IMPLEMENTATION OF TPM IN FOOD INDUSTRY USING OEE TOOL

A PROJECT REPORT

Submitted By

R.Kathirvel - 71206409005

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COIMBATORE – 641 006

ANNA UNIVERSITY :: CHENNAI 600 025

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ANNA UNIVERSITY :: CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report entitled "**Implementation of TPM in Food Industry Using OEE Tool**" is the bonafide work of

Mr. R.Kathirvel - Register No. 71206409005

who carried out the project work under my supervision.

Signature of the HOD **Signature of the Supervisor**

Internal Examiner **External Examiner**

Department of Mechanical Engineering

KUMARAGURU COLLEGE OF TECHNOLOGY
COIMBATORE – 641 006

MAHENDRA ENGINEERING COLLEGE

FS68172

Mahendhirapuri, Mallasamudram (West), Thiruchengode (Tk), Namakkal (Dt) - 637503, Tamil Nadu

DEPARTMENT OF MECHANICAL ENGINEERING

CERTIFICATE

THIS CERTIFICATE IS AWARDED TO

Mr. R.KATHIRVEL

for having presented a paper on

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Prof. P. Tamilchelvan
Convener

Dr. R. Vadivel
Principal

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GOBI (Tk) Pin-638 455, ERODE (Dt) TAMIL NADU

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PERMIT No. 432
R.C.No.2962186/155
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CERTIFICATE

This is to certify that **Mr.R. Kathirvel (71206409005), M.E- Industrial Engineering** Student of **Kumaraguru College of Technology, Coimbatore,** has carried out a project in our Organization titled " **Implementation of Total Productive Maintenance in Food Industry Using OEE Tool**" from **October 2007 to May 2008.**

His attendance and conduct during the training was good.

We wish him success in all his future endeavours.

For **SELVI FOOD PRODUCTS**

Sathishkumar. M

Managing director

ABSTRACT

The purpose of this project is to adopt the total productive maintenance in food industry using OEE tool kit and especially in bakery products. The project aims to develop a methodology for increasing production rate, improving the quality of product and providing a healthier and safer work environment.

The methodology is based on analyzing the reliability data of an automatic production line. It is divided into four steps. The aim is to bring forth improved maintenance policies of the mechanical equipment. Also the continuous and through inspection of the production process is achieved through measurement of the overall equipment effectiveness using OEE tool.

The goal of development methodology is to bring competitive advantages, such as: increasing the productivity, improving the quality of the products, and reducing the cost production of the line. One way to think of TPM is "deterioration prevention" and "maintenance reduction", for this reason many people refer to TPM as "Total Productive Manufacturing" Or "Total Process Management". TPM is a proactive approach that essentially aims to prevent any kind of slack before occurrence. Its motto is "zero error, zero work related accident, and zero loss"

.

The development methodology in the food industry increases the production rate. Improving the quality and providing a healthier and safer work environment. It can be useful to guide food product manufacturers to improve the design and operation of the production lines.

ஆய்வு சுருக்கம்

இந்த ஆய்வின் முக்கிய குறிக்கோள் அடுமனையில் உள்ள அனைத்து இயந்திரங்களின் பராமரிப்பை, இயந்திரங்களின் மொத்த செயல் திறன் என்ற முறையை அமல் படுத்துதல். புதிய உக்தியைக் கொண்டு அடுமனையின் உற்பத்தி தரம் மற்றும் சுகாதாரத்துடன் கூடிய பொருட்களை சமைத்தலை இவ்வாய்வின் நோக்கமாக எடுத்துக்கொள்ளபட்டது.

தானியங்கி உற்பத்தியின் நம்பகதன்மையை ஆராய்வது இவ்வாய்வில் வழிமுறையாக கைலாளப்பட்டுள்ளது. இதனை நான்கு படிகளாக பிரிக்கப்பட்டுள்ளது. இயந்திரங்களின் இயக்கங்களை சீர்மையாக பராமரித்தல் மேலும் தொடர்ச்சியான கண்காணிப்பு மூலம் உற்பத்தி திறனை சரியான அளவில் எட்டுதல் இந்த ஆய்வின் முக்கியத்துவம் ஆகும். மேலும் இந்த ஆய்வின் குறிக்கோள், வழிமுறைகளை மேம்படுத்தி பொருள் உற்பத்தியை அதிகரித்தல், பொருளின் தரத்தை மேம்படுத்தல் மற்றும் உற்பத்திச் செலவைக் குறைத்தலாகும். இயந்திர பராமரிப்பின் முக்கிய நோக்கம் தவறுகள், வேலை தொடர்பான விபத்துகளை தவிர்த்தல், இழப்புகளை குறைத்தல் ஆகியவையாகும். இம்முறையில் உணவுத் தொழிற்சாலையில் உற்பத்தி திறனை மேம்படுத்தி பாதுக்காப்பான, தரமான உற்பத்தியை உருவாக்குதல் ஆகும். இந்த முறையின் மூலம் உணவுத் தொழிற்சாலைகளில் செய்முறைகளையும் உற்பத்தியையும் பெருக்கிக் கொள்ள முடியும்.

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CHAPTER 1

INTRODUCTION

In today's global marketplace, opportunities and competition are the catch phrases companies are drawing business strategies to deliver reliable products and service satisfying the customer's requirements on time. The prices of the product or service must be competitive and at the same time fetch profitable revenues for the company. It follows that manufacturing companies should focus more on the reduction and elimination of unwarranted costs associated with material and time wastage. Thus, a great deal of attention should be paid to the reliability of production lines and their efficient functioning. Although many companies automate most of their manufacturing operations. Maintenance activities depend profoundly on human inputs. So, to achieve reliable products or service satisfying the customer's requirements on time the companies should improve their performance in all areas especially in machines maintenance. TPM is an innovative approach to maintenance maximizes equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance through day to day activities. The effectiveness of TPM is measured by a matrix of P, Q, C, D, S and M (production, cost, quality, delivery, safety and morale). Hence, the performance of the machines is analyzed in this project thesis.

