WHITE PAPER

Device Connectivity Is the Key to Optimal OEE in Industry 4.0

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Abstract

A convergence of market drivers is reshaping factory automation. The increasing demand for customized products is just one example of how these trends are transforming production lines worldwide. In the pursuit of perfect production at assembly lines, overall efficiency effectiveness (OEE) has emerged as the yardstick that tells manufacturers whether they are producing quality products or components, as fast as possible, and with fewer interruptions. OEE focuses on three elements—availability, performance, and quality—to help factory managers keep their finger on the pulse of production.

OEE has come a long way

The first reference to OEE dates back to 1982 when Seiichi Nakajima outlined it as an integral part of Total Productive Manufacturing (TPM) methodology in his book TPM Tenkai. Developed in Japan in 1971, TPM only came to the Western world's attention when Fuji Photo-Film opened three factories in The Netherlands in the 1980s. For the Europeans, the challenge was to achieve zero defects and zero loss on their assembly lines by applying a Japanese approach in a European manufacturing environment. According to the OEE Foundation, Arno Koch was charged with the task to standardize OEE in order to continuously increase production in factories. With the publication of the OEE Toolkit and OEE for Operators in the late 1990s, perfect production became attainable in Western manufacturing plants. In 2001, at the behest of corporations that applied OEE, Koch initiated the "OEE Industry Standard Endeavor," which gave rise to the OEE Industry Standard. Nowadays, OEE is the gold standard in most manufacturing operations.

How OEE works

OEE measures the effectiveness of manufacturing by means of a numerical value. A formula calculates the availability rate, performance rate, and quality of output of any given machine or tool to show how many usable components it has manufactured in a set time frame. OEE is calculated as follows: **`availability rate x performance rate x quality rate = OEE`**

Each factor is first calculated separately. The availability rate indicates the percentage of time a machine is operating fully without any downtime. The formula is as follows: **`running time ÷ planned production time`**

The performance rate refers to the actual output compared to a standard output. The formula

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Both the availability and performance rates refer to the status of the machine.

The third component of the formula, the quality rate, reflects directly on the produced units. It measures the ratio of products passing quality control processes against the actual output. It is calculated as follows: **good count ÷ total count**

If a machine underperforms according to its OEE benchmark, then OEE can help line managers and operators identify the problem areas in their factory. Normally, one of the three aforementioned factors needs to be addressed to ensure that a piece of equipment remains effective in its value stream. Furthermore, it is unlikely that any manufacturing process can run at an OEE value of 100%. Many manufacturers benchmark a challenging target; 85% is not uncommon.

Moreover, OEE is related to the three major levels in a factory: the device level, the control level, and the information level. This means all the production data needs to be collected from machines or sensors and sent via a network to a manufacturing execution system (MES). In the past, the OEE information was limited to shop floors only. With the advent of Industry 4.0, the collected data can now be uploaded to the cloud for big data analytics.

The importance of OEE in Industry 4.0

OEE and Industry 4.0 go hand in hand. In fact, OEE is the outflow from the manufacturing industry's endeavors to address the challenges of Industry 4.0. With the rise of Industry 4.0, manufacturers soon realized that a high degree of flexibility will be required from their assembly lines as market forces are now dictated by an era of mass customization. Customers want products tailored for their specific needs and personal tastes, and the Henry Ford-style business model of mass production, which minimizes variation, no longer meets their demands. Thus, the trend is shifting towards mixed-model production lines that put out a larger variety of products, but fewer quantities of a specific product. Toyota originally developed the concept of mixed-model production in the 1960s to undo the hold-ups created by line changeovers. The biggest challenge is not to compromise efficiency during changeovers in order to achieve a high degree of variation. This is where OEE helps manufacturers make mass customization work for them. As this kind of manufacturing is more complex and has more challenges with regard to workflow and material flow, OEE benchmarks help mixed-model production lines incur minimal or no losses in time, quality, cost, or quantity.

Why do manufacturers fail OEE benchmarks?

