

The Ultimate Guide to Maximizing Your Throughput

Bottlenecks, Constraints, and Efficiencies
for Food, Beverage, and Pharmaceutical Processors



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In this book, we cover why throughput is the most important metric for assessing the quality of your production line, as well as how to maximize throughput by finding and solving common issues.

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“The system Garvey came up with is simple, cost-effective, and works well. They just seem to have a knack for this sort of thing.”

Lindy Vejar, Project Leader, Bio-Rad

What Is Throughput?

(And Why You Should Care)



Throughput is the #1 metric for assessing the quality of your production line. Not just an important metric, but the most important metric.

In business-bottom-line terms, throughput is the difference between:

- Meeting your production goals and missing your targets
- Having a competitive advantage and falling behind
- Keeping your customers and losing them to someone who can produce more / better / faster

If you're a plant manager, a process improvement engineer, or someone else whose compensation is tied to production, throughput is the difference between a nice fat quarterly bonus and having to dial back those vacation plans.

Given all this, you might be surprised to know that most production lines, especially in the food and beverage manufacturing industry, are seriously underperforming on this metric. As in, their throughput is a good 20-30% lower than it could be. And that's just the average – we've seen production lines with room for up to 60% improvement in their throughput. Can you imagine what a 60% improvement would look like?

The reason production lines underperform is because throughput too often takes a backseat to efficiency. Now, don't get me wrong – efficiency is important. But if your goal is to maximize the amount of product coming off of your line every shift, efficiency alone won't get you there. You could have every piece of equipment running at peak efficiency and still have suboptimal throughput.

Let's dive into why that is and, most importantly, what you can do about it.

What is throughput?

Simply put, throughput is a way to measure the effectiveness of your entire production line. In technical terms, it's the rate of production, i.e., how much you can produce over a certain period of time.

Throughput = Units Produced / Time

If a wine bottling line produces 6,000 bottles of wine an hour, then its throughput is 100 bottles per minute.

There are two types of throughput we can calculate:

- Throughput of individual machines
- Throughput of the entire line

The reason most production lines underperform is that companies only consider the throughput of individual machines. But it's the throughput of the entire line that determines whether or not you meet your production goals.

Throughput of individual machines

On a machine-by-machine basis, throughput is highly related to efficiency, which is equivalent to uptime percentage.

In a perfect world, every machine along a production line would run nonstop, which means the uptime percentage would be 100%. But, in the real world, machines fail all of the time. Going back to our example of the wine bottling line, maybe the labeler runs out of labels, or the foil in the capsuler gets jammed, or someone trips and accidentally shuts off the decaser.

When these things happen, it takes time to get the machines back up and running again. We can use the mean time between failures (MTBF) and the mean time to repair (MTR) to calculate a machine's probability of run (POR).

$$POR = MTBF / (MTR + MTBF)$$

In English: Uptime % = Uptime / Total Time

Move the decimal a couple of places, and you have the machine's efficiency.

It may sound complicated, but, once we put it into an example, you'll see that it's actually quite simple. Suppose the decaser on our wine bottling line can decase 240 bottles per minute (bpm). It takes 1.5 minutes to repair and the mean time between failures is 30 minutes.

First, we calculate the probability of run:

$$POR = 30 / (1.5+30)$$

$$POR = 30 / 31.5$$

$$POR = 0.9523$$

For simplicity, let's call it 0.95. Then, we move the decimal point two places:

$$Efficiency = 95\%$$

Now, we calculate throughput by multiplying the POR by the decaser's maximum rate:

$$0.95 \times 240 \text{ bpm} = 228 \text{ bpm}$$

I know what you're thinking – 95% efficiency is very good. And you're right! No machine runs at 100% efficiency, so we're likely getting the maximum throughput out of this machine already. Case closed!

Not so fast.



This is where most companies stop. They analyze their individual machines, see high efficiency numbers, and call it good.

And that's exactly why their lines underperform.

To understand why, we need to perform a line analysis...

Throughput of the entire line

So, we've established that the decaser is working as hard as it can. That's great! But the decaser isn't the only machine on the line. There's also a filler, a capsuler, a labeler, and a case packer. How are they doing?

Imagine we repeat the efficiency and throughput calculations for each piece of equipment. We won't go through them in detail, but you can verify them using the formulas provided above. The table below shows the results for all five machines.

Machine	MTR	MTBF	Max Rate	Efficiency	Throughput
Decaser	1.5 min	30 min	240 bpm	95%	228 bpm
Filler	4.0 min	60 min	180 bpm	93%	167 bpm
Capsuler	30 sec	15 min	240 bpm	96%	230 bpm
Labeler	45 sec	10 min	240 bpm	92%	220 bpm
Case packer	3 min	40 min	300 bpm	93%	279 bpm

At first glance, this looks pretty good. It would be nice to see those low-90s move up a point or two, but surely we're getting somewhere close to maximum throughput on this line, right?

Not even close.

Here's why: Machines don't all go down and then come back up at the same time. They all have different MTRs and MTBFs, and every time one machine goes down, it affects all of the other machines on the line. So, to find the efficiency of the entire line, we have to multiply the efficiencies of all of the machines together:

$$0.95 \times 0.93 \times 0.96 \times 0.92 \times 0.93 = 0.725$$

The efficiency of the entire line is only 72.5%.

You would never buy a single piece of equipment that was only up and running 72.5% of the time. If you did, you'd send it back to the manufacturer as defective and demand a refund.

But, wait, we're not done. We still have to calculate the throughput.