1.1 NEED FOR PERFORMANCE ANALYSIS

Recent trends indicate that, in general, machines are increasing in complexity with the introduction of new technologies, are not meeting customer expectations in terms of performance and effectiveness, and are becoming costlier in their operation and support. In the production of goods manufacturing systems are often operating at less than full capacity, with low productivity and high costs of factory operations this is happening at a time when international competition is increasing worldwide.

In many companies, the costs of operating and maintaining equipment in the factory have become a significant factor in the production of goods. According to a survey, from 15 to 40 percent (with an average of 28 percent) of the total cost of finished goods can be attributed to the maintenance activities given the on going addition of new technologies, the introduction of more robotics and automation, the increasing use of computer aided devices, etc., maintenance costs are likely to be even higher in the future with the continuation of existing practices.

With regard the issue of cost due to maintenance activates, a large portion of this cost can be categorized under production losses, which often range from 2 to 15 times the direct costs for the maintenance and direct costs for the maintenance and repair of equipment.

While the initial acquisition costs associated with factory design and construction have in most instances been quite visible, the costs of sustaining operation, maintenance and support have not been quit visible. As a result, there have been some surprises, with the cost of many products being higher than initially anticipated. This, of course, has had an impact on a given company's profits in the competitive market. So, analysis and improvements in performance of the machine could be useful.

Many companies who recognize the improvement roll of equipment and process performance as bottom line results are turning to performance measures, the following are some of the tools that are in performance evolution of the machines.

1) Overall Equipment Effectiveness (OEE)
2) Total Production Ratio (TPR)
3) Number of Machine Failures
4) Duration of Machine Failures
5) Machine capacity Assurance
6) Factory output and product output

1.2 LITERATURE SURVEY

TPM is a fundamental change in the entire organization, which focuses towards improved equipment effectiveness. TPM is not a short term fix, but a long, never ending journey to 'best in class factory' performance through:

1. Continuous management commitment
2. Increased employee responsibilities
3. Continues improvement

It can be considered as the medical science of machines. Total productive maintenance (TPM) is a maintenance program, which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction. TPM brings maintenance into focus as a necessary and vitally important part of the business.

TPM is no longer regarded as a non profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to hold emergency and unscheduled maintenance to a minimum.

1.2.1 Why TPM?

TPM was introduced to achieve the following objectives.

- Avoid wastage in a quickly changing economic environment.
- Producing goods without reducing product quality.
- Reduce cost
- Produce a low batch quantity at the earliest possible time.

1.3 TYPES OF MAINTENANCE

1.3.1 Breakdown Maintenance

It means that people wait until equipment fails and repair it. Such a thing could be used when the equipment failure does not significantly affect the operation or production or generate any significant loss other than repair cost.

1.3.2 Preventive Maintenance

It is a daily maintenance (cleaning, inspection, oiling and retightening), design to retain healthy condition of equipment and prevent failure through the prevention of deterioration, periodic inspection or equipment condition diagnosis, to measure deterioration. It is further divided into periodic maintenance. Just like human life is extended by preventive maintenance.

1.3.3 Periodic Maintenance

It is time based maintenance consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems.

1.3.4 Predictive maintenance

This is a method in which the service life of important parts is predicted based on inspection or diagnosis, in order to use parts to the limit of their service life. Compared to periodic maintenance, predictive maintenance is condition-based maintenance. It manages trend values, by measuring and analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system.

1.3.5 Corrective Maintenance

It improves equipment and its components so the preventive maintenance can be carried out reliably. Equipment with design weakness must be redesigned to improving maintainability.

1.3.5 Maintenance Prevention

It indicates the design of new equipment. Weaknesses of current machines are thoroughly studied (on site information leading to failure prevention, easier maintenance and prevents of defects, safety and ease of manufacturing) and are incorporated before commissioning new equipment.

1.4 EVOLUTION OF TPM

TPM is an innovative Japanese concept. The origin of TPM can be tracked back to 1951 when preventive maintenance was introduced in Japan. However, the concept of preventive maintenance was taken from USA. Nippondenso was the first company to introduced plant wide preventive maintenance in 1960. Preventive maintenance is the concept where in, operators produced goods using machines and the maintenance group was dedicated with work of maintenance became a problem, as more maintenance personnel were required. So, the management decided that the operators would carry out the routine maintenance of equipment.

Thus, Nippondenso that already followed preventive maintenance also added autonomous maintenance done by production operators. The maintenance crew went into the equipment modification for improving reliability. The modifications were made or incorporated in new equipment. This lead to the breakdowns maintenance prevention. Thus preventive maintenance along with maintenance prevention and maintainability improving gave birth to productive maintenance. The aim of productive maintenance was to maximize plant and equipment effectiveness to achieve optimum life cycle cost of production equipment.

By then Nippondenso had made quality circles, involving the employee's participation. All employees took part in implementing productive maintenance. Based on these developments Nippondenso was awarded the distinguished plant prize for developing and implementing TPM, by the Japanese institute of plant engineers. Nippondenso of the Toyota group became the first company to obtain the TPM certification.

1.4.1 TPM Targets

P: Obtain minimum 80% OPE. Obtain minimum 90% over all Equipment Effectiveness. Run the machines even during lunch.

Q: Operate in a manner, so that there are no customer complaints.

C: Reduced the manufacturing costs by 30%

D: Achieve 100% success in delivering the goods as required by the customer.

S: Maintain an accident free environment.

M: Increase the suggestions by 3 times. Develop multi skilled and flexible workers.

1.4.2 TPM Objectives

1. Achieve zero defects, zero breakdowns and zero accidents in all functional areas of the organization.
2. Involve people in all level of organization.
3. Form different teams to reduce defects and self maintenance.

1.4.3 Direct Benefits of TPM

1. Increase productivity and OPE (overall plant efficiency) by 1.5 or 2 times.
2. Rectify customer complaints.
3. Reduce the manufacturing costs by 30%.
4. Satisfy the customer's needs by 100%.
5. Reduced accidents.
6. Follow pollution control measures.

