CAR Master training

CONTENT UNIT 1

PRINCIPLES OF TOTAL PRODUCTIVE MAINTENANCE

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1 Principles of Total Productive Maintenance

1.1 The introduction

The topic

More than a hundred years ago, the Ford Model T started an industrial revolution. It was not so much the car itself that triggered it, but the way it was produced. To give as many people as possible the opportunity to own their car, the entrepreneur of the time, Henry Ford, came up with a production system that was as cost-saving as possible - modern assembly line production was created.

Then as now, it is primarily the automotive industry that promotes innovations and technologies along the assembly line. Whereas a hundred years ago people still carried out the individual steps along the production line manually, in modern factories it is mostly robots that are automated and work tirelessly.

The tasks of assembly line production are predominantly the following: to produce as much as possible in as short a time as possible - or other words: maximum efficiency with as little downtime as possible. Because in technologically increasingly complex production lines with sensitive profit margins, it is critical for success that the "plant runs".

In this unit, you will learn which methods are used in the automotive industry today to ensure and improve efficiency along production lines. After completing the module "Principles of Total Productive Maintenance" you will know and be able to:

- the basics around maintenance
- describe maintenance strategies
- the economic importance of maintenance
- describe typical weak points
- the most important basics of Total Productive Maintenance (TPM)
- the 8 pillars concept of TPM
- goals of TPM
- the 5S method
- the most important basics of people management under TPM
- the concept of autonomous maintenance
- how to introduce the concept of TPM to employees
- how to delegate tasks
- the concept of autonomous maintenance

1.2 Maintenance strategies

If there is one thing that should be avoided in the industrial production of cars, it is idle time - i.e., the time during which individual stations or even the entire production process is at a standstill. This is critical because in the automotive industry, due to the short cycle times, even a few minutes of idle time at the end of the day means that many fewer cars leave the factory than planned. This happens, for example, when machines are defective, or errors occur because individual work steps are not well coordinated. The term **maintenance** is therefore a very important one in the automotive industry. It is even regulated by its DIN standard, namely DIN 31051.

Note

Maintenance according to DIN 31051 is the **interplay of all technical, administrative and management measures** so that an "object" (in our case an entire production plant) performs its function properly - what is meant here is the **preservation of the** function as well as a possibly necessary **restoration of** the function.

Maintenance can be divided into **four basic measures:**

1. **Maintenance:** These are all activities that serve to ensure or extend the "life expectancy" of objects (for example, filling up operating materials, replacing, or readjusting wearing parts, but also cleaning).
2. **Inspection:** These are all measures for recording and assessing the current condition of an object.
3. **Repair:** These are all activities to restore the defined target state of a defective object.
4. **Improvement:** This refers to all measures that serve to eliminate possible weak points or to generally increase the reliability of an object.

The goals of maintenance can be manifold. In the automotive industry, the following factors are particularly important:

- Optimization of the operating processes to be able to produce faster and more error-free
- Increasing plant availability to be able to produce more and longer
- Minimize breakdowns as well as disruptions to reduce standing and downtime
- Maintaining operational safety to prevent injuries and accidents

Note

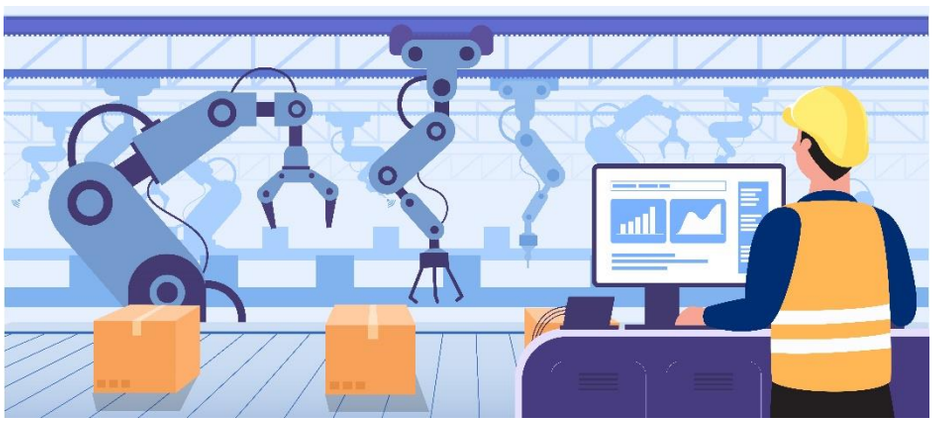
While the technologies and methods surrounding production processes are constantly becoming more modern and complex, the principles of maintenance described above have hardly changed over the past decades. However, the impending consequences of poor maintenance have become much more serious. Production downtime and the resulting overtime costs for personnel can quickly become very expensive.