For this, we use the individual throughput of slowest machine on the line. As they say, "a chain is only as strong as its weakest link." On a production line, that means that the whole process can only go as fast as the slowest machine, which we call the constraint. In our example, the constraint is the filler, which has a maximum throughput of 180 bpm.

$$\text{Total Throughput} = \text{Throughput of the Constraint} \times \text{Total Efficiency}$$

$$\text{Total Throughput} = 180 \text{ bpm} \times 0.725$$

$$\text{Total Throughput} = \sim 130 \text{ bpm}$$

At this point, you've probably gone from thinking "That's pretty good!" to thinking "Yuck." Now you can see why so many lines underperform. This line has machines that can run anywhere from 180 to 300 bottles per minute, and it's averaging 130. By running the line at such low capacity, we're leaving a lot of money on the table.

How to maximize your throughput

You'll be happy to hear that there's a light at the end of this production line tunnel.

Since the slowest machine is the one that's constraining production, this is where we need to focus. And don't worry – it doesn't require going out and buying a new filler! We can solve the problem by putting buffers in the form of accumulation tables before and after the filler. The buffers isolate the filler from the rest of the line so that even when other machines go down, the filler can keep on keeping on.

- When a downstream machine, such as the capsuler, fails, the filler can create a store of products in the buffer that will be ready to proceed down the line as soon as the problem is resolved.
- When an upstream machine, in this case the decaser, fails, the filler can keep working on the products that have accumulated in the buffer.

The buffers ensure that the filler performs at its maximum efficiency, rather than being affected by stoppages elsewhere along the line.

This simple solution is amazingly effective. Let's do the math.



In the original example, the overall efficiency was so low because the individual machines were interdependent. If one went down, the whole line went down, and the total throughput was limited by the constraint.

When we add buffers before and after the filler, we effectively split the line into three sections:

- Section 1: Decaser
- Section 2: Filler
- Section 3: Capsuler + labeler + case packer

The filler is still the constraint, but, thanks to the buffers, it can keep running regardless of what happens upstream or downstream. So, our new calculations look like this:

- **Decaser: $240 \text{ bpm} \times 0.95 = 228 \text{ bpm}$**
- Filler: $180 \text{ bpm} \times 0.93 = 167 \text{ bpm}$
- Capsuler + labeler + case packer: $240 \text{ bpm}^* \times (0.96 \times 0.92 \times 0.93^{**}) = 197 \text{ bpm}$

**The max rate for this section of the line is the rate of the slowest machine.*

***The efficiency for this section of the line is 83% ($0.96 \times 0.92 \times 0.93 = 0.82$).*

Now for the kicker. Because the filler can keep operating even when the other machines go down and products can accumulate in the buffers, the throughput of the entire line is equal to the throughput of the filler. In other words, the throughput on this line is now 167 bpm, rather than 130 bpm. **That's an increase of more than 28%.**

At this point, I hope you've gone from "Yuck" to "Wow!"

Here's one more set of calculations to consider.

Before we added the buffers, the line was running at 130 bpm. At that rate, over an 8-hour shift, the total production would be:

$$130 \text{ bpm} \times 480 \text{ min} = 62,400 \text{ bottles}$$

With the buffers, that same 8-hour shift would produce:

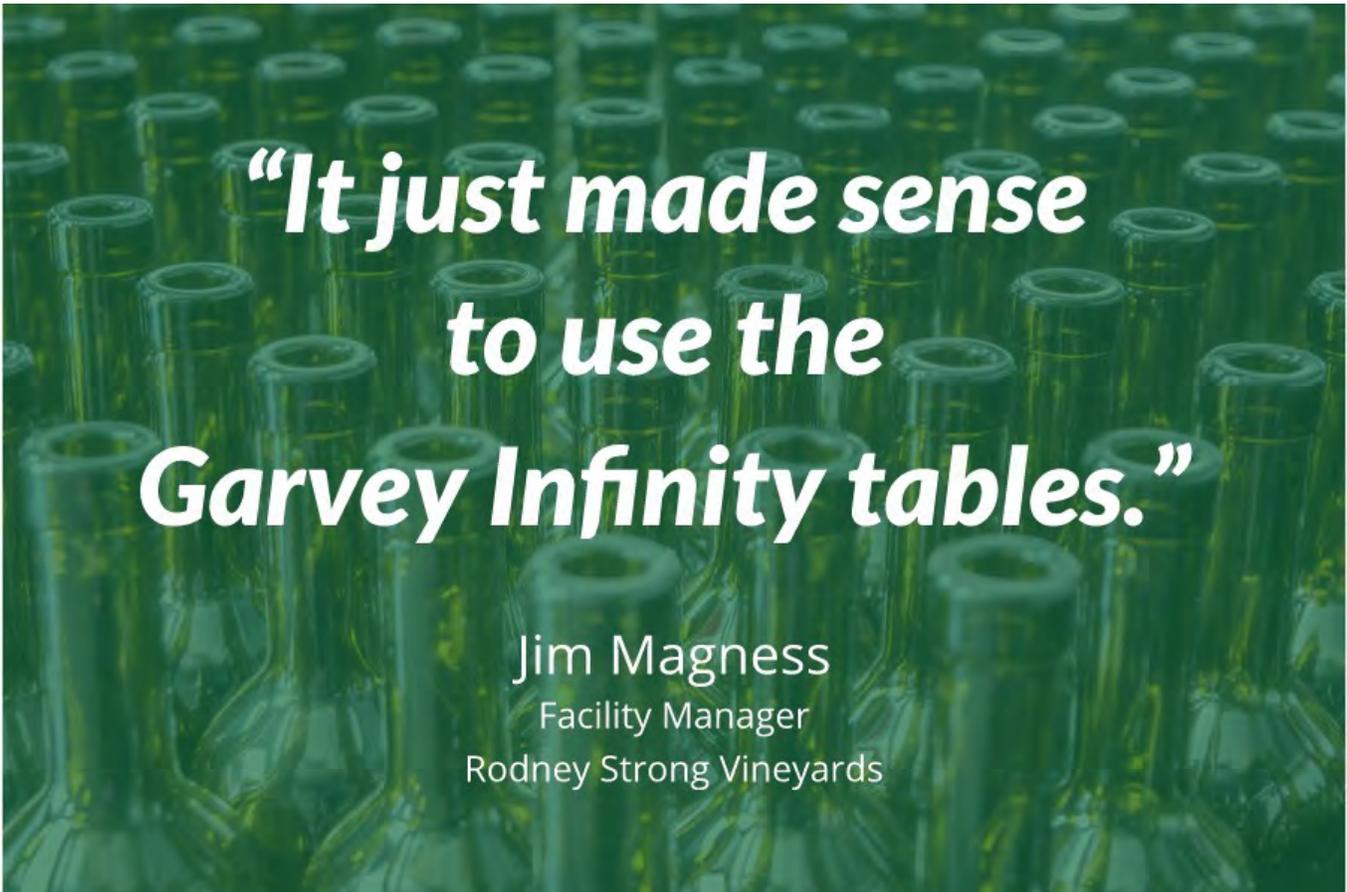
$$167 \text{ bpm} \times 480 \text{ min} = 80,160 \text{ bottles}$$