1.4.4 Indirect Benefits of TPM

1. Higher confidence level among the employees.
2. Keep the work place clean, neat and attractive.
3. Favorable change in the attitude of the operators.
4. Employee satisfaction.

1.5 Overall Plant Effectiveness

It is a function of three factors namely management losses, scheduled downtime loss and OEE. Management losses due to want of tools, want of raw materials, want of trays, want of men etc., scheduled downtime includes any activity, preventive maintenance activity or meetings.

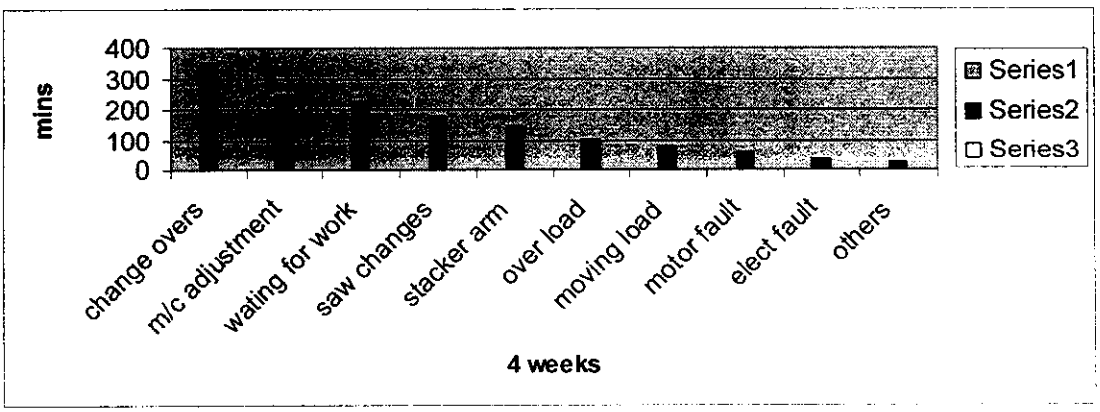


Fig 1.1 Downtime losses

1.6 OVERALL EQUIPMENT EFFECTIVNESS

Overall Equipment Effectiveness (OEE) offers a simple but powerful measurement tool to get inside information on what is actually happening. The OEE calculation is a metric that gives us daily information about how effectively the machine is running and which of the six big losses to be improved. Overall equipment effectiveness is not the only indicator to assess a production system, but it is certainly very important if our goal is improvement.

Overall equipment effectiveness is calculated by combining three factors that reflect these losses: the availability rate, the performance rate, and the quality rate. The availability rate is the time the equipment is really running, versus the time it could have been running. A low availability rate reflects downtime losses:

- equipment failures
- setup and adjustments

The performance rate is the quantity produced during the running time, versus the potential quantity, given the designed speed of the equipment. A low performance rate reflects speed losses:

- idling and minor stoppages
- reduced speed operation

The quality rate is the amount of good products versus the total amount of products produced. A low quality rate reflects defects losses:

- scrap and rework
- start up losses

To calculate OEE, the three factors are multiplied together:

OEE = Availability Rate * Performance Rate * Quality Rate

The OEE calculation is based on three contributing factors, Availability, Performance and Quality. Here is how each of these factors is calculated...

1.6.1 Availability

Availability takes into account availability loss and is calculated as:
Availability index =Operating time/Planned production Time

1.6.2 Performance

Performance takes into account speed loss, and is calculated as:
Performance Index = (Idle cycle time* Pieces Produced)/ Operating time

Idle cycle time is the minimum cycle times that process can be expected to achieve in optimal circumstance. It is sometimes called design cycle time or Nameplate capacity.

1.6.3 Quality

Quality takes into account quality loss, and is calculated as:

Quality index = Good Pieces/ Pieces Produced

1.6.4 OEE Scope

Several parties, such as production teams, line managers and top management may different scope when looking at "effectiveness". Being aware of those differences, it is a possible to calculate different indices representing those different scopes; all based upon the same data. In the literature we find several attempts to do so, unfortunately they are not always consistent.