To be able to implement the above-mentioned measures and goals in a meaningful way, there are various maintenance strategies. These can be divided into three different approaches:

1. The damage-dependent maintenance strategy
   Here the focus is on damage repair - that is, measures are only taken when there is already damage to the object, or it has failed. Such a strategy is pursued when no information is available about the condition or wear and tear of the object. The disadvantage is, of course, the unpredictability of the potential failure as well as the possible long waiting times if spare parts or replacement machines are missing.

2. The preventive maintenance strategy
   Here, preventive maintenance is ensured with planned and regular measures already during the regular operation of the object. This makes downtimes easier to plan and reduces the risk of failure. A disadvantage here, however, is that work equipment is not necessarily fully utilized at fixed maintenance intervals (e.g. an oil change). This can be remedied by a condition-oriented approach, in which regular inspections are carried out, but the maintenance measure is only carried out when necessary.

3. The predictive maintenance strategy
   This is an extension of the two previous maintenance strategies. Based on various influencing factors, an attempt is made to predict the course of wear and to find the most efficient times for the necessary maintenance measures. In doing so, measures can also be bundled, and work resources can be used more efficiently.



Unlike in the past, maintenance measures and strategies in most companies are no longer seen as a necessary evil or even a mere cost generator, but **as an essential part and driver of corporate success**. Due to the ever-increasing competition in terms of productivity and quality, downtimes must therefore be kept as low as possible, as they can have serious economic consequences for a company.

Important

Due to the great economic importance, **internal know-how about efficient maintenance** is becoming **increasingly important in** companies. What counts here above all is an experience in daily use, because it is not uncommon for **problems to arise in practice that were** not yet recognized by the manufacturer of the machines.

An important point of maintenance here is the search for **possible weak points in** the production process - i.e. circumstances that lead to failures particularly often, but also make maintenance more inefficient. The most important are:

- **Handling of spare parts**: Spare parts are stored in an unsystematic or non-transparent manner.
- **Incomplete documentation:** The documentation of all current or past work is either not done at all or only on paper - an allocation or data selection, for example in the sense of the predictive maintenance strategy, is therefore not possible.
- **Lack and transparency of key figures:** Instead of determining precise key figures for maintenance measures, inaccurate or only makeshift data is used. This makes it difficult to plan preventive measures or their costs.

- **Inaccurate strategy:** No clear maintenance strategy is defined that is coordinated across the company.
- **Isolation of the department concerned:** technical staff act too autonomously instead of in close cooperation with production staff as well as maintenance staff.
- **Too much external maintenance:** If there is no internal maintenance know-how, the company becomes dependent on an external service provider, which makes it difficult to react quickly to failures.

1.3 Basics of TPM

Total Productive Maintenance (usually simply called TPM) is a particularly comprehensive and popular programme to promote continuous improvement in all areas of a company.

Especially in the automotive industry, TPM is used to support the success driver for a company already mentioned above: namely, a **trouble-free production system without losses or waste** with as few defects, downtimes, accidents as well as quality losses as possible.

Excursus

Where does TPM come from?
Do you remember the preventive maintenance strategy? This approach was popular in America in the mid-20th century under the name "Preventive Maintenance" - so popular that Japanese companies began to adopt and adapt this concept to prevent operational failures.
Over the course of several decades, this led to the development of various maintenance concepts, which were brought together in TPM from the 1970s onwards. Related to this are the concepts of **Kaizen** and **Lean Production**, which were also developed in Japan and are based equally on continuous improvement and the avoidance of weak points.

