



A Guide to OEE Overall Equipment Effectiveness

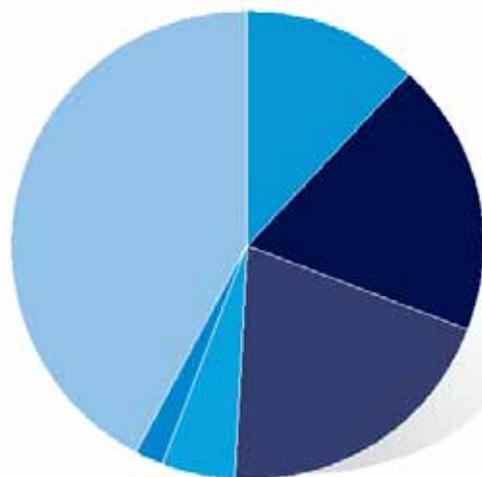
METTLER TOLEDO

Understanding OEE

Overall Equipment Effectiveness (OEE) is an important tool in the pharmaceutical, packaging and food processing industries. In fact, in any capital intensive business OEE improvement is a critical methodology to drive improved efficiency, higher quality and reduced cost. This white paper is intended to serve as a guide for professionals in the pharmaceutical, life sciences and other regulated manufacturing industries who want to understand what Overall Equipment Effectiveness (OEE) can deliver for their business.

OEE WAS FIRST USED BY SEIICHI NAKAJIMA, THE FATHER OF TOTAL PRODUCTIVE MAINTENANCE, IN DESCRIBING ONE OF THE FUNDAMENTAL MEASURES TO TRACK PRODUCTION PERFORMANCE.

OEE tracks the value-added productivity of equipment. It is a measure of the number of good (shippable) units produced compared to the quantity which should be produced based on the scheduled time and the specified equipment rate. On average, plants waste up to 40% of their capacity through stops, speed losses, interruptions and defects.



Despite investments in manufacturing planning and control systems most plants have a poor overall performance rate. Plant managers often don't know the true performance of the factory and may be unsure of how to improve it. Implementing OEE measurement tools and techniques provides a much clearer understanding of where improvements can be made. There are many ways to improve OEE performance. Some of these improvements may require substantial financial investments, while others can be achieved at minimal cost.

With accurate OEE measurement it is possible to pick the projects with the quickest returns. Accurate OEE measurement makes it possible to identify the correct approach and select the appropriate improvement tools and techniques.

WHY MEASURING DOWNTIME IS NOT ENOUGH !

While many companies focus on downtime losses as a measure of equipment performance, an OEE approach will quickly make it apparent that there are also other forms of losses on most manufacturing lines. Downtime measurement alone ignores the losses due to reduced speed and minor stoppages, as well as the sensitivities of the equipment to different product types. Some products can be more difficult to make and have more breakdowns and quality problems. OEE captures all the losses and ensures that no performance improvement opportunities are ignored.

“Accurate OEE measurement makes it possible to identify the correct approach and select the appropriate improvement tools and techniques.”

15 STEPS TO A SUCCESSFUL OEE PROGRAM

1. Identify the Project Team.
2. Communicate the program objectives.
3. Establish the current OEE level.
4. Validate existing data.
5. Carry out Activity Analyses and identify bottlenecks.
6. Evaluate work methods and staffing.
7. Analyse maintenance planning and execution.
8. Compare existing performance to industry 'best practices'.
9. Identify and quantify the OEE opportunities.
10. Define the target OEE performance.
11. Identify the actions and resources.
12. Develop an Implementation Plan with specific milestones.
13. Communicate the plan and set-up project boards.
14. Set up a regular measurement and review process.
15. Identify the mechanisms which will sustain the improvements.