Most factories don't have sufficient access to data that is related to their real-time production. The dilemma this entails can be illustrated in the following example: A factory manager oversees 50 CNC machines and has set a key performance index (KPI) of 200 manufactured pieces per week. The line manager instructs the operators to produce the required quantity and record the production data manually. The recorded data is passed on daily to an assistant who puts it into an enterprise resource planning (ERP) system manually. After one week, the line manager learns to his surprise that only 80 pieces have been produced— far below the set

KPI. This raises the question of how managers can readily access real-time production data so that they can take faster action and not wait one week, for example, to restore production.

A lackluster production usually echoes back to any of the three elements of OEE. From the above example, it can be inferred that any machine that shuts down unexpectedly will go undetected for some time due the absence of a proper machine condition monitoring system. Therefore, the availability rate is low due to a long downtime. The challenge is to provide a reliable communication network to capture essential production data and reduce the downtime of the machine.

With respect to the performance rate of equipment, operators are constantly under pressure to reduce the changeover times of machines. As high customization is a significant value of Industry 4.0, regular changes in the programming of computer numerical control (CNC) machines become necessary. However, because a CNC buffer is limited, and programs are relatively large, CNC machines always take a long time to download new programs. Spending more time on data transfers means less manufacturing time, which machine operators cannot afford as they are pressed to tap their machine’s maximum potential. For this reason, the stability of data transfers is very important, especially in old machines with serial interfaces. The absence of a full-fledged Ethernet infrastructure often creates bottlenecks with regard to data transfers. Ethernet networks provide high bandwidth, allowing for the transfer of large volumes of data, which will have a positive effect on productivity.

When it comes to the quality of products, it is clear that not enough safeguards are built into a system to catch a defective product in the early stages of production. In the past, quality control processes were mostly reliant on the human factor, which is usually prone to oversight and error. Defective products were only removed during quality control processes, which meant that money and time were wasted on faulty items. Safeguards need to be incorporated in a system to detect defects as soon as possible by sending early warning signals. A dependable communication system is vital to achieve zero defects as reliable production data is the key to assess the real-time production status.

Integrated solutions for a bevy of benefits

Because OEE conveys a lot of information within one number, it is influential. At all times, OEE must be a yardstick for improvement and not a rod for handing out punishment. The best approach is to try understanding what needs to be changed in the manufacturing process to get better results on shop floors. A three-pronged approach that examines the availability, performance, and quality rates is suggested. Once the problem areas have been identified, new technologies can be sought to address the shortcomings in a manufacturing process.

