



Industry 4.0 Brings Total Productive Maintenance into the Digital Age

Industry 4.0 is disrupting manufacturing on multiple fronts – from production throughput, predictive maintenance and quality, to supply chain and inventory management.

While this wave of innovation is being greeted with much enthusiasm by a traditionally conservative industry, a clear strategy for deployment and ongoing management is required to successfully adopt Industry 4.0 technologies.

Total Productive Maintenance (TPM) is a lean manufacturing approach – developed in Japan in 1971 and widely used today – which is being proposed as a strategy that is well suited to the smart factory and its [IoT use cases](#).

In this article, we'll cover:

- The fundamentals of Total Productive Maintenance
- How TPM is enhanced by Industry 4.0 technologies
- Choosing a pilot for TPM implementation in the smart factory

What is Total Productive Maintenance?

In a nutshell, Total Productive Maintenance is a system for optimizing maintenance and reaching a state of perfect efficiency in production.

TPM focuses on driving efficiencies by organic means ie. by using existing company resources.

The main goals of Total Productive Maintenance are:

- No short stoppages or sub-optimal production rates
- No defects
- No unplanned downtime
- No accidents

A photograph of a wind farm at sunset or sunrise. The sky is a mix of orange, yellow, and dark blue. Several wind turbines are visible, their silhouettes against the bright horizon. The water in the foreground reflects the light from the sky and the turbines.

The Origins of Total Productive Maintenance

The TPM approach is credited to [Nippondenso](#) (known today as Denso Corp.), a company that created parts for Toyota.

Dissatisfied with preventive maintenance methods carried over from the United States in the 1960s, [Seiichi Nakajima](#), considered the founder of TPM, promoted the idea that factory workers should take on a wider range of responsibilities regarding the upkeep of machinery.

Instead of every machine/production line having separate employees for operation and maintenance, employees would be trained with the tools and knowledge to do both, giving them a more holistic approach to ensuring machine health.

The TPM methodology creates a shared responsibility amongst factory workers and an increase in morale and pride in the efficiency and condition of machinery and production.

5S – The Foundation of Lean TPM

TPM has as its foundation in another management methodology, also originating from Japan, known as **5S**.

5S is focused on organizing the workplace environment to improve efficiency and effectiveness through 5 main activities:

Sort (Seiri)

Action – the equipment and materials in an area are sorted, with unnecessary items moved to another area or disposed of.

Result – reduced clutter makes inspection easier, frees up available space, and makes things easier to find.

Set in order (Seiton)

Action – Tools and equipment are placed in a way that suits the work. Tools that are most frequently used are easiest to reach, and storage is marked to make it easy to return items to their designated spots.

Result – Smoother workflow.

Shine/Sweep (Seiso)

Action – Work areas, tools, and machinery are cleaned and inspected regularly.

Result – Slower deterioration of equipment and infrastructure, and improved safety.

Standardize (Seiketsu)

Action – Employees are informed of the different procedures in detail and provided with an organized schedule, clear instructions and necessary on-site visual aides in the form of markings, photographs, and illustrations.

Result – Procedures covering the first 3 “S” practices are scheduled, performed regularly, and monitored.