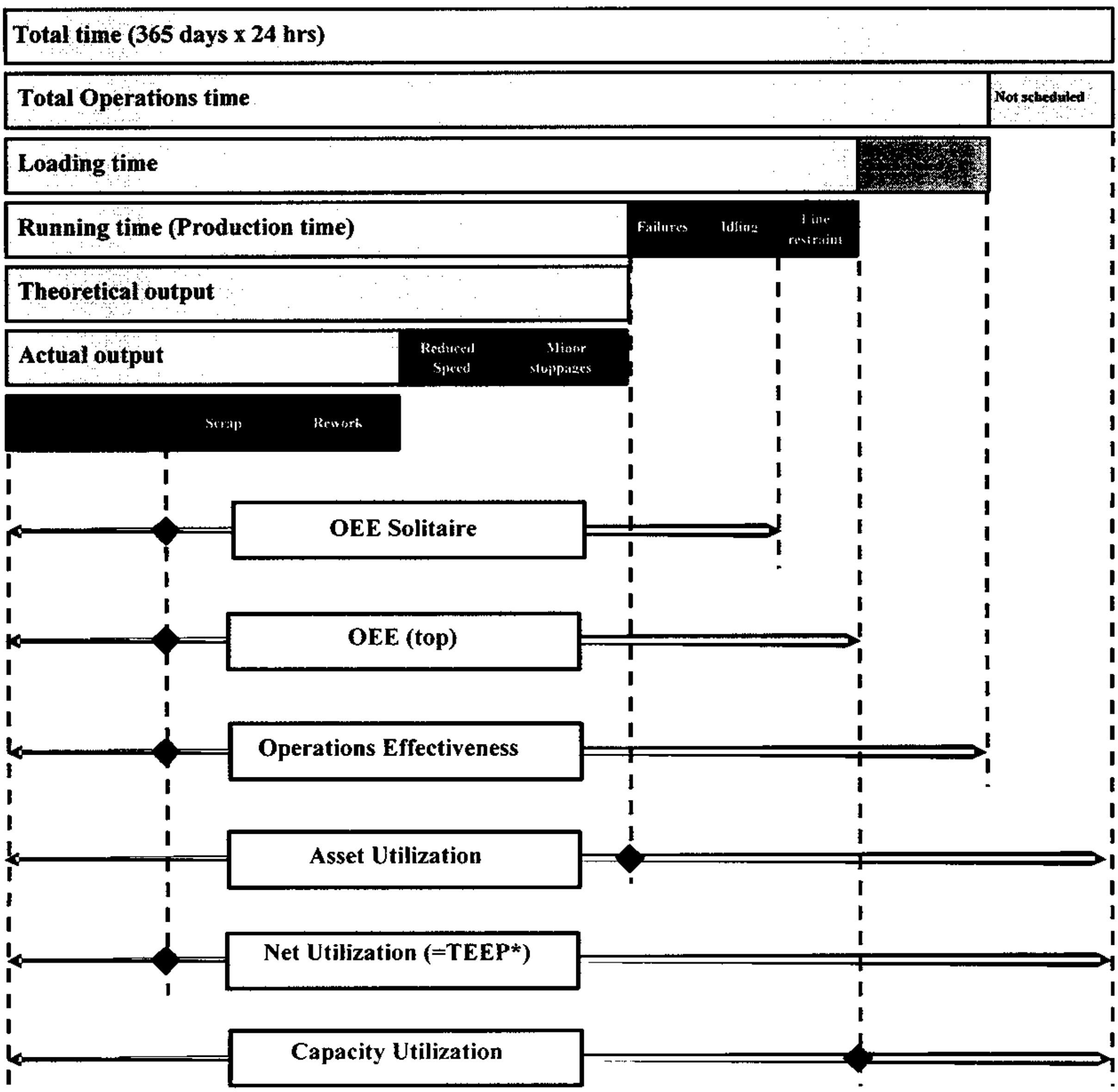


Fig 1.2 Overall Equipment Effectiveness Scope

1.7 PILLARS OF TPM

- Autonomous maintenance
- Kobetsu Kaizen
- Planned Maintenance
- Quality Maintenance
- Training
- Office TPM
- Safety, Health & Environment

1.7.1 Pillar-1 5s

TPM starts with 5s. Problems cannot be clearly seen when the work placed is unorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step of improvement.

1.7.1.1 SEIRI- Sort out

This means sorting and organizing the items as critical, improvement, frequently used items, useless, or items that are not need as of now. Unwanted items can be salvaged. Critical items should be kept for use nearby and items that are not be used in future, should be stored in some other place. For this step, the worth of the item should be decide based on utility and not cost alone. As a result of this step, the search time is reduced.

1.7.1.2 SETION- Organise

The concept here is that "each items has a place, and only one place". The items should be placed back after usage at the same place. To identify items easily, name plats and colored tags has to be used. Vertical racks can be used for this purpose, and heavy items occupy the bottom position in the racks.

1.7.1.3 SEISO- Shine the workplace

This involves cleaning the work place free of burrs, grease, oil, waste, scrap etc., no loosely hanging wires or oil leakage from machines.

1.7.1.4 SEIKETSU- Standardization

Employees have to discuss together and decide on standards for keeping the work place/ pathways neat and clean. These standards are implemented for organization and are tested/ inspected randomly.

1.7.1.5 SHITSUKE- Self discipline

Considering 5s as a way of life and bring about self discipline among the employees of the organization. This includes wearing badges, following work procedures, punctuality, dedication to the organization etc.

1.7.2 Pillar 2- Jishu Hozen (Autonomous Maintenance)

This pillar is geared towards developing operators to be able to take care of small maintenance people to spend time on more value added activity and technical repairs. The operators are responsible for upkeep of their equipment to prevent it from deteriorating.

1.7.3 Pillar 3- Kaizen

"Kai" means change, and "Zen" means good (for the better). Basically Kaizen is for small improvements, but carried out on a continual basis and involve all people in the organization. Kaizan is opposite to big spectacular innovations. Kaizen requires no or a little investment. The principle behind is that " a very large number of small improvements are move effective in an organizational environment than a few improvements of large value. This pillar is aimed at reducing losses in the workplace that affect our efficiencies. By using a detailed and through prouder we eliminate losses in a systematic method using various kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

1.7.5 Piller 4- Planned Maintenance

It is aimed to have trouble free machines and equipments producing defects free products for total customer satisfaction. This breaks maintenance down into 4 "families" or groups, which was defined earlier.

1. Preventive maintenance
2. Breakdown Maintenance
3. Corrective Maintenance
4. Maintenance Prevention

1.7.5 Pillar 5- Quality Maintenance

It is aimed towards customer delight through highest quality through defect free manufacturing. Focus is on eliminating non-conformances in asystematic manner, must like focused improvement.

1.7.6 Pillar 6-Training

It is aimed to have multi-skilled revitalized employees whose morale is high and who has eager to come to work and perform all required functions effectively and independently. Education is given to operators to upgrade their skill. The employees are trained to achieve the four phases of skill. The goal is to create a factory full of experts.

1.7.7 Pillar 7- Office TPM

Office TPM should be started after activating four other pillars of TPM (JH, KK, QM, and PM). Office TPM must be followed to improve productivity, efficiency in the administrative functions and identify and eliminate losses.

1.8 THE SIX GREAT LOSSES

Looking at machine operation, one could distinguish six types of waste referred to as losses, because they reflect lost effectiveness of the equipment. These six big losses are grouped in three major categories : downtime, speed losses, and defect losses.

Availability loss

1. Equipment failure.
2. Setup and adjustment.

Speed loss

3. Idling and minor stoppages.
4. Reduced speed operation.

Quality loss

5. Scrap and rework.
6. Start up losses.

CHAPTER 2

TPM IN INDUDTRY

2.1 WHAT IS THE REASON BEHIND IMPLEMENT TPM IN INDUSTRY

1. Equipment breaks down Frequently,
2. Setups and adjustment take too long,
3. Machines constantly suffer minor stoppages,
4. Actual production output falls short of expected.

