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OEE, the New Gauge on the Dashboard for the PCB Assembly Industry

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Abstract

OEE (Overall Equipment Effectiveness) is commonly used in a wide range of businesses when it comes to measuring and monitoring manufacturing performance. Even though OEE has been applied in various areas of businesses for a while, it has gained less traction in the electronics-manufacturing arena, despite the fact that it is an excellent tool to compare overall performance between production lines and manufacturing sites.

OEE is defined as *Availability x Performance x Quality*, which means that it is the first tool that provides a true picture of the total performance ratio taking also the quality aspect into full consideration. The overall objective of implementing OEE is to obtain a reliable measurement of the production performance across factories, production lines, work groups, etc., while still being able to compare performance ratios across different products as well as across different equipment types from various machine vendors.

The goal is of course to use OEE as a tool to continuously improve the throughput and quality of production cycles. In this respect, it is essential to have exact and reliable background data, and a good tool-set to drilldown on the actual causes of performance loss or deterioration.

It is basically quite easy to calculate OEE by simply counting the number of produced boards and the accumulated number of defects. However, without detailed drilldown capabilities to capture relevant production data OEE lacks the information depth to provide an accurate reflection of the current production process to suggest measures leading to improvements in performance and end product quality.

The best way to assure that detailed and accurate data is available is by automatically capturing it from the production equipment and embedded systems. Operator involvement in the data collection process is not only time consuming, but always leads to impaired data accuracy and timing deviations.

This article will elaborate on best practices how to obtain the necessary production data, extract the relevant information and properly evaluate it before implementing into the OEE model for results generation.

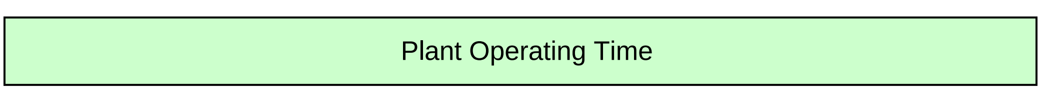
Overall Equipment Effectiveness (OEE) is a new tool for measuring and improving overall production performance, and makes it possible to compare performance across factories, production lines and even production teams. OEE is widely used across different industries, and is now also introduced into electronic production. This article specifically deals with OEE in the PCB assembly industry.

OEE Basics

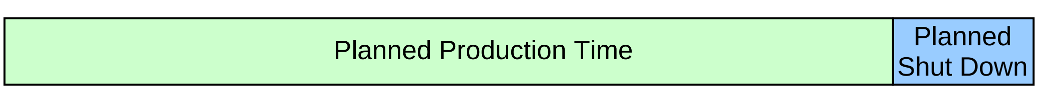
OEE = Availability x Performance x Quality

Here is a breakdown of the major components of OEE:

The **<u>Plant Operating Time</u>** is the period during which the plant is expected to be open. For instance, 24 hours x 6 days per week.

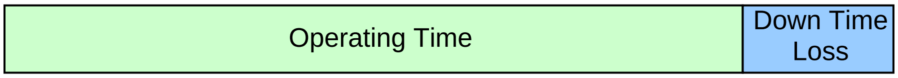


The **<u>Planned Production Time</u>** is the “Plant Operating Time” minus “Planned Shut Down time”, i.e. breaks, lunch, scheduled maintenance, or the period where there is nothing to produce.



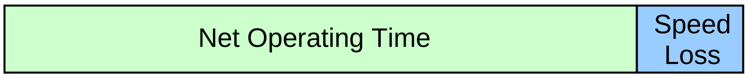
Availability = Operating Time / Planned Production Time

The **<u>Operating Time</u>** is the "Planned Production Time" minus "Down Time Loss" i.e. every event that stops planned production for an appreciable length of time (more than a couple of minutes), e.g. equipment failures, unscheduled maintenance and cleaning, process adjustments, material shortage, change-over time.



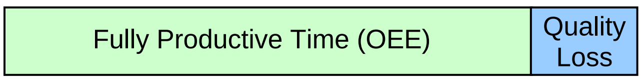
Productivity = Net Operating Time / Operating Time

The **<u>Net Operating Time</u>** is the "Operating Time" minus "Speed Loss", i.e. short stops caused by refilling components, jammed feeders, etc., as well as speed loss related to placing program optimization, line balance, PCB loading and unloading, pick-up errors, skipped heads and nozzles, etc.



Quality = Fully Productive Time / Net Operating Time

The **<u>Fully Productive Time</u>** is the "Net Operating Time" minus "Quality Loss". The Quality Loss accounts for the PCBs produced with errors, according to the specified quality standard, including errors that are reworked at a later stage.



Implementation of OEE in Electronic Production

The overall objective of implementing OEE is to obtain a reliable measurement of the production performance across factories, lines, work groups, etc; while still making it possible to compare the performance across different products and even across different equipment types and brands. The goal is of course to use OEE as a tool to continuously improve the throughput and quality. In this respect, it is essential to have exact and reliable background data, and good tools to drilldown the causes of performance losses.