In TPM, eight different "pillars" are defined, each of which is to be built up and further developed in the company. These pillars are:

Continuous improvement

This basic principle of quality management provides for continuous improvement in smaller steps (comparable to the previously mentioned Kaizen), carried out by working groups or teams. The flexibility and interaction of the employees in the company should also be promoted. Important support for action is the so-called PDCA circle:

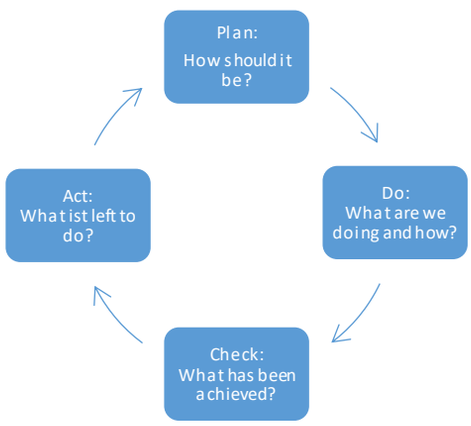


Figure 3 (created with Smart-Art in Word)

Autonomous maintenance

The staff that operates the system should be largely trained in the functioning and maintenance tasks of the system in question. In this way, they can independently carry out simple maintenance tasks such as inspecting, cleaning, and lubricating, as well as smaller maintenance tasks. Standing and waiting times can thus be greatly reduced.

Planned maintenance

This is a method of the already mentioned predictive maintenance to ensure the highest possible availability and the failure safety of all machines and plants. This is proactively improved through planned downtimes.

Competence management

This pillar is also called "training and education". The competencies of the employees at the plants in terms of TPM are to be ensured on three levels: professional (i.e., technical knowledge), methodological (the knowledge about the correct implementation of TPM) as well as social (working in a team).

Start-up monitoring

This aspect concerns the phase from the first prototype development to the production capability of the final product. TPM aims to achieve a "start-up curve" that is as vertical as possible, i.e. essentially to be able to meet new market demands as quickly as possible.

Quality management

Using this pillar, one deals with the minimization of quality defects - both in the end product and in the plant itself. Errors that occur in production should be recognized and eliminated. An important keyword here is the so-called "Poka Yoke" - this means the avoidance of unintentional errors through the approach that each tool and each process can only be used correctly in one way.

TPM in administrative areas

This pillar also deals with the implementation of TPM in company departments that are not directly involved in the production, to minimize losses and waste there as well - for example in purchasing, logistics or human resources. A classic example is a tidy office workplace. The 5S method, which we will look at in more detail below, is popular here.

Occupational safety, environmental and health protection

This pillar concerns the sensitization of employees to potential hazards and risks in the work environment. The aim is to reduce accidents affecting the staff or the environment to zero or to minimize the consequences by practising emergencies.

Important

To be able to use TPM in the company, key figures are indispensable. These form the benchmark for all activities. The most important key figure is the so-called **total plant effectiveness** - essentially the total added value of the plant.
Depending on the company, there are also the following key figures that can be consulted and adapted accordingly: **Productivity** (e.g., value-added per person), **quality** (e.g. how often a defect occurs), **costs (e.g.** maintenance costs), **delivery** (e.g. quantity of stock), **safety** (e.g. several accidents) and **morale** (e.g. a number of suggestions for improvement from employees).

Example

A company manufacturing mainly transmissions (manual and automatic) and engines (petrol and diesel), with 75 employees, started its lean journey when one of its customer's engineers visited the facility and made a recommendation to implement 5S. The company has also standardized the way components are handled, the bench layout, workplaces, and the tooling that is used. An employee can now move from one workbench to another and recognize everything that is there. Workbenches are dedicated to particular product types. Different baskets for different gearboxes have been designed to standardize transportation boxes. The company keeps all components from each gearbox in a single storage tray. This helps to control the process and ensure that respective components will be remanufactured. Moreover, it also allows simple identification of which components were removed from the core and which must be replaced with new parts.

The pillars of TPM just described having **a clear goal** - to eliminate the 16 so-called "JPIM loss types". These **loss types were** developed by the Japan Institute of Plant Maintenance and defined in a scheme to make it **easier to name inefficiencies in companies**. They are an essential basis of TPM and are also used in other process improvement strategies.

The 16 types of loss concern all factors that cause malfunctions and stoppages in machines and processes and are divided into three main categories:

1. Machinery and equipment
   Eight types of loss that can affect the efficiency of the production system are listed here. These are also referred to as major loss types: **Equipment breakdowns**, **changeover** and **adjustment, tool change**, **start-up losses**, **short stops** and **idling**, **speed losses**, **scrap and rework**, **planned stops** and **shutdown**.

