FabTime Cycle Time Management Newsletter

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Information

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

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Welcome

Welcome to Issue #7 of the FabTime Cycle Time Management Newsletter. This month we have a response from Walt Trybula of SEMATECH to last month's performance measurement topic. Walt poses a question regarding tool performance by drawing a simple analogy to the interest earned in a bank. The idea is that if a bank told you that your interest rate was 6%, but only applied that interest to your account when the bank was open, you would in actuality have a much lower rate of return then 6%. And yet we buy tools rated at 120 units per hour, when that 120 uph only applies to time when the tool is up and running at peak performance. It's an interesting and thought-provoking perspective.

This month's main topic is improving factory cycle time by making changes at non-bottleneck tools. We have talked recently about theory of constraints, and we believe, as TOC advocates, that you should pay attention to your bottleneck tools. And we agree with the TOC fundamental that you can only improve your factory capacity by improving the capacity of the bottleneck. However, the same is not necessarily true regarding cycle time. Cycle time improvements at non-bottleneck tools can directly reduce total factory cycle times. This issue gives simple, concrete examples as to why this is true. We also have several job change announcements in this issue - not so surprising in today's dynamic marketplace. If anyone else has a job change announcement, or would like to post a notice for an open position, please let us know. And as always, thanks for reading!

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Response To Last Month's Discussion Topic

From Walt Trybula (SEMATECH): "Here is a challenge for your readers. If you invest $1,000 in a certificate of deposit at 6%, what is the total value of your investment at the end of one year? According to most people, it should be $1,060. However, let's consider the utilization of the money. First, the availability of accessing the money is limited. Weekends provide restricted access - sort of downtime for maintenance. So the 52 weeks have 104 days of maintenance. Therefore a 6% return of the available scheduled time is actually 4.3% (263/365 days times 6%). On the other hand, the time that you can access your money is limited to the hours of 8AM to 5PM or 9 hours a day. If your annual return were 1.6% or $16 on a $1,000, it could be claimed (by the same method used for equipment) that the return was 6%! Obviously an exaggeration - or is it?

There are stepper manufacturers that advertise rates of 120 wafers per hour or higher. If one considers a 5,000 wafer start per week facility with 20 levels, the total number of levels is 100,000 per week. There are 168 hours a week. This implies that an average of 595 wafers per hour must be processed. At a rate of 120 wafers per hour, this implies that at maximum efficiency (100%), the facility would need 5 steppers!!! At 50% efficiency (60 wafers per hour), there would be 10 steppers needed. In actuality, the number of steppers is a number that is greater than the number of levels. So what is the efficiency of the steppers? Ask in the industry and you will find numbers that approach 50%. Is it the $16 or the $60 that is the 6% return? Obviously, it depends on the case in question." If anyone has a response to Walt's question, we would be glad to hear it.

Improving Factory Cycle Time at Non-Bottleneck Tools

Introduction

Back in issue #4 we talked about the theory of constraints, and the importance of locating and focusing on the bottleneck. Because, of course, the capacity of a fab is limited by the capacity of the bottleneck. As Goldratt said: "An hour lost at the bottleneck is an hour lost for the entire system." If you want to improve throughput for your fab, you need to start with the bottleneck (or bottlenecks), and work from there. However, this is not true when you're trying to reduce cycle time. We believe that you can reduce overall cycle time by reducing cycle time at any tool group in the factory.

The notion that you can improve overall cycle times by reducing cycle time at the bottleneck is obvious. And in fact, the bottleneck is a good place to start cycle time improvement efforts, since you probably have a large queue there, and plenty of waiting time. The purpose of this article, however, is to point out that you can ALSO reduce cycle time by making changes at non-bottleneck tools. This is far less obvious. With throughput, it doesn't matter if you process at a higher rate at non-bottleneck tools, because things get held up at the bottleneck anyway. Sometimes this happens with cycle time, too. But not always. We'll divide the discussion below into three cases: tools located after all visits to the bottleneck in the process flow, tools located before all visits to the bottleneck, and tools located between visits to the bottleneck.