Let's assume that the winery makes \$0.80 profit per bottle (a very low estimate). Running one 8-hour shift per day, 5 days a week, for 50 weeks a year, the additional profit would be:

\$14,208 per shift and \$71,040 per week, adding up to \$3,552,000 per year!

You read that right. \$3.5 million extra profit simply from adding two accumulation tables onto the line.

And just so you know, this isn't a hypothetical exercise. This is a real example of a bottling line at one of our customers' facilities. You may have heard of them. They make excellent wine.



***“It just made sense
to use the
Garvey Infinity tables.”***

Jim Magness
Facility Manager
Rodney Strong Vineyards

Is Waiting Killing Your Throughput... and Your Bottom Line?



When you think about your production lines, do you have a vague sense that you could be producing more / better / faster, but aren't sure exactly what's standing in your way? This is common. We talk to many plant managers who know they should be getting more out of their lines, but aren't sure how to make that happen.

You can't solve a problem that you can't articulate. So, pinpointing exactly where things are going south should always be Step 1.

There are several factors that can get in the way of you achieving your production goals. In lean manufacturing, these often take the form of wastes.

The 8 Wastes of Lean Manufacturing

Abbreviation	Waste	Description
D	Defects	Products or services that fail to meet specifications, resulting in product loss or rework
O	Overproduction	Producing too much product before there's demand for it
W	Waiting	Time spent waiting because work is stopped for some reason
N	Non-utilized talent	Human resources not being used to their fullest advantage
T	Transportation	Moving products around more than necessary to perform the process
I	Inventory excess	Raw materials not being processed or too much finished product sitting on the shelf
M	Motion	Excess movement of people, machines, or products
E	Extra processing	Any activities performed that aren't required or don't add value

The fact that these eight wastes can be remembered by the handy acronym DOWNTIME is telling – all of them can spell trouble for your bottom line. To make things worse, they often attack in groups. For example, poor communication between departments can lead to tasks being done in duplicate (think data entry and report generation). This is an example of both non-utilized talent and extra processing.

The eight wastes can be applied to all business environments, from manufacturing plants to back offices. That's a big umbrella, so let's narrow the focus for a moment to a single production line on a plant floor.

Over the past few decades, we've been in many manufacturing facilities and analyzed many production lines using our [Garvey Line Analysis method](#). What we've found – overwhelmingly – is that the biggest waste impacting production lines is waiting. Specifically, waiting due to unplanned downtime.

Often, production lines are throttled because of a [piece of equipment that's causing a bottleneck](#). This machine is called your constraint because it's the machine that's running at the lowest rate already (check out the most common constraints on [beverage](#) and [food packaging](#) lines). When your constraint goes down, even for just a minute or two, all of the other machines need to stop as well. Not only is this a waste of time, but it has ripple effects that create other wastes as well. For example, unplanned downtime leads to inventory excess because materials aren't being processed.

In our experience, addressing this constraint through accumulation (which keeps the rest of the line running, even when the machine is down) can result in throughput gains of as much as 30%. In other words, accumulation counteracts the waste of waiting.

We know what you're thinking: "Of course Garvey will recommend accumulation...they make accumulation systems!" And you're not wrong. Accumulation is our business.

But we didn't go into this business just to sell accumulation tables. We started with a common problem manufacturers face – i.e., losses due to downtime caused by production line bottlenecks – and developed our accumulation systems to address this problem.

Obviously, identifying and removing all of the wastes in your process is a bigger project, and accumulation isn't the answer to everything. But it is the answer to [maximizing your throughput](#) by eliminating the waste of time due to products waiting to be processed when a machine on your line goes down.

How Much Are Production Line Bottlenecks Costing You?



\$3,552,000!

I know that seems like a lot. But that's how much profit one winery was missing out on before they took steps to reduce the impact of the bottleneck on their production line.

We've performed our [Garvey Line Analysis](#) with hundreds of companies. And, while the results vary, we typically find that companies are operating their lines at 20-30% below capacity, which means they're missing out on significant revenues. Depending on your current production, your bottleneck could be costing you hundreds of thousands or even millions of dollars per year.

Let's see how one client got their \$3.5 million back, as well as how you can calculate how much your bottlenecks are costing you.

What is your bottleneck?

To figure out how much potential profit you're losing because of bottlenecks, you first need to identify what those bottlenecks are.

In lean manufacturing, this is called finding your constraint, i.e., the piece of equipment on your line with the lowest net output. No matter how fast the other machines can run, your entire line will never be able to run faster than this machine. That's why it's called the constraint – it constrains the output of the line.

To learn how to identify your bottleneck, read our article [How to Find the Constraint in Your Production Line](#).