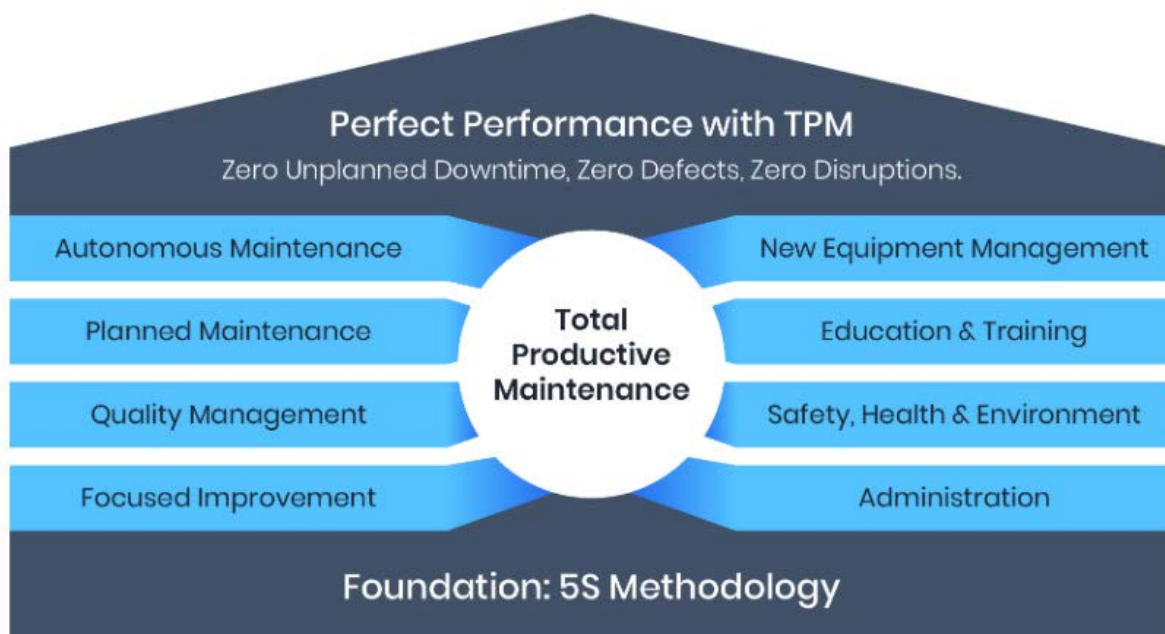
Sustain/Self-discipline (Shitsuke)

Action – Training sessions are set up and regular monitoring is done to ensure compliance.

Result – The 5S methodology is followed not because workers are told to, but because they choose to, initiating additional improvements through experience.

Industry 4.0 & The 8 Pillars of Total Productive Maintenance

With 5S as a foundation, TPM proposes an 8-pillar approach that aims to cover every possible aspect of maintenance in the industrial manufacturing setting.



Here is an outline of these 8 pillars along with how Industry 4.0 can take this approach even further:

1. Autonomous Maintenance

Probably the most unique characteristic of TPM – the idea here is that the people working with a machine on a day-to-day basis are the most “in-tune” with its behavior and performance.

Operators are trained to claim “ownership” over their machines, taking care of routine maintenance activities such as cleanliness, lubrication and inspection, and should be the first to attempt handling issues within the realm of their training, before calling upon expert technicians.

With Industry 4.0: As machines become more automated, monitoring improved, and dashboards easier to read, operation will become less complex making the “ownership” suggested by TPM much simpler and therefore more accessible to workers.

2. Planned Maintenance

Maintenance preempts malfunction while interventions by high-level technicians are carefully planned so that minimal downtime is required for any software updates or part replacements.

With Industry 4.0: Using predictive maintenance by means of **machine learning**, maintenance activities are only performed when necessary and can be timed to avoid downtime completely.

3. Quality Management

Workers are trained and encouraged to identify issues in production that ultimately lead to defects and quality issues.

With Industry 4.0: Enter “**predictive quality**” – sensor data and machine learning help identify anomalies in machine behavior, alerting operators, who can then perform focused **root cause analysis**. Problems can be corrected much earlier than what was previously possible, reducing the financial damage of quality deterioration and defects.

4. Focused Improvement

Cross-functional teams are formed and proactive involvement is encouraged. Problems affecting production are tackled by workers who start with the major hindrances/showstoppers, moving down to more minor inefficiencies.

With Industry 4.0: Through organized data collection and the application of artificial intelligence algorithms (eg. artificial neural networks), less obvious correlations between defects and root causes can be exposed. Inspection information and hypotheses can be shared company-wide, allowing for better synchronized and more successful collaboration.

