

The ABCs of Overall Equipment Effectiveness

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With the constant pressures of global competition, OEE (Overall Equipment Effectiveness) has become a hot topic for many manufacturers. It provides a simple way to “keep score” of manufacturing performance, and is a tool for continuous improvement and lean manufacturing initiatives. This article provides you with the information you need to understand OEE, and more importantly to understand how OEE can help make your company’s production assets, more efficient and profitable.

Start Simple

Let’s start with a simple truth it is very difficult to manage or improve what you don’t measure. OEE provides a way to measure the effectiveness of manufacturing operations from a single piece of equipment to an entire manufacturing plant. In doing so, it provides a complete picture of where productive manufacturing time is being lost.



So what is OEE? Technically, it is the ratio of Fully Productive Time to Planned Production Time. In simpler terms, OEE is the percentage of production time that is truly productive. For example, if OEE is 50%, that means the equipment is running at only half of its theoretical potential. On the other hand, if OEE is 100%, that means production is running perfectly no down time, no slow cycles, and no defects. It’s that simple!

Small improvements in OEE can result in big improvements in profitability. For example, Hansen [2001] shows how a 10% improvement in OEE can result in a 50% improvement in ROA (Return on Assets). Hansen also shows that investment in OEE initiatives can be ten times more cost-effective than purchasing new capital equipment. In fact, many companies use OEE to ensure that existing equipment is fully utilized before new equipment is purchased. Ronald Rocha, Flex-Factory Global Operations Director for Flextronics (a global electronics manufacturing services company) states, “The main reason we use OEE is because we want our sites to be

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at a certain productivity level before we decide to purchase more equipment.”

Dig Deeper

OEE is based on three underlying components: Availability, Performance and Quality. Each of these components accounts for a different type of waste in the manufacturing process. Like OEE, each is expressed as a percentage. The higher the percentage, the more effective the process. Availability takes into account *down time loss*, which is productivity lost due to stops in planned production that are long enough (usually several minutes) that they should each be tracked as a separate event. Common causes of down time loss include equipment failures, material shortages, and changeovers. Why changeovers? Although it's usually not possible to eliminate changeover time, in most cases it can be reduced (the basis of SMED or Single Minute Exchange of Die programs). Bottom line: if changeovers cut into planned production time, they should be counted as a down time loss. Availability of 90% is considered world class for discrete manufacturing. This means that the process is running 90% of the time during planned production time.

Performance takes into account *speed loss*, which is productivity lost due to the process operating at less than the maximum possible speed when running. Common causes of speed loss include machine wear, substandard materials, and misfeeds. Performance of 95% is considered world class for discrete manufacturing. This means that when the process is running (i.e. not down), on average it is running at 95% of its theoretical maximum speed.

Quality takes into account *quality loss* which is productivity lost due to manufactured parts that do not meet quality standards. Common categories of quality loss include scrapped parts and parts that require rework. Quality of 99.9% is considered world class for discrete manufacturing. Of course, for some types of operations the minimum acceptable quality level will be much higher. OEE combines these three factors into one metric by multiplying them together resulting in one score that provides a complete measure of equipment efficiency and effectiveness. OEE of 85% is considered world class for discrete manufacturing. This means that when looking at planned production time, 85% of that time is fully productive.

Measure It

The next step is to learn how to calculate OEE. To do so, just five pieces of information are needed:

Planned Production Time The intended (i.e. scheduled) production time. This includes all time in which production is scheduled to run.

Down Time The amount of time the process is not running during Planned Production Time.

Ideal Cycle Time The theoretical minimum time to produce one piece. This is sometimes referred to as nameplate capacity or design cycle time.

Total Pieces The total number of pieces produced.

Good Pieces The number of pieces produced that meet quality standards.

In the beginning, it's a good idea to use manual data collection to “learn the process”. Roy Smith, a Manufacturing Manager for Federal-Mogul (a global

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automotive supplier) advises, “Manually collected data is very useful in helping the operators understand OEE and where the numbers come from, especially if they have to do the math themselves.”

Here's a sample set of calculations.

First calculate Operating Time.
Operating Time = Planned Production Time - Down Time
Operating Time = 440 minutes - 98 minutes = 342 minutes

Next calculate Availability, Performance and Quality.
Availability = Operating Time / Planned Production Time
Availability = 342 minutes / 440 minutes = 77.7%
Performance = (Ideal Cycle Time x Total Pieces) / Operating Time
Performance = (1.00 minutes x 296 pieces) / 342 minutes = 86.5%
Quality = Good Pieces / Total Pieces
Quality = 291 pieces / 296 pieces = 98.3%

Now OEE can be calculated as:
OEE = Availability x Performance x Quality
OEE = 77.7% x 86.5% x 98.3% = 66.1%

An alternative calculation for OEE is:
OEE = Good Pieces x Ideal Cycle Time / Planned Production Time
OEE = 291 pieces x 1.00 minutes / 440 minutes = 66.1%

With a bit of reflection you will realize that the alternative calculation for OEE brings us right back to where we started defining OEE as the ratio of Fully Productive Time to Planned Production Time. After all, multiplying Good Pieces by Ideal Cycle Time is another way of calculating Fully Productive Time (producing only good pieces, as fast as possible, with no down time).

