FabTime Cycle Time Management Newsletter

Volume 11, No. 4 October 2010

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 this month include SQL "where" filtering within object fields on charts and a site-specific cap on the number of data table rows displayed by users.

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Welcome

Welcome to Volume 11, Number 4 of the FabTime Cycle Time Management Newsletter! It's great to be back on track with the newsletter. Many thanks to all of you who welcomed us back to your inboxes, and to those who sent me good wishes regarding my daughter. In this issue, we have a community announcement about a new position for Professor Scott Mason. Our FabTime User Tip of the Month is about using the Quick Jump feature to navigate within FabTime. We have several subscriber discussion topics, ranging from a couple of changes requested in the newsletter format to responses to the topics raised in the last issue (OEE and capacity planning). We welcome your feedback.

Our main article this month sprang from a subscriber discussion comment about the importance of tracking lots that are early. In most fabs that we've observed, lots that are late garner a lot of attention, while lots that are early exit without fanfare. It turns out, however, that early lots can be a symptom of an underlying problem, such as too wide a distribution of cycle times, or inaccurate planning models. In this article, we discuss both the underlying fab behavior that contributes to early lots (including a brief mention of hot lots), and list a few potential consequences of having lots be significantly early.

Thanks for reading!—Jennifer

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Community News/Announcements

Endowed Chair Appointment for Professor Scott Mason

FabTime's founders would like to congratulate long-time friend and FabTime contributor Professor Scott Mason. Dr. Mason recently joined the Clemson Department of Industrial Engineering as the inaugural Fluor Endowed Chair in Supply Chain Optimization and Logistics. Here's a bit of background from his bio (http://people.clemson.edu/~mason/):

"Prior to joining Clemson, Dr. Mason spent 10 years in the Department of Industrial Engineering at the University of Arkansas. He received his Ph. D. in Industrial Engineering from Arizona State University after earning Bachelor's and Master's degrees from The University of Texas at Austin. Dr. Mason's areas of focus include operations planning, scheduling, and control of capital project supply chains and large-scale systems modeling, optimization, and algorithms, with domain expertise in semiconductor manufacturing. He is an Associate Editor for IEEE Transactions on Electronics Packaging Manufacturing, a senior member of the Institute for Industrial Engineers, and a member of INFORMS." And, we'll just add, a valued consultant to FabTime, and occasional contributor to the FabTime newsletter.

Congratulations, Scott! Clemson is lucky to have you.

FabTime welcomes the opportunity to publish community announcements. Send them to newsletter@FabTime.com.

FabTime User Tip of the Month

Remember that Quick Jump Takes All Filters Along

If you've been using FabTime for any length of time, you have probably been using the Quick Jump feature. The Quick Jump drop-down appears above the data table when you're looking at a Trend chart or a Lot chart. Expanding the Quick Jump list reveals a list of charts that you can "jump" to from the current chart, taking with you the date range and filters settings. The Quick Jump capability is nice for doing what-if analysis. For example, you might be looking at the Operation Cycle Time Trend chart for a particular tool group from last week, wondering why the cycle time increased dramatically from one day to the next. You can use Quick Jump to look at the Tool State Trend chart for the same period, to see if a key tool from the tool group was down, or to look at the Arrivals chart, to see if there was a spike in arrivals.

Although taking the full set of filters with you is usually what's needed, there are sometimes cases where this causes Quick Jump to give you unexpected results. For example, suppose you are looking at a Factory Cycle Time chart, and you've filtered the chart to only display lots with cycle times greater than one day (to

eliminate short loops, and only show full production lots). Now suppose you use Quick Jump to switch to the Moves Trend chart for the fab, over the same time period. The CT>1 day filter comes through. However, when this filter is applied to the moves chart, it filters out all lot moves where the cycle time was less than one day, a significant and unintended consequence that makes the overall moves number appear much too low.