It is basically quite easy to calculate the OEE by simply counting the number of boards produced, and the number of defects. However, without detailed breakdown possibilities being available, it is of no use in respect to performance and quality improvements.

The best way to assure detailed and accurate data is to automatically capture it from the production equipment and associated systems. Operator involvement in the data capturing process is not only time consuming, but always jeopardizes the data's accuracy and timing.

How to make OEE Comparable

As mentioned earlier, it is very important to obtain reliable OEE figures. If users (managers, group leaders, operators etc.) do not believe in the data, then it is completely useless. This means that OEE should be trustworthy across different lines, machine brands, products produced, etc. At the same time it is important to decide if OEE is used purely to measure production performance, or if it should also take into account product development and/or logistics decisions.

Here are a couple of examples to illustrate these considerations:

1) One approach could be to set the maximum placing speed to the nominal value, specified from the supplier (i.e. 50,000 cph. for a Siemens HS-50), and then reduce all "Speed Losses" from that value. The result of this would be that if the machine runs 100% of the time, and is error-free, then the performance could be 60% for one product, but 90% on another product, even if they are both running at 100% and are well optimized. The big difference is only caused by the product itself, such as the number and shapes of components, feeder variants, etc. It means that even if the production is performing at 100%, OEE varies greatly.
2) Another approach could be to simply look at the operation of the line, working, stops, etc, as it will eliminate the dependability of the product and machine speed. On the other hand it introduces another problem. Lets say that you have a quite flexible production with many changeovers, and you spend 20% of the time for that. You decide to go from an individual feeder set-up for each product to a common set-up. It may reduce the changeover stops from 20% to 10%, but at the same time the cycle time becomes 20% longer, caused by the speed loss due to the permanent feeder set-up. If you only look at the stop time to determine the OEE, then it seems like it has increased by 10%, but actually the output was 10% less!!

3) Another situation could be that you decide to invest in better machine-program-optimization tools. This may increase the output by 15%, but if the speed or cycle time is not taken into account, then it will not increase the OEE even if it should do so.

A feasible solution could be to let the machine-programming tool generate optimum balanced programs without any constraints regarding fixed feeder and nozzle set-ups. This generated cycle time could be used as the nominal cycle time, and the speed-loss due to a fixed feeder set-up (optimization loss) will be visible in the OEE breakdown.

Quality-Loss for Various Board Complexities

It is well-known that the complexity of PCB assemblies varies greatly, from the simplest sensor or power supply circuit with less than 100 components and a few hundred solder joints, to the most complex computer or telecom products with thousands of components, and several thousand solder joints. It is obvious that such two products cannot be compared when measuring the quality loss (number of faulty boards per 100 produced boards).

Number of components plus number of solder joints could be the denominator in such a correction equation. A good reference could be that 100 ppm faults equals a quality loss of 10% (10% defective boards). It means that if the reference board used is a board with 1000 fault possibilities (#components + #solder joints = 1000, or app. 200 components), it is a relatively small board. On a very complex board with 10000 fault possibilities, 100 ppm faults, means that each board has an average of one defect, but by this way of measuring, it will still count 10% quality loss.

How OEE can be Useful across the Industry

First of all it is essential to build OEE calculations on detailed, reliable and accurate data. Otherwise, the result will not be trustworthy, and it will not be useful. OEE is only useful if it is possible to break the measurements down into the individual reasons for losses, and this is only possible if the raw data is detailed and accurate. The only way to get detailed and reliable data is by interfacing directly to the machines or their host systems, and depending on machine type, it is necessary to use vendor specific interfaces, or standard interfaces like GEM/SECS or CamX so long as these protocols deliver the much needed depth in data content. By combining the data from the machines with detailed information in the database of a “line-level MES system”, it is possible to perform further breakdowns such as analyzing which feeders are causing pick-up errors, or if performance losses are related to a specific part shape, etc.

Overall, the OEE tool can be both a reliable and standardized measure of assembly operations performance, delivering meaningful indications of assets productivity, and also an operational management tool for diagnosing the performance and supporting the process of performance improvement by accurately pointing to the factors which offer the greatest scope for performance improvement, based on quantitative data.

The PCB assembly industry has been going through a process of consolidation for some years now, in response to intense market pressure to cut costs overall. After maximizing savings of consumables via implementation of best practice supply chain management methods, and now that manufacturing capacity ratios are returning to normal after the recession, the next opportunity for competitive advantage lies in maximizing the specific performance of the capital assets locked into the production process. In the case of PCB assembly, this means taking steps to maximize the performance of the assembly lines without getting lost in the complexity of the multiple and conflicting factors which come into play. OEE provides the standardized basis for approaching the challenge of assets utilization maximization, to carry industry to new levels of performance on the factory floor. See Figures 1-3 for OEE graph examples.