2. Employees
   These five losses concern the efficiency of human labour in the process - i.e., the working time of all employees used productively. These are **Management losses** (i.e., inefficient management), **movement** (concerns the arrangement and flow of the workplace), **line organization** (i.e. the coordination of production lines with each other), **logistics,** and **measuring** and **adjusting** during quality controls.

3. Resources
   These last three types of losses hinder the efficient use of production resources. These are **energy losses** (for example, when conveyor belts run unnecessarily), **quantity losses** (wastage of maintenance supplies such as lubricating oil), and **moulds**, **fixtures** and **tools** (for example, when product changes require new tools).

Note

The previously mentioned losses also want to be measured in figures. In very modern industrial companies (also called "Industry 4.0"), this is already done **automatically via process data management systems that are** fed directly from machines equipped with sensors. In less modern companies, the data must be collected manually by employees.

Example

They have a reaction plan available **in Jaguar Land Rover Slovakia** to anticipate situations that may arise in production and interrupt production. It is **a document** containing the escalation procedure, and what a given worker – operator, group leader, senior production leader, senior production leaders, and managers – should do in a given situation. According to the criteria, e.g., Problems with parts (threat of interruption of production), in case there is a shortage of parts (< 20 pieces), the document contains instructions on **how to escalate** and **what to do specifically**, i.e. assigning a task to a given worker (e.g. operator, group leader – checking the current stock inventory on the line). This greatly increases responsiveness and reduces reaction time. Thanks to this plan, **leaders at different levels can react quickly in a given situation** and work **quickly to eliminate the problem**. This reduces the time for downtime, or even prevents downtime. Thanks to the immediate reaction, the escalation is moved on to the support department, which immediately communicates with the suppliers and solves the possible consequences (non-delivery of parts, delivery of damaged parts...), which makes it possible **to flexibly plan imminent shutdowns or downtimes**. It is also a tool for **safety awareness**, where in the event of an accident there is an automatic escalation to the remaining departments, so we can prevent possible further similar accidents.

One principle of TPM is the continuous improvement of the working environment - this also requires the commitment of the employees themselves. A systematic approach that can be implemented in all areas of the company is the **5S method**.

This should help to **minimize all non-value-adding activities** (in the sense of TPM, i.e., waste of working time) at one's workplace (whether producing at a production line or administrating at a desk).

Note

The five "S" are derived from the Japanese terms “Seiri”, “Seiton”, “Seison”, “Seiketsu” and “Shitsuke” - of course, you don't have to memorize them. But they can also be translated appropriately into English: sort, set in order, shine, standardize, and sustain.

The elements of the 5S method are as follows:

1. S like sort
   In this step, all elements that are not needed for the work should be sorted out - this should increase the clarity at the workplace and create more space for actually necessary material or work equipment.
2. S like set in orderr
   A system of all work equipment and materials is introduced, ordered according to aspects such as sequence, frequency of use or ergonomics. Markings on, for example, the tool and its storage location should help to quickly recognize deviations from the system.
3. S as in shine
   The work area should not simply be kept clean - in the course of cleaning, the cause of soiling should also be inspected and whether it can be avoided in the long term. The target condition is also compared with the actual condition of the work equipment and any deficiencies are identified.
4. S for standardised
   By arranging work equipment, markings and cleaning schedules across work areas, workplace changes should be able to be carried out as efficiently as possible (to minimize familiarization times).
5. S as in sustain
   This point essentially concerns the actions of the employees - only if they independently and conscientiously observe the rules and apply them constantly will the 5S method be successful in the long term.

1.4 Delegation of employees at TPM

The key point about TPM is that its pillars and actions are not the responsibility and implementation of management alone or individual employees. TPM can only work successfully if it is understood and lived by every single person in a company - in other words: if it becomes part of the corporate culture.

An important task of management is therefore to communicate TPM to employees and to delegate the tasks and approaches that go along with it. After all, it is no longer management that is responsible for the processes and procedures, but each employee.

For this to work successfully, **three important prerequisites** must be observed:

- Management must be prepared to implement an improvement process continuously and in the long term, involving all employees.
- A correspondingly high budget must be provided for the training and education of staff.
- All stakeholders need to be patient in accepting and continuing the constant corporate culture change that TPM brings.