Therefore, we recommend when using Quick Jump to move between charts that you take a quick look at the filters on the destination chart, to make sure that there aren't any filters hanging around that you don't need any more.

If you have any questions about this feature (or any other software-related issues), just use the Feedback form in the software.

Subscriber Discussion Forum

Modification to Monthly Subscriber Listing

Abbie Gregg, founder of Abbie Gregg, Inc., emailed with a suggestion that we thought was a good idea. She noted that it would be nice to see more of the subscribing companies listed on a regular basis, instead of just seeing the list of top 20 subscribing companies and top 3 subscribing universities (by number of subscribers). She said: that it's just "nice to read it knowing who else is out there sometimes….." And we agree. Because there are more than 400 subscribing companies, it isn't practical to list them all each month. But what we're going to do going forward is add a sample set of 20 subscribing companies and universities to the Current Subscribers section of the newsletter (at the end) each month. We'll select randomly from the list of subscribers (not including the top 20, since they are already included), and won't repeat a company until everyone on the list right now has been included once.

Changing the PDF Newsletter to a Single Column Format

A subscriber wrote in to request that we change the format of the newsletters to a single column, in the PDF version, to make the newsletter easier to read. Back when we first launched this column format, we were actually (believe it or not!) printing out the newsletters and sending them, and the columns gave the newsletter a newspaper-like feel. It's possible that someone even suggested the columns - we can't quite remember back that far. Now, of course, most people are reading the newsletter on screen, and we could see a single column being easier. Before making a format change, though, we thought it best to ask for your input. So, if anyone has a strong preference about the columns either way, please write to Jennifer.Robinson@FabTime.com, to let us know. Thanks!

Data Structures for Capacity Models

In the last issue, a subscriber asked about data structures for fab capacity models. **James Ignizio** wrote: "if (with an emphasis on "if") I understand the subscriber's inquiry, I would suggest using the General Capacity Model for such a situation. The GCM model is covered and illustrated in Chapter 13 of my book: *Optimizing Factory Performance*, Prentice-Hall, 2009. The approach has been and is being employed for capacity determinations of tool sets that involve multiple tools, multiple process steps, different process times, multiple products, and reentrancy. Hopefully it would either provide the result the subscriber desires or else allow for modification of the model to encompass his/her situation."

Another anonymous subscriber added: "On the subject of the subscriber with a recipe many-to-one problem, if the recipe info is stored in the database at the same level as the associated cycle time then the issue should not exist. I don't know the MES that is being used but in PROMIS this can be done using planning parameters."

OEE

The same anonymous subscriber also wrote in response to last month's main issue about computing OEE. He said:

"I doubt that many in the industry would agree with me but I believe OEE is actually detrimental to FAB management. The fact that it does not take into account either batching or cluster tools properly should be enough to convince anyone that it is obsolete. It doesn't take into account the value of holding tools idle for very high priority lots either. I bet I could come up with many more issues if pressed. The real issue however in my mind is that it detracts from equipment engineering time that should be spent on improving the throughput of constraint tools. Anything that does this is going to result in lower FAB throughput.

A better approach is to focus engineering (process and equipment) on constraint tools only (while doing PM's everywhere on-time) until it is impossible to keep these tools busy. When that happens you have eliminated that constraint and you will know where the constraint has moved to. Of course if you overload FAB starts (which is so easy to do) or have a highly variable mix then this may not happen, but then you know the true capacity of the FAB and can reduce starts to a lower level with no loss of throughput and a better cycle time."

FabTime Response: We actually tend to agree with you that OEE, if applied broadly to all tools, can be detrimental to fab performance. Our issue is not so much the batching and cluster tools, but the fact that OEE doesn't take into account the value of planned idle at all. For that reason, we tend to more recommend that people focus on the other loss factors that make up OEE (availability loss, quality loss, rate loss), and try to reduce those losses. We think that this is more valuable than driving some particular rolled up OEE number, especially for non-bottleneck tools.