Tools Located After the Bottleneck

Cycle time improvements that take place at tools after the bottleneck in a process flow have a direct impact on overall cycle time. For example, suppose that you have a very simple production line, with two operations in series. The first operation takes place on Tool B (the bottleneck), and takes two hours per lot, on average (including any queue time). The second operation takes place on Tool C, and takes one hour per lot. The total average cycle time is three hours:

Start -> Tool B (2 hours) -> Tool C (1 hour) -> Ship (Total Cycle Time = 3 hours)

If you now make improvements to Tool C such that the average cycle time is only 30 minutes, making no changes to Tool B, then the total average cycle time decreases to 2.5 hours:

Start -> Tool B (2 hours) -> Tool C (0.5 hours) -> Ship (Total Cycle Time = 2.5 hours)

--> Reducing Tool C's cycle time by 30 minutes directly reduces total cycle time by 30 minutes.

In a more complex environment, with reentrant flow, you still see this improvement for operations that take place after all operations on the bottleneck. To expand the example above, suppose that lots go through a process flow that looks like this:

Start -> Tool B (2 hours) -> Tool C (1 hour) -> Tool B (2 hours) -> Tool C (1 hour) -> Ship (Total Cycle Time = 6 hours)

Suppose now that we make improvements to Tool C such that the average cycle time per visit is 30 minutes.

Start -> Tool B (2 hours) -> Tool C (0.5 hours) -> Tool B (2 hours) -> Tool C (0.5 hours) -> Ship (Total Cycle Time = ???)

With no other changes, lots will get to their second visit at Tool B 30 minutes earlier. They might have to wait an extra 30 minutes before getting through Tool B on this visit, canceling out the savings (more on this in a later section). However, on the second visit to Tool C, the 30 minute savings is still a keeper, and the overall cycle time is reduced by at least 30 minutes, from six hours to 5.5 hours.

--> Reducing Tool C's cycle time by 30 minutes per layer may only reduce total cycle time by 30 minutes.

"An hour lost at the bottleneck is an hour lost for the entire system."

Tools Located Before the Bottleneck

Cycle time improvements at operations that take place before the bottleneck can reduce cycle time by lowering the lead time that you use to allow lots to get to the bottleneck. For example, suppose we have another production line in which lots first go to Tool A for one hour, and then go to Tool B (the bottleneck) for two hours. If we follow a theory of constraints methodology, and release lots into the system according to the rate at which the bottleneck can handle them, then we release lots an hour before we would like them to be in queue for Tool B, and we have a total cycle time of three hours:

Start -> Tool A (1 hour) -> Tool B (2 hours) -> Ship (Total Cycle Time = 3 hours)

If, however, we make improvements to Tool A that reduce the average cycle time to 30 minutes, then we can actually wait an extra 30 minutes before releasing lots into the system (in order to keep things the same at the bottleneck). Thus we can reduce the average cycle time to 2.5 hours by releasing lots 30 minutes later relative to when they will be needed at the bottleneck:

Start (one-time delay of 0.5 hours) -> Tool A (0.5 hours) -> Tool B (2 hours) -> Ship (Total Cycle Time = 2.5 hours)

--> Reducing Tool A's cycle time by 30 minutes, and delaying additional starts for 30 minutes, directly reduces total cycle time by 30 minutes.

Tools Located Between Visits to the Bottleneck

Because of reentrant flow, the situations described above only represent a portion of the operations in a wafer fab. Many operations take place after one visit to the bottleneck and before another visit, like the first visit to Tool C in the B - C - B - C example described above. The impact of cycle time reductions at such operations is less clear. In many cases, these changes improve overall cycle time by smoothing the flow of WIP to subsequent bottleneck operations. This is especially true if the bottleneck is sometimes starved, because the change will mean that lots sit in queue in front of the bottleneck, rather than being at a non-bottleneck. This can lead to significant improvements in overall cycle time. In other cases, the lots simply end up spending the time saved at Tool C sitting in queue at Tool B. However, we don't believe that this will ever make the total cycle time through Tool B and Tool C worse, because the total arrival rate to Tool B remains the same, and the variability of arrivals should always be decreased by improvements at Tool C.

We would also like to add that predicting the exact impact of an improvement to Tool C, even in this very simple case, is non-trivial. Try constructing a sample event-by-event timeline, and you'll see what we mean very quickly. Now magnify this by 600 steps, to represent the situation in a real wafer fab. However, what we believe is that if improvements at Tool C might make things much better, and won't make things worse, there's good reason to go ahead with an improvement program for the non-bottleneck Tool C, in addition to any that might already be in place for the bottleneck Tool B. Note that this is a good use of simulation, to test out the potential impact of cycle time improvements at non-bottleneck tools.