UNDER CURRENT ECONOMIC CONDITIONS, SEVERE GLOBAL COMPETITION AND POSTPONEMENT OF NEW EQUIPMENT PURCHASES ARE CAUSING BUSINESS EXECUTIVES TO BE SENSITIVE ABOUT ALL ASPECTS OF MANUFACTURING OPERATIONAL COSTS. IN THIS ENVIRONMENT, IT PAYS TO CONSIDER BOTH CREATIVE AND PROVEN METHODS THAT MANUFACTURERS CAN USE TO BRING THEIR PRODUCT TO MARKET AT MINIMUM COST. "OVERALL EQUIPMENT EFFECTIVENESS" (OEE) IS A METHOD THAT MEETS THIS OBJECTIVE.

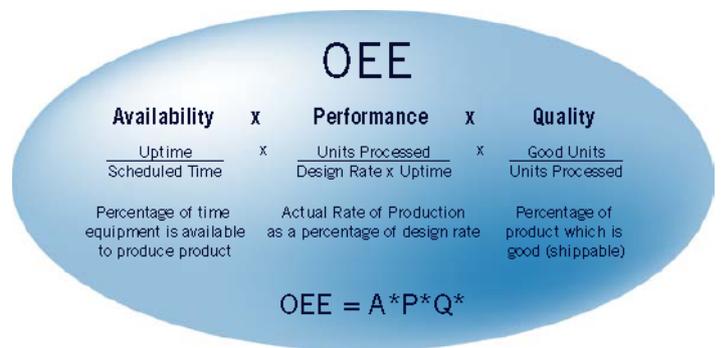
BENEFITS

An OEE solution can enable manufacturers to achieve world-class status. More specifically, it can provide benefits in three key areas:

1. **Equipment:** Reduced equipment downtime and maintenance costs, and better management of the equipment life cycle.
2. **Personnel:** Labour efficiencies and increased productivity by improving visibility into operations and empowering operators.
3. **Process:** Increased productivity by identifying bottlenecks.
4. **Quality:** Increased rate of quality and reduced scrap.

SCOPE

The need for OEE is indicated by the Industry Week 2001 census of Key Performance Metrics for manufacturing. The survey shows that the top 4% of world-class manufacturers benefit from a low 2% (median value) of unscheduled machine downtime. This means that the remaining 96% have an opportunity to improve performance by reducing unscheduled downtime. Downtime reductions can be readily achieved by using OEE to gain visibility into machine status and to perform root-cause analysis of problems. Fundamentally, OEE is a performance metric compiled from data on Machine Availability, Performance Efficiency and Rate of Quality that is collected either manually or automatically. These three data points are calculated as follows:



OEE also captures reasons for downtime (due to machine conditions, material status or quality issues) and can encompass the individual machine level, a line or cell level, or the entire plant. At the plant level, OEE metrics can be correlated with other plant metrics to provide Key Performance Indicators (KPI's). With enterprise level technologies managers can monitor OEE plant metrics and drill down to find root causes of problems, getting minute-by-minute updates to enable real-time process improvement.





VALUE PROPOSITION

Implementing an adequate OEE system brings immediate financial benefits to manufacturing operations. Some of these benefits are listed below. Reduced downtime costs.

1. Reduced repair costs.
2. Increased labour efficiencies.
3. Reduced quality costs.
4. Increased personnel productivity.
5. Increased production capability.

REDUCED DOWNTIME COSTS

When a critical machine is inoperable, it brings downstream operations to a standstill. This can negatively affect delivery commitments to the customer, which in turn impacts cash flow and revenue. For example, in a typical semiconductor fab (based on year 2000 data), it is estimated that each hour of downtime for a critical unit of process equipment can translate into EUR 100,000 of lost revenue. Conversely, reducing downtime by 1% on the 50 most critical tools in a typical fab can provide revenue opportunities and cost savings nearing EUR 100,000,000 annually.

REDUCED REPAIR COSTS

OEE enables predictive maintenance that can dramatically reduce repair costs. As the historical database of downtime reasons grows, the maintenance department can discern trends to predict an impending failure. Also, by interfacing the OEE system to a CMMS (Computerized Maintenance Management System) system, the maintenance department can take proactive steps to do predictive maintenance. For example, the maintenance department can order the necessary part in advance and get better rates. It can allocate repair personnel from an existing pool of resources instead of hiring someone

on an emergency basis. This can result in huge savings compared to repairing a machine after the breakdown has happened.

