SIMUL8 WHITEPAPER

SIMUL8 CORPORATION

More than a Cycle? What you need to know about cycle times

Simulation expert Brian Harrington explains the key pieces of information that go into designing a manufacturing facility and focuses on the cycle time of the tasks and operations within the stations.

Written By: **Brian Harrington**

About the Author

Brian Harrington is a Six Sigma Black Belt with 20 years operations research and simulation experience at Ford Motor Company. He designs and implements manufacturing process improvements which incorporate many conflicting objectives such as robust, flexible, and Lean systems.

For more information please visit:
SIMUL8.com or e-mail **info**@SIMUL8.com

More than a Cycle?

This paper outlines the key steps that are involved in designing a manufacturing facility and focuses on the cycle time of the tasks and operations within the stations.

Designing an advanced manufacturing facility today is challenging, with several conflicting objectives. Today's facilities strive to meet the demands of their customers, offering a multitude of variants and options within their product lines. This usually equates to running several product variations down the same assembly lines using flexible manufacturing techniques.

In turn this will increase the number of cycle times and changeovers that may occur within respective stations. To make it even more complicated, product-mix variation may change throughout the year, depending on the market demand. For example, the demand for a convertible car variant usually will increase within the summer months.

Simulation leads the way for designing flexible and balanced manufacturing facilities and avoids the complicated calculations to achieve the cycle time number.

The key topics we will focus on are:

1. **Collecting the necessary data**
2. **Using the data within a dynamic simulation**

❶ Collecting the necessary data

Manufacturing facilities are usually designed and sized to meet customer demand. How do industrial engineers know where to start when it comes to creating the capability of a plant?

Takt Time

Often we will start with the "takt time" for a line or station. The takt time is a calculation for what is required to meet demand.

Takt time = Available working Time/ Customer Demand

For example, an 8 hour shift with 30 minutes of planned downtime (lunch & breaks); and a demand for 500 units per shift. Therefore, the takt time would be calculated as:

Takt time = 450 minutes / 500 units = 54 seconds

Therefore, assembly lines would be designed around meeting a 54 second cycle time. But there is an important factor missing: the takt time calculation does not account for random downtime occurrences and assumes that adjacent lines are evenly balanced. Therefore, the ***design cycle time*** will have to account for these other factors that impede takt time calculations.

It is important to remember that takt time is a "calculation", and the cycle time is a "measurement" of time. Therefore, often "Actual Cycle Times" can be measured with a stopwatch once the facility is up and running.

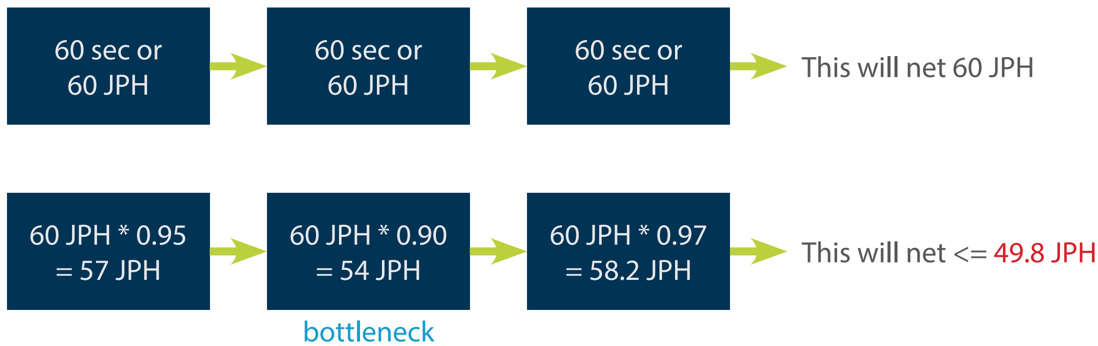
Design Cycle Time

When we look at the cycle time of an operation it will usually consist of the time to complete all the tasks within a station's process. This may include several simultaneous operations within the cell, such as robots, tooling, and manual operations. Industrial engineers usually calculate what the "design cycle time" should be for the entire cell.

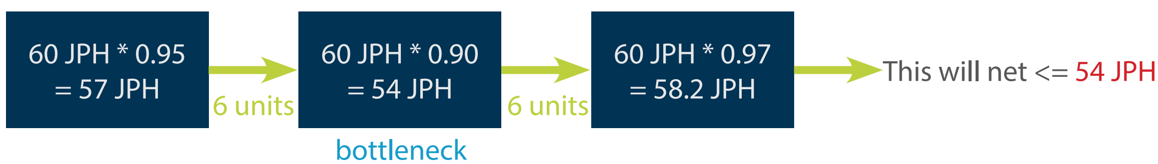
Often the initial design cycle times are derived from the stations "Bill of Material" and the stations "Process Steps". Industrial engineers then will place specific operation times for all the various tasks within the cell's process. One technique that is used for obtaining operation times and developing an overall station cycle time is through the use of MODAPTS (Modular Arrangement of Predetermined Time).