When many organizations first measure overall Equipment Effectiveness (OEE), it is not uncommon to find that they are only achieving around 40% - 60% (batch) or 50% - 75% (continuous process), (BiKash Bhadury 1998) where as a survey shows in plan maintenance website that the international best practice figure is recognized to be 85% (batch) and 95% (continuous process). In effect, this means there exists in most companies of an opportunity to increase capacity/productive by 25% - 100%. TPM is a company wide strategy to increase the effectiveness of production environments, especially through methods for increasing the effectiveness of production environments, especially through methods for increasing the efficient use of equipment. A key objective of TPM is to cost effectively maximize OEE through the elimination or minimization of all losses.

In am ideal factory, equipment would operate 100 percent of the time at 100 percent capacity, with an output of 100 percent good quality. In real life, however, this is rare. The difference between the ideal and the actual situation is due to losses. Equipment operators face the results of these losses on a daily basis. TPM gives them the tools to identify the losses and make improvements. A key strategy in TPM is identifying and reducing what we call the six big losses.

2.2 METHODOLOGY

In the food industry and more specifically in the production of bakery products, the process of production requires the unhindered operation of mechanical equipment. An attitude in one of the line workstations can be a reason of failure, and beyond the reduction of production, can also involve qualitative problems in the produced products. For this reason we develop a methodology for direct confrontation of the problem, ensuring simultaneous and better safety and health conditions in the workplace.

For reasons of better analysis all the methodology will be separated into four steps, which are as follows

2.2.1 Step 1: Collection of data, timing and recording

In the production line we must make a detailed recording of the company's maintenance files (if they are recorded), time to failure and time to repair so that a database is created. Together with the mathematic models of Ebeling (1997) and Bain and Engelhardt (1991), we will have the reliability for each machine and each workstation of the production line. In case the data is not available, the process of recording it should begin immediately so that an elementary database is created and the same policy that we described above is applied.

Then all the components that compose the production and maintenance of the system will be recorded from the first to the last machine of the production line.

The above process will be useful to locate the critical points of the line. As "critical" points we consider these points that constitute sources of problems and prevent smooth operation of the line.

Also it will be timing and recording the time losses that are observed in the production process. The following are included in the tasks that must be done:

- determination of operations when the model time will be measured;

- planning of implementation method (choice between instantaneous observations or direct timing);
- implementation of timing; and
- Publication of model times per machine or workstation in the production line.

At this point, the following times will be calculated for each machine and each product that is produced in the machine:

- start-up time (beginning of production until stabilization);
- set-up time (change of product in the production line and adjustments up to the smooth flow of operation); and
- Time process of the product.

Also to be recorded:

- the downtime due to failure;
- the speed operation of the machine (real) which will be compared to that given by the manufacturer (nominal);
- the number of products which require rework and the useless products (scrap); and
- Lost time from the small stoppages of machines (i.e. blocking pans) that are easily and immediately corrected.

2.2.2 Step 2: Growth of a training program and measurement of overall equipment effectiveness

Personnel's training is one of the main causes of success in the installation, application and development of the work. The training would be insufficient and substantially inadequate if it does not include work tools and leadership in the new requirements that we will place. These requirements should become comprehensible and consolidate themselves completely. after they constitute daily duty of personnel who are involved. With the combination of equations (1)-(3), we obtain the overall equipment effectiveness OEE for the production line. The indicator OEE gives us the measurement of equipment performance; taking into account all factors that reduce the capacity utilization.

2.2.3 Step 3: Methods for minimizing time loss

In the production line the manager will be focused on the improvements that are possible to be achieved. In this step the following questions will be answered:

- Is the reduction of time for implementation work, adjustment and cleaning of equipment possible?
- Which ways of maintenance planning for technological equipment are best so that the production and the quality of the products are ensured?
- Which profit is expected by the better exploitation of machines?
- How much easier will quality control be henceforth?

2.2.4 Step 4: Estimation of the personnel's opinion of the results of study – Second estimation of time losses

Then, the quotations of indicators with the opinion of the persons that are involved with the methodology should be compared. That is with the operators of the machines, the foremen, the maintenance technicians, the heads of production of qualitative control and maintenance. In this way we will also have an internal indicator, a self-valuation of work that has been done. With the experience that we will have acquired after the use of "new" maintenance policy new quotations - objectives will be fixed for the indicators. Then the process of calculating times and recalculating of indicators will be applied again. The interesting thing is that the personnel will be called to reach objectives that they will have placed. Finally the whole effort will be globally evaluated and we will be gaining important experience on how we will become better and more efficient in the future.

2.3 Autonomous Maintenance

The main reason for the poor availability of equipment, plants and production facilities is that the basic equipment conditions are not maintained. The periodic preventive maintenance tasks of cleaning, lubrication, tightening of bolts and fasteners, replacements of wearing parts, equipment inspections and servicing are not performed. The maintenance department, in most cases, doesn't get the time to attend to these tasks and is too busy taking care of equipment breakdowns. This makes matter worse and the maintenance departments find it all the more difficult to carry out the preventive maintenance tasks and ensure that the basic equipment conditions are maintained (BiKash Bhadury, 1998).

Autonomous maintenance helps to reduce the workload of the maintenance department as well as to improve the machine performance. Autonomous maintenance consists of the maintenance tasks performed by the production operators. The operators are required to perform these tasks in addition to their basic job of running, or operating the production equipment. In TPM, the production operators are required not only to operate the equipment and produce components/products, but also to take care of their equipment.