INCREASED LABOUR EFFICIENCIES

Due to current economic conditions, most manufacturing companies have downsized considerably. Consequently, manufacturers are eager to optimise the productivity of their existing work force. An OEE system helps, because it not only captures downtime reasons,

but also shows capacity loss data and cycle times. With this information, management can better judge the most appropriate allocation of staff to optimise the line balance and the utilisation of resources.

REDUCED QUALITY COSTS

As indicated in the introductory section, Rate of Quality is a percentage of good parts produced versus the total parts produced. Thus, an OEE system must capture the quantity

of total parts produced, the number of scraps and defects and the reason for defects. Because this information is captured at a specific machine or line level, this capability actually captures quality in the context of the part produced. By tracking context-rich quality data using OEE, production managers can identify root causes and eliminate further costs associated with rework and scrap. Improving the focus on quality at every stage of production also reduces warranty costs. In the previously cited Industry Week survey, world-class manufacturers benefit from first pass yields of 97% (median value), while scrap and rework are 2% (median value) and warranty cost is 1%.

“With Enterprise-level technologies Managers can monitor OEE plant metrics and drill down to find the root causes of problems, getting minute-by-minute updates to enable realtime process improvement”

INCREASED PERSONNEL PRODUCTIVITY

An OEE system enables the shop floor to go paperless. Typically, facility operators and supervisors spend an enormous amount of clerical time recording, analysing and reporting downtime reasons and root causes on paper, then further explaining these reports to management. An OEE system captures and reports downtime and efficiency automatically. This saves time lost in non-value added reporting activities and allows personnel to focus on more valuable tasks. With OEE, everyone from the plant floor to the boardroom is more informed, more often, more easily.

INCREASED PRODUCTION CAPABILITY

The net effect of reduced machine downtime, higher productivity of operators and reduced defects is the ability to achieve higher production levels with the same amount of resources.

INDUSTRY APPLICATIONS

Three scenarios from different industries illustrate where OEE helps manufacturers improve productivity and get better visibility into their operations.

AUTOMOTIVE MANUFACTURING

An automotive company was trying to extract additional productivity out of their assembly lines by improving equipment availability. They had already reduced all known causes of downtime through diligently applied process engineering steps. To further improve the process, they implemented a downtime detection and efficiency calculation (OEE) system. Within two weeks of implementing the OEE system in the department that was identified as the plant's bottle neck area, they noticed that overall productivity was significantly affected by hundreds of brief line stoppages caused by a simple mechanical misalignment that was not recorded



by operators. By observing these downtimes on the OEE system, it was determined that the cumulative effect of these brief unscheduled downtimes was the primary cause of downtime in that department. Without an OEE system automatically detecting all events, these downtimes and their effects on overall productivity would have gone unnoticed. After process engineers fixed the alignment problem, eight more vehicles per day could be produced by the plant without adding resources.

FOOD & BEVERAGE MANUFACTURING

At a food manufacturing facility, an OEE system helped supervisors to detect that operators of a particular production line were deliberately and prematurely slowing down the bottleneck machine. This was done to keep the machine from automati-

cally slowing when a fault was triggered by surge bins being filled whenever downstream machines were delayed. If proper settings had been maintained, the bottleneck machine would have operated at rated speed until the surge bin buffer zones filled with stock which the downstream machines would eventually consume, thereby catching up with the line-limiting machine as designed. Tampering with the machine speed changed this process. With the OEE system, management was able to detect the tampered settings, view the production conditions and understand what was happening to the process.