Important

TPM must become part of the company culture. Use what you have learned about the **basics of TPM**, **live it** and pass this knowledge on to your staff. Let employees discuss **working groups** and always have an open ear for **ideas** and suggestions for improvement. In this way, you actively exert a positive influence on the corporate culture.

To implement activities within the framework of TPM together with the staff, a step-by-step and systematic approach in four phases, which can be constantly repeated, helps per action:

1. **Preparation:** A possible improvement has been identified, for example during an inspection. The manager now prepares possible key figures, actions as well as the knowledge necessary for the staff.
2. **Kick-off:** All people involved are informed about planned actions in a joint meeting and at the same time included in the process. The aim is a joint evaluation.
3. **Roll-out: The** actions are implemented by all stakeholders.

4. **Consolidation:** Key figures after implementation are collected in practice, evaluated and flow into the process database.

Practical Relevance

A good method to delegate actions according to TPM is the **appointment of internal working groups**, which jointly work out weak points in the course of process analysis (e.g., according to the 16 failure modes) and discuss solutions models. Employees from all relevant production areas as well as from areas not directly involved in the production should be included.

In the automotive industry, it is particularly important to teach one pillar of TPM - **autonomous maintenance**. According to this, all employees who work directly on a plant also take responsibility for the maintenance of the equipment or the prevention of plant failures.

In the first step, this concerns, for example, **regular cleaning or the changing of operating materials** such as lubricating oil, but it can also go so far that **major maintenance work or repairs** are carried out independently and, above all, immediately. On the one hand, this requires sufficient training on the equipment, but on the other hand, it also requires a comprehensive understanding of factors such as cleanliness at the workplace, correct checking of the equipment for proper functioning and complete access to all necessary areas.

Example

In the production plan, there is a line consisting of several machines. The production line is difficult to set up. The line is serviced by about eighteen operators working in three shifts. It took one worker about 45 minutes to set up one production line. Today, setup takes about 15 minutes. A machine setup plan and a TPM sheet for the given machine are prepared for each machine. For example, a plan for setting up a sensor using a setting jig. The preparation control is carried out by manufacturing the first part, measuring on the spot, and removing impurities, by suction, or rinsing. The TPM sheet is set for a certain time. After one hour of operation, the operator is alerted in the TPM sheet about what needs to be checked, set, or adjusted. Similarly, **TPM sheets** available for the **shift**, alert the operator of steps to be performed during the shift. TPM **sheets for a day** alert the operator of steps to be performed once a day, and so on, once a week – for example, once a week it is necessary to perform a longer preventive or more complex check on the equipment according to the manual, with individual **steps highlighted in pictures or photographs**, **the exact location** of the intervention is marked, and so on. This takes into account the difficulty of maintaining machines in operation and the need to minimize downtime in the production process.

1.5 Summary

Save knowledge

In the automotive industry, the maintenance of production facilities is a very important part of corporate success. This includes all technical, administrative and management measures that concern the maintenance and restoration of the function of all facilities.

Various maintenance strategies are used to avoid downtimes, failures, accidents and malfunctions and to optimize operating processes and plant availability. These maintenance strategies are generally divided into damage-dependent, preventive and anticipatory strategies. It is also important to identify weak points in the production process, such as incomplete documentation, lack of transparency in key figures, isolated departments, and others.

Total Productive Maintenance (TPM) is a concept developed in Japan to promote a trouble-free production system without losses or waste, with as few defects, downtimes, accidents, and quality losses as possible. TPM is based on eight different pillars that are to be built up and implemented in the company.

The aim is to eliminate the 16 types of loss according to JPIM. These loss types were developed to be able to identify weaknesses in companies as transparently as possible and can be divided into three categories: Machinery and equipment, employees and resources.

The 5S method, another concept developed in Japan, is also particularly popular as a way of constantly developing one's work as efficiently as possible. The 5S method is designed in such a way that every single employee can implement it, regardless of whether they are directly involved in the production, administration, or other activities.

TPM is not the responsibility of individuals but must be understood and lived by every single person in the company. Therefore, managers must anchor the knowledge about TPM in the company in the long term and anchor it in the corporate culture. Tasks and responsibilities must be delegated to the employees. A systematic approach in which working groups cooperate across departments is helpful.

A particularly important aspect of delegation in the sense of TPM is the pillar of autonomous maintenance. This transfers maintenance and repair tasks of plants directly to the people who also operate them. Extensive training and a broad understanding of all necessary areas are essential.

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