Forerunners

UNLOCKING YOUR FACILITY AUTOMATION:

How to Measure Operational Equipment Effectiveness

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

In the supply chain market today, there are dozens of automation opportunities that promise to boost capacity and productivity in manufacturing, distribution and warehousing. Everything from machines and robots to smart conveyance and storage methods are promising to do more with less operational processes, and supply chains are buying in. Recent market data shows a historical jump from $5 billion spent by global supply chains on warehouse automation a decade ago, to now over $23 billion as of 2023. Furthermore, markets are forecasting a CAGR year over year of 15%, which will push the $23 billion to north of $40 billion by 2027[1].

With increased capital being spent on the promised value of automation, supply chains often implement a disappointing simple measurement to insure they're getting what they paid for. When an automated solution is successfully integrated into a process, such as an automated packaging machine or an automated storage and retrieval system, a traditional KPI called Asset Utilization is measured to ensure the automation is working as expected.

$$\textit{Asset Utilization} = \frac{\textit{Operating Time}}{\textit{Total Shift Time}}$$

While this metric is in some cases sufficient, more often it leaves supply chain and operational leaders scrambling for how to manage / improve the KPI or root cause issues within the automation to correct. This is due to an inherent flaw baked into the Asset Utilization formula that consolidates too much valuable insight into the Operating Time, such as preventative maintenance, downtime, poor quality, shift changes, etc. What this paper will discuss is a more capable alternative to Asset Utilization that when measured, can give supply chain leaders faster, actionable insight into the total value and potential of their automation. This metric is called Operational Equipment Effectiveness or OEE for short.

[1] Placek, Martin, "Size of the warehouse automation market worldwide from 2023 to 2027", (Hamburg, Germany, Statista, INC., June 27th 2023), https://www.statista.com/statistics/1094202/global-warehouse-automation-market-size/, (accessed September 13th, 2024)

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

What Is OEE?

Operational Equipment Effectiveness (OEE) is an aggregated score of historical performance from a single piece of equipment to a fully automated process. Through the measurement process, OEE showcases a breakdown of what drives lost operating time and how supply chains can improve the automation being measured. OEE focuses on three measurement areas: Availability, Performance and Quality. Availability measures events that can cause or contribute to the physical breakdown of the equipment or automation. This is typically thought of in terms of time and machine breakdowns or process stoppage. Performance measures the physical action or process the equipment or automation is tasked with and measuring whether planned or maximum output is achieved Quality measures any errors encountered during processing such as miss-picks, bad label reads or incorrect weighing of inventory.[2]

[2] *Overall Equipment Effectiveness, (Itasca, IL, Vorne, INC.), https://www.oee.com/, (accessed September 13th, 2024)*

How to Calculate OEE

Arguably, the more challenging and rewarding aspects of implementing OEE happen before and after capturing your measurements. The actual math, on the other hand, is relatively straight forward. The starting point is establishing how much available processing time your automation has. Starting with this metric filters out any planned unavailable time that we don't want to negatively impact our scoring.

$$\textit{Available Time} = \textit{Working Time} - \textit{Planned Unavailable Time}$$

Next, using your Available Time, calculate the Availability percentage by dividing the total running time of your automation by your Available Time. It is important to make sure your time bounds match between your Available Time and your Availability percent. For example, if you used one working shift in hours to measure Available Time as opposed to a whole day (24 hours), capture the running time measurement using the same constraint.

$$\textit{Availability \%} = \frac{\textit{Running Time}}{\textit{Available Time}}$$

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

After that, calculate your Performance percentage by dividing how many units your automation was able to successfully process by the maximum potential units (engineered design rate) that your automation could process. Simply put, divide what you did against what your potential is. Understanding your engineered design rate should be a standard rate you can reference for the piece of equipment or automation that's established at the time of installation. Reach out to your Integrator or Manufacturer if you don't know what that value is.

$$\text{Performance \%} = \frac{\text{Actual Units Processed}}{\text{Engineered Design Rate}}$$

