



# Manager's Guide to Overall Equipment Effectiveness (OEE)

## Overview

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, plus better management of the equipment life cycle
2. *Personnel*: Labor 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, 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.<sup>1</sup> This means that the remaining 96% percent 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.

<sup>1</sup> David Drickhamer, "IW Census targets key manufacturing metrics", November 1, 2001, *Industry Week Magazine*.

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:

1. *Availability* = (Operating time – Downtime) / Total Operating Time
2. *Performance* = Total output/potential output
3. *Quality* = Good output/total output

OEE is then calculated by multiplying those factors:

$$\text{OEE} = \text{Availability} * \text{Performance} * \text{Quality}$$

More generally, OEE also captures *reasons* for downtime (due to machine conditions, material status, production personnel 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 (KPIs). 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.

## History

The first application of OEE can be traced to the late 1960's when it was used by Seiichi Nakajima at Nippon Denso as a key metric in TPM (Total Productive Maintenance).<sup>2</sup> According to Nakajima, "*TPM is a plant improvement methodology, which enables continuous and rapid improvement of the manufacturing process through the use of employee involvement, employee empowerment and closed-loop measurement of results.*"

<sup>2</sup> Simon Bragg, "Implementing OEE", ARC Insights, Insight#2003-07E, February 12, 2003, ARC Advisory Group.

In the mid 1990's, coordinated by SEMATECH (www.sematech.org) the semiconductor wafer fabrication industry adopted OEE to improve the productivity of the fabs. Since then, manufacturers in other industries throughout the world have embraced OEE methodology to improve their asset utilization.

**Value Proposition**

Implementing an adequate OEE system brings immediate financial benefits to manufacturing operations. Some of these 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 fab (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 in a typical fab can provide revenue opportunities and cost savings nearing \$100,000,000 annually.<sup>3</sup>

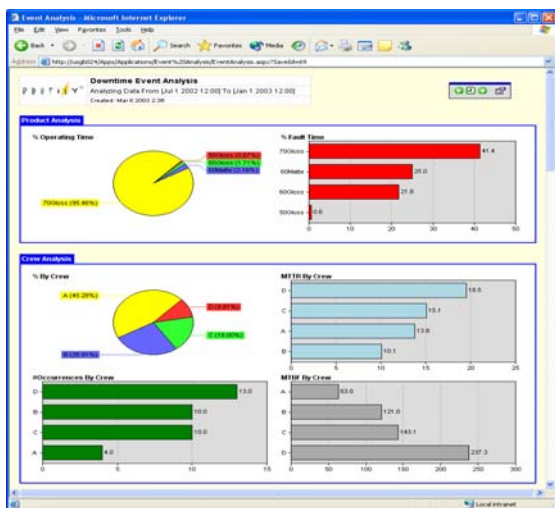


Figure 1: Downtime Event Analysis is an important element in the overall OEE evaluation of a production environment

**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 Labor Efficiencies**

Due to current economic conditions, most manufacturing companies have downsized considerably. Consequently, manufacturers are eager to optimize 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, an OEE system could enable managers to identify additional capacity within the existing workforce instead of hiring new labor.

**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%.

<sup>3</sup> International Technology Roadmap for Semiconductors 2002 Update.

### **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, analyzing 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**

One of GE Fanuc's automotive customers 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 from GE Fanuc. 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 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, GE Fanuc's 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 automatically 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 without human intervention.

#### **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 centers 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 center 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.

### **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 manufacturing cell or even part of a line, 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 a pilot system:

- ❑ Number, type and complexity of reports required
- ❑ Number of users accessing the system
- ❑ Number of manual data entry terminals and mechanism for data entry (i.e., bar code reader interface, Biometrics interface)
- ❑ Number of machines to interface
- ❑ Number of parameters to monitor per machine

### **GE Fanuc Offering**

GE Fanuc offers a diverse array of powerful yet easy-to-use applications that enable manufacturers to achieve new levels of operational excellence by making business sense out of plant data in real time. Our OEE offering allows plant managers and production personnel to perform in-depth analysis aimed at significantly improving plant operations and overall business profitability. Scalable from a single production unit to multi-plant implementations, GE Fanuc's software solutions are highly configurable and are producing outstanding results for companies in virtually every industry and in every corner of the globe. Easy to install, administer and maintain, our solutions are designed to work seamlessly with the hardware and software solutions that are already in your plant today, adding powerful data collection, web visualization and analysis capabilities.

GE Fanuc's OEE solution provides the mechanism to collect manual data, as well as the machine interfaces to automatically pull data from PLCs, CNCs and other industrial automation devices. Our solution is also ideal for industries that require electronic records, electronic signature and audit trails for regulatory compliance purposes. Additionally, we provide consulting services to analyze customer requirements and implement custom projects, as well as deliver award-winning, 24x7 technical support.

The remarkable solutions we deliver within the manufacturing space are a direct result of our unique position within the industrial landscape. Not only is General Electric an industrial automation solution provider, but we're also one of the world's largest, most efficient and most effective global manufacturers as well. Through our world-renowned Six Sigma approach, our dedication to comprehensive implementation and our heritage for innovation, the solutions that have helped our company to become a global leader can also help your business to achieve new levels of operational and business excellence.

For more information, visit us online at: [www.gefanuautomation.com](http://www.gefanuautomation.com).