The *Independent* Solution Provider for Industrial and Process Automation, Quality & IT

ATS MES Excellence Centres

Overall Equipment Effectiveness (OEE)

For various industries

www.ats-global.com

Overall Equipment Effectiveness (OEE)

Questions and answers

More and more businesses push their assets for more output at minimum cost. The analytical power of manufacturing intelligence solutions may reveal the secrets of production efficiency and effectiveness, but how do you know what to look for? This comprehensive white paper describes the three core OEE elements, how to calculate OEE, the purpose of OEE, the Enterprise Benefits, 16 Frequently asked questions, a few industry examples and a glossary of terms.

The three core elements of OEE

Overall Equipment Effectiveness is a major KPI (Key Performance Indicator) that accounts for three constituent elements:

1. Availability

Availability is the percentage of time that machines are available for scheduled production compared with the amount of time they were actually producing. Scheduled maintenance, planned downtime events, or equipment trials are not considered to be part of the time that machines are available for production. This allows a plant manager to readily identify whether machine downtime issues are part of a known calendar, or if there is a more serious problem. Availability is calculated as:

Availability = Operating Time / Planned Production Time

2. Performance

Performance compares the theoretical machine rate with the number of items actually produced on a machine during its operating time. Performance allows a facility to compare availability downtime with efficiency. This can show whether a specific line is having problems due to low output, or if the problem is excess downtime. In addition, if a machine has recurring efficiency issues, performance measurements can indicate problems with the machine itself, rather than an operator issue. Performance is calculated as:

Performance = Ideal Cycle Time/Operating Time

Ideal Cycle Time is the minimum cycle time that a process can be expected to achieve in optimal circumstances. It can sometimes be called Design Cycle Time, Theoretical Cycle Time or Nameplate Capacity. Since Run Rate is the reciprocal of Cycle Time, Performance can also be calculated as:

Performance = Total Pieces/Operating Time)/Ideal Run Rate

Performance is capped at 100%, to ensure that if an error is made in specifying the Ideal Cycle Time or Ideal Run Rate the effect on OEE will be limited.

3. Quality

Quality is the percentage of items that pass the first quality inspection. This allows a plant manager to compare consistency between individual machines and, in turn, allows for comparisons between different manufacturers, as well as machine, specifications, and even individual operators. Quality is calculated as:

Quality = Good Pieces / Total Pieces

OEE takes into account all three OEE Factors, and is calculated as:

OEE = Availability X Performance X Quality X 100

It is important to recognize that improving OEE is not the only objective. The following data for two shifts illustrates this:

OEE Factor	Shift 1	Shift 2
Availability	90.0%	95.0%
Performance	95.0%	95.0%
Quality	99.5%	96.0%
OEE	85.1%	86.6%

It may appear that the second shift is performing better than the first, since its OEE is higher. However, very few companies would want to trade a 5% increase in availability for a 3,5% decline in quality. OEE doesn't only offer one magic number; it provides three numbers, which are all useful individually as a situation can change from day to day. It also helps visualising performance in simple terms.

The purpose of OEE

By implementing a system that can measure and analyse OEE, manufacturers can improve equipment performance, operating procedures, and maintenance processes. The following are six

categories of productivity losses that are almost universally experienced in manufacturing:

1. Breakdowns
2. Setup and Adjustments
3. Small Stops
4. Reduced Speed
5. Start-up Rejects
6. Production Rejects.

The main purpose of any OEE initiative is to become the most efficient, most effective manufacturer within a market, minimising the above main losses. A world-class OEE has a benchmark OEE rating of at least 85%. However, simply maintaining an 85% rating does not guarantee world-class status. Each component of OEE must meet different levels of individual performance; availability should be at 90%, performance should be at 95% and quality at 99%. These benchmarks allow manufacturers to have a point of reference for determining when these components meet acceptable levels.

Instead of making reactive maintenance decisions based on breakdown reports and product-manufacturing decisions based on plant schedules, OEE measurements enable proactive decisions based on throughput, efficiency, effectiveness and process bottleneck constraint analysis. Tracking OEE can help manufacturers to spot patterns and influences of equipment problems and allows them to see the results of their improvement efforts.

More generally, OEE also captures *reasons* for downtime (due to machine conditions, material status, production personnel or quality issues) and can encompass the entire plant. At the plant level, OEE metrics can be correlated with other plant metrics to provide more KPI's. With enterprise level technologies, such as Executive Dashboard, 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.

The Enterprise benefits

Implementing an adequate OEE system brings immediate financial benefits to manufacturing operations. A few major benefits are listed below.

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 application (based on year 2000 data), it is estimated that each hour of downtime for a critical unit of process equipment can translate into $100,000 of lost revenue. Conversely, reducing downtime by 1% on the 50 most critical tools can provide revenue opportunities and cost savings nearing $100,000,000 annually. *

*International Technology Roadmap for Semiconductors 2002 Update

Reduced Repair Costs

OEE enables predictive maintenance that can considerably reduce repair costs. As the historical database of downtime reasons grows, the maintenance department can discern trends to predict an impeding failure. Also, by interfacing the OEE system to for instance a Computerized Maintenance Management System, the maintenance department can take proactive predictive maintenance steps.

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 economic conditions, many manufacturing companies have downsized considerably. Consequently, manufacturers are eager to optimise the productivity of their existing workforce. An OEE system helps, because it not only captures operator downtime reasons, but also productivity data. With this information, management can better judge the proper allocation of resources based on personnel productivity. When the business climate improves, OEE systems could enable managers to identify additional capacity within the existing workforce instead of hiring new labour.