The purpose of autonomous maintenance is to teach operators how to maintain their equipment by performing:

Daily checks like

1. Lubrication
2. Replacement of parts
3. Repairs
4. Precision checks

And also to improve the machine performance to eliminate the losses like

1. Failure losses – Breakdown loss

2. Setup/adjustment losses
3. Cutting blade loss
4. Start up loss
5. Minor stoppage/idling loss.
6. Speed loss – operating at low speeds.
7. Defect/rework loss
8. Scheduled downtime loss

Losses that impede equipment efficiency

9. Management loss
10. Operating motion loss
11. Line organization loss
12. Logistic loss
13. Measurement and adjustment loss

Losses that impede human work efficiency

14. Energy loss
15. Die jig and tool breakage loss
16. Yield loss.

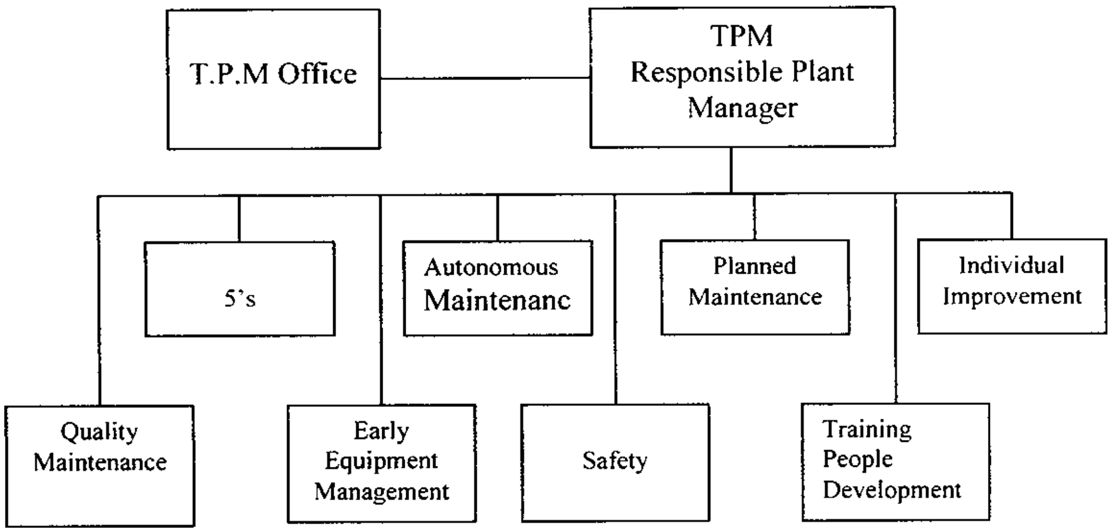


Fig 2.1 T.P.M Plant Wide Structure

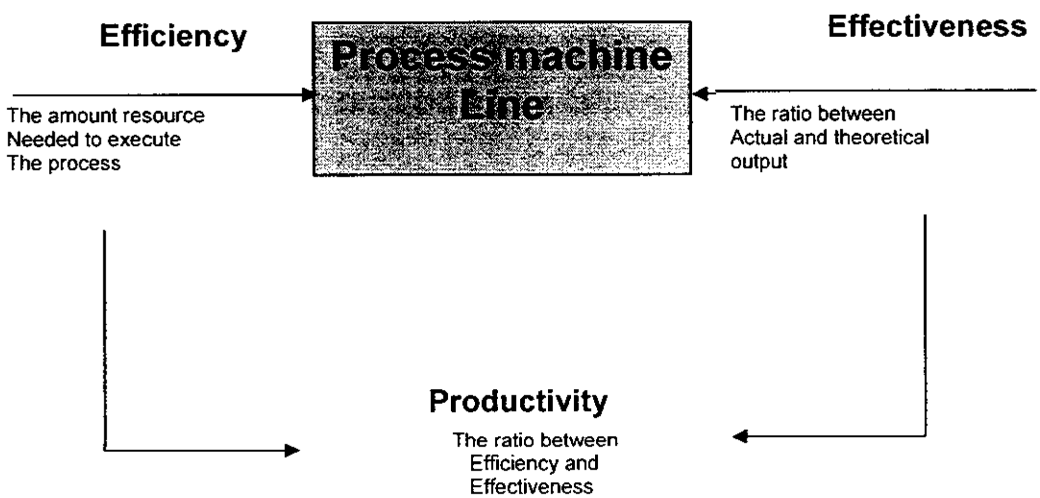


Fig 2.2 Overall Equipment Effectiveness

CHAPTER 3

TPM PROCESS

3.1 ABOUT THE COMPANY-SELVI FOOD PRODUCTS:

Selvi food products, largest manufacture of food items in the Tamilnadu (bakery items, biscuits, bread), has one manufacturing locations in Gobichettipalayam, Erode District, Tamilnadu, India, with 8 acres of land and 120,000 sq.ft of built up factory area. Selvi endeavors to continuously improve processes, products and technology, with the objective of serving customer better.

Major machines used for production process:

- Mixer machine
- Bakery tray
- Conveyor
- Cooking machine
- Packaging machine
- Cutting machine

In the food industry, the production process requires the non-stop operation of automatic production line equipment. A stoppage in a production line, due to failure, causes a drop in the production rate as well as quality problems on the products. The most important type of quality deterioration in such products is the rise of the dough in the stages before baking. In a recent study of an automated biscuit transfer line, Liberopoulos and Tsarouhas (2002), found that the effective input rate of the line was equal to 95.45 percent of its nominal production rate, due to the unavailability of the system during failures. Yet, due to the scrapping of material during long failures, the effective output rate of the line dropped to only 90.43 percent of its nominal production rate. In other words, approximately half of the 10 percent drop in efficiency of the line was due to the gap in production caused by failures, while the other half was due to the gap caused by scrapping of material during long failures. In another study of a croissant transfer line by Liberopoulos and Tsarouhas (2002), the analysis showed that the effect of scrapping was less severe, because the dough used in croissants can remain blocked without having to be scrapped for twice as long as the dough used in food, due to the different types of yeast utilized in the two products.

The aim of this paper is the implementation of TPM in a food production line and under certain assumption the generalization of the results in bakery production lines. To achieve this, we develop a methodology for increasing the production rate, improving product quality and providing a healthier and safer work environment. The methodology is based on analyzing the reliability data of an automatic production line. It is divided into four steps, whose aims are to bring forth improved maintenance policies of the mechanical equipment. Moreover, we achieve the continuous and thorough inspection of the production process through measurements of the overall equipment effectiveness (OEE).