Accurately measuring OEE for the first time can be a humbling experience. Roy Smith observes, “The numbers are going to start low.” Mike Fraley, a Process Engineer for Crown Battery (a Fremont, OH manufacturer of commercial and industrial batteries) agrees, “When we brought on an additional shift we saw a dramatic increase in OEE as people learned the equipment...we saw their OEE go from 40-50% all the way up to 85-90%.” In fact, it is quite common for discrete manufacturing plants to discover that their OEE is below 60%, sometimes as low as 35 to 40%. But that’s OK! Armed with this knowledge, and having established a baseline, the focus can turn to improvements.

Train the Team

One of the most important principles for improving OEE is to extend accountability all the way to the plant floor. And that starts with training. According to Ronald Rocha, “If our employees know how important OEE is, if they understand why they are doing it and the benefits it creates then we have a better chance of putting it in place and making it work.” Begin by training managers as they will drive the initiative. Then move to the plant floor.

Training front-line employees on the “how” and “why” of OEE instills a sense of ownership. Keep training simple, and focus on how the numbers relate to the production process. It is much easier to grasp OEE in terms of down time, slow cycles and rejects than the associated Availability, Performance, and Quality metrics. Roy Smith comments, “As each new cell is put in place we sit down with the group to discuss what the numbers actually mean.”

Some companies find that OEE is a bit abstract for the plant floor, and while they

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track OEE for various reporting and management purposes they prefer to focus on simpler metrics for plant floor employees. A popular alternative for the plant floor is to provide visual feedback in the form of target, actual, and efficiency metrics:

- Target represents an automatically increasing number that indicates how many pieces should have been produced at any given moment of time.
- Actual represents the actual number of pieces that have been produced. With an eye to OEE, it is important that this metric be based on good pieces (not total pieces).
- Efficiency represents how far ahead or behind production is running in terms of a percentage.

However goals are presented to the plant floor – keep it simple! It is far more effective to focus on a few tightly focused metrics than to present an overload of information. In Ronald Rocha’s experience, “Management has to set specific improvement goals and that will drive everything else.”

Take it to the Next Level

Once OEE tracking is firmly in place, how do you take it to the next level? Here are some tips.

Standardize. Resist the temptation to “tweak” the calculations. Standard OEE has withstood the test of time, and enables benchmarking machines, cells, lines and in some cases even entire plants. Roy Smith remarks, “The main importance of a standard OEE calculation is that it makes it easy to compare numbers from plant to plant”. Ronald Rocha agrees, “The biggest eye opener for us was that as we went from site to site we found that the engineering data for production rates was not standard, meaning we were using different criteria on the same equipment.”

Automate. Manual tracking is far better than no tracking, but automated tracking is better yet. From Ronald Rocha’s perspective, “The difference between manual data collection and automated methods is the integrity of the data.” For example, companies switching from manual to automatic tracking of down time are often shocked when they discover their true down time.

Motivate. Setting realistic and attainable goals for plant floor employees can be amazingly effective. People are naturally competitive setting real-time visual goals harnesses their desire to win. Mike Fraley relates, “We post our data on the floor so everyone can see it. It’s a motivational force...if our employees see a dip they work hard to bring it back up.”

Benchmark. OEE is a highly effective tool for encouraging best practices, which can then be replicated as needed. For example, plants that show significant improvement in reducing down time can transfer knowledge to plants that may not have seen the same gains. Learn. Vorne maintains an educational web site at www.oeecom.com, and there are also a number of excellent books focused on OEE. For example:

OEE for Operators (*Productivity Development Team, Productivity Press, 1999*)
Overall Equipment Effectiveness: A Powerful Production/Maintenance Tool for

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Increased Profits (*Robert C. Hansen, Industrial Press Inc, 2001*)

Lost Production Time is Lost Forever

Tracking OEE is a great way to drive improvements in manufacturing effectiveness and efficiency. It exposes exactly what proportion of production time is truly productive (the OEE metric). Delving deeper, it reveals how much productivity is lost to down time (through the Availability metric), slow cycles (through the Performance metric), and quality issues (through the Quality metric).

Remember - lost production time is lost forever. That's why OEE is so compelling - it provides a framework and an opportunity for turning lost production time into found profits.

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