How your bottleneck impacts your profitability

The main way your bottleneck impacts your profitability is by compounding the effect of downtime along your production line.

Downtime costs manufacturers a huge amount of money. By one estimate, companies in the food and beverage industry experience as much as 500 hours of downtime every year, to the tune of \$20,000 to \$30,000 an hour. **That's \$10 to \$15 million dollars lost to downtime a year!**

Unfortunately, downtime is inevitable – it's simply the nature of machines. However, the effect of downtime is often worse than it needs to be. When the non-constraints on your line (all of the machines except for the constraint) go down, they typically cause the constraint to stop as well. For example, if a machine upstream of the constraint stops working, the constraint won't have any products to process. This compounds the effect of downtime by making the slowest machine on your line even slower.



How to calculate what your bottleneck is costing you

Fortunately, it's easy to calculate exactly how much this compounding effect is costing you. All you have to do is determine the difference between what you're actually producing and what you could be producing if the bottleneck didn't have to stop every time another machine on the line went down.

Potential Throughput - Actual Throughput = Lost Opportunity

The \$3.5 million figure is from an example of a bottling line that we worked through in a [previous article on calculating throughput](#). By analyzing that bottling line, we found that the constraint was the filler.

The filler is capable of filling 180 bottles per minute at 93% efficiency. So, the potential throughput is:

Potential Throughput = Throughput of the Constraint x Efficiency of the Constraint

Potential Throughput = 180 bpm x 0.93

Potential Throughput = 167 bpm

To find the actual throughput, we need to take into account the compounding effects of downtime. We do this by replacing the efficiency of the constraint with the efficiency of the entire line, which in our example is 72.5%:

Actual Throughput = Throughput of the Constraint x Total Efficiency

Actual Throughput = 180 bpm x 0.725

Actual Throughput = ~130 bpm

Then, we subtract the actual throughput from the potential throughput.

167 bpm - 130 bpm = 37 bpm

If the line were running at maximum capacity, it would be able to produce 37 additional bottles per minute. To put this into dollars and cents, we need to know the average profit per bottle. In the example, the per-bottle profit was \$0.80.

So:

37 bpm x \$0.80 = \$29.60 per minute

which translates to:

\$1,776 per hour

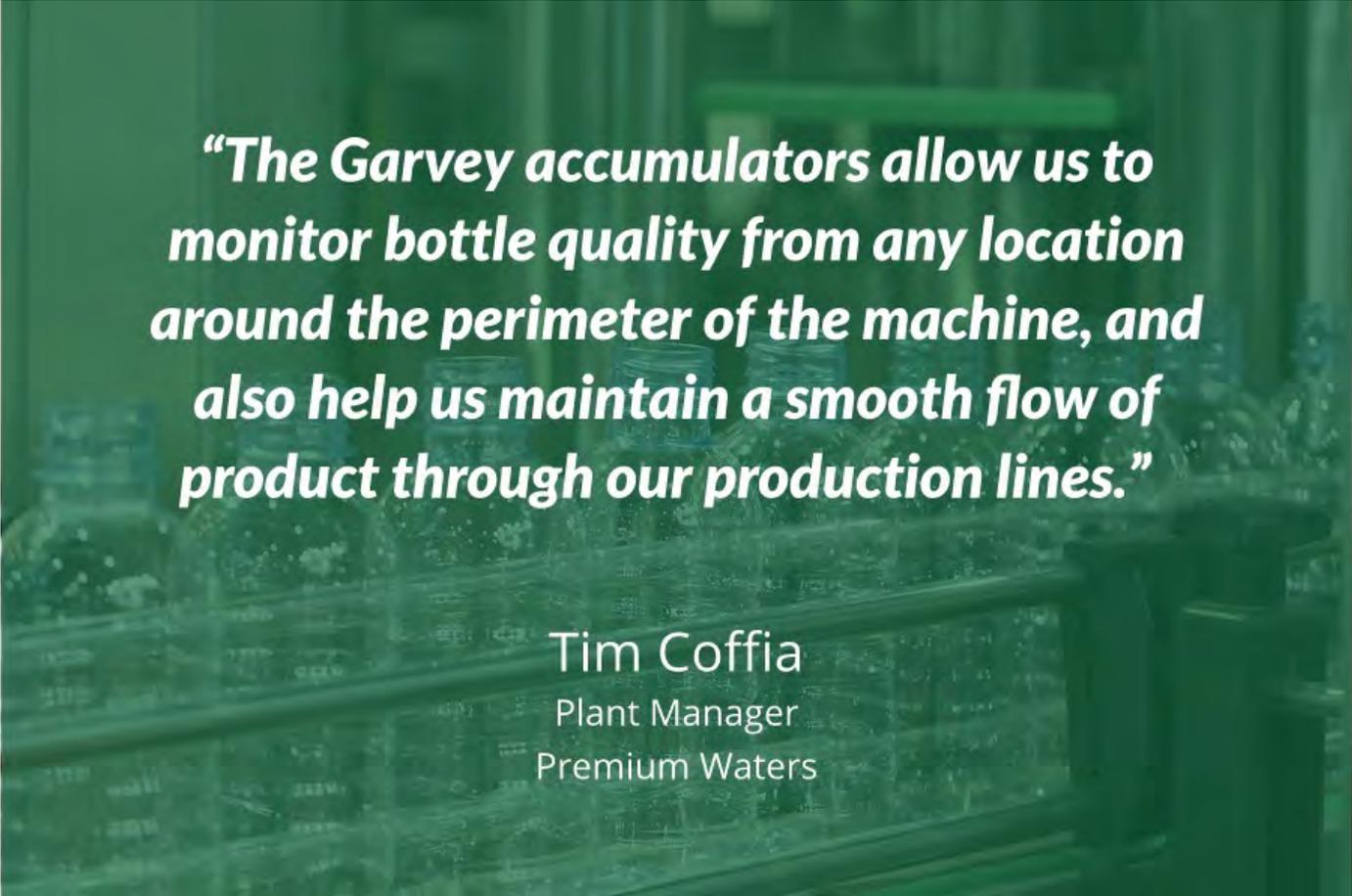
\$14,208 per 8-hour shift

\$71,040 per week (5 shifts/week)

And...

