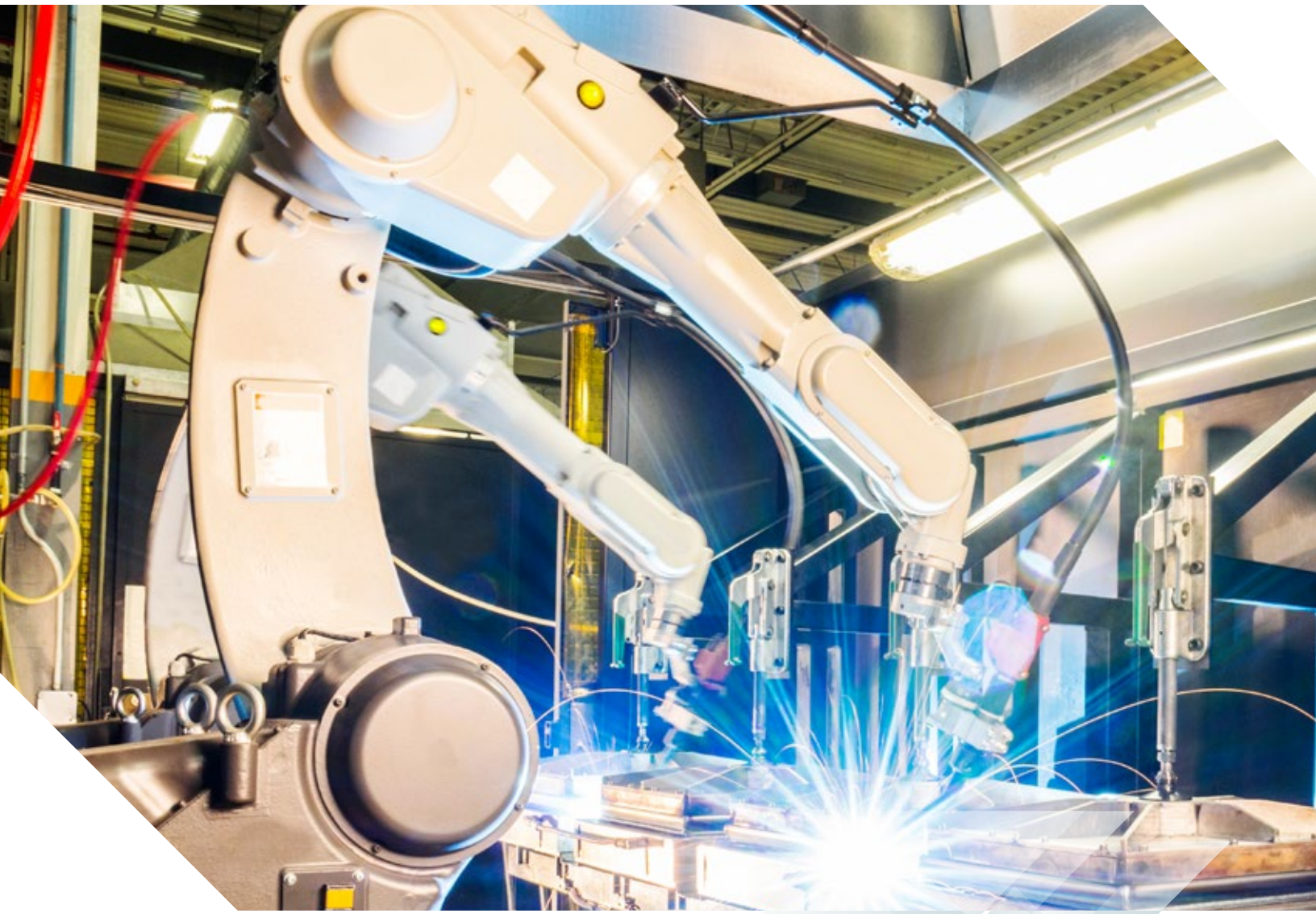
Competing in the 21st-century manufacturing industry

Driving better business performance with Manufacturing Operations Management



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Introduction

Manufacturing in the 21st century is becoming more competitive than ever before with the previously bloated margins steadily decreasing, and the modern manufacturing businesses having to look closely at their efficiencies and productivity and improve them. This quest for improvement is driving manufacturers to re-evaluate the use of known technologies and consider newer relatively untried technologies to introduce some kind of competitive advantage to their organizations.