3.2 QUALITY MAINTENANCE

It is aimed towards customer delight through highest quality through defect free manufacturing. Focus is on eliminating non conformances in a systematic manner, much like focused improvement. We gain understanding of what parts of the equipment affect product concerns. Transition is from reactive to proactive.

QM activities are to set equipment conditions that preclude quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of products. The conditions are checked and measure in time series to very that measure values are within standard values to prevent defects. The transition of measured values is watched to predict possibilities of defects occurring and to take counter measures before hand.

3.2.1 Policy:

- Defect free conditions and control of equipments.
- QM activities to support quality assurance.
- Focus of prevention of defects at source.

- Focus on poka-yoke (fool proof system).
- In-line detection and segregation of defects.
- Effective implementation of operator quality assurance.

3.2.2 Target:

- Achieve and sustain customer complaints at zero.
- Reduce in-process defects by 50%
- Reduce cost of quality by 50%

3.2.3 Data requirements:

Quality defects are classified as customer end defects and in house defects. For customer-end data, we have to get data on

- Customer end line rejection.
- Field complaints.

In-house, data include data related to products and data related to process.

3.2.4 Data related to product:

- Product wise defects.
- Severity of the defect and its contribution – major/minor.
- Location of the defect with reference to the layout.
- Magnitude and frequency of its occurrence at each stage of measurement.
- Occurrence trend in beginning and the end of each production/process/changes. (Like pattern change, ladle/furnace lining etc.)
- Occurrence trend with respect to restoration of breakdown/modifications/ periodical replacement of quality components.

3.2.5 Data related to processes:

- The operating condition for individual sub-process related to men, method, material and machine.
- The standard settings/conditions of the sub-process.
- The actual record of the settings/conditions during the defect occurrence.

3.3 Training:

It is aimed to have multi-skilled revitalized employees whose morale is high and who has eager to come to work and perform all required functions effectively and independently. Education is given to operators to upgrade their skill. It is not sufficient know only "Know-How" by they should also learn "Know-Why". By experience, they gain "Know-How" to overcome problems what to be done. This they do without knowing the root cause of the problem and why they are doing so. Hence it become necessary to train them on knowing "Know-Why". The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts. The different phase of skilled are

Phase 1: Do not know.

Phase 2: Know the theory but can not do.

Phase 3: Can do but can not teach.

Phase 4: Can do and also teach.

3.3.1 Policy:

- Focus on improvement of knowledge, skills and techniques.
- Creating a training environment for self learning based on felt needs.
- Training curriculum/tools/assessment etc. conductive to employee revitalization.
- Training to remove employee fatigue and make work enjoyable.

3.3.2 Target:

- Achieve and sustain downtime due to want men at zero on critical machines.
- Achieve and sustain zero losses due to lack of knowledge/skills/techniques.
- Aim for 100% participation in suggestion scheme.

3.3.3 Steps in Educating and training activities:

- Setting policies and priorities and checking present status of education and training.
- Establish of training system for operation and maintenance skill up gradation.
- Training the employees for upgrading the operation and maintenance skill.
- Preparation of training calendar.
- Kick off system for training.
- Evaluation of activities and study of future approach.

3.4 STUDY ABOUT THE MIXER MACHINE

Before entering in to the mixer operations like powdering, mixer cooking etc... Are to be done for inlet housing, and outlet housing in mixer machine. These operation are noted as key operations this is an automatic machine having grinding and finishing, a numerical control display unit is attached with this machine for guiding a proper direction and does the operations as desired/ set required.

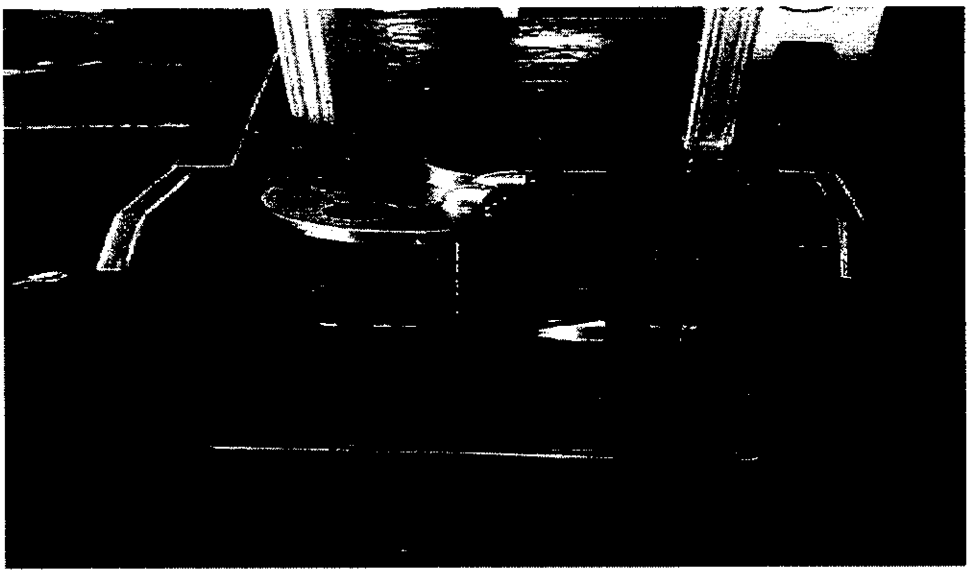


Fig 3.1 Mixing Machine

The operator fixes the operation and start the machine, then the mixer blades moves in clock direction for doing the operation as per the program which is already stored in the machine. According to the requirement the operator keeps on changing the programs in the monitor with codes.