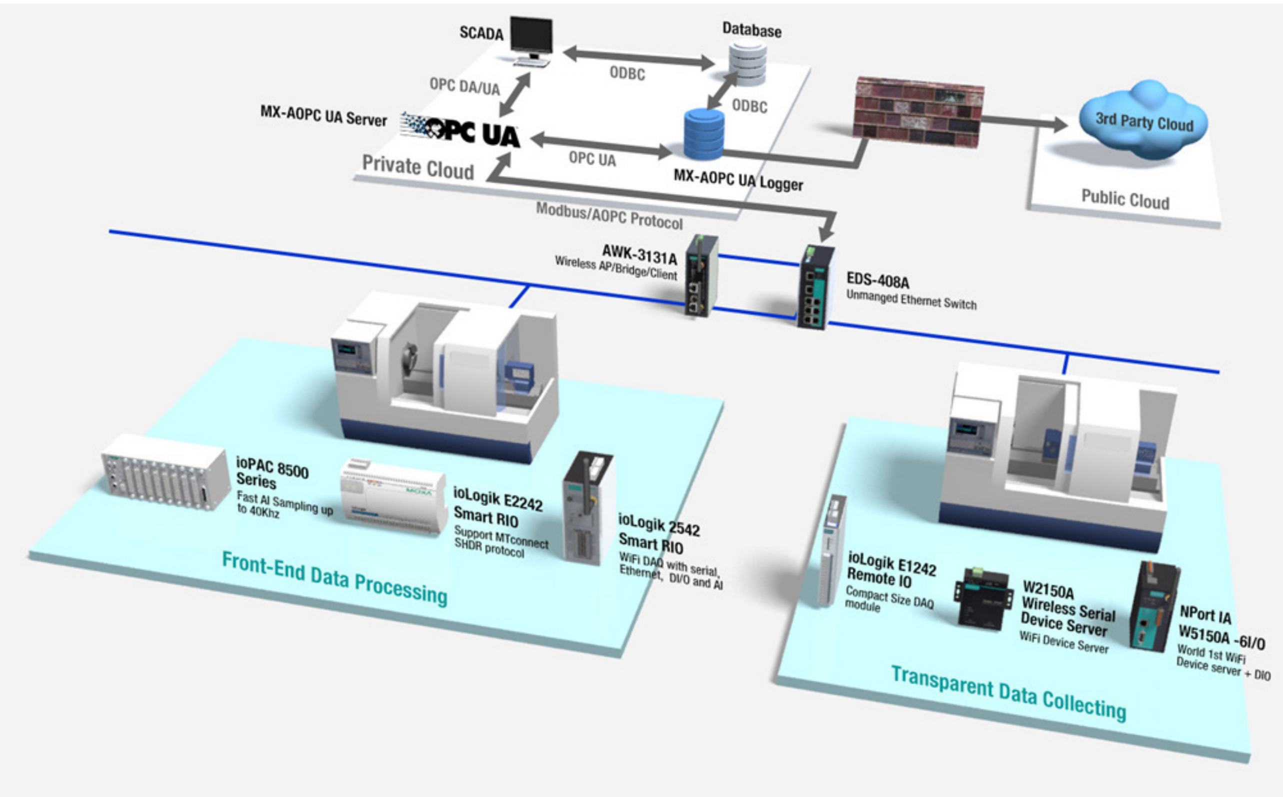
Solutions to improve the availability rate of machines

The crux is to interpret the working status of the machines at all times during production to reduce downtime and improve network availability in order to ensure maximum uptime.

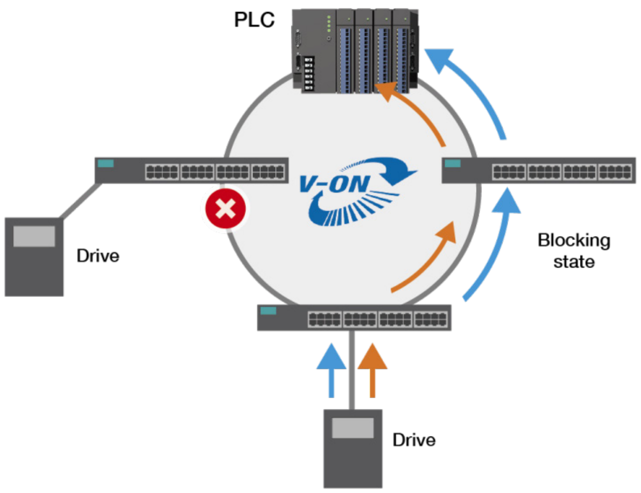
Predictive maintenance

For many, it is perplexing how real-time production data can prevent unexpected downtime. The simple answer lies in predictive maintenance—for which you need real-time production data. During production, machines generate different types of data, such as machine vibration, motor current, tool level, coolant level, and many more. Based on this data, machine maintenance engineers schedule maintenance tasks (predictive maintenance) to avoid any unexpected machine downtime. However, the data presents itself in different forms. One is streaming data, which is transmitted in large volumes and requires preprocessing before it is sent to a back-end system. The other is status data, which is transmitted in small volumes and via a transparent method without any preprocessing. Thus, the system has to use different methods to collect both status and streaming data. For status data, the best way is to use transparent data collection. For streaming data, the best method is to use front-end data processing to reduce the amount of data sent so that only valuable data is sent to the back-end system. Downsizing is necessary because there will be too much streaming data to transfer all the raw data to a back-end system. In terms of front-end processing, a device with a programmable platform that is designed to handle different formats of streaming data is the best fit for the job. Sometimes, a math function is also required in the programming platform to cope with streaming data. If users only need to process simple status data, then an I/O gateway or protocol gateway offers the best solution.