As we embark on this journey into the 21st Century, we look to Manufacturing and see how this technological evolution has forged a path to digital transformation. Manufacturing, as part of the journey, is being forced to abandon its 20th-century approaches, as the most unpredictable factor that manufacturers faced previously was uncertainty of demand – this has now become uncertainty of raw material supply, a far greater problem. Today, change is coming from many sources, right from technological advances in equipment to advanced digital and analytical techniques that are spurring further innovation. New entrants, using technology that was previously unavailable ten years ago, are entering the market and unless manufacturers respond, they will be overtaken.

The traditional shop floor is changing – becoming faster, more automated, more connected, and working in smaller batch sizes, using smarter assembly. Some manufacturers have realized that these new digital technologies can significantly improve upon costs, productivity, and reduce errors. Unlike the characters in "Who moved my cheese?", they understand that change is happening, and must be prepared to embrace the change to enjoy the benefits it brings.

Manufacturing technology is changing

Manufacturers have been using these newer technologies for several years but have not fully exploited the benefits that can be derived from them. For example, a significant off-shoot of the newer technologies is data-driven decision-making. Many manufacturing businesses, however, do not have an ability to process all the data produced from the factory, leaving a lot of the data untapped. The initial manufacturing execution systems (MES) were created to manage and monitor work in progress on the shop floor. The problem was that these MES systems were unable to integrate data from multiple sources on the shop floor, and nor could they aggregate data in real-time. As a result, the MES had a limited ability to give a comprehensive overview of plant performance as data was siloed, and valuable insights that could be shared with the rest of the organization were lost.

The manufacturing execution system market is expected to grow

USD 11.5 billion in 2021

USD 17.1 billion by 2026

CAGR of 8.3% from 2021 to 2026

Source: MarketsandMarkets - Manufacturing Execution Systems Market
www.marketsandmarkets.com/Market-Reports/manufacturing-execution-systems-mes-market-536.html

The manufacturing efficiency challenge

Manufacturers over the years have continued to strive for operational efficiency, even though a significant improvement would require a fundamental shift in their generic business model. Consequently, methodologies and guidelines proposed by **The Association of Supply Chain Management** (www.ascm.org), are available to aid such initiatives and help businesses adopt best practice. Some manufacturers have implemented programs like Total Productive Maintenance (TPM) and focused on improving Overall Equipment Effectiveness (OEE) with the same aim of streamlining manufacturing process and increasing output.

While TPM is an equipment maintenance model that strives to use everyone to maintain the plant, it also aims to achieve perfect production with no breakdowns, slow running or any other machine related problem that affects throughput. OEE is a metric that measures how well the machine is being utilized (uptime), the speed of the machine (speed) and the quality of the production. OEE supports TPM based initiatives by measuring progress towards “perfect production”.

OEE supports TPM based initiatives

While increasing production efficiency and acknowledging that output is important, many businesses still struggle to measure their downtime. A common belief is anywhere from 5% to 20% of lost productivity is due to unforeseen downtime. By using TPM and measuring OEE, the manufacturer measures what has been achieved but cannot change the outcome. However, this historical information can be used to build a platform to anticipate potential obstacles and minimize future downtime by forecasting productivity and output figures.

With a rigorous TPM program in place, manufacturers can reduce these losses and the initiative can deliver significant benefits. For example:

- Measure Overall Equipment Effectiveness (OEE), Total Effective Equipment Performance (TEEP) and Overall Labor Effectiveness (OLE) and benchmark against world-class standards.
- Increase productivity and reduce costs by focusing on reducing the simple everyday losses.
- Optimize operational efficiencies by systematically improving the core manufacturing activities using a P-D-C-A (Plan-Do-Check-Act) cycle. Focus needs to be on planning the shop floor (Schedule), executing the plan (Do), checking the performance (Collect data from the shop floor) and improving the areas of loss (analyze performance and design improvement programs).