MODAPTS is a technique that determines cycle time without the use of a stopwatch; it uses predetermined time stamps for the various body motions to complete certain manufacturing tasks. Additional information on the use of MODAPTS can be found at www.modapts.org.

Once a cycle time has been established and set as a target for the station (i.e. Design Cycle Time) it still may have to be adjusted to protect it against some of the stochastic behavior that exists within a plant. For example, if we look at 3 adjacent stations all with a 60 sec cycle time, and unique values for their availability due to downtime failures, their availabilities might be 95%, 90%, and 97%, therefore we might adjust the cycle time to accommodate the performance loss within these stations.



Adding "Protective Capacity" in the form of buffers or decouplers between stations will be necessary to break this "synchronous accumulative availability" effect.



Line Balancing

Conducting Line Balancing might help achieve the goal. We might want to add additional resources to the 2nd station, to bring it up to 57 JPH - if our target throughput was to achieve at least 57 JPH. This example is a simple case of "line balancing"; attempting to have similar capability per station. When we have simulated a manufacturing facility it is often a good idea to look at the simple "stand alone JPH" - the capability per station with consideration to downtime.

Obviously any over-cycle to an operations design cycle time may cause performance issues as well. An over-cycle may be caused by a slower operator, maybe someone who is not accustomed to working at a specific work cell. In automation an over-cycle may occur if the machine has to reset itself, or recalibrate some dimensional control logic. Either way these examples of over-cycles are usually adding costly seconds on to the design cycle time of the station. If the operation happens to be in a sensitive area or a bottleneck; throughput losses are likely to occur. This is another reason to attempt to keep stations relatively balanced with respect to workload, tasks, and content. Doing so will greatly reduce the impacts of over-cycles when there are fewer sensitive areas, or bottlenecks within the facility. If the facility is reporting any under-cycles, this may be a sign that the design cycle time needs to be recalculated, or verified that no quality steps are being skipped.

Changeovers

Another common area for concern is with "changeovers". A changeover usually occurs when we are running a mix of products down the same line. A changeover might occur when the product type changes, or when a certain number of units have been processed. The major steps within a changeover consist of clean-up, set-up and start-up.

The clean-up phase consists of cleaning out any of the previous parts components. The set-up phase includes the actual adjustments to the stations equipment. Lastly the start-up phase is where any final adjustments are made before coming up to design cycle time. This is typical on batch build schemes, where we are building according to specified batch sizes. The scheduler might group certain product types together within a batch to minimize the number of changeovers that occur when the product mix changes. A changeover time can often be longer than a typical cycle time, therefore changeover schemes must be accounted for when designing a flexible manufacturing facility. Most of today's lean manufacturing companies have implemented advanced changeover schemes that focus on reducing the internal setup time within typical changeovers.

❷ Using the data within a dynamic simulation

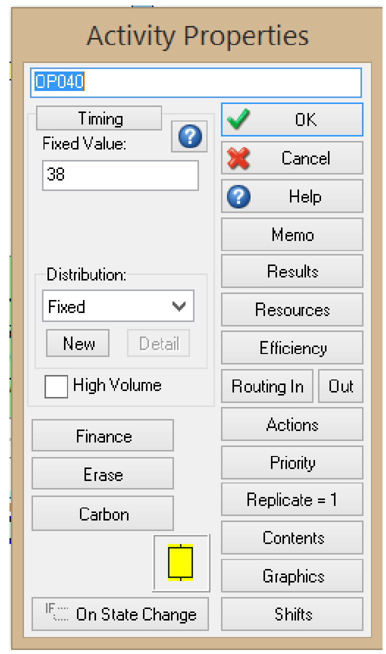
Now that we covered some of the major topics when it comes to cycle times, how do we apply it to our simulation analysis? More than likely you will be receiving datasets from your manufacturing engineering colleagues. The datasets will often be organized within Excel spreadsheets.

You will want to ask these questions:

1. How were these datasets derived?
2. From a real-time manufacturing data collection system?
3. Recorded from a stopwatch?
4. Design cycle times derived from calculations?

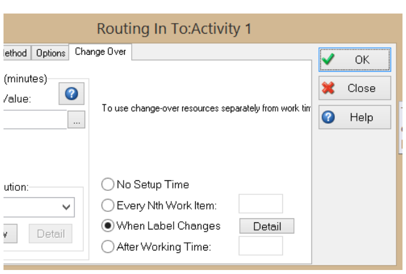
Having some insight into the origins of the datasets can give you some important clues on the integrity of the data. Often real-time data collection systems are skewed because of the various complex performance aspects encounter within a typical shift. There might be several data points that include some sort of fault time. Most online data collection systems will also include outliers that will skew the data; hence filtering the data becomes necessary. These outliers usually include catastrophic delays; major breakdowns that way be 45 minutes long. We are seeking clean cycle times; cycle times that do not include performance issues such as “Waits & Blocks”, or outliers.