For the fourth step, calculate your Quality percentage by taking the same number of units successfully processed, subtract any errors encountered during the process and divide by the units processed. If during your measurement period, no errors were encountered, this formula will look like you're dividing the same units processed into itself.

$$\text{Quality \%} = \frac{\text{(Actual Units Processed – Errors)}}{\text{Actual Units Processed}}$$

Finally, we have our metrics to calculate OEE. As the last step, multiply your percentage results for Availability, Performance and Quality together to get your OEE score. It is recommended that you reference your individual metrics to prioritize areas for root cause analysis and improve and track your OEE scores over time for improvement.

$$\text{OEE} = \text{Availability \%} \times \text{Performance \%} \times \text{Quality \%}$$

OEE Industry Scenarios:

The following 3 hypothetical scenarios focus on organizations from different industries, all on a journey to either implement or improve upon OEE within their respective operations.

Parcel Unit Sorter for a Transportation Logistics Service Provider

A Transportation Logistics Service Provider (LSP) operating out of the Midwest operates a cross-belt unit sorter to sort and organize inbound parcel packages from several shippers and partner asset carriers. Inbound freight is unloaded and received into the LSP where it is then sorted into full truckloads via palletized gaylord containers for outbound delivery to a middle mile or final mile facility. Freight is a mix of poly and paper bags, and small boxes.

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

A cross-belt unit sorter was implemented to support the sortation of inbound freight to the outbound gaylords. The engineered capacity for the sorter is about 20,000 units per hour. The LSP is a 24/7 facility but only runs the sorter on 2 of its 3 shifts for a total of 15 running hours. Routine maintenance is performed weekly, which takes 2 hours of running time away. Management has determined they want to run the OEE score with a MS Excel worksheet and manual reporting from the sorter's control system. In addition, a corresponding stand-up results review will be held weekly with the department to review results and implement corrective action plans.

The Available Time is 103 hours weekly and the past week's running time was 85 hours as per what was captured via the cross-belt control system. The Available percentage for our initial week is 0.82 or 82%. Next, the control system also confirmed during the week that 61,877 units were sorted successfully to their destination gaylords. The weekly engineered capacity is 140,000 units making the Performance percentage 0.44 or 44%. In addition to the 61,877 units sorted captured from the sorter's control system, of those units sorted, the system recorded 7,112 errors it encountered and logged throughout the week. These errors range from bad scans or reads of inbound packages to equipment or systemic issues. Due to this, the Quality percent is 0.88 or 88%. For this measurement week, the overall OEE score for the cross-belt sorter is 0.31 or 31%.

With this initial OEE score, it's clear that focusing on performance will likely bring the largest impact. Here are several options this Management Team could consider as next steps to improve the sorter's performance:

- Cross-reference the units sorted with overall volume and demand forecasts. Perhaps this is a slow month or period and expected outcomes should be adjusted including reallocating labor and operating time of the sorter until volume picks up.
- Conduct a kaizen event and capture some live observations of the sorting process to build some hypotheses to test. For example, are you getting clean sorts from package induction to destination (gaylord)? Are the divert chutes staying clear?
- Temporarily (or permanently) scale the OEE capture to daily from weekly to observe if theirs is a consistent event or time of day that contributing to the performance hit.

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

Order Fulfillment Auto-pack Machine for E-commerce Warehouse

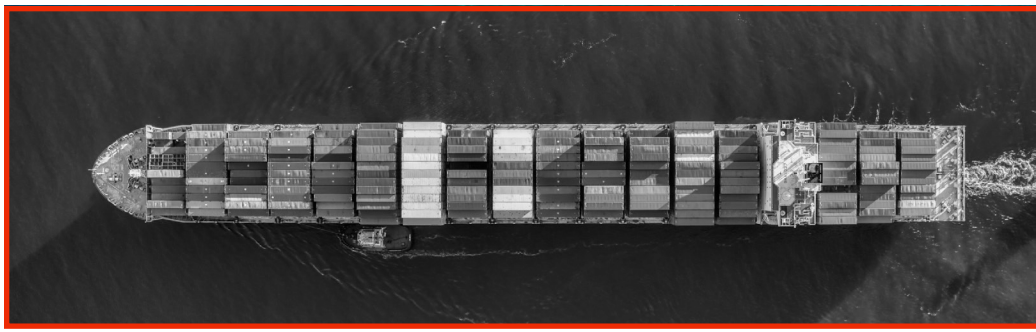
A North American retailer just wrapped up a project with their transportation team that revealed a significant freight savings opportunity by switching to poly and paper bags from boxes when fulfilling orders to customers. The retailer piloted the switch with their manual packers and, even with the impact to cost and labor hours for the increased packing time, proved out the freight savings with the switch to bags.