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

Early Delivery Times in Wafer Fabs

Introduction

Responding to Jennifer's announcement last month about her daughter's early delivery, a subscriber who asked to be kept anonymous said: "I don't know if you have been asked this but everyone "knows" that a larger number of priority lots increases the cycle-time of non-priority lots. They just don't know how much. What no-one seems to know is that lots completing before they should is also a major problem. In fabs where on-time delivery is the driving force there is usually tremendous interest in lots that don't make it in time.

However there is no interest in lots that are early because no-one actually complains. The Moves and Outs have been counted so who cares? But if some lots finish early and you are late on others it means that, since the same tools are used in many areas, the fast lots are stealing tool time from the slow lots. If some lots finish early and you are NOT late on others, it means the factory has too many reports to look at and you are not measuring reality any more."

We thought that early delivery times would make a good main article for the newsletter. It's a nice follow-on to Issue 7.04, in which we wrote about Cycle Time Variability. The idea behind that article was that there are many benefits to having a tight distribution of lot cycle times. A tighter distribution makes it easier to predict when individual lots will complete manufacturing, and to meet on-time delivery targets. After briefly discussing general ways to reduce cycle time variability (by reducing process time variability and arrival time variability), we shared a number of metrics for tracking cycle time variability.

In this article, we'd like to specifically discuss lots that finish early, and look at what underlying behavior might lead to this. We'll also briefly highlight a few other problems that could result from an excess of early lots.

Some Lots Are Very Early, Other Lots Are Very Late

We cited in Issue 7.04 research by our friends at the University of Wuerzburg that found the normal distribution "a very good approximation of the cycle time distribution" in the fabs studied. Whether or not your fab follows a perfect normal distribution regarding cycle times, a bell curve seems to be a reasonable mental image for understanding the behavior of fab cycle times. The tighter the distribution of your cycle times, the more likely you are to be consistently hitting your fab's due dates. The wider the distribution, the more likely you are to have both early and late lots. Having a number of early lots, and a corresponding number of late lots, suggests that your cycle time distribution is too wide.

A wide cycle time distribution can be the result of variable lot releases into the fab, or can stem from variability within the fab. Within the fab, variation in tool uptimes can impact overall cycle time variability, especially for fabs with many one-of-a-kind tools. Dispatching also often plays a major factor. A Critical Ratio dispatch rule will try to slow down the early lots, and speed up the late lots. However, poor dispatch compliance can sabotage these results. This is especially true in cases where some lots are easier to process than others, and operators are more focused on tracking their own moves than on following the dispatch list.

If you find that you have a significant number of both early and late lots, we recommend generating a histogram of lot cycle times for your fab, by major process route. This will give you a sense of how much variability you have in your cycle time distribution, and you can then work to tighten it up. This tightening can be