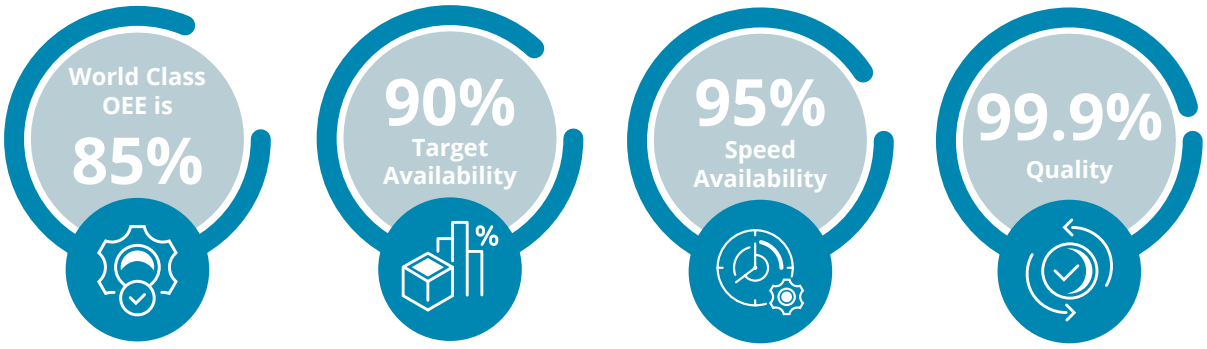
How does OEE assist the factory?

OEE Calculation:

Overall Equipment Effectiveness (OEE) | **Availability** | **Performance** | **Quality**

(uptime of planned running time)

(of machine design capacity – or "nameplate capacity")



The Six Big Losses

Fortunately, a lot of Operations Management Research exists to assist businesses with their "improve" phase. One of these models is the "Six Big Losses" which focusses on the losses directly affecting OEE. Using the "Six Big Losses" model gives the business a starting point and a well-defined template to use. All of these losses are pretty generic and occur in every business, so this is a good place to start for any manufacturing business.

OEE	6 Big Losses Area		Definition
⚠ Availability Loss	1	Unplanned Stops	Equipment Failure accounts for any significant period of time in which equipment is scheduled for production but is not running due a failure of some sort. A more generalized way to think of equipment failure is as any unplanned stop or downtime. Equipment failure is an Availability Loss.
	2	Planned Stops	Setup and Adjustments accounts for any significant periods of time in which equipment is scheduled for production but is not running due to a changeover or other equipment adjustment. A more generalized way to think of Setups & Adjustments is as any planned stop. Setup and Adjustments is an Availability Loss.
⚠ Speed Loss	3	Small Stops	Idling and Minor Stops accounts for time where the equipment stops for a short period of time (typically a minute or two) with the stop resolved by the operator. Another name for Idling and Minor Stops is small stops. Idling and Minor Stops is a Performance Loss.
	4	Slow Cycles	Reduced Speed accounts for time where equipment runs slower than the Ideal Cycle Time (the theoretical fastest possible time to manufacture one part). Another name for reduced speed is slow cycles. Reduced speed is a Performance Loss.
⚠ Quality Loss	5	Production Rejects	Process Defects account for defective parts produced during stable (steady state) production. This includes scrapped parts as well as parts that can be reworked, since OEE measures quality from a First Pass Yield perspective. Process defects are a Quality Loss.
	6	Startup Rejects	Reduced Yield accounts for defective parts produced from startup until stable (steady state) production is reached. This includes scrapped parts as well as parts that can be reworked, since OEE measures quality from a First Pass Yield perspective. Reduced Yield can occur after any equipment startup; however, it is most commonly tracked after changeovers. Reduced Yield is a Quality Loss.
OEE	Fully Productive Time		Actual operating time

(Ref: www.oee.com)

Note – OEE is only measured at the bottleneck as this is where the plant needs to operate at full capacity. All other machines (non-bottleneck) will have idle time while they wait for the bottleneck to clear, giving low "Speed" and low OEE. This is misleading as the speed at the bottleneck is going to be much higher than a machine with available capacity.