Their next step in the transformation was to introduce automation into the packing process to recover the labor impacts. The Retailer engaged with an Engineering Integrator and purchased several auto-baggers to install in their facilities. The average, daily order volume for the Retailer's network is 30,000, with about 80% of those orders qualifying for shipping in a bag based on data from their initial pilot. The run rate for the auto-bagger they selected is roughly 850 pieces per hour which, according to the integrator, would be enough capacity to support the retailer's network. After about two months running the bagger in production, the daily PPH for the bagger barely reached over 250 despite its asset utilization being close to 95%.

Unsure how to approach this issue or how to get more capacity out of the bagger, the Retailer engaged back with the Integrator who installed the bagger. Their recommendation was to implement OEE to give the Retailer a clearer picture of why they're not getting a higher run rate. The Retailer engaged with their IT Team and integrated the data from their WMS and the auto-bagger's control system into their existing data warehouse, to model the OEE calculations in their standard BI system. Operations leaders aligned with packing department managers on the OEE measurements, and integrated both a daily standup review of the previous day's OEE metrics during the first/second shift change over, as well as pulled the OEE data averaged out for the week into the broader weekly business review with general and executive managers.

The first week's OEE averages came out to 79% Availability, 51% Performance and 39% Quality for an OEE score of 15%. The week over week measurements followed a similar trend with some fluctuation in individual scores.

In this OEE example, both Quality and Performance are being impacted somewhere in the process. Here are some options the Retailer's operations and department leaders could consider as next steps to improve the bagger's capacity:



Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

- Quality and Performance both track the number of units packed through the bagger, but Quality also accounts for errors during the bagging process. Since Quality is the lower value, leaders could investigate issues at induction before bagging. Problems during bagging affect Performance, while errors after sealing are considered separately.
- Review the item's master data for dimension and weight accuracy. Any automation introduced into a packing process is going to require some level of accuracy in the data for items it can send to be packed through automation. This data problem could ultimately stem from the WMS and or broader WCS sending items that are too big or heavy to the auto-bagger, thinking they can be packed when in fact they cannot and the bagger is rejecting them.
- Consider examining potential Quality-related issues post-bagging before packed orders exit the bagger. Examples of these could be dimension or weight validation based on rate shop/carrier data the order was labeled with not aligning with the now gross weight or seal integrity issues with the glue or adhesives used to close the package. Root cause of these types of Quality issues should be a easier to ascertain since they should be contained within the machine itself versus needing to engage with other systems and processes.

Harvest Greens Auto-bagger Manufacturing for a Fresh Produce Grower/Shipper

A fresh produce grower and packing operation based out of the Southwest US produces its own consumer-facing brand and extends its packing operations to other brands as a 3PL service. The Grower has several automated processes to support product grading, sortation, cleaning and packaging and is currently averaging a weekly OEE score of 62% for its entire processing facility.

Recently the Grower, who is seeking to reduce facility overhead and maintenance costs, rolled out a consolidated grading, cleaning and packing process for all leafy greens (romaine, iceberg, spring mix, etc.) whereas previously, each one of their packaged greens had a dedicated processing line. While the process consolidation achieved its projected cost savings, an unforeseen impact to capacity and throughput was encountered almost immediately post implementation. The Availability percentage for the greens processing dropped from 88% to 36% causing the OEE score to plumet a little over 30 points to 35%.

Seeing this change in the OEE, Operations Leaders and Department Heads reviewed the implementation and training details from the recent consolidation. While compliance to the new process standards was confirmed with Teams, Leaders discovered that cleaning and change-over times had jumped exponentially.