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MEDICAL DEVICE MANUFACTURING

Recently a large Medical Device manufacturer started a project to improve the capacity of an artificial joint production facility one specifically designed to create replacement hips and knees. Although the process was fairly well understood from a manufacturing process standpoint, new machining centres were required to keep up with new product introductions as their business expanded. Plant managers knew that the existing machinery was not operating at full capacity but had no data to reference when seeking ways to improve capacity to accommodate new product introductions. After implementing a data collection system with analysis software based around OEE, however, the plant managers were able to quantify the productivity of ten work cells within six months of implementing the system. Each work cell has an average of five machines dedicated to producing a particular joint. Using the new system, the manufacturer was able to identify downtime-related reasons in real-time, thereby indicating the cause of bottlenecks and identifying where improvements could be made to the actual machining process to enhance the yield of individual machines. In this case, both production rate data and quality information were being used to improve the overall operation. Based on the results from the past year, the manufacturer has been able to avoid the large capital expenditure associated with purchasing a new machining-centre while still being able to support the

“Since an OEE system is scalable, its cost can also be scaled to yield an appealing ROI.”

introduction of three new products. In addition to the improved production capacity, the plant has improved their overall quality and reduced rework time.

OEE SYSTEM COST ESTIMATION

Since an OEE system is scalable, its cost can also be scaled to yield an appealing ROI. For example, manufacturers can start by implementing a pilot system, encompassing a checkweigher or a manufacturing cell, wherever they think an opportunity for improvement exists. Depending on the size of the pilot, manufacturers can choose to buy off-the-shelf OEE products and implement a system quickly through internal engineering resources or hire the services of outside integrators.

The following variables influence the estimated cost of an OEE system:

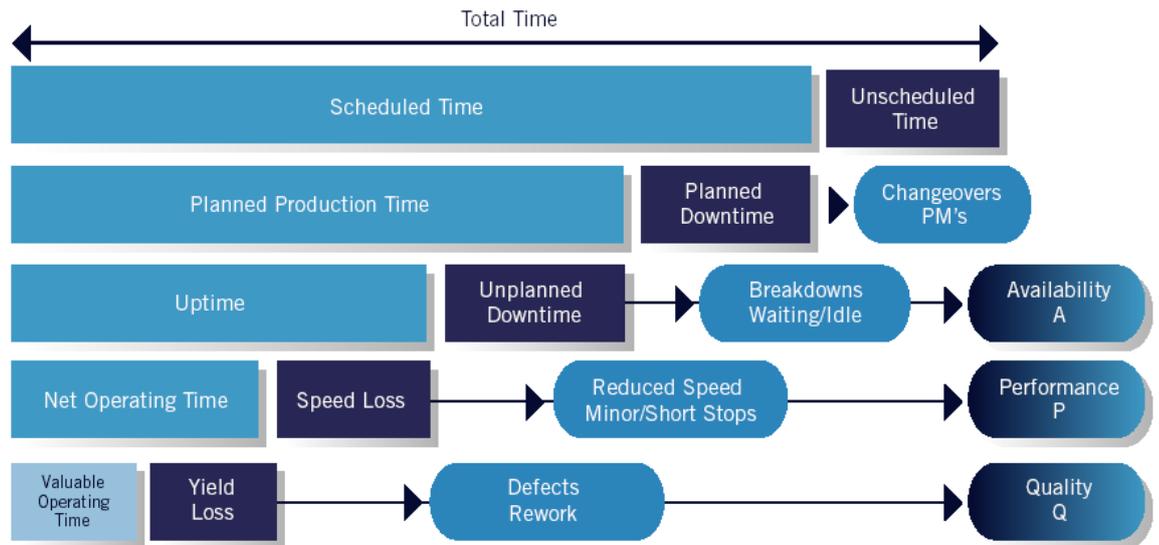
- Number of machines to interface
- Number of manual data entry terminals and mechanism for data entry
- Automatic vs. Manual data collection
- Integration with other plant data applications (e.g. ERP, CMMS)

OEE SOFTWARE TOOLS

A number of software tools exist to capture manufacturing performance data and display OEE performance graphically. Selection of an appropriate OEE software tool is critical to the success of any OEE initiative. A mistake to be avoided is the belief that this tool will drive OEE improvement - remember that any OEE software application is just a tool, and if not harnessed correctly will merely measure OEE, not improve it. Development of Functional Specifications and detailed Application Requirements are vital elements in the success of selecting an appropriate package to support an OEE Improvement program.



The OEE Model



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

WORLD CLASS OEE

When discussing OEE, a question commonly heard is - "What is 'World Class' OEE performance?"