\$3,552,000 per year (50 weeks/year)

Not too shabby!



“The Garvey accumulators allow us to monitor bottle quality from any location around the perimeter of the machine, and also help us maintain a smooth flow of product through our production lines.”

Tim Coffia
Plant Manager
Premium Waters

How to Find the Constraint in Your Production Line



Do you know what the bottleneck is in your manufacturing process? The limiting factor that's keeping you from ramping up your production or sometimes even meeting your goals?

This bottleneck is your constraint, and it should be your top priority because it's setting the pace for the rest of your line. Until you increase the capacity of your constraint, you won't be able to increase your throughput.

So, how do you find it?

Constraints can take many forms. Labor shortages, regulatory requirements, and outdated ways of thinking can all impact your operations and, in turn, your production capacity. But at most of the companies we deal with, the primary constraint is a piece of equipment. Specifically, it's the piece of equipment that has the lowest net output.

That may sound simple, and it is. But there are a few qualifications we need to make:

- First, you can't determine the lowest net output just by looking at a machine's settings or specs. A labeler on a bottling line may be able to label 300 bottles per minute in theory, but in reality 100% efficiency is impossible. At some point, the machine will run out of labels or become jammed, etc.
- Second, the net output of each machine — including the constraint — is likely much higher than the actual throughput of your entire line. This is due to the effects of downtime of the non-constraints (i.e., all machines except for the constraint). When non-constraints go down, they typically stop the constraint from running. This can lead to a 20-30% reduction in overall throughput.

How to identify your constraint by looking at your production line

The truth is, you probably already know what machine is slowing down your production line. If not, there's an easy way to make an educated guess — look at the spacing between the units going into the machines vs. the spacing between the units coming out.

To illustrate this, let's consider a story from [Eliyahu Goldratt's The Goal](#), which is the book that first introduced the Theory of Constraints back in 1984:

Alex Rogo is the manager of a struggling manufacturing plant. He has three months to turn it around. Otherwise, the plant will close and all of the employees will be laid off.

One weekend, Alex takes his son's scout troop on an overnight hiking trip. As the leader, Alex's goal is to get everyone to the campsite as quickly as possible while also keeping the troop together so he can keep an eye on them. But there's a problem — one particular scout, Herbie, is a very slow hiker. The kids in front of Herbie keep running ahead, while the kids behind Herbie are trapped moving at a very slow pace.

Alex realizes that it doesn't matter how fast the rest of the hikers are, the troop as a whole can't go any faster than Herbie. That means that the only way to keep the troop together and get to the campsite faster is for Herbie to hike faster. (We won't tell you how Alex accomplishes this or how he applies this same concept to save the plant – we highly recommend you read the book!)

Alex has his epiphany that Herbie is the bottleneck when he notices the inconsistent spacing in the line of hikers. There's a huge space in front of Herbie because the faster kids have zoomed ahead, while the hikers behind Herbie are all in a clump.

You can use this same logic to find the constraint on your production line. It's the machine that has a huge backlog of units to process, while not providing enough units to keep the downstream machine running steadily.



How to identify your constraint by calculating machine output

A more systematic way to find your constraint – and determine its impact on your production – is by calculating the net output for each machine on your line. To do this, you need to know two things:

1. The rate of each machine
2. Each machine's efficiency (to learn how to calculate efficiency, [click here](#))

All you have to do is multiply the two numbers.

Example:

- Rate = 300 units per minute
- Efficiency = 93%
- Output = $300 \times 0.93 = 279$ units/minute

Do this for every machine on your line (you can use our [Line Efficiency Calculator](#) to get the answers quickly). The one with the lowest output is your constraint.

(Hint: Any piece of equipment can be the constraint. But if you're running a bottling line, we'll hazard a guess that your constraint is the filler.)



Efficiency Isn't a Good Measure of Performance. Here's What You Should Use Instead.



Efficiency sounds like a good thing. Whether it's in our personal lives or on our production lines, we all want to do things as efficiently as possible. That will help us reach our goals. Right?

Not always.

In fact, there are times when our quest for efficiency can actually make us less efficient. On a manufacturing line, efficiency improvements can even reduce your throughput, which is certainly not a desirable outcome. (For a fascinating non-manufacturing take on this topic, check out historian [Edward Tenner's TED Talk: "The Paradox of Efficiency"](#).)

We've [written about this topic before](#), but now seems like a good time to revisit it because efficiency is once again at the top of many manufacturers' lists of objectives. For example, [Food Engineering's latest State of Food Manufacturing Survey](#) found that, having improved their throughput, food processors are placing renewed focus on increasing efficiency.

If you're in this group, it's important that you think carefully about how you approach efficiency improvements so that they don't end up having unintended consequences, like throughput reductions.

How can higher efficiency possibly be a bad thing?

When manufacturers talk about efficiency, they're typically talking about the amount of time a particular machine is up and running relative to the amount of time it could be up and running.

$$\text{Efficiency} = \text{Uptime} / \text{Total Time}$$

If a machine runs for 85 out of every 100 minutes, its efficiency is 85%. If you can take an action to increase the machine's uptime to 92 minutes, then its efficiency will be 92%. That's an improvement, right?

Maybe, but maybe not. There's a lot of wiggle room in the "take an action" part of the scenario. And this wiggle room makes efficiency alone a poor measure of performance. It's counterintuitive, but we've been in plants where machine operators took an action that resulted in higher efficiency, but lower throughput.

