IMPLEMENTING TPM METHOD IN THE PRODUCTION ENTERPRISE

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Summary: Lean Manufacturing is a philosophy of production management. Total Productive Maintenance is one of Lean Manufacturing tools. In this paper TPM philosophy is described. Advantages of this Lean Manufacturing tool implementation are recognized. Examples of TPM maintenance schedules are presented. Assumption of autonomous maintenance like continuous cleanness, immediate failure remove are described in details. Planned maintenance based on periodic maintenance involving preventive and predictive maintenance is explained as well.

Keywords: TPM, Total Productive Maintenance, Lean Manufacturing, autonomous maintenance, planned maintenance, Overall Equipment Effectiveness.

1. Introduction

Lean Manufacturing is a philosophy focused on wastes elimination i.e. from overproduction, waiting times, transportation and handling, related to useless and excess inventories, waste in production process, useless motions, waste from scrap and defects. Those are the factors which do not add value to the produced goods. The main goal of Lean Manufacturing is develop standardization and reduction of processes, employee empowerment, reduction of material stocks, continuous improvement of quality goods and quality at the source. This guarantees continuous pursuit of perfection [1, 2].

The main tools of Lean Manufacturing are: 5S (Sort, Storage, Shine, Standardize, Sustain), VSM (Value Stream Mapping), SMED (Single Minute Exchange of Die), Kaizen (continuous improvement), TPM (Total Productive Maintenance).

2. Total Productive Maintenance

Total Productive Maintenance (TPM) aims are: zero of machine damage, high utilization of equipment effectiveness, elimination of wastes and creation of a good work place. It is an approach completely different from a traditional one where, the maintenance department takes an action when machine failure occurs. In TPM conception everybody are responsible for trouble-free operation of machine, in contradistinction to the statement that one part of plant is working and another is repairing [3, 4].

The main target of TPM is maximum use of production equipment capacity and transfer of elementary activities, connected with operating and maintenance, to the operator. The operator knows the machine best as he works on it every day. TPM integrates improving activities undertaken by different departments of the plant. All employees, from the highest level to the production workers, should be engaged in pursuit to achieve a success [4].

Main goal of TPM is zero failures and zero defect production. When failures and defects are eliminated, operational rate of machines will increase, costs will be reduced and productivity will be higher. It is impossible to achieve this kind of results in one day.

Usually it takes around three years to recognize results of implementation. In the first stages of TPM implementation additional costs incur as the machines have to be adopted to proper cycle and the staff have to be trained to operate it properly. Real costs depend on the quality of equipment and efficiency of maintenance. When productivity increase costs will be quickly replaced with profits [5, 6, 7].

Traditional system of maintenance assume that the enterprise is divided into individual departments – production department, maintenance department, engineering department. TPM integrates all departments and makes everyone responsible for the perfect equipment condition. The most important is to encourage operators to involve in the improvement. Usually they are the one who have most information that can be used to avoid failures. However making operators responsible for the equipment is not enough – they have to be allowed to make certain decisions.

Another important factor is to make inspections and conservations high priority. Moving conservations in time is a mistake as it may cause failure or damage of machine in the future. If the inspections are done periodically according to properly prepared schedule then the failure-free time of the machines and life time will increase. In many companies old approach, in which repairs of the machine are done after it brakes, dominates. This type of approach can be called “firefighting”, and in general it takes more time than prevention, therefore generates higher costs, due to production line stoppage [3, 4, 6, 7].

3. Autonomous Maintenance

Autonomous maintenance connect production department with maintenance department. The purpose of this connection is common responsibility for proper conservation of machine stock. It is incentive to change the stereotype „I produce, you repair”, which still reign in a lot of plants. In many cases operator only receives the product from the machine or is responsible for “press the button”. When the smallest breakdown appears for its elimination maintenance department is being called. If the operator has more rights to make his own decision, than just operate machine, he could eliminate participation of another people during small breakdowns.

Operator should feel responsible for his workplace. Operator works every day with a given machine so he has a big knowledge on the subject of its function and appearing failures. We can compare him to a car driver who knows best when something bad happens with his car.