5. New Equipment Management

The design and installation processes of new equipment should be planned based upon previous experiences to ensure that performance targets are reached quickly with minimal startup issues and for improved safety.

With Industry 4.0: Production data in historian systems can be analyzed to identify best practices from previous installations/designs while taking into account current plant/factory conditions.

6. Education & Training

See Pillar 1 – operators receive training giving them the necessary skills to maintain machinery and identify problems. In turn, maintenance technicians learn approaches to more proactive work while managers are encouraged to improve leadership skills.

With Industry 4.0: **Digital Twin visualization** provides an excellent opportunity to learn about the complexities of manufacturing on all levels: from components and machines to production lines and overall facility management.

Educational content can be online and available to employees 24/7. Novice personnel can be assigned experienced mentors who can have access to their activities and be available to answer queries.

7. Safety, Health & Environment

A safer work environment is created by identifying health risks and potential hazards and working to eliminate them. Uncomfortable conditions harm productivity and employees should not be expected to be productive while at risk.

With Industry 4.0: Sensors can measure air quality, radiation, temperature and other environmental conditions which may affect health and performance while the early detection of harmful gases, electrical surges and fire can save lives and prevent damage to equipment.

8. Administration

The TPM approach can be applied to systems that aren't directly involved in manufacturing, including office administration. The significance of including administrative functions as one of the eight pillars is that this level of management – order processing, scheduling, workforce management, accounting – should be in sync with the other facets of the facility through effective communication, transparency and tried and tested protocols.

With Industry 4.0: **Artificial Intelligence algorithms** are very well suited to analysis and decision-making processes making this technology extremely advantageous to office automation.

Office automation is destined to develop and will include demand forecasting, intelligent pricing, and smart purchasing and outsourcing.

According to the Total Productive Maintenance approach, achieving excellence in each of the 8 pillars mentioned above is verification that a manufacturing facility is producing “World Class” results.

OEE & TPM

TPM gave birth to one of the most widely used KPIs in manufacturing – Overall Equipment Efficiency (OEE).

OEE is an important metric in TPM, used to gauge the facility's overall efficiency status.

If we take a look at the goals we previously outlined for TPM, it becomes apparent how these line up for OEE calculation:

TPM Goals	OEE Calculation
No downtime	Availability
+	+
No short stops or slow production rates	Performance
+	+
No defects	Quality
=	=
World Class Results	OEE



Applying Smart Factory Solutions for Next-Level TPM

When implementing TPM in Industry 4.0, it's a good idea to start with a proof of concept, analyze, and then scale up to bigger challenges. Deciding upon the right pilot is an important first step in the implementation process.

Consider these 3 levels of complexity when choosing a TPM pilot for your Industry 4.0 project:

1. Simple Improvements

- Pros

Initiating a small improvement is a good opportunity to score a “win” in a short amount of time and doesn't require a deep level of TPM knowledge. This is a good pilot type for recruiting stakeholders and building confidence in the process right from the start.

- Cons

Making only a small improvement will result in a relatively low ROI for the project and won't yield that much information on the TPM process.

2. Optimization

- Pros

By addressing a bottleneck in your production line or relieving a constraint, you'll see an immediate increase in total output.

- Cons

Focused optimization may require some planned downtime for experimentation and analysis and there is the risk that you may not achieve a measured improvement on the original output rate.

3. Solving a problem

- Pros

Solving a longstanding issue with a machine/process will garner support for TPM implementation and will be received well by operators.

- Cons

ROI might be relatively small. Also, a complex problem might be too much of a challenge as a starting point, causing the project to lose momentum.

The Impact of Industry 4.0 on Total Productive Maintenance

As Industry 4.0 advances, further disrupting the way products and materials are manufactured and the market itself, new factory/plant management issues will arise.

To meet these challenges, managers will do well to make use of methodologies such as TPM to smoothen the transition into Industry 4.0, and to ensure bottom-line impact through improved output rates, quality, and customer satisfaction.