> *"actions that you take to improve cycle time at non-bottleneck tools often improve overall cycle times"*

How Do You Improve Cycle Time at Non-Bottleneck Tools?

If we've convinced you that cycle time improvement programs at non-bottleneck tools makes sense, a logical question to ask is: what specifically should you do? Of course there are many possible answers. We've drawn the list below from published studies, as well as from our own experience. (This list is reprinted from our paper "Wafer Fab Cycle Time Management Using MES Data," which you can request from www.fabtime.com /abs_MASM00.htm.)

- Eliminate large minimum batch size requirements for all but very highly loaded tools.
- Cross-train equipment maintenance personnel, to reduce long delays waiting for the right repair person.
- Reduce tool dedication.
- Cross-train regular operators to handle more types of equipment, and to balance schedules.
- Change preventive maintenance schedules to minimize variability.

- Modify setup avoidance policies to ensure that low-volume products are not excessively delayed.
- Reduce transfer lot batch sizes.
- Modify lot release policies to smooth flow through the early steps of the process (lower variability).
- Explore process changes to alleviate single-pass operations, e.g. operations that can only be performed on a single piece of equipment.
- Explore batching rules, to make sure that all lots that can be batched together are batched together (eliminate unnecessary waiting to form batches)
- Check batching and setup assumptions for rework wafers. The entire parent lot is usually delayed whenever the rework wafers are waiting for processing. Also make sure all operations within the rework loop are necessary.

Perhaps some of your have other suggestions to add - we would like to hear them, and I'm sure that our other readers would, too.

Conclusions

Our point is very simple: actions that you take to improve cycle time at non-bottleneck tools often improve overall product cycle times. For operations located before the first visit to the bottleneck, or after the last visit to the bottleneck, the cycle time reduction leads to an essentially direct reduction in the overall cycle time. For intermediate operations the situation is less clear, but we believe that improvements here can sometimes improve cycle time dramatically, and in the worst case, will not make cycle time any worse. If you focus your efforts strictly on bottleneck tools, then, you miss out on many opportunities for improvement.

Community News / Announcements

Job Change Announcement - Brent Bogue

Brent Bogue recently left Motorola, where he worked for the past seven years, to take a job with Amkor. His new position will involve developing operational excellence within the factories that report under the World Wide Test organization of Amkor. Prior to working for Motorola, Brent worked for 11 years at Western Digital.

Job Change Announcement - Guy Gandenberger

Guy Gandenberger recently left National Semiconductor, where he was Managing Director of the Santa Clara wafer fab operations. He is now working as Managing Director of Wafer Fabrication for Micrel Semiconductor, where he has responsibility for both the San Jose and Santa Clara fabrication facilities. He started this new position on September 29th.

Job Change Announcement - Steven Simmons

Steven Simmons recently left Micron Technology, where he headed up Yield Modeling and Ramp Optimization to take a position with LSI Logic in Fort Collins, CO. His new responsibilities will include capacity modeling and management, supply-chain optimization, and demand-management.

FabTime welcomes the opportunity to publish announcements for individuals or companies. Simply send them to Jennifer.Robinson@FabTime.com.

FabTime Recommendations

■ Some of you probably already subscribe to FutureFab magazine. This week we took at look at their website (www.future-fab.com), and found a number of papers related to Manufacturing Productivity: Methods & Enablers available for download. Just select "Manufacturing ..." from the "Select A Topic" drop-down list.

■ FabTime's book recommendation of the month for November is "The Non-Designer's Design Book" by Robin Williams. This book postulates four basic design principles for conveying information effectively. We think that it's helped us, and wanted to share the reference with you. You can find the review at http://www.fabtime.com/designer.htm.

■ The SEMATECH website has a nice list of resources for the industry at http://www.sematech.org/public/resources/virtlib/index.htm. Included are definitions, acronym lists, and various organized collections of internet resources. I like the Quick Reference Shelf, which has links to things like currency counters, zip codes, online calculators, etc. Nothing you can't find elsewhere, but it's a convenient and well-organized starting point. For something similar, without the semiconductor industry slant, try CEO-Express (www.ceo-express.com). CEO-Express also has a nice combined search engine that checks 11 search engines, and categorizes the results for you.

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