Operator may not know the reason why there is a problem but like a driver can indicate where the problem occurs. Autonomous maintenance is mainly based on ideas and engagement of the machine operators.

There are seven steps of Autonomous Maintenance [8, 9, 10]:

1) clean and check machine,
2) eliminate source of dust,
3) keep machines in perfect condition ,
4) train machine operators,
5) individual maintenance done by operator,
6) assure quality,
7) assure continuous improvement.

4. Planned Maintenance

Planned maintenance indicates that activities are done by maintenance department. Mechanics have to do this part of work which operators of machine are not able to do. Such activities are:

- repairs of not easily accessible parts,
- periodic inspections of parts, which wear quickly,
- repairs which involve special skills.

First pillar of planned maintenance is preventive maintenance. It consists of detection and elimination of factors which can have an impact on failure frequency of machines. It means realization of maintenance activities advised by the producer of machine, in a particular interval of time, i.e. exchange of parts according to a plan – apart from a rate of wear. The advantage of working with the maintenance plan is the increased confidence in machine proper operation, and disadvantage is that the maintenance plan must be superior to the production plan. In many companies there is a lack of time to implement this step of TPM, because the most important is implementation of the production plan.

Second pillar is predictive maintenance. It consists of database of all machine repairs and statistical probability analysis of reoccurrence of the same defect. The advantage of predictive maintenance and continuous monitoring of machine condition is less number of stoppages.

The most important step is to work out a schedule of planned maintenance and implement it on the work station 5. 6. 11. .

5. Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is the most important factor of the TPM philosophy. It describes the effectiveness of use of the machine.

Machines in a large majority of enterprises are used to add value to the products. Effective addition of value requires the effective operation of the machines. Overall equipment effectiveness is a measure used to determine how efficiently machines are used. It often happens that the concept of the total efficiency is understood as a performance of the machine. This approach is improper as the total efficiency is in fact the performance divided by the number of parts that can be produced with the machine per shift, it is one of the three factors that make up the OEE. The other is the availability and quality. Availability is a comparison of the potential operating time with the time in which the machine is actually used for production. Quality is the ratio of the elements made correctly to the total number of manufactured devices.

In the TPM approach, we distinguish six losses:

- Damages,
- Retooling and adjustments,
- Minor downtime and idle,
- Reduced operating speed,
- Quality defects,
- Reduced performance during start-up.

Improving OEE factor allows to reduce these losses.

Damage means equipment failure. Damages can be divided into two types: occasional failures and chronic failures. Occasional failure is easy to see - the breakdown - it appears unexpectedly. We can see the effect: the machine does not work. While chronic failure is when the machine works, but some of its features do not work. Therefore it is difficult to see. The cause of failure can be bad spacing of the machine – wrong layout of factory, which makes inspection impossible. It can also be disregard for the problems and ignoring minor faults – common problem. Also a way of thinking about machines is very important. We strive to think that machines will never break. There is often lack of the time to eliminate the root causes of failure and only consequences of it are repaired like replacement of broken part, oil refill. It is a mistake, as it is necessary to prevent failures. This can be achieved by collecting information after each failure. Another negative effect are defective products caused by failures, and therefore additional costs to produce the product again.

To achieve the goal - zero failures - four-phase program is required:

- stabilization of Mean Time Between Failure (MTBF) - the average time period over which the device can operate without interruption, this step can be achieved by repairing all the minor faults;
- extension the lifetime of equipment - obtained by correction of design faults;
- systematic repairs;
- prediction of device lifetime, through the use of diagnostic equipment.

Retooling of machine are the whole technical and logistical operations necessary to change the type of product, if the device produces more than one type.

The following types of losses can be distinguish:

- defective products after retooling – it is associated with the time before the machine is properly adjusted,
- long time for retooling and adjustments.

Retooling time is understood as the time between production of last product of previous type and first product of next type without defects. To eliminate long time of retooling of the machine, method proposed by Shigeo Shingo is used. This method is called Single Minute Exchange of Die (SMED). The aim is to reduce the time of retooling to single digit number of minutes - less than 10 minutes. This method divides all activities related to machine retooling onto two types:

External - feasible during operation,

Internal - feasible only after turning off the machine.