It is often a good idea to treat the initial dataset as design cycle times, introducing no variation or over-cycles. Therefore, we would use a fixed distribution for all cycle times. In this example we are using 38 seconds for the operation time and have selected a fixed distribution. It is always a good idea to have a base scenario that is populated with design cycle times. This will allow for better analysis interpretation of the various working states within the facility.



We are usually seeking, optimizing or increasing the working state, thereby reducing the performance issues of “waits & blocks”. Inflating cycle times with additional random time only abstracts this part of the analysis. Remember, there will be plenty of stochastic variation caused by downtime and performance (wait & block).

Once you have completed base runs at fixed design rates, you are ready to add over-cycles if desired. Having separate scenarios will allow you to compare the effects of over-cycles, and pinpoint where they might cause losses. Typically an over-cycle may only be a few seconds; but a few seconds in any sensitive area of the facility can become a potential bottleneck. If we are simulating an over-cycle condition, usually a bounded distribution using the limits [design cycle time, maximum cycle time] will capture this behavior.



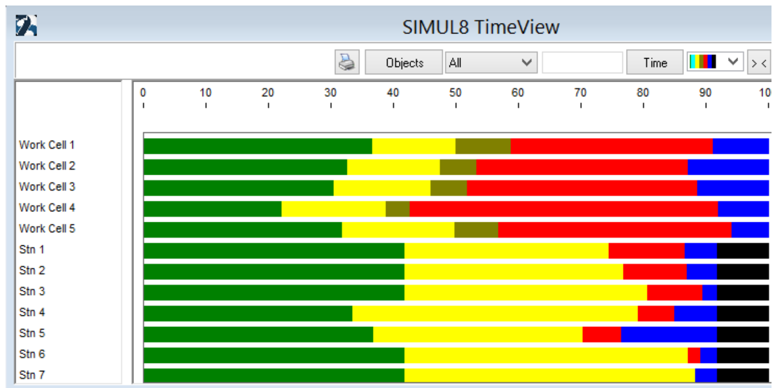
The changeover state can be captured with an Activity on Routing In/Changeover. Most simulation software will have changeover as a unique state. Therefore, we can examine how changeovers affect the performance and overall capability of a work cell. In this example we are invoking a changeover when a label changes such as “lbl_part type”; it will then cycle for 48 seconds, and capture that time in the unique changeover state. Changeovers are becoming more common with the advancement of flexible tooling and the increasing the number of product variants traveling down the same lines. Therefore, the underlying build schedule, release sequence, and batch size are all factors to be considered when designing an efficient changeover scheme.

Do we need to simulate dedicated operators?

Generally not. They are treated as one of many tasks within the stations overall operation time. On the contrary, if the operators are a shared resource, which perform various tasks at different stations; then it is advised to use operators within your simulation. The activities cycle time will not start unless the resource (operators) are present. We can also include the operator's travel times as a unique time element within the analysis.

How can we tell if the lines are balanced with respect to cycle times?

Usually looking at how the lines are interacting with one another; this is accomplished by analyzing the accumulated activity states. In this example let's look at SIMUL8's "Timeview". Timeview is a gantt chart view of the various states of an object such as an activity or station.



Placing the facilities production lines in order of process flow will help you see the performance characteristics of how lines are interacting with one another. The green sections to the left of the chart are the activities "working state", that is a reflection of the cycle times within the simulation.

The other states such as: Waiting, Blocked, Downtime, Offshift, and starved for a resource, are all chipping away at opportunities to work. Usually when we balance the workload, and add protection around bottleneck we can maximize the working state, and improve the overall performance of the facility.

Concluding thoughts on Cycle Times

The cycle time field is usually considered a relatively easy piece of data to obtain, but we can see that there are a lot of calculations and engineering behind that single number. Today effective and efficient manufacturing facilities usually have a systematic scheme behind calculating their design cycle times, incorporating these stochastic uncertainties.

These schemes will attempt to reduce the negative impacts of downtime, over-cycles, and changeovers. Simulation studies will continue to lead the way for designing flexible, balanced and robust manufacturing facilities. So, the next time you hear that a particular station runs at 45 seconds, be prepared to find out what's behind the number!

Further Reading

The Balancing Act: An Example of Line Balancing

If you'd like some more in-depth reading about line balancing, see "The Balancing Act: An Example of Line Balancing" where Brian Harrington explains the key steps of line balancing and how simulation can take your analysis to the next level.

Line Balancing at Chrysler

Read about how SIMUL8 have developed a relationship with Chrysler over a number of years. Across various line balancing projects SIMUL8 helped the Chrysler simulation team save **millions of dollars.**