practices or recommendations for me, please do let me know."

FabTime Response: What we do in our software for line linearity (something we've worked on with our User Group) is create a chart that shows the WIP Delta from Goal. If you look at this by segment (or sub-segment) of the line and set a goal that's the same for all the segments/sub-segments, then you want the WIP Delta from Goal to be as low as possible. Here a segment is usually a linear chunk of the flow that's about a week long, and the sub-segments are smaller. Here's an example. On the left, the WIP by Segment of the line, in segment order, with a black goal line. On the right, the Delta from Goal chart for the same data.



People have been using a WIP Pareto by Segment for many years to estimate linearity. The Delta to Goal chart is a way to quantify how far each segment is from the goal/average.

In our software, the goal can be set to be different for each segment. But if your primary goal was linearity, it would make sense to automate setting the same goal for all the segments based on the total level of WIP (just divide that across the line).

Do other subscribers have different ways of measuring line linearity?

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

Managing Fab Cycle Time while Ramping Starts

Introduction

In today's capacity-constrained environment, many fabs are working to increase start rates, either within an existing toolset or as part of a capacity ramp. Running more wafers can certainly increase the profitability of a fab (and help with the global chip shortage). However, any time a fab ramps starts, that fab also runs the risk of driving up cycle time.

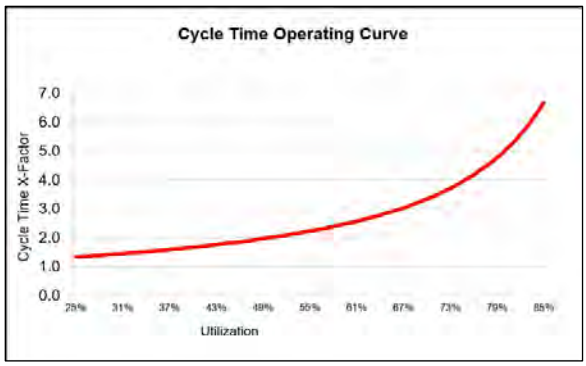
There are two primary situations in which fabs increase starts. In the first, management is attempting to push more wafers through an existing toolset. In the second, the fab is increasing capacity through equipment purchases and increasing starts as fab capacity allows. Of course, these two situations can overlap and iterate in practice. We might increase starts by a small amount while waiting for the new equipment to be brought online, for example.

In both cases, the primary risk to cycle time comes from driving utilization too high on one or more tool groups. [See Issue 22.04 for an explanation of the relationship between utilization and cycle time at the tool group level.] In this article, we share several recommendations for mitigating this risk, including through variability reduction, while focusing on increased throughput.

Increasing Starts with an Existing Toolset

If you have an existing toolset and you're increasing starts into the fab, you're presumably in a situation where you have some amount of spare capacity (because otherwise you couldn't increase starts). Maybe you've operated more as a development fab, but now your management is pushing you to operate as more of a production facility. Maybe you've been operating with a relatively generous capacity buffer on your tools because your fab is focused on cycle time performance. But now … that focus has shifted, and you're going to push down on that capacity buffer. What should you do / watch out for? Here are a few suggestions.

Monitor overall tool group utilizations. You can't sustain a utilization rate on any tool group that is greater than 100% over time, no matter how much your management might like to believe you can.

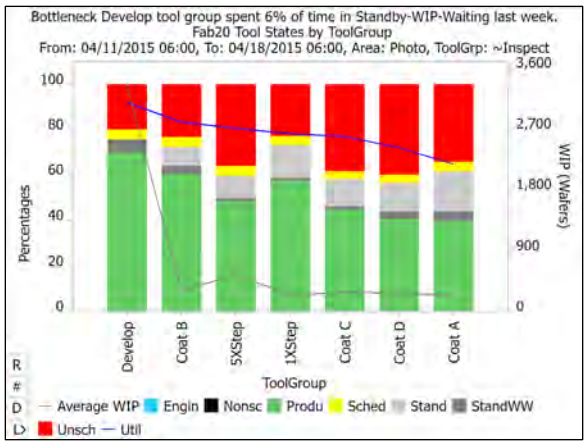


- It can be helpful to have early warning systems in place for when actual utilization goes above a target value for any tool group.
- It can also sometimes be helpful to provide education to top-level management about the relationship between cycle time and utilization (as shown to the right)

Drive for higher availability, especially on bottleneck tool groups. Any time you can convert unavailable time into standby time (buffer capacity), you lower the effective utilization rate on that tool, and hence lower cycle time. During a starts ramp, the resulting standby time might be quickly taken up by additional throughput, but that's the point – to get more wafers through. We will add that you shouldn't neglect PMs. The last thing you want is the risk of longer unscheduled downtimes.

Reduce forced idle time on bottleneck tools. One way to squeeze a bit of extra throughput out of an existing tool set is to identify and eliminate force idle time (wasted capacity) on key tool groups. Sources of forced idle time in fabs include:

- Lack of availability of operators and technicians. [See Issue 22.05: Managing Operators During a Staffing Shortage.] Consider staggering break schedules. Also try to re-allocate personnel where you see significant Standby-WIP-Waiting time or time spent waiting for technicians. In the example to the right, the bottleneck tool group has significant Standby-WIP-Waiting time (the dark grey component of the first stacked bar). Fixing that offers an improvement opportunity. In general, do whatever you can to keep your operators and technicians happy, to minimize the chance of staffing shortages hampering your ability to ramp production.



- Hot lots. Try to resist the temptation/pressure to increase the number of hot lots as the overall average cycle time goes up (which it will tend to do, if you are increasing tool utilization). Hot lots themselves add variability, and further increase cycle time. Adding more hot lots to combat cycle time increases can lead to a vicious cycle.
- Dispatching. It's especially important during a time of constrained capacity to make dispatch decisions to keep downstream bottlenecks from starving.