Here's how:

Suppose you have a beverage bottling line that includes a decaser, a filler, a capsuler, a labeler, and a case packer.

Your decaser is capable of processing 240 bpm. Of course, machines can't run constantly, so we assume some downtime, which we quantify based on two metrics: the mean time between failures (MTBF) and the mean time to repair (MTR). For your decaser, failures happen an average of every 15 minutes of runtime and they take an average of 1.5 minutes to repair.

Let's calculate the efficiency and throughput for this machine using the following equations:

- $\text{Efficiency} = (\text{MTBF} / (\text{MTR} + \text{MTBF})) \times 100$
- $\text{Throughput} = \text{Efficiency} \times \text{Rate}$

For a full explanation of these calculations, see our article [“What Is Throughput? \(And Why You Should Care\).”](#)

Machine	MTR	MTBF	Rate	Efficiency	Throughput
Decaser	1.5 min	15 min	240 bpm	91%	218 bpm

In terms of efficiency, 91% is pretty good. But let's say you have a goal of 95%. What can you do?

Perhaps one of your operators has discovered that if you run the decaser at a slightly lower rate, processing only 220 bpm, the mean time between failures increases from 15 minutes to 30 minutes. Slowing the machine down will result in greater efficiency, because you'll have to stop it less often.

That sounds like a great idea! But what happens when we plug these numbers into the efficiency and throughput equations?

Machine	MTR	MTBF	Rate	Efficiency	Throughput
Decaser	1.5 min	30 min	220 bpm	95%	209 bpm

As you can see, when the machine slows down, its efficiency increases to an impressive 95%. But, at the same time, its throughput declines by 9 bpm. That's a decrease of 540 bottles per hour and 4,320 bottles over the course of an 8-hour shift. If you run just one shift a day, five days a week, then by the end of the year, **your efficiency improvement will have reduced your throughput by 1,123,200 bottles!**

A different way of thinking about efficiency

In the example above, greater efficiency didn't result in higher throughput – on the contrary, it did exactly the opposite – because efficiency alone isn't a good measure of performance. The ultimate goal isn't just to have your machines running all of the time; it's to have more quality products coming off of the line.

The problem with efficiency-based approaches to production line improvements is that they're too narrow. The example above illustrates a special case where boosting efficiency was detrimental to throughput. A more common scenario is that an efficiency improvement to a particular machine has no material impact on the throughput of the entire process at all.



Of course, we're not suggesting that efficiency doesn't matter at all. If your machines were down all of the time, you wouldn't be able to make any products. But, once you get to a reasonable level of efficiency, like the 91% in the decaser example, increasing it a couple of percentage points won't likely make huge difference for your overall production goals.

The reason for this is that machines don't work alone. In the example line, there was a decaser, a filler, a capsuler, a labeler, and a case packer. But we only looked at the efficiency of the decaser. And on a bottling line, the decaser isn't typically the rate-limiting machine.

A lot of us here at Garvey are runners, so let's use a running analogy.

Say you and I are running a 6-mile partner race – not a relay, but one where we start together and cross the finish line together. You’re in much better shape than I am – while you can easily run a 6-minute mile, I struggle to consistently hit the 10-minute mark. For us to finish the race together in 60 minutes, I need to run the whole time (efficiency at 100%), while you could run for just 36 minutes (efficiency at 60%). You could slow down to an 8-minute mile, which would improve your efficiency to 80%, but it would still take 60 minutes for us to cross the finish line. We could even add three more people to the team, all running at peak efficiency somewhere between 6 and 10 minutes a mile, and we still wouldn’t finish the race in less than an hour.

In other words, it’s not you (or the rest of the team), it’s me.

I’m the constraint. Everyone else can run as fast or as slow as they want. As long as I’m the slowest person, I will set the pace for everybody.

The exact same thing happens on your production line. The slowest machine is your constraint, and it’s the one that’s setting the pace. Even if you haven’t done the calculations, chances are you already know what this machine is. On bottling lines like the one described above, the slowest machine is typically the filler. (Check out our articles on common production constraints on [beverage](#) and [food packaging](#) lines.)

Here’s an example of efficiency and throughput calculations for a complete bottling line:

Machine	MTR	MTBF	Max Rate	Efficiency	Throughput
Decaser	1.5 min	30 min	240 bpm	95%	228 bpm
Filler	4.0 min	60 min	180 bpm	93%	167 bpm
Capsuler	30 sec	15 min	240 bpm	95%	230 bpm
Labeler	45 sec	10 min	240 bpm	92%	220 bpm
Case packer	3 min	40 min	300 bpm	93%	279 bpm

Here you can see that no matter how quickly the other machines can run, you'll never achieve throughput of greater than 167 bpm on this line, because that's the pace being set by the constraint. We can use this idea to reframe how we think about efficiency:

1. The constraint is the only machine for which maximizing efficiency really matters – only by maximizing this machine's runtime can you achieve peak throughput.
2. Rate differences between the constraint and the machines immediately upstream and downstream of it are desirable because they allow you to recover from malfunctions on the non-constraint machines without sacrificing throughput.

Let's dig into these ideas.

Maximizing the efficiency and throughput of your constraint

Since the constraint sets the pace for the rest of your line, you want to make sure that it's working as much as possible. Just like every minute of rest I take during our race immediately translates into a later finish for the entire team, every minute your constraint is down represents an immediate hit to your throughput, and, in turn, your bottom line.

Of course, no machine can run at 100% efficiency. But, say your constraint reaches a respectable 93%. The key is to make sure that for that 93% of the time the machine is up and running, it has products to process – that, for example, an upstream machine hasn't stopped working and caused the constraint to stop as well by starving it of products.

How do you do that? By adding **buffers**.

Buffers protect your constraint from the malfunctions of other machines by giving products a space to accumulate when they're not actively being processed. This is why the most effective buffers are **accumulation systems**.