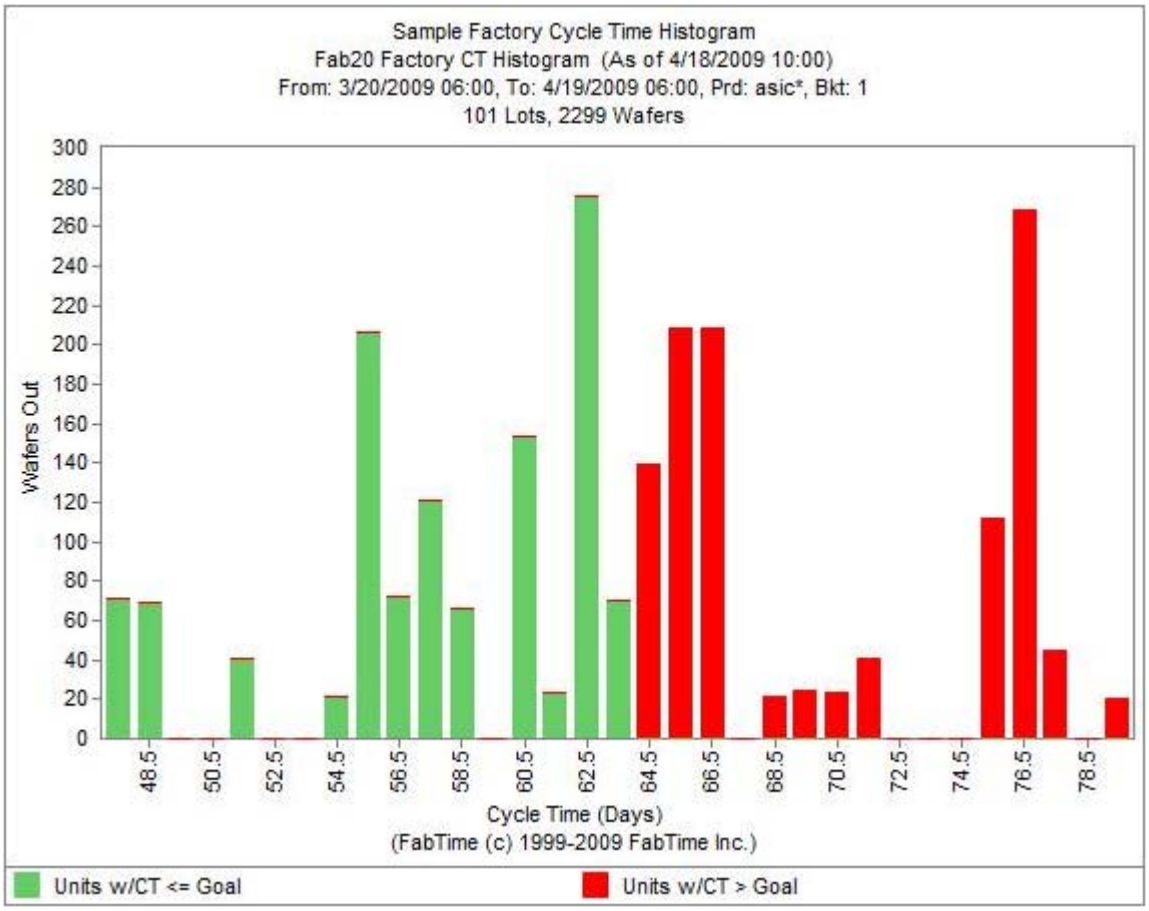
achieved by smoothing lot releases into the fab, and/or by making operational decisions within the fab to minimize variability (as described in Issue 6.10). An example of a Factory Cycle Time Histogram chart from FabTime, with a bucket size of one day, is shown below. This example was generated using simulation from demo data. Although the histogram doesn't follow a perfect normal distribution, it remains clear that tightening the distribution would improve the fab's performance.

Most Lots Are Early

If, on the other hand, you look at your fab's due date performance, and you find that most of your lots are early, this suggests that your due dates aren't realistic, and don't reflect the mean of your cycle time distribution. In essence, your due date line is somewhere to the right of center relative to your cycle time distribution. This might mean that you've made capacity or operational improvements and haven't reflected them yet in your plans (the best scenario). Alternatively, this might mean that you're not running your fab cost-effectively, because your tool utilizations are significantly lower than expected (the worst scenario). In the either case, the solution (in terms of the early shipment dates) is to update your planning system, to generate more accurate cycle time targets.

Hot Lots are Making Other Lots Late

Hot lots, of course, have their own due date. So, it's not that your hot lots are early. However, what hot lots do is create a bimodal distribution of cycle times. You have a few lots with low cycle times (the hot lots), and the rest of the lots normally distributed around some higher cycle time. The hot lots take capacity away from other lots, and dump extra queue time on them. The more hot lots you have, the higher the



cycle time of the other lots. If you find that your hot lots are making other lots late, then you'll have to make some decisions about the relative importance of your cycle time goals. If all of the hot lots are necessary, and their aggressive shipment dates are required, then you may have to adjust the due dates for the regular lots upward. On the other hand, if anything can be done to tone down the hot lots, then you'll see improvement in the cycle time of the other lots in the fab.