A Availability

$$\frac{\text{Total Hours Planned - Lost Time}}{\text{Total Hours Planned}} = \%$$

X

P Performance Rate

$$\frac{\text{Actual Machine Speed}}{\text{Design Machine Speed}} = \%$$

X

Q Quality Rate

$$\frac{\text{Number of Good Products}}{\text{Total Products Made}} = \%$$

The Development of Manufacturing Execution Systems

Manufacturing Execution Systems (MES) are computerized systems used in manufacturing to track and document the transformation of raw materials to finished goods. An MES provides information that helps manufacturing decision-makers understand how current conditions on the shop floor can be optimized to improve production output.

An MES generally works in real-time to control multiple elements of the production process (e.g. inputs, personnel, machines and support services). This made it a useful tool to start capturing information in real-time to measure OEE and proactively begin to reduce the Six Big Losses.

These systems first appeared in the 1990's, and the initial Manufacturing Execution Systems (MES) didn't really deliver on the manufacturers' requirements, especially the need for online real-time data collection, system collaboration and data analysis from a single platform.

Like so many other areas of manufacturing, this technology has been developed significantly in the last few years. There is now even an organization and standards governing the minimum requirements and abilities of the MES before it can be classified as an MES.

The newer MES systems have multiple levels of integration into industry specific systems, making them a critical part of the move to a flexible business-specific platform that measures and collates all of the inputs from the various manufacturing processes. For many businesses, the integration platform is their ERP system.

There are several common elements in an MES solution:

1. Advanced Planning and Scheduling

Planning and scheduling are a major challenge in any manufacturing business. A finite capacity Advanced Planning and Scheduling (APS) solution allows managers and supervisors to create accurate schedules that factor in manufacturing constraints around tooling, machine availability, personnel availability, and inventory. The APS assists production planners to make smarter use of materials and resources, helping them to improve customer service in the most cost-effective way possible.

An APS provides several useful tools:

- **Visual Planning Board** – to define resources and their available capacity using an online production schedule.
- **Dashboard** – to balance equipment utilization, available capacity, and order fulfilment to maximize factory output.
- **Production Plan** – to view and update the agreed production plan, including hours reported, quantities produced, and issues logged.
- **Equipment Plan** – to review the impact of the production plan on equipment availability and expected outputs.
- **Production Status** – to check the status of open jobs, have visibility of hours booked, materials issued and overall progress.
- **Material List** – to view specific material requirements of the individual resources.
- **Job Lists** – to monitor how jobs are progressing against their deadlines.

2. Shop Floor Data Collection

Production managers need real-time visibility of the shop floor to prevent losses such as overruns, bottlenecks, unplanned downtime, poor employee or machine performance, or excessive scrap. Previously this data was collected on paper reports – which was time-consuming and expensive to produce and read. Being on paper made it also inaccessible for analysis using any of the new analytical tools as they need the data in a digital format.

A Shop Floor Data Collection (SFDC) solution connects staff and equipment to the published schedules and collects progress against the schedule electronically, and collects the data automatically. The first step toward Industry 4.0 requires the collection of data in digital format so that it can be analyzed. The Digital Transformation refers to this as digitization of the shop floor, an Industry 4.0 cornerstone. The data can then be manipulated as required, giving real-time shop floor visibility.

Once this process has been implemented, production plans can be steadily improved and better executed through the improved capturing and measuring of labor hours, materials issued, setup times, quantities reported, scrap, etc.