By placing one buffer before the constraint and another one after the constraint, we can effectively isolate the constraint from the other machines on the line:

- **Protecting the constraint from upstream malfunctions:** On our line, the decaser processes 61 more bottles a minute than the filler. Rather than waiting for the filler to be ready, the decaser can feed products to an accumulator. Then, when the decaser fails, which it does roughly every 30 minutes, the filler can keep working on the products that have stockpiled in the buffer.
- **Protecting the constraint from downstream malfunctions:** Similarly, we don't want the filler to stop working because the capsuler is down, so we place another accumulator after the filler to create a store of products ready to proceed down the line.

By doing this, we guarantee that the filler is working at maximum capacity at all times.

Understanding rate differences

In the table above, you'll notice that the throughput rates are strikingly different between machines. Even working its hardest, the filler can only process 167 bpm, while all of the other machines can easily handle 200+. This isn't a problem. In fact, it's a desirable characteristic that helps your line recover more quickly from malfunctions.

There are two ways rate differences help keep your line running, even when machines fail:

1. **They guarantee enough products have accumulated in the buffer so that a stoppage of one machine doesn't starve the next machine.** The decaser sends an extra 61 products to the buffer every minute, which means that after 10 minutes, there are 610 bottles in the buffer. That's enough to keep the filler busy for almost 4 minutes if the decaser malfunctions.
2. **They make the efficiency of the non-constraint less important.** The greater the rate difference between the constraint and the non-constraint, the less efficiently the non-constraint can run without hurting your overall output. If, for some reason, the efficiency of the decaser decreased from 95% to 93%, or even to the 91% of our original example, that would be okay as long as it doesn't fall to the point of impacting the constraint. You can run a 6-minute mile, a 7-minute mile, and 8-minute mile, or a 9-minute mile — the important thing is that you don't prevent me from trucking along at my 10-minute pace.

The key takeaway is that if you want to increase production, efficiency isn't going to get you there.

The greater the rate difference between the constraint and the non-constraint, the less efficiently the non-constraint can run without hurting your overall output.

So, what will?

The metric that will help you reach your goal is throughput.



Common Production Constraints

Part 1: Beverage Lines



We've analyzed thousands of production lines across the food and beverage manufacturing industries. And, although a bottleneck can occur anywhere, there are a few usual suspects that account for the majority of constraints.

In the next two articles, we'll identify these usual suspects and discuss how accumulation can help keep them from limiting the throughput of the entire line.

The top two sources of constraints on beverage lines are fillers and (for thermally processed products) coolers.

Fillers

On bottling lines, the most common constraint by far is the filler. This is typically the most expensive machine on the line. That doesn't necessarily mean it had the highest price tag, but that it costs the most to run. This is because the filler usually has the lowest throughput per minute compared to all of the other equipment.

For example, on the wine bottling line we outlined in our article [“What Is Throughput? \(And Why You Should Care\),”](#) the filler had a max rate of 180 bottles per minute (bpm), while several of the other machines could process over 200 bpm. The case packer could process as many as 300 bpm! That means that even if the filler were to run at 100% efficiency – which is impossible – it would still only be able to supply a little more than half of what the case packer can handle. So, you can see why any decrease in the filler's efficiency drastically cuts the throughput of the entire line.

But the main throughput killer for fillers isn't efficiency problems with the machine itself. It's that if a downstream machine, like the capsuler, goes offline, the filler has to stop as well because there's no place for the filled bottles to go.

By adding accumulation, you can keep the filler running, creating a store of bottles for the capsuler (or whatever) to process when it comes back online. When you do your accounting at the end of the run, you won't even notice the effect of the machine going down because it will easily be able to catch up with the filler.

Here are several case studies where adding an accumulation table after the filler increased line throughput by as much as 30%:

- Glass wine bottles
- Tapered glass wine bottles
- Craft beer bottles
- PET soft drink bottles
- HDPE infant formula

Coolers

Beverages that go through thermal processing (like juices) often need to be cooled before they enter the packaging portion of the line. This cooler is a constraint simply because cooling takes a lot longer than packaging.

Placing an accumulator between the cooler and the packaging portion of the line provides a buffer where product coming out of the cooler can wait. This means the processing part of the line can keep running even one of the packaging machines fails.

We've worked with several clients to install accumulation machines between coolers and packaging equipment:

- Glass soda bottles and cans
- PET juice bottles
- Round PET juice bottles

These may be the top two constraints on beverage lines, but they're not the only ones. We've also used accumulation to transfer wrapped aluminum bottles to an outfeed conveyor, wine bottles from a labeler to a case packer, and PET milk bottles from an inspection machine to a palletizer.

Common Production Constraints

Part 2: Food Packaging Lines



In the [previous article](#), we identified the main places bottling lines get hung up during beverage processing. Here, we look five common constraints along food packaging lines.

Wrappers/baggers

Like with beverages, in food manufacturing, moving from processing to packaging can be challenging.

For example, we worked with a client that made bagels. The line moved the bagels from the oven to the cooler to four different bagging machines. The problem was that the baggers would go down relatively often. This would jam the line, causing a huge pileup of bagels on the conveyor, and many of the bagels would fall on the floor. Since they could no longer be safely consumed by humans, the bagels were used for animal food.

The company was losing a full third of their product to animal feed because the bagels fell on the floor.

Putting an accumulation table between the cooler and the bagging machines solved the problem. Reducing product loss and keeping the lines running resulted in a 30% increase in throughput. [View the case study.](#)

Labelers

Labelers are another common spot for bottlenecks. They may need frequent refilling, the label printer may jam, or the die cutters may not function properly (an **increasingly common problem** as the industry moves toward thinner labels to reduce waste). In any case, if your labeler goes down, the rest of the line must stop as well.