Other Potential Problems from Early Lots

Here are a few other issues that can stem from having lots finish ahead of schedule:

- If lots are early, your transportation network or back-end facilities might not be ready for them. You may be creating variability in lot releases to the back-end, and causing cycle time problems there.

- The more lots you hold in your finished goods inventory, the higher the chance of having to write them off due to changing market conditions.

- If you deliver, say, an entire order early, this might give your customers an unrealistic expectation of what your delivery performance will be in the future, leading to unhappiness (or the inability to charge a premium for hot lots) later.

Conclusions

In wafer fabs, lots that are running late tend to get plenty of attention. We try to speed them along the way, we might make them temporarily hot, and we analyze after the fact what it was that caused them to be late. Lots that are early garner far less attention. As long as the lot wasn't late, it's often considered fine. However, the reality of the situation is that early lots are symptoms of larger issues. If you have significant numbers of both early and late lots, you probably have too wide a cycle time distribution. Tightening up that distribution will reduce both the number of early lots and the number of late lots. If you find that a majority of your lots are finishing significantly early, you can't rest on your laurels and say "Excellent! Well done." If most of your lots are early, then you have some sort of disconnect in your planning, a disconnect that should be resolved, if you want to keep your fab profitable. Early lots can also cause problems of their own, sending variability downstream to your back-end facilities, and/or creating unrealistic expectations among your customers. The goal with delivery dates, as with fab performance in general, is to be consistent and predictable.

Closing Questions for FabTime Subscribers

Do you strive for true on-time delivery, meeting each due date exactly, and penalizing earliness? Or do you focus more on keeping cycle times down, and just focus energy on lots that are late?

Further Reading

- S. C. H. Lu, D. Ramaswamy, and P. R. Kumar, "Efficient Scheduling Policies to Reduce Mean and Variance of Cycle-Time in Semiconductor Manufacturing Plants," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 7, No. 3, 1994, 374-380. This study reported that their "Fluctuation Smoothing policies achieved a reduction of 22.4% in the Mean Queueing Time, and a reduction of 52% in the Standard Deviation of Cycle Time, over the baseline FIFO policy."

- M. Mittler, N. Gerlich and A. K. Schoemig, "On Cycle Times and Interdeparture Times in Semiconductor Manufacturing," Report No. 124, Institute of Computer Science Research Report Series, University of Wuerzburg, 1995. This paper showed that for the two semiconductor facilities studied the normal distribution was "a very good approximation of the cycle time distribution."

■ J. Robinson and F. Chance, "Cycle Time Variability," *FabTime Cycle Time Management Newsletter*, Vol. 7, No. 4, 2006.

■ J. Robinson and F. Chance, "Operational Recommendations for Wafer Fab Cycle Time Improvement," *FabTime Cycle Time Management Newsletter*, Vol. 6, No. 10, 2005.

■ J. Robinson and F. Chance, "Quantifying Wafer Fab Variability," *FabTime Cycle Time Management Newsletter*, Vol. 4, No. 1, 2003.

■ L. Sattler, S. O'Connor, M. Hallinan and T. Finucane, "Techniques for Analyzing Cycle Time Variability in Fab and Probe," *Proceedings of the 1999 Advanced Semiconductor Manufacturing Conference (ASMC)*, Boston, MA, 1999. This study found that probe cycle time variability could be significantly reduced by altering fab schedules to smooth the flow of lots into the probe area.

■ A. I. Sivakumar, "Simulation Based Cause and Effect Analysis of Cycle Time Distribution in Semiconductor Backend," *Proceedings of the 2000 Winter Simulation Conference*, 2000. (All 1997 to 2005 WSC papers are available for free download from http://www.informs-cs.org/wscpapers.html). This study showed the impact of lot release scheduling on cycle time distribution.