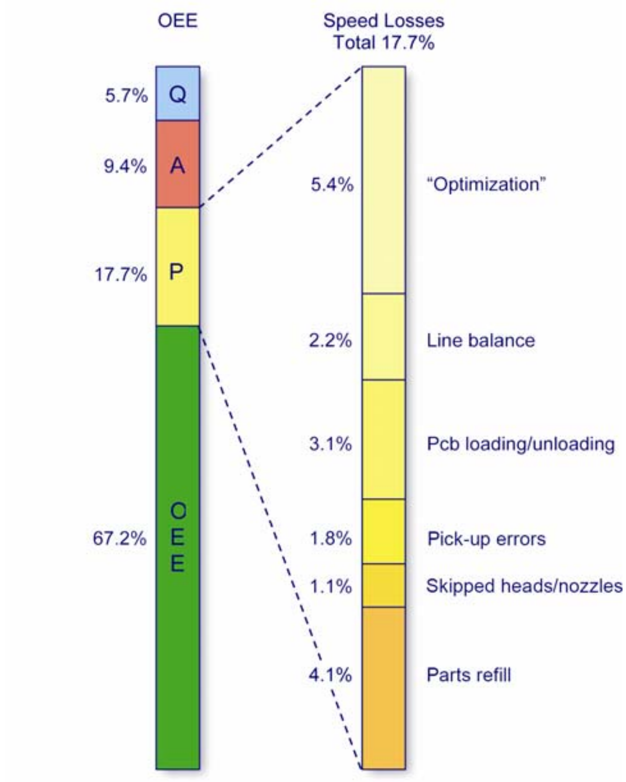


Figure 1 - Performance Breakdown

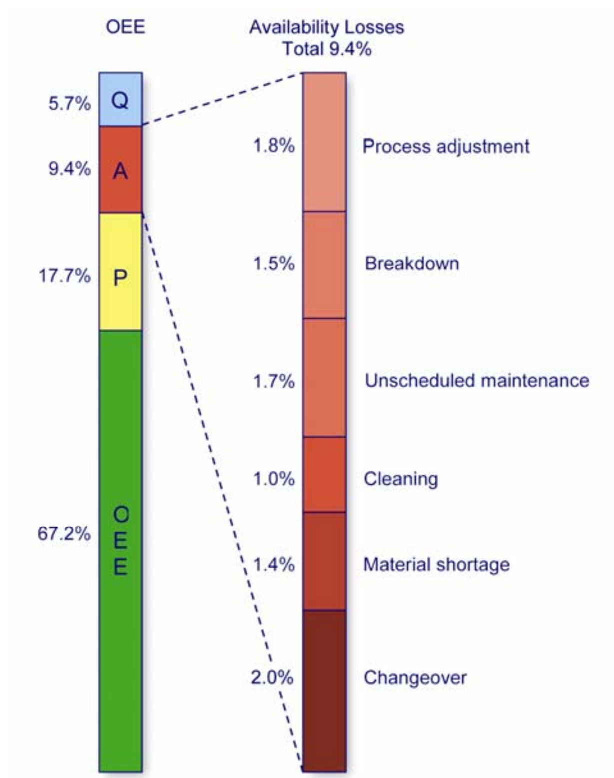


Figure 2 - Availability Breakdown

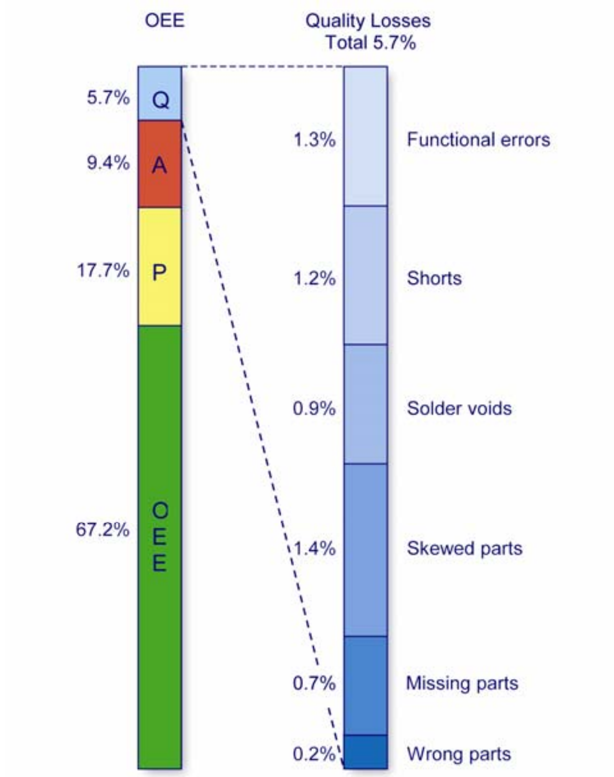


Figure 3 - Quality Breakdown