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

The previously dedicated lines allotted for minimal downtime and enabled a single shift to produce the required demand for 1 to 2-day delivery. With the new process, a full cleaning, equipment, and supplier change was required before packing new product, which caused the shift hours of lost production time.

In our final OEE example, Availability was the key driver impacting the OEE score. Some slight differences here are that the Grower is a more senior organization with existing OEE measurements that allow quick diagnosis of issues caused by their process consolidation project . With the preliminary understanding that change-over times are now impacting Availability more so than before, here are some options leaders at the Grower / Shipper can review:

- Given the Grower already has a strong integration with OEE measurement and management within Operations, a logical next step would be to start measuring and accompanying OEE with Takt Time. In a nutshell, Takt Time takes some of the same OEE components and measures them against customer demand to create the optimal balance of efficiency and speed or flow. If the Grower were to implement Takt Time measuring along with their OEE metrics, they could better plan against expected demand considering the data inputs it now has to manage with process availability.
- Utilize LEAN Six Sigma tools to evaluate the implemented process for optimization opportunities. Value stream mapping could be one such tool that will help quantify, within the change-over steps, the amount of value-added versus non-value-added time consumed by Team Members, thus working to eliminate that waste.
- Modelling different labor and shift designs for processing to help minimize down-time. The Grower has indicated that prior to the consolidation effort, dedicated processing lines allowed for a single shift to manage the required customer demand. What if the Grower accompanies a Takt Time measurement from point 1 with a second shift?

Regional Less-Than-Truckload Asset Carrier

A regional less-than-truckload (LTL) asset carrier operating out of the Northeast has recently acquired a smaller competitor and with it several more customers. In addition to a respectable fleet of tractors and trailers to handle customer pickups and deliveries, the LTL carrier has several terminal facilities designed for cross docking freight and some light pallet storage. The acquisition also provided for two additional terminals with dock operators to support plus several tractors, trailers and drivers.

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

Several months after the acquisition has been fully integrated and stabilized, the LTL carrier has been challenged with significant productivity impacts at most, but not all, of their existing terminals. Cross dock flow, unloading and reloading of trailers, has dropped from pre-acquisition levels and is impacting delivery SLA's. Leadership was able to quickly determine that the challenged terminals consumed most of the new customer volume from the acquired competitor but don't seem to understand why the dip in productivity. Terminal managers, anticipating the change, did increase dock worker staff and leased several more forklifts commensurate to the increase in pallet volume yet productivity challenges persisted.

Despite the desire by some to expand through additional square footage, some members of the Leadership team were able to persuade others to instead pursue capturing an OEE score for the dock operators to improve productivity instead of taking on additional lease expenses. Those Leaders had recently attended a peer industry conference that talked about how others were using OEE to effectively utilize new equipment and automation. The LTL carrier invited in a few engineers (outside consultants) who recommended that they develop the measurement and scoring given the objective wasn't to capture OEE for a contained piece of machinery but for dock operators using manual forklift trucks.

After a few weeks of daily measurement and reporting, the average OEE for all measured terminals was 12% with Performance and Quality, 48% and 35% respectively, being the drivers. Availability scored at 72%. Seeing both the averages and trends in Performance and Quality, leaders next pursued a deeper dive into process on the dock to help make sense of the data. What they discovered was the current dock operational system is managed entirely in paper and spreadsheets and, while there is a transportation system supporting the delivery routing, Dock operators and managers are left largely to manage the pallet and cross dock flow manually. Both errors in the movement of pallets from an inbound trailer to its outbound one and several starts and stops by dock operators to check paperwork, pallet labels and confer with supervisors seem to be the root cause of the lower Quality score and the subsequent impact to Performance.