■ A. I. Sivakumar, N. F. Choong and C. S. Chong, "Modeling Causes and Effects of Semiconductor Backend Cycle Time," *Solid State Technology*, Vol. 44, No. 12,51-53, 2001. This study (by the same author as above) said that "smooth lot release scheduling of demanded capacity gave shorter queue times and a narrower cycle-time distribution."

■ H. J. Yoon and D. Y. Lee, "A Control Method To Reduce The Standard Deviation Of Flow Time In Wafer Fabrication," *IEEE Transactions in Semiconductor Manufacturing*, Volume 13, No. 3, 389-392, 2000.

Acknowledgement

This article owes a debt to discussions with a subscriber who has chosen to remain anonymous, but who is certainly appreciated. Thank you!

Subscriber List

Total number of subscribers: 2795, from 468 companies and universities.

Top 21 subscribing companies:

- Maxim Integrated Products, Inc (180)
- Intel Corporation (151)
- Chartered Semiconductor Mfg (86)
- Micron Technology, Inc (81)
- Western Digital Corporation (77)
- X-FAB Inc. (68)
- Texas Instruments (67)
- International Rectifier (64)
- TECH Semiconductor Singapore (61)
- ON Semiconductor (56)
- Freescale Semiconductor (55)
- STMicroelectronics (54)
- Analog Devices (53)
- IBM (49)
- NEC Electronics (49)
- Infineon Technologies (47)
- GLOBALFOUNDRIES (43)
- Cypress Semiconductor (38)
- Skyworks Solutions, Inc (36)
- ATMEL (33)
- Seagate Technology (33)

Top 4 subscribing universities:

- Ben Gurion University of the Negev (9)
- Arizona State University (8)
- Nanyang Technological University (8)
- Virginia Tech (8)

New companies and universities this month:

- HEC Paris
- Areva T&D
- Defense Contract Management Agency (DCMA)

Sampler Set of Other Subscribing Companies and Universities:

- Advanced Semiconductor Mfg. Corp (1)
- AFPD Pte., Ltd (5)
- Albany Nanotech (2)
- Austriamicrosystems (5)
- COM DEV Space (1)
- Eindhoven University of Technology (1)
- FlipChip International (24)
- Gebze Institute of Technology (1)
- IMEC (7)
- M/A-COM / Tyco Electronics (2)
- MEMSCAP, Inc (1)
- Nepes Pte Ltd (1)
- Neuberger Berman (1)
- Onix Microsystems (1)
- Philips LumiLeds (2)
- SAT Simulations- und Automations-Technologie AG (1)
- Sun Microsystems (1)
- TSMC (17)
- UMC (10)
- Zetek PLC (3)

Note: Inclusion in the subscriber profile for this newsletter indicates an interest, on the part of individual subscribers, in cycle time management. It does not imply any endorsement of FabTime or its products by any individual or his or her company.

There is no charge to subscribe and receive the current issue of the newsletter each month. Past issues of the newsletter are currently only available to customers of FabTime's web-based digital dashboard software or cycle time management course.

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Cycle Time and Line Yield Improvement Manager
Spansion Fab 25

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Turn fab MES data into information and save time and money

- Are your supervisors swamped with daily reports, but lacking real-time information?
- Is it difficult to link equipment performance to cycle time?
- Does each new cycle time analysis require IT resources?

FabTime can help. FabTime saves your management team time daily by turning fab 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. With FabTime, the end user can filter for exactly what he or she needs, while staying in a comprehensive framework of pre-defined charts. Most importantly, FabTime can help your company to increase revenue by reducing cycle times up to 20%.

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Jim Wright
Production Manager
Headway Technologies

FabTime Benefits

- Cut cycle times by up to by 20%.
- Focus improvement efforts on the tools that inflate cycle time.
- Improve supervisor productivity – cut reporting time by 50%.
- Improve IT productivity – eliminate need for custom reports.