When applied to OEE, it is common to see 85% OEE quoted as 'World Class'.

But what does this mean for a typical manufacturing process - is 85% OEE a realistic goal which should be set for a typical manufacturing process?

In practice, in order to arrive at a meaningful OEE goal the three elements of OEE need to be assessed separately.

While benchmark performance levels for the 'Quality' and 'Performance' components of OEE are readily available, what about the 'Availability' factor?

'Availability' is probably the least well understood factor in OEE and is highly dependant on maintenance regimes, changeover frequency, and SKU count.

Depending on these, and other operating parameters, an OEE as low as 50% could very well still reflect 'World Class' performance.

OEE DEFINITION

The preferred definition of OEE accounts for all scheduled time and includes planned downtime as an opportunity area.

"There is always enough times to fix a problem, but rarely enough time to prevent it."



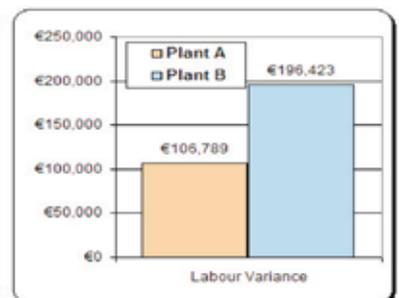
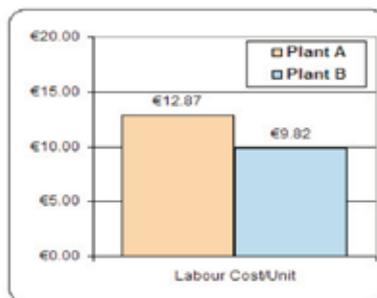
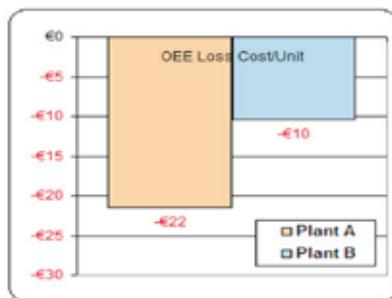
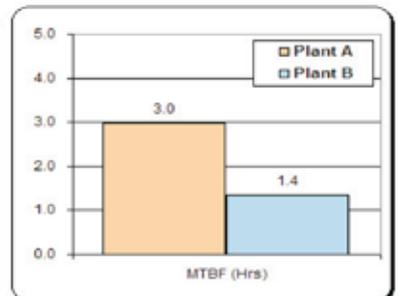
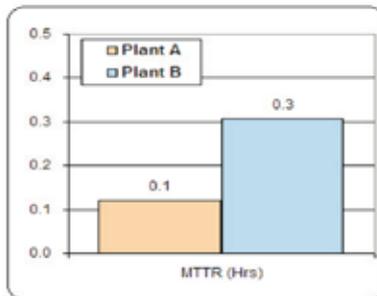
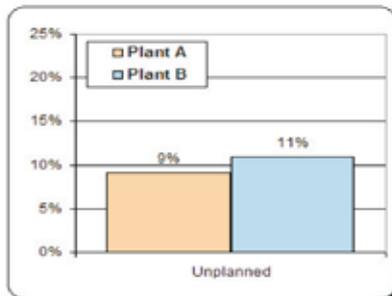
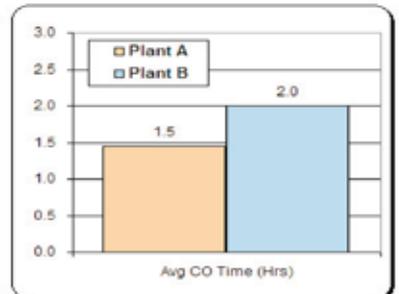
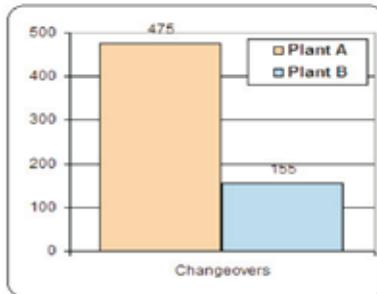
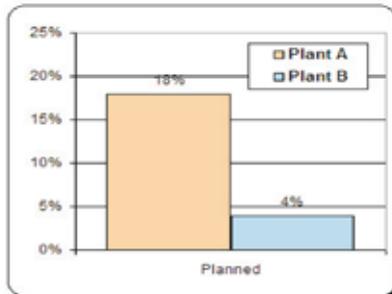
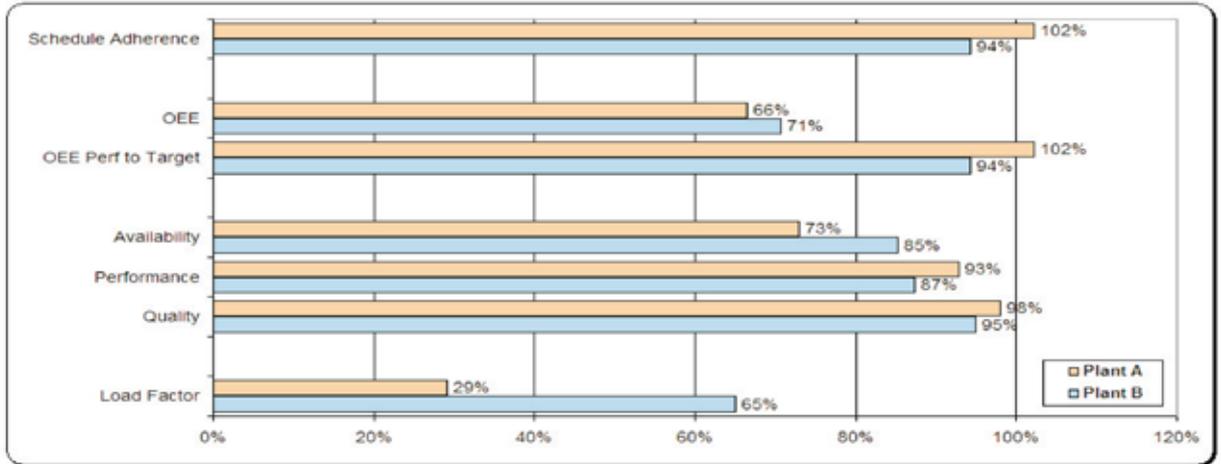
1. David Drickhamer, "IW Census targets key manufacturing metrics", November 1, 2001, Industry Week Magazine.
2. Simon Bragg, "Implementing OEE", ARC Insights, Insight#2003-07E, February 12, 2003, ARC Advisory Group.
3. International Technology Roadmap for Semiconductors 2002 Update.