There are standard elements to a SFDC solution:

- **Workbench** – to collect shop floor data from employees and equipment in real-time. Data can be used to calculate a range of measures like overall equipment effectiveness (OEE) and overall labor effectiveness (OLE).
- **Dashboard** – a high-level view of orders, products, employees and equipment.
- **Employee Status** – a real-time view of the current status of staff and their workbenches, the jobs they are currently running, and their performance during their shift.
- **Equipment Status** – real-time view of equipment status, what jobs are currently running, and how they are performing.
- **Job Status** – review of open jobs, track hours booked, and materials issued against that job, as well as overall progress of the job.
- **Transaction Review** – review and approve transactions generated via a workbench or entered from timesheets.
- **Employee Performance** – provides an analysis of each employee's equipment performance and the issues encountered that have affected the employee's performance.
- **Equipment Performance** – provides details of individual equipment performance and the issues encountered by that machine.

3. Factory automation

Connecting machines and other devices to digitize the factory is the starting point of any Industry 4.0 journey. An MES solution provides an integration platform to connect machines, gather critical data from those machines and analyze it. This allows better decision making and improves organizational effectiveness and optimization.

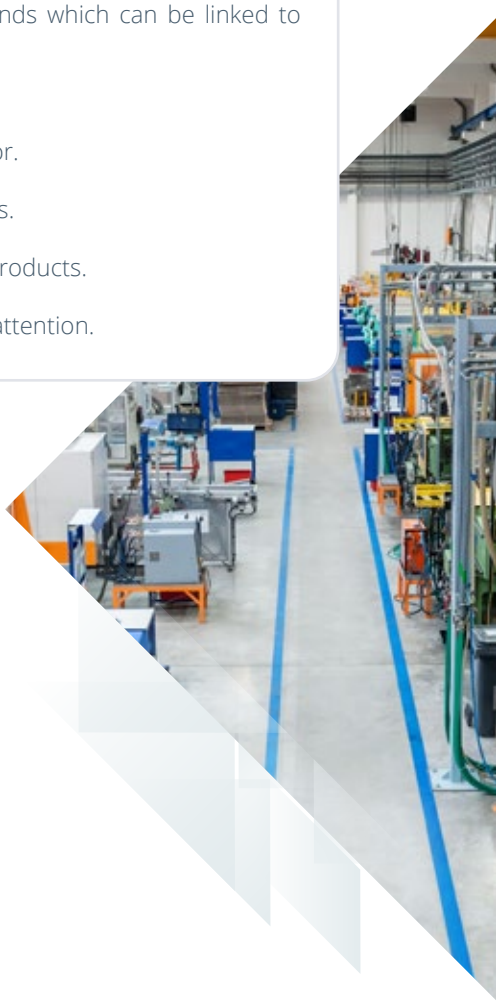
The most common approach to digitizing the factory is to use the Open Platform Communications (OPC) protocols, an industry standard for data exchange between different machines. The modern machines are already configured for digital data collection, while the older machinery may not have this capability. A stand-alone digital system with sensors will need to be added to the machine to capture the required data.

4. Factory performance

Using an MES solution will assist the manufacturer to continuously improve their processes while aiming for best-in-class standards. The data and analysis will identify areas of improvement, especially the Six Big Losses, and measure their improvement over time. Often the data will be presented as time series graphs allowing identification of trends which can be linked to individual activities or products.

The typical benefits of an MES solution are:

- Measure labor and machine costs by shift, product, or operator.
- Identify unnecessary downtime and help to reduce bottlenecks.
- Measure product quality and highlight problem machines or products.
- Measure operational efficiencies and highlight areas needing attention.



Most importantly an MES solution provides an overall view of the manufacturing operations. The ability to monitor and analyze multiple plant variables simultaneously helps manufacturers find previously invisible problems and helps to identify initiatives to improve the performance of machines and processes.

An MES solution helps organizations to generate accurate production schedules that consider capacity constraints like people, machines, tooling, materials, etc. and can help identify production lines that need to be rescheduled to match changing customer demand, balancing available capacity. The end result is an improved delivery to customers on-time, and in full.