Reduce wasted capacity. Another way to squeeze out some extra throughput is to find and eliminate sources of wasted capacity, where a tool is running in some non-value-added way. Examples here (most of which will show up in OEE loss factors) include:

- Running rework lots.
- Missing time link targets, such that lots must be re-processed.
- Doing excess setups.
- Recording post-process time (the time between end-run and move out transactions). This is another indicator of insufficient or poorly allocated operators.

Time spent working to identify and reduce these sources of capacity loss, especially for bottleneck tools, will be time well spent.

Look at the balance of tool utilization within tool groups. In addition to overall tool utilization, something to watch during a ramp (where start rates are changing frequently) is the balance of tool utilizations across tools in a tool group.

- This is the time to identify (and potentially crack down on) soft dedication (where operators prefer certain tools that is not reflected in the capacity model). Behaviors that you can ignore when there's more slack in your capacity buffers are luxuries you can't afford if you're pushing extra hard on capacity.
- If you do have large, cross-qualified tool groups, you can consider breaking those into smaller sub-groups dedicated to recipes with like process times. This can help to reduce process time variability as well as setups, but you do need to be careful. It's important not to have the groups be too small (they should have at least three or four tools) and to balance the utilizations across those sub-groups (otherwise you'll have utilization be too high on one or more of them).

Reduce the variability of lot releases. Consider not just the quantity of lots being released into the fab, but also the release patterns. In general, smaller, more frequent releases of lots reduce arrival variability and help reduce cycle time. One exception might be releasing lots in batches to maximize loading of a key early batch tool.

Increasing Starts while Expanding Capacity

If you're in a situation where your fab is adding capacity (or trying to – equipment is hard to find these days), here are a couple of additional things to consider.

Where should you add capacity first if you have the choice? The obvious answer is "at the bottleneck." However, most fabs have multiple tools that are near-bottlenecks. Which one is *the* bottleneck can change over time as product mix changes. There are other factors to consider.

- Adding capacity at batch tools can help reduce cycle time by allowing smaller batches/smoother flow, often at relatively low cost. However, it's important to make sure that as you add batch capacity, you aren't artificially inflating cycle time by keeping minimum batch size requirements that are too high. [See Grewal et. al. for a description of a project we worked on many years ago with Seagate to identify candidate tools for capacity expansion based on cycle time reduction per dollar.]

- Adding capacity at smaller tool groups, especially one-of-a-kind tools, has a disproportionate impact on cycle time. All else being equal, add capacity first at the one-or-two tool groups over the five-or-six tool groups.
- Given the choice between capacity expansion targets, choose the tool that's more reliable vs. less reliable. This will pay dividends in variability reduction for years to come.

Of course, these days, the answer might also be "wherever we can find capacity at all."

What should you watch for as you bring the new tools online? Most fabs have plenty of experience bringing tools online. A couple of things to watch for to keep cycle time under control while you are ramping starts are:

- Process restrictions on new flows/new tools. As you add new tools, make sure that you get enough recipes qualified to run on those tools. Look for the recipes that are currently single or dual path and get those qualified on the new tool first.
- Keep utilizations as balanced as you can across sub-groups of tools as you add capacity, revisiting tool qualifications as needed.

Where Else Should You Spend Money?

Capital equipment spending is through the roof these days. But if you don't have the budget for that, and/or you're stuck in limbo waiting for new tools, there are a few other places to consider spending during a starts ramp. These include:

- Spare parts (to reduce the capacity lost while waiting for parts to be ordered).
- Computer-based reticle management systems (to reduce the time that lots spend waiting for reticles).
- Dispatch systems (including dispatch compliance).
- Systems to automatically alert personnel about things like key tools idle due to lack of an operator and lots nearing expiration of a time constraint.
- Training (both cross-training for operators and training for your team on methods for improving cycle time and manufacturing performance).
- Additional staff (if you can find people) including Industrial Engineers or other team members who can help you crunch data to find specific opportunities.

Conclusions

The chip shortage is here and is expected to continue. Many fabs are under pressure to squeeze additional throughput out of an existing tool set. Other fabs are scrambling to procure and install additional capacity. As these fabs navigate ramping starts, cycle time has been a frequent casualty. In this article, we have outlined suggestions for eking additional capacity out of a toolset while also keeping an eye on cycle time performance. We've also discussed what to watch for while you do bring new capacity online, and identified a few other places to consider spending money to mitigate cycle time during a ramp. As always, we welcome your feedback.

Closing Questions for Newsletter Subscribers

Is your fab facing pressure to ramp starts right now? Or do you have experience with this challenge from prior industry cycles? What are you doing (or did you do) to mitigate the cycle time impacts of ramping? What have we missed in the above discussion?

Acknowledgements

Thank you to the recent FabTime newsletter subscriber who listed as her fab's biggest current cycle time challenge "Ramping up starts and maintaining cycle time" and thus inspired this article.

Further Reading

- N. S. Grewal, A. C. Bruska, T. M. Wulf, and J. K. Robinson, "Integrating Targeted Cycle-Time Reduction Into The Capital Planning Process," Proceedings of the 1998 Winter Simulation Conference, Washington, DC, 1005-1010, 1998. Available for download from FabTime's website.
- J. Robinson and F. Chance. "Fundamental Drivers of Wafer Fab Cycle Time," *FabTime Cycle Time Management Newsletter*, Vol. 22, No. 4, 2021. All past newsletters are available for download by subscribers from FabTime's newsletter archive. The current password is "FabTimeCommunity".
- J. Robinson and F. Chance. "Managing Operators During a Staffing Shortage," *FabTime Cycle Time Management Newsletter*, Vol. 22, No. 5, 2021.

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