	Front-End Data Processing	Transparent Data Collection
Data Format	Complex	Simple
Local Response	Yes	No
Data Size	Large	Small
Standard Protocol	Depends	Yes

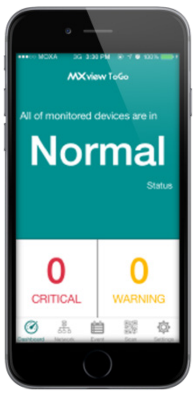


Reliable redundancy



Without reliable redundancy in a communications network, continuous uptime cannot be guaranteed in production lines. Most PLC networks rely on the Internet Group Management Protocol (IGMP) for multicast transmissions. For example, implicit communications, usually used to check the availability of systems that connect PLCs and devices, are based on multicast. However, IGMP requires up to 125 seconds to update a multicast transmission path. While the physical network is down, the ring transmission path changes immediately, and traffic in unicast type communication can be recovered almost instantly, but not for multicast transmission communications. Consequently, communications may be lost for a long time. A fast-recovery technology for multicast communication is needed to keep critical systems up and running. V-ON technology, a pioneering technology, enables a physical network, unicast traffic, and multicast traffic to recover within milliseconds when there is a failure in a network.

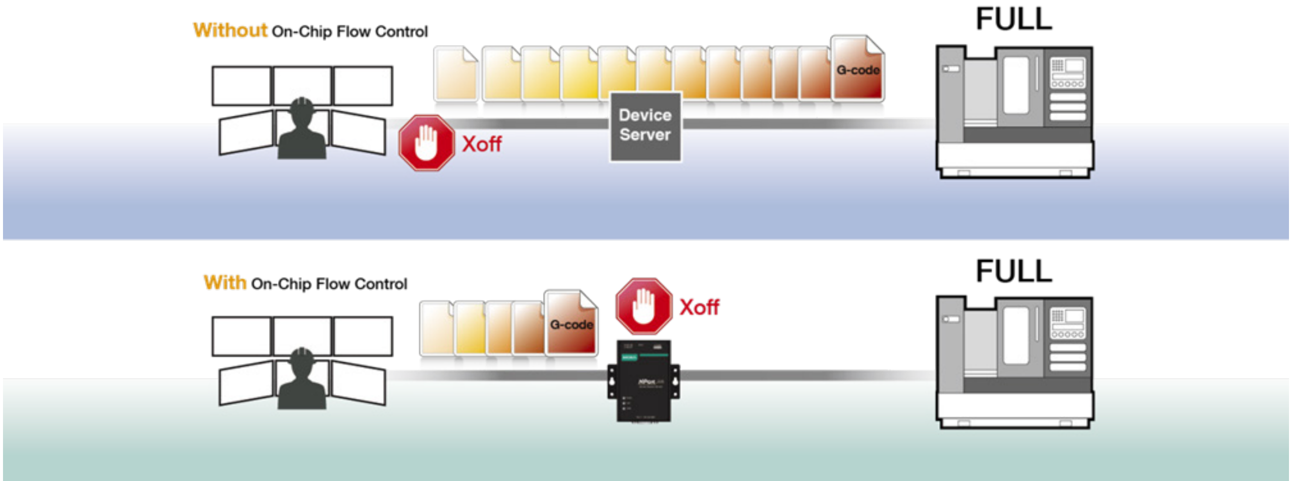
Increased mobility



Increased mobility on manufacturing floors has become an all-important requirement of Industry 4.0. Floor managers need hands-on information at all times, even when they are not at their desks. The most obvious solution is to provide all real-time production information on their mobile devices. Real-time notifications about the network status will help increase availability and shorten downtime. These types of notifications should also provide the ability to check detailed information right away. In addition, an easy-to-use device-locating function to find the inoperable device in a network makes engineers' jobs easier.