Enterprise Performance Analysis

This Info Sheet outlines the approach to using OEE (Overall equipment Effectiveness) to analyse and compare the performance of manufacturing plants across the enterprise.

Perform OEE is a premier Manufacturing Intelligence and Performance Management software application, used by the world's leading regulated manufacturing companies as their preferred application for managing real-time operational performance improvement. Performance Management software application, used by the world's leading regulated manufacturing companies as their preferred application for managing real-time operational performance improvement.

OEE Scorecard



Comparing Plant Performance across the Enterprise

OEE (Overall Equipment Effectiveness) is a metric used to measure the effectiveness of the utilisation of capacity in a manufacturing plant or on a production line. It quantifies how much of the planned capacity is used to produce shippable product. It also quantifies the detailed capacity losses and pinpoints the root-causes for these losses. Within plant operations OEE is familiar to Operations Managers and Plant Managers as an excellent capacity management tool. Of course OEE is also an excellent tool (and metric) to analyse and compare the performance of different plants.

Limitations of using OEE alone for plant performance comparison

In order to make valid comparisons between different plants using OEE it is important to consider the business environments in which the plants operate. This business environment has a significant impact on the elements of OEE performance.

Using OEE alone as a metric to compare plant performance can give misleading results if the operating environment of the plant is not considered. It is often much more enlightening to use the component metrics of OEE (Availability, Performance and Quality) to make more meaningful comparisons. So, the OEE performance of a plant which manufactures a diversity of products for different markets and different customers may be much lower than the OEE performance of a single product plant which is manufacturing for a single market or for a small number of customers. This does not necessarily mean that the multi-product plant is the poorer performer !