The Next Generation: Manufacturing Operations Management (MOM)

The MES has now evolved into a more complete offering for the manufacturer – the Manufacturing Operations Management (MOM) solution. This is a collection of inter-connected systems for managing the end-to-end manufacturing process. There are many different types of MOM software, ranging from basic production management, performance analysis, quality and compliance, to the human machine interface (HMI).

- The Production Management software provides real-time information about jobs and orders, labor and materials, machine status, and product shipments.
- The Performance Analysis software displays metrics at the machine, line, plant, and enterprise level for situational and historical analysis. This is similar to the MES functionality.
- Quality and compliance software are used to promote compliance to standards and specifications for operational processes.
- The Human Machine Interface (HMI) software is the most advanced form of manufacturing operations management (MOM) software, and enables operators to connect and manage industrial and process control machinery using a computer-based interface.

Manufacturing Operations Management (MOM) encourages businesses to break down the siloes that exist between departments and to focus on optimizing operations. It uses a manufacturing lifecycle approach that integrates the core manufacturing activities (schedule, publish, collect, track, analyze and improve) and allows them to be viewed from within a single platform.

Advancements in technology combined with specific market demands are enabling new capabilities to be added into the MOM solution, closing the gaps identified by the end-users.

There are a range of key capabilities that are part of the solution:

- **Collaboration Capabilities** – collaboration and workflow services support people-to-people, people-to-systems, and systems-to-systems interactions, ensuring procedures and rules are followed while allowing the solution to adapt to real-time situations and use alternate workflows and processes to mitigate potential problems.
- **Security Services** – the MOM solution is expected to leverage the ERP's security protocols that determine roles, responsibilities, authorities, and allow access to other capabilities and applications, while complying with the corporate IT security configurations.

- **Asset & Production Model** – the MOM solution should offer a unified asset and production model that supports all of the business's unique interrelationships between the physical production equipment, facilities, inventory and people, as well as production definitions such as the manufacturing bill of materials, productions orders, etc. The older systems had subsets of these interrelationships across multiple databases and could not effectively deal with federating across multiple systems of record. At SYSPRO, our ERP is seen as the integration platform for the SYSPRO MOM solution.
- **Operations Database and Archived Database** – the older systems had separate archives and live production databases that made the consolidation of information difficult, while the newer platforms have a unified archive and operations database. This will capture and aggregate all production data for each product and production run with a full history of materials and performance information collected from all of the other systems and devices.
- **Visualization and Mobility** – the current MOM solutions support different graphical user interfaces, Web interfaces, specific mobile applications, etc., providing common visualization and mobility for a consistent User Experience (UX). The focus on a consolidated set of capabilities i.e. consistent workflows and procedures, with a common and intuitive User Experience is expected of a MOM solution.
- **Smaller and Focused "Apps"** – being able to take advantage of many of the common software platform services, modular apps will become the preferred approach due to their significantly smaller size, simpler to use, and focused functionality. While these apps will be smaller and quicker to operate while delivering the required functionality, they will be significantly easier and faster to develop.

MOM works best with ERP

Early versions of a MOM solution ran independently alongside other software like the ERP. MOM was seen as a costly addition to the manufacturing infrastructure, requiring expensive additional training to run it effectively. They were also seen as independent systems that required costly experts to integrate them with the other business systems, like the ERP, as well as requiring costly experts to maintain it.

A MOM solution performs better as part of a unified ERP system, providing updates to the ERP as transactions occur, allowing manufacturers to have a consolidated system of record for all business transactions. This is very important to business leaders as there should only be a single source of the truth. Having different systems may lead to reporting of different results for some areas, making it difficult to reconcile differences and agree on the problems.

Most importantly, with an integrated MOM solution, there is also a single system to measure the entire shop floor and unambiguously report performance. The basic process is:

- Manufacturing transactions are created in the ERP system, creating information such as production demand, master schedules, bills of material, change orders, inventories, planned resources, and performance metrics.
- The ERP data is then passed to the MOM solution to produce the optimum plan for production. The planning and scheduling of the manufacturing resources is completed in the MOM solution.
- The MOM solution then tracks production performance, while feeding back updates such as order status in real time to the ERP system. Managers are then able to monitor plant performance and progress of jobs through production.
- When the job is completed, the MOM solution then updates the job information in the ERP solution with the required information like resource usage (labor, equipment, materials), machine efficiencies, costs, etc.