Reductions of the retooling time can be achieved by:

- elimination of external actions,
- replacement of internal activities by external one,
- shortening the duration of the remaining internal activities.

An important factor in this method is standardization. It eliminates the search for parts, tools needed for retooling.

Minor downtime and idle is related to stoppage of the machine, even though the machine did not fail. This stoppages may be caused by blocking, jamming, clogging, lack of raw materials, problems with sensors, automatic shutdown of the machine, tool replacement, etc. With this problem one can fight, by creating a system of informing of any downtime.

Reduced operating speed is often associated with lack of knowledge of the optimum speed of the machine. Even when it is known we are dealing with one of two problems. The first one is work with lower than optimal speed. This is because there are often problems with failures, downtime, product quality problems. The second situation is the work above the optimal speed, for example, to reach the lost piece of failures overdue. Both of these cases will have repercussions in the future on the machine.

Quality defects occur in products which characteristics do not meet customer requirements. Such products must be repaired or discarded. The loss, in this case is the cost of re-manufactured product, or time to repair.

Reduced performance during start-up - losses associated with the preparation for the start of production, measured as the time needed to produce the first good product, or the cost of materials consumed during this time.

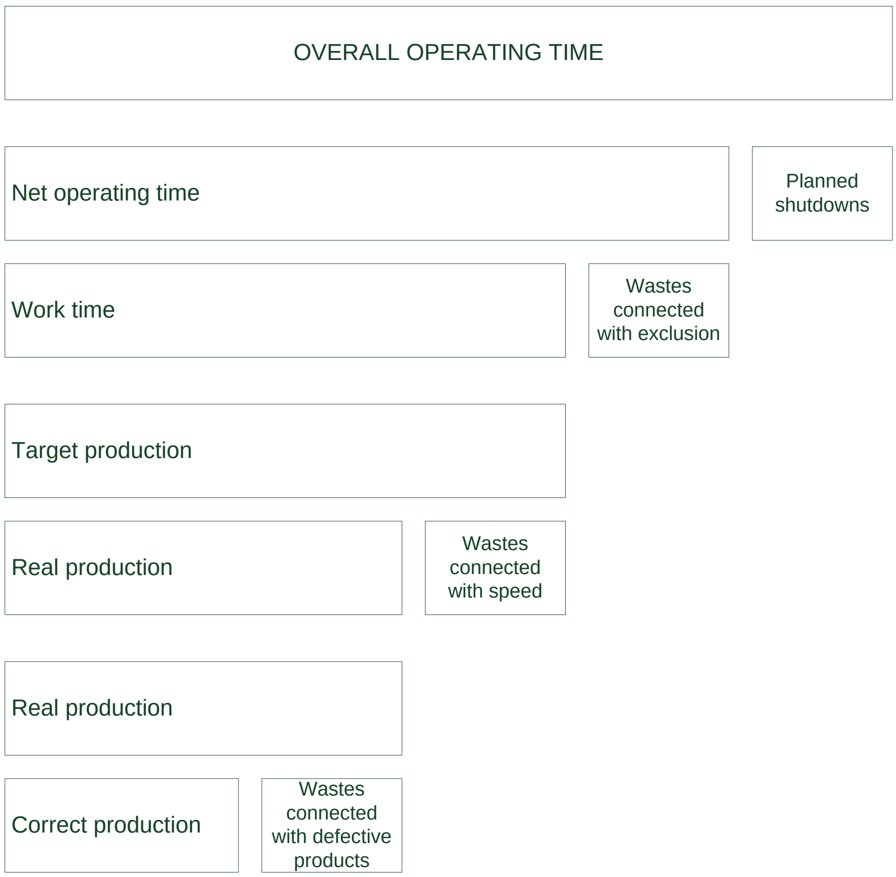

Fig. 1. OEE elements

All those loses can be divided into three types (fig. 1):

- Wastes connected with exclusion:
    - Damages,

        - Retooling and adjustments.
- Wastes connected with speed:
    - Minor downtime and idle,
    - The reduced operating speed.
- Wastes connected with defective products:
    - Quality defects,
    - The reduced performance during start-up.