An example of two Manufacturing Plants

Let's take the example of two manufacturing plants - Plant A is a high-volume manufacturer of multiple products for multiple markets. Its business is characterised by a high diversity of product, small lot-sizes and frequent changeovers. It runs two shifts, five days per week. Plant B manufactures product for a single market in very high volume. Producing in a low-cost location, the plant runs high volume production lots of a small number of products in a three-shift 24x7 operation.

Comparison Metrics

If we compare the overall performance of the two plants using the OEE Scorecard shown here we can draw the following conclusions :

Plant A has a schedule adherence of 102% compared to 94% for Plant B. However, the OEE performance for Plant A is only 66% compared to 71% for Plant B, although Plant A has exceeded its OEE goal while Plant B has failed to meet its OEE target.

So which plant is the better performer ? Which plant in

the candidate for new products ? And which plant has the capacity flexibility to deliver increased production output cost effectively ?

Delving deeper . . .

Let's look a little closer at the OEE Scorecard and the components of OEE performance -

Plant A has a lower OEE performance because, although its Performance and Quality is superior to that of Plant B, the Availability metric in Plant A is significantly worse than that in Plant B.

As we drill deeper and analyse Availability performance we see that the planned downtime in Plant A is more than four times that of Plant B. This is due to the fact that it carries out three times as many changeovers as Plant B, but with an average changeover time of 1.5 hours compared to 2.0 hours for Plant B. If we accept that the number of changeovers in Plant A is necessary because of the diversity of its product range and the number of markets it serves, then the performance of Plant A is superior to that of Plant B with regard to Availability.

If we then look at the unplanned downtime performance of the plant we see that although Plant A is only slightly less than that of Plant B, the MTTR (mean time to repair) is three times faster than Plant B and the frequency of unplanned downtime events, or MTBF (mean time between failures), is twice as good as that of Plant B.

When we then look at some of the OEE related costs for the plants we see that the OEE cost per unit in Plant A is more than double that of Plant B, primarily due to its higher operating cost and the higher value of the product it produces. For similar reasons the labour cost per unit in Plant A is higher than Plant B although it runs a labour variance one half of that of Plant B. Finally, if we look at the load factor in each of the plants we see that Plant A is operating at less than one third of its total capacity capability while Plant B is operating at almost two-thirds of its capability. Plant A has significant latent capacity which can be delivered by adding shifts.

Conclusion

So in summary which plant is performing better ? Plant A, while lightly loaded and operating in a higher cost environment, performs better than Plant B. Although it has lower Availability, it has better Performance and higher Yield. Plant A has faster changeovers, fewer breakdowns, faster response times and runs a lower labour variance. It also has the potential to more than double its current output while operating at a higher performance level. Using OEE and its component metrics we have successfully compared the plants' performances.

Most of the benefits derived through the use of our products and Services positively impact a customer's OEE. The fact that a Checkweigher is very often used as the final piece of equipment in a production line, for the final check of all products prior to despatch, makes it ideal for capturing valuable data when calculating OEE. Below are a few ways that METTLER TOLEDO Garvens can improve a user's OEE:

- Our X series touchscreen interface reduces the time it takes for product set-up and changeovers thereby increasing **Availability**.
- Preventative Maintenance programs like our Bronze, Silver, Gold and Platinum service contracts pro actively maintain the checkweigher's ability to run at the designed line rate, positively affecting **Performance**.
- Advanced weigh cell technology and accuracy as well as software options such as feedback to filler control keep tolerances within specification over longer periods of time and reduce the number of rejects, thus increasing the **Quality** of products being produced.

For more information on this subject please contact your local METTLER TOLEDO Garvens representative.



This OEE Guide was prepared with expert information from OEEsystems. OEEsystems are a leading supplier of OEE software solutions and work with manufacturing companies worldwide to improve competitiveness, increase capacity, reduce costs and deliver business performance excellence.

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