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

For our final OEE example, we can see two concepts come into play that have not yet been discussed: a non-machine driven process and multiple metrics impacting the OEE score. This example showed us that OEE is not exclusive to just machine driven or fully automated processes. Here the measurement focus was a human operator using a manual piece of equipment to follow a process using all the same measurement techniques. The result was two significantly impacted metrics in Quality and Performance where the existence of the former was the main driver of the latter. With these in hand, here are some examples Leadership at the LTL carrier can investigate to get some of that pre-acquisition performance back:

- Introducing some technology into the dock operations will dramatically improve the number of errors and touches between unloading and loading of pallets. In addition to the Quality bump, Performance would also benefit with better instructions and task management for operators. Having to stop work, manually check paperwork and/or pallet labels and then determine a destination is a productivity killer, especially in a high activity LTL terminal.
- While the engineers did not touch on the terminal layout in this OEE example, revisiting how the terminal is physically designed could also improve Quality and Performance. Relegate more complicated or cumbersome freight movements away from easier freight and augment the layout with designated pallet spaces on the floor and hanging signage will create some faster wins in your OEE score while longer term investments are being considered.
- Revisit (or further develop) the training regimen to build more autonomy with some of the senior operators. This can be especially effective when paired with the previous point on terminal layout and alleviate decision bottlenecks, especially with simpler Quality metric issues, away from just supervisors and managers. Creating more firefighters to support the freight flow unlocks more leadership bandwidth and showcases an investment not just in technology or process but in people.

What You Can Do with OEE

As we've seen from our organizational examples above, OEE allows for better and more accurate measures of automation. That accuracy unlocks more precise and effective action and drives improvements to your core warehouse KPI's of capacity, throughput and cost. Whether a new piece of equipment or machine or an existing automated process is being evaluated, insights from establishing OEE can uncover previously unknown savings and create the best opportunity for realizing maximum throughput and value.

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

Let's look again at our examples from above. If the LSP expands the cross-belt sorter to run all three shifts and align the inbound demand with those sorter teams, Performance and PPH will go up driving the cost per unit sorted down. Next, if the Retailer can get the Quality issues resolved with better SKU data, the auto-bagger already has a proven use-case for higher yields at a lower cost for just Operations. In addition to those Ops savings, there's also the Transportation parcel savings for switching to bags from boxes. Third, when the Grower/Shipper gets uptime back to its previous levels with the consolidated processing, their Availability will improve, and they'll be able to sustain the overhead and facilities savings initially identified. And finally, the LTL carrier gets a powerful new metric to support goals and management of its dock operations and guidance to stabilize and improve productivity across their newly expanded Network. In all instances, the Supply Chain within these organizations is directly impacting EBITA or margin by implementing a measurement methodology in OEE and acutely apply resources to enact the most value with the least amount of effort.

OEE Factors for Success

Here are some helpful points to consider when evaluating OEE for your organizations:

- Don't focus on an OEE score of 100%. While certainly aspirational, 100% OEE is total efficiency all the time and frankly, unrealistic. The consensus across most industries is that world-class OEE is somewhere between 80 and 85%. The breaks down to mid/high 90's for Availability, Performance and Quality, which is exceptional when you consider all the internal and external factors Supply Chains must contend with daily.
- Prioritize daily or weekly progress versus targeting a number to hit when measuring OEE. OEE is as much about change management with the Teams it impacts as it is about optimizing the processes and equipment. Getting your Teams and Leaders bought in on the culture around capturing and acting on OEE will deliver value as represented in an improved score. Celebrate those improvements rather than the time it takes to get to high performing OEE.
- You don't need a whole suite of technology or fancy tools to start measuring. OEE can be captured and published with tools like manual reports and MS Excel as it can by more advanced BI applications or integrated control systems. However, you can get started measuring your automation will enable you to act faster on improving that automation.

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.

About Forerunners

Forerunners Consulting delivers specialized and focused consulting services, solving today's most challenging supply chain and transportation opportunities. Our differentiated and targeted approach is what sets us apart; we execute strategy, analytics, and implementation projects with an energy that inspires and builds momentum for our clients and trust in our ability to execute. We are made up of a team of strategic, technical, and experienced consultants that are skilled in delivering value and a quick return on investment. The way we approach problems is a mindset, and we challenge our clients to move them towards impactful change. To learn more about Forerunners, visit www.forerunnersconsulting.com.

Forerunners Consulting LLC, Copyright © 2024 All rights reserved.