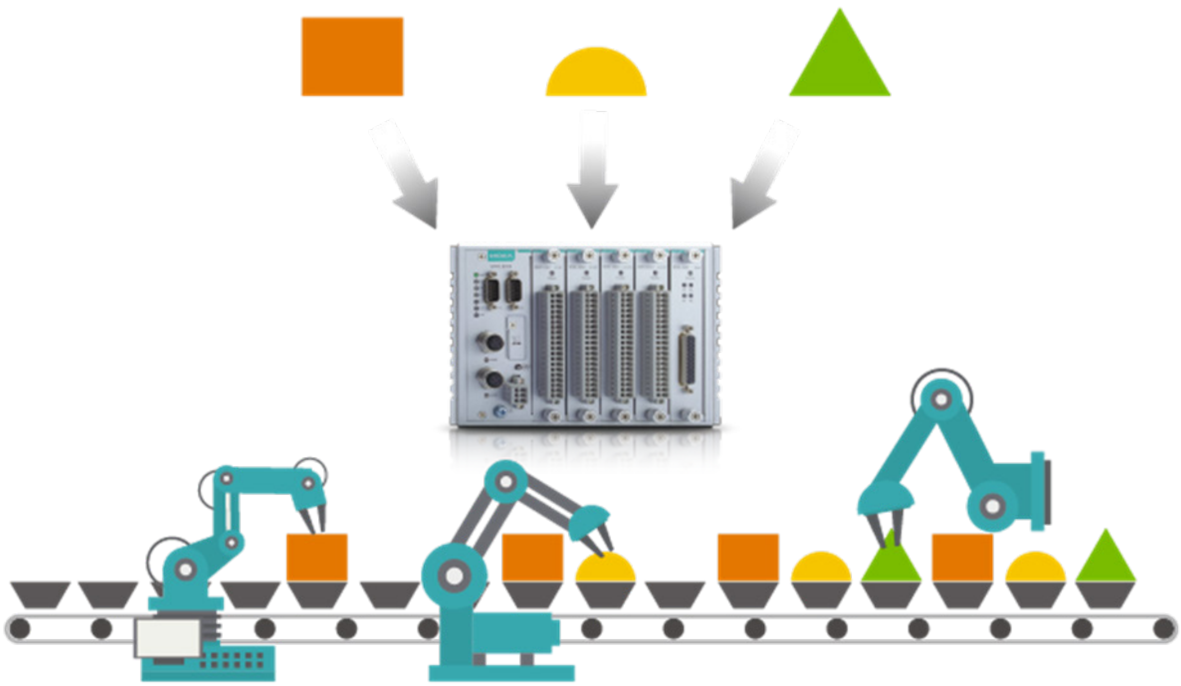
Solutions to improve the performance rate of machines

The focus is to reduce changeover times to increase the productivity of machines and operators. Clearly, reliable data transmission is the key here to increase productivity. A serial-to-Ethernet device server with a flow-control feature is normally used to stop incoming data to prevent data drop; otherwise, the dropped data has to be resent, which results in wasted time and unnecessary costs. To secure data transmission, the device should provide an on-chip flow-control feature that is able to process the stoppage (Xoff) directly from a UART, which eliminates data loss when a program is changed.



In a mixed-model production line, a programmable controller that supports multiple functions and interfaces, such as serial interface, DI/O, and AI/O, is a huge asset.

The controller helps categorize production tasks by automatically retrieving the task sequence from an MES. For example, tools are identified by an RFID tag, and the controller retrieves the production method from the MES via RESTful API and notifies all the relevant machines via an industrial protocol, such as EtherNet/IP, ProfiBus, or Modbus. The production information can be retrieved via an IT protocol, such as RESTful API.