We recently helped a customer increase throughput by installing an accumulation table between the leak detection system and the labelers on a canned food line. [View the case study.](#)

Cappers

Does your capper have a high reject rate? Does faulty cap position or torque control necessitate rework? Are products frequently spilled? All of these can necessitate shutdowns for maintenance.

[Check out a case study](#) in which we placed an accumulator between the labeler and cappers on a canned biscuit dough line.

Case packers

Case packers can be an efficiency nightmare. They frequently go down, changeovers can take a long time, and, particularly if you're packing glass jars or bottles, mistakes can be messy.

Here are a couple of examples of how accumulation can eliminate bottlenecks at case packers:

- [Yogurt cups](#)
- [Frozen food trays](#)

Fillers

Finally, just like on beverage bottling lines, fillers on food packaging production lines are frequent sources of lost productivity. There are many reasons for this. Sometimes, the machines are simply slower than the rest of the line. Since fillers have food contact surfaces, they can also require extra care and maintenance to ensure food safety. Regardless, we've found that installing an accumulation table after, and sometimes before, the filler can have a huge impact on total throughput.

Explore an example where placing an accumulation table between a manually loaded mass conveyor and a filler increased total line efficiency.

Bagels, canned foods, frozen food trays, yogurt, brownies (we didn't talk about that one, but [check it out here](#)) — as you can see, accumulation can boost production throughput for all kinds of products.



“The upstream filler continually supplies cups. If there is a jam or back-up at the downstream case packer, the Garvey unit can convey those filled cups to prevent excessive back-ups at the case packer.”

John Daigle
VP of Operations
Stonyfield Farm

How Accumulation Solves 3 Common Problems on Pharma Production Lines



If you're a regular reader of our blog, then you know that we're big into **maximizing throughput** by helping food and beverage companies unleash the hidden capacity in their production lines.

The pharma industry is a bit different. Like food and beverage processors, pharma manufacturers also face pressure to reduce processing time and increase output, but they have added complications, such as fragile products (e.g., glass vials) and strict regulations (e.g., rules about storage temperatures for temperature-sensitive products).

The good news is that accumulation can address these issues as well! Let's take a look at a few ways accumulation helps solve three common problems on pharma production lines.

Eliminating vial damage

One major problem pharma manufacturers face is vial damage. This is becoming much more of a problem as throughputs increase.

For example, an older line running 300 vials per minute won't see much damage under normal operating conditions. But companies are now pushing to run 500, 600, or even 800 vials per minute. Most accumulation equipment simply can't run that fast without damaging the vials.

If a single vial breaks on the line, it could represent upwards of \$5,000 in immediate product loss. Even worse, the glass may fracture on the line, but not break immediately. Instead, it gets packaged and shipped out to a customer. Later, when a doctor or nurse picks up the vial to insert a needle, it breaks in their hand. The result in this situation is much worse than product loss, especially if the product is toxic.

The trick to eliminating vial damage is eliminating back pressure, which we do using our patented pressureless loop technology.

Our Infinity Rx accumulation table can safely handle vials of all sizes. Check out our case studies:

- [Small vials](#)
- [Large vials](#)

Speeding up vial drying

Many drugs, like vaccines and serums, are temperature-sensitive. If they spend too long at elevated temperatures, they'll lose their potency. This effect is permanent and irreversible, and it often results in products having to be destroyed.

Much of the focus in cold chain management is on storage and transportation, but the packaging process is critical as well, because drugs often spend up to two days outside of the cold chain during this step.

Here's a typical scenario:

Glass vials of drugs are stored in refrigerators or freezers. When it's time to ship the drugs, the vials are removed from the refrigerator or freezer for inspection and labeling.

If you've ever taken a cold beverage from a cooler on a hot summer day, you know what happens next: condensation forms on the outside of the vials. This makes visual inspection impossible and prevents a label from adhering to the glass.

In most facilities, the current solution is to move the vials into a conditioning room for 24 to 48 hours until they dry completely. The problem is that spending this amount of time out of the cold chain has an adverse effect on the temperature-sensitive products.

Does this sound familiar? Have you ever had to throw out product because it lost its potency, and 24-48 hours would have made a difference?

What if you could reduce that time down to 15, or even 5, minutes – not only ensuring your products stay cold, but also shaving a day or two off of your shipping time?

Good news: You can!

Our innovative automatic vial drying system combines pressureless loop technology with a high-volume laminar flow accumulator. This system can dry up to 500 vials per minute, and then feed them single-file into a labeler or inspection machine.

[Click here to learn more and watch a video of the Garvey Automatic Vial Dryer in action.](#)

Controlling traffic flow – combining, merging, and dividing

Finally, even with plastic bottles, where breakage and condensation aren't an issue, the flow of bottles through the packaging line can be complex. This is because the lines themselves are complex. For example, a single unscrambler may have to feed 14 separate labelers on demand.

Accumulation can help keep the bottles running through the system in a constant, seamless flow, even if a bottle falls over or a labeler goes down. In our experience, the right accumulation system can double the performance of an existing line simply by eliminating traffic challenges related to combining, merging, and dividing.





Schedule a Test

Send us your pharmaceutical, food, beverage, or personal care product, and our team of experts will test it out with our patented and proven solutions.

[Schedule Now](#)



About Garvey

Established in 1926, Garvey Corporation has grown into a global leader, producing conveying, accumulating, and automation solutions. Our designs are unmatched in the food, beverage, pharmaceutical, and personal care industries.

Our Mission: Maximize Your Production

We pride ourselves in handling unstable products better than anyone in the world. We specialize in helping companies build efficient production lines and maximize their throughput for increased profitability.

We do this by performing an expert line analysis on current automated lines and placing accumulation in the right location. This boosts overall, end-of-line, throughput by up to 30%.

Garvey

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