Reduced Quality Costs

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.

Increased Personnel Productivity

An OEE system enables the shop floor to go paperless. Typically, facility operators and supervisors spend an enormous amount of 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.

Frequently asked Questions

1. How universal are the key terms that constitute Overall Equipment Effectiveness

While there are many variants, generally they use the same approach. This includes availability, performance and quality. It is important to set up standard definitions for your company.

2. Are terms like "Operating Time" and "Net Operating Time" industry standards?

No. For historical reasons, companies use their own variations of these terms – such as Planned Production Time, Gross Production Hours or Scheduled Production Time.

3. Where is the greatest potential for improvement with availability, performance and quality?

This depends on the industry and process. In many cases, availability hasn't been a focal point for improvement. While many companies have improved performance and quality over the years, many have not focussed on improving the line availability.

4. Can OEE be applied to any process?

In the most practical sense, OEE is going to provide the highest value when it measures the capability of automated production and processing systems.

5. Why is performance measured by counting parts rather than by adding up the stoppages?

The performance component of OEE accounts for speed losses, which result from short stops of the production system or running it at a speed less than its theoretical capacity. Comparing "actual parts produced" to the "theoretical number of parts" that should be produced is an ingenious simplification, since this technique captures the losses due to short stops and speed reduction. In addition, this technique does away with all the complication that would be required to calculate the true duration of many short stops on complex lines, where different accumulation may allow parts of the line to keep producing even when some systems are down, due to short stop failures.

6. What is the biggest issue that typically drags down the performance of automated lines?

Many automated lines have 1.000 or more shortstop failures per week with typical durations of 1 to 2 minutes each. Everyone knows about failures that take a line down for several hours, but very few are aware of the losses occurring every day, 1 or 2 minutes at a time!

7. How does OEE data typically compare with the manual downtime data that most manufacturers ask the operators to report on clipboards?

Since is it not possible for operators to manually capture all the short stops, they tend to only report a few major events per line per shift. Often they fill in the same amount of time for a given event, rather than the actual time required.

8. How do OEE performance numbers relate to plant efficiency numbers already being collected?

If OEE is properly applied, all of the potential losses are included, so the OEE figure will be much lower. Most plants have developed ways of measuring their "efficiency" where the key detractors are excluded from the equation i.e. efficiency is often measured only when the line is running. Consequently a plant that has been reporting efficiency of 85-90 percent, may find their OEE is actually in the 40-60 percent range.

9. What type of Return on investment should we expect from an OEE program?

Many manufacturers who implement OEE achieve a 4 to 10 percent improvement in the first year. Depending on the line output and the value of the product, this often produces a seven-figure return in the first year.

10. Who needs to be involved in an OEE effort?

Top management must be included to set objectives and establish the importance of the program. It is also vital to have the support of the operations team. Finally, the engineering, maintenance, quality and scheduling groups should be on the improvement team.

11. Who is achieving World Class OEE?

The World Class OEE figure of 85 percent needs to be tempered, based on the industry and process under consideration. Continuous processes will be more likely to approach the 85 percent World Class level than discrete processes.

12. What is the biggest "gap" in setting up an automated OEE system?

Most highly automated lines, even those including SCADA systems, don't have provision for tracking availability related losses. It is important that the automated solution allows operator or equipment triggered availability related downtimes.

13. What events are not included in OEE?

Items classified as planned shutdown, which do not count against the OEE, typically include "not scheduled to run", "weekend" and "holiday". If you don't measure it, you probably won't be focused on improving it.

14. What other data is important to get out of an OEE program?

To fully understand the performance of the system/area/line being measured, it is important to be able to overlay the OEE, availability, performance or quality data against: date, time, and shift; product being manufactured; job or work order; batch (if applicable); quantity produced; total produced; total rejected; total good (first pass yield); and other factors that provide context to the data.

15. How significant is it to monitor OEE in real time through a Web browser?

Often, operators will struggle with an emerging problem far too long without asking for help. The fast recognition and response to problems is a major advantage of implementing a real-time system for tracking OEE and detailed downtime information.

16. Is it a good idea to involve operators in all performances related short stops?

No. Since many lines have 100 or more failures per day, it is important that the tool interacting with the operators provides configurability related to when they get involved.

Industry Examples

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

Automotive Manufacturing

An automotive customer was trying to extract additional productivity out of their assembly line by improving equipment availability. They had already reduced all known causes of downtime through diligently applied process engineering steps; 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 bottleneck 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 to 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, the plant was able to produce eight more vehicles per day without adding resources.

Food & Beverages Manufacturing

At a food manufacturing facility, OEE 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 automatically

slowing, when surge bins being filled whenever downstream machines were delayed, triggered a fault. 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 without human intervention.

Medical Device Manufacturing

ARTIFICIAL KNEE JOINT

ARTIFICIAL ELBOW JOINT

A medical device manufacturer started a project to improve the capacity of an artificial joint production facility 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 10 work cells within 6 months of implementing the system. Each work cell has an average of 5 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 introduction of three new products. In addition to the improved production capacity, the plant has improved their overall quality and reduced rework time on existing products. Encouraged by these outstanding results, the manufacturer plans to begin collecting data on the remaining work cells next year in the hopes of raising the overall efficiency of the plant.

Mike James is Group Managing Director of ATS Applied Tech Systems.

The *Independent* Solution Provider for Industrial and Process Automation, Quality & IT

About ATS

ATS is an ***Independent*** **Solution Provider**, with over 20 years experience and a wealth of experience undertaking Continuous Improvement initiatives and Manufacturing IT solution design, deployments and 24/7 support assignments.