As time and the industry has progressed, better MOM solutions have been developed. SYSPRO has an industry-focused MOM solution, SYSPRO Manufacturing Operations Management (MOM) that is fully integrated into the SYSPRO ERP system, operating as the integration platform for the manufacturing data. This introduces a huge range of benefits for the business:

- By having access to up-to-date production information, the sales team is better positioned to provide accurate delivery estimates to customers.
- By integrating inventory and production, it allows the business to keep the minimum amount of a raw materials and completed product in warehouses, reducing warehouse space, and costs of upgrading the raw materials.
- With knowledge of raw material demand in production together with raw material availability, the procurement department can procure with greater accuracy and more timeously, thus avoiding sudden and costly expediting of orders. It also leads to a "just-in-time" delivery process improving cash flow.
- A MOM solution makes it possible to align manufacturing and supply chain operations, aligning manufacturing KPIs with other business objectives.
- An integrated MOM solution within your ERP enables data to be gathered from different sources and consolidated into the ERP. This allows for it to be analyzed on the company-wide analytics solution giving "a single source of the truth" for decision making. This improves decision-making within the business.

Selecting an ERP system with an integrated MOM solution enables manufacturers to reduce cost and time to implement the solution, rapidly deploy it across the business, collect data easily while ensuring data integrity and security. There should also be an improved ease of use due to the single system.

Where is manufacturing going?

The manufacturing sector has begun its digital transformation journey as part of the move to Industry 4.0. Industry 4.0 is built on a growing need to gather and analyze data based on the business operations looking for previously unidentified trends and information. This will require the business to digitize both machines and the workforce i.e. collect information in digital format to allow analysis. With this is the requirement to digitalize the shop floor i.e. leverage the digital data to improve operational performance and efficiency while reducing costs of manufacture. The next step in the journey is the development of the "Smart Factory", a factory that only produces exactly what is required.

Digitalization of the shop floor, should be a priority on every manufacturer's "To Do" list as it is the foundation to build the next generation of Smart Factories. The manufacturing world is moving to a scenario of Smart Factories; factories interconnected with factories and interconnected with the supply chain. By receiving the exact demand from the supply chain, it orders the raw materials it needs from the other factories and produces exactly what is required. A useful example is to imagine if your refrigerator monitors your quantity of milk, knows your daily consumption, and automatically orders milk when you run low. The milk will automatically be delivered to your door in an autonomously driven delivery vehicle.

Simply put, the next generation of manufacturing plants are based upon the digitalization of the shop floor to support a production process that is connected, agile, and proactive. Increased connectivity and more effective use of data means improved raw material utilization, asset efficiency, less downtime, better capacity planning, and ultimately more value created for the customer.

Far from being an end state, the Smart Factory concept is an evolving solution. It is seen as an investment objective that authorities and manufacturers are increasingly agreeing is essential, yet many manufacturers are understandably concerned about preserving cash, while the investment is important to their survival.

Our recommendation remains:

1. **Start small**
   – build a small-scale project to help you understand the technology.
2. **Decide what is required**
   – be specific about what data you require, or you will quickly find yourself flooding the business with data that is not required or used.
3. **Understand what is possible**
   – there will always be constraints whether it is in the machine, the data you require is not available or similar.
4. **Scale up**
   – once you have understood what can and cannot be done, what is worthwhile and adds value, then scale up from there and expand the initiative to other machines and eventually the whole factory.

In preparation for the change, manufacturers should also begin encouraging a culture that sees data as an asset for better decision-making. With a central database provided by an ERP system, and with integrated MOM system in place, manufacturers can begin accelerating their move to a Smart Factory.

The process of digitalizing a manufacturing operation will enable the possibility of entirely new categories of products and creating new alternatives for customers, while keeping ahead of existing and new competitors.

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