The formula for calculating OEE ratio is as follows:

OEE = machine availability coefficient × machine performance coefficient × production quality coefficient × 100

6. Autonomous and Planned Maintenance and Overall Effectiveness Equipment - examples

In table 1 and 2 setting of activities for autonomous maintenance, for a bending machine, has been shown.

Tables are weekly, monthly, quarterly, annual. They depend on the type of production and the need for individual action. In this case, there are weekly schedules (autonomous maintenance) and half-yearly schedules (planned maintenance). The task of the operator or maintenance worker is completing the activity and put the signature in the proper box.

Tab. 1. Autonomous maintenance

AUTONOMOUS MAINTENACE				
TASK	WHO?	HOW OFTEN?	HOW LONG?	WHEN?
verify mountings on every shield on the enclosures	bending machine operator	every day	2 min	before turning on the machine
verify cables placement	bending machine operator	every day	1 min	before turning on the machine
verify functioning of safety switch	bending machine operator	every day	1 min	before turning on the machine
verify oil level	bending machine operator	every day	1 min	before turning on the machine
clean the work surfaces	bending machine operator	every day	3 min	before turning on the machine

Tab. 2. Autonomous maintenance (week 1)

Week 1/2010	ACTIVITIES				
	verify mountings on every shield on the enclosures	verify cables placement	verify functioning of safety switch	verify oil level	clean the work surfaces
Mon					
Tue					
Wed					
Thu					
Fri					
Sat					
Sun					

In table 3 and 4 setting of activities for planned maintenance, for a bending machine, has been shown.

Tab. 3. Planned maintenance

PLANNED MAINTENANCE				
TASK	WHO?	HOW OFTEN?	HOW LONG?	WHEN?
verify entire hydraulic system	mechanic	every month	60 min	before the end of the shift
replace filter and oil (about 14l ESSO NUTO H32 or similar)	mechanic	every 6 months	60 min	before the end of the shift

Tab. 4. Planned maintenance (six months schedule)

<table>
<tr><td rowspan="2">Date</td><td colspan="2">ACTIVITIES</td></tr>
<tr><td>verify entire hydraulic system</td><td>replace filter and oil</td></tr>
<tr><td>01/01</td><td></td><td rowspan="5">X</td></tr>
<tr><td>02/01</td><td></td></tr>
<tr><td>03/01</td><td></td></tr>
<tr><td>04/01</td><td></td></tr>
<tr><td>05/01</td><td></td></tr>
<tr><td>06/01</td><td></td><td></td></tr>
</table>

In table 5 method for OEE parameter calculation has been shown. Its value is seventy eight percent which is quite good. However the goal is to get the value of OEE over eighty fife percent.

Tab. 5. OEE calculation sheet

OEE calculation sheet			
MACHINE AVAILBILITY			
A. The operating time per shift (480 min for 8 h shift)	480	min	
B. The planned machine downtime	40	min	
C. The planned working time	440	min	A-B
D. Unplanned machine stops, including:	70	min	a+b+c
a. failures	20	min	
b. retooling	50	min	
c. other stops		min	
E. Machine real work time	370	min	C-D
F. Machine availability coefficient	0,84		E/C
PERFORMANCE MACHINES			
G. Number of manufactured devices (the sum of good and bad)	38	pcs.	
H. Production target	40	pcs.	
I. Machine performance coefficient	0,95		G/H
QUALITY			
J. Number of defective units	1	pcs.	
K. Production quality coefficient	0,97		(G-J)/G
OEE FACTOR			
L. Overall equipment effectiveness	78	%	F×I×K×100

7. Conclusions

Total Productive Maintenance is an important method of the complex maintenance. Implementation of this Lean Manufacturing tool helps the company to strive for perfection. Advantages of TPM implementation are: increase of equipment productivity, reduced shutdowns, increase of plant capacity, lower production and maintenance costs, growth of work satisfaction, return on investment.

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