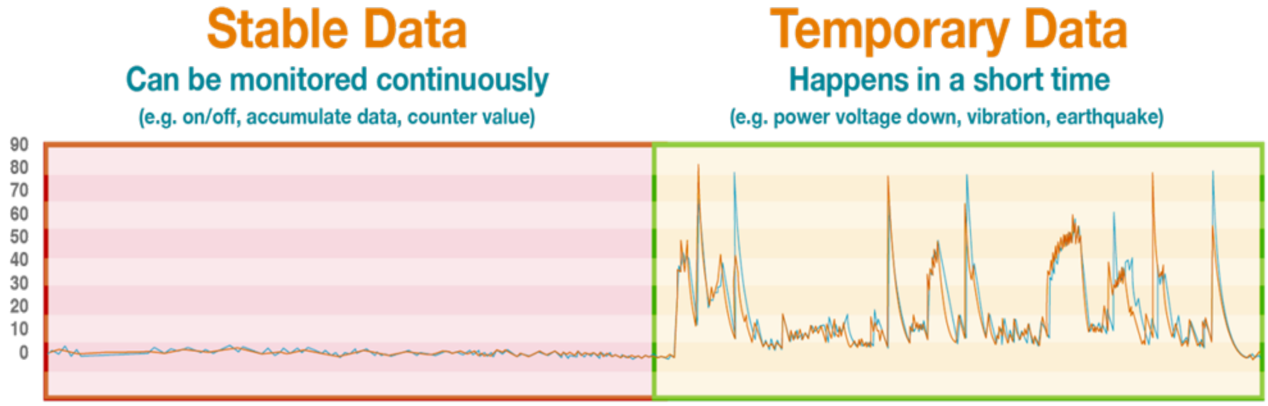


Furthermore, a factory environment presents challenges, such as dust, surge, or vibration, which potentially can damage a controller. So, a ruggedly designed controller is a must for harsh environments.

Solutions to improve the quality output of machines

Perfect production is characterized by zero defects. Once again, production data is the key to achieve zero defects. Two types of data are applicable: stable data (on/off status) and temporary data (generated over short periods and needs to be recorded without missing any parts). When the latter is generated, an alert should be sent immediately to operators that an interruption is occurring. As the production quality is reflected in this temporary data, the challenge is to capture this data precisely.

A ruggedly designed IIoT controller collects precise data in harsh environments to keep line managers up-to-date about the status of all devices in the field.



Conclusion

The real value of OEE comes from interpreting the losses incurred due to availability, performance, or quality. By focusing on these losses, and more importantly, by taking action to reduce these losses, your OEE score will naturally improve. For factories to enjoy optimal OEE, device connectivity is essential in order to collect precise data. Several solutions are available for factories to upgrade their production technology in order to improve the availability and performance rates of their equipment as well as their quality output.

Moxa Solutions

To help you reap the benefits of Industry 4.0, Moxa offers a comprehensive portfolio of solutions that will upgrade your production technology for increased productivity.

- **Industrial Ethernet switches:** The ESD E500 Series supports the V-On function to help physical networks, unicast traffic, and multicast traffic recover within milliseconds when there is a failure on a network.
- **Mobility management:** MXview ToGo, a leading-edge industrial network management mobile application, provides real-time network information to reduce downtime.
- **Serial Device Servers:** Moxa is the leading company to provide complete serial-to-Ethernet device servers

- **Rugged IIoT Controllers:** The ioPAC 8500 programmable controller provides a fast AI sampling rate to collect streaming data for predictive maintenance.
- **Smart Remote IO:** The ioLogik E2200 and 2500 Series provide front-end intelligence to reduce the traffic between field sites and back-end systems for IIoT applications.
- **IT/OT coverage remote IO:** The ioLogik E1200 Series is a multiprotocol solution:IT users can access IO data via RESTful API, SNMP, or MXIO library. IA users can access IO data via Modbus and EtherNet IP.

For more information about these and other solutions, visit
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