Before implementing the autonomous maintenance the machines over all Equipment Effectiveness was calculated as per table

Table3.1 OEE for Mixer Machine before Implementing Total Productive Maintenance

period	A	B	C	D	E	F	G	H	I	J	K	OEE
Week1	8450	550	7900	1050	6850	86.7%	94	60	82.3%	10	93.3%	66.5%
Week2	8450	550	7900	1080	6820	86.3%	92	60	80.9%	5	95.6%	66.7%
Week3	8450	550	7900	1240	6660	84.3%	88	60	79.2%	13	97.4%	65.%
Week4	8450	550	7900	1430	6470	81.8%	85	60	78.8%	12	98.5%	63.4%

A = gross available time
B = planned down time
C = running time (A-B)
D = down time
E = operating time(C-D)
F = availability (E/C*100)
G = output
H = theoretical cycle time
I = performance (H*G/E*100)
J = rejects
K = quality (G-J/G*100)

Average OEE = 64.3%

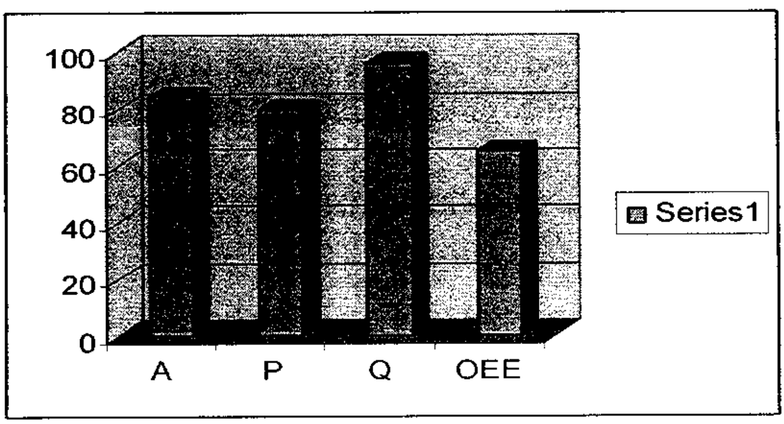


Fig 3.2 Graph for Mixer Machine

Critical defects shut the machine down and prevent it from running altogether. Usually a broken machine will contain only one major defect that can be corrected with normal troubleshooting and repair skills.

Major defects impair the machines performance but usually won't stop it from running. It may run more slowly or product with a lower quality level.

Minor defects by themselves seem to do no harm. This probably because one can observe a machine with several minor defects and notice that it appears to be running just fine.

Minor defects don't seem to matter at the moment. But minor defects, left unattended may affect machine performance in many ways. Some of the minor defects are to be eliminated before implementing the autonomous maintenance.

The minor defects in mixer machine are identified and rectified which is shown in table. To improve the performance of the machine autonomous maintenance checklist was generated as per table.

Table 3.2 Detail of defects in mixer machine

S.No.	Detail of defects	Action taken
1	Conveyor motor to be clamped	Additional support plate added
2	Saw changes	Proper adjustment
3	tail stock pressure gauges changed	New pressure gauge are fixed
4	Electric fault	Proper supervising
5	Moving load, over load	Correct load setting
6	Gabbi bold snapped	Checking & cleaning

3.4.1 Improvements of OEE

- Implement the autonomous maintenance for each machine.
- Kaizen implementation
- 5s
- planned maintenance
- training
- eliminate the down time losses

Table 3.3 Autonomous Maintenance Check List for Mixer Machine

Criteria	Sub ass.	Where	What	How	Time	Res.	Remark	Freq.
inspection	machine	front	lamp	visual	2min	operator	check	daily
inspection	Rotating M/c	M/c inside	check	visual	2min	operator	avoid	daily
cleaning	machine	overall	check	hand	30min	mechanic	maintenance	week
Inspect & tight	Operator panel	front	Elect switch	hand	2min	operator	Avoid force	daily
inspection	motor	M/c back side	noise	ear	2min	operator	avoid	Daily
tightening	Electric panel	inside	Electrical lines	hand	30min	electrician	avoid	3month
Inspection	Rotating belt	Outside M/c	conveyor	hand	10min	operator	check	Week
Cleaning/ inspection/ tightening	Overall M/c	All area	lubricant	manual	8hrs	Mechanic & elect	Preventive maintenance	6mont

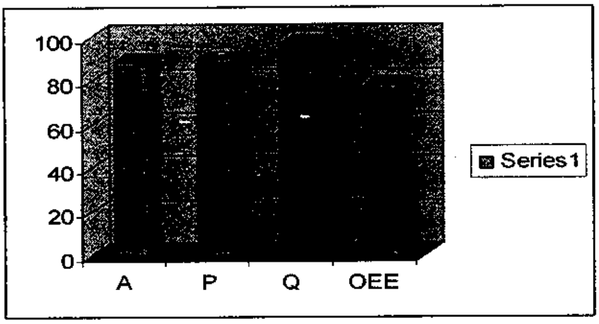
Table 3.4 Implementing 5s & Eliminate Downtime Loss

Japanese term	English translation	Equivalent S term
seiri	organization	Sort
seiton	tidiness	Systematize
seiso	cleaning	Sweep
seiketsu	standardization	Standardize
shitsuke	discipline	Self discipline

Table 3.5 OEE for Mixer Machine after Implementing Total Productive Maintenance

Period	A	B	C	D	E	F	G	H	I	J	K	OEE
Week1	8450	550	7900	830	7070	89.4%	102	60	86.5	3	98.1	75.8
Week2	8450	550	7900	780	7120	90.1%	110	60	92.6	2	98	81.7
Week3	8450	550	7900	800	7100	89.87%	105	60	88.7	2	97.1	72.4
Week4	8450	550	7900	760	7140	90.3%	112	60	94.1	1	99.1	84.2

A = gross available time
B = planned down time
C = running time (A-B)
D = down time
E = operating time(C-D)
F = availability (E/C*100)
G = output
H = theoretical cycle time
I = performance (H*G/E*100)
J = rejects
K = quality (G-J/G*100)



OEE Average=78.525%

Fig 3.3 Graph for Mixer Machine after Implementing TPM

3.5 STUDY ABOUT COOKING MACHINE

Before entering in to the cooking process operations like powdering, mixing, boiling is to be done for rotors in cooking machine. These operations are noted as key operations this is an automatic machine having regulator heating point. A led control display unit is attached with this machine for guiding the proper direction and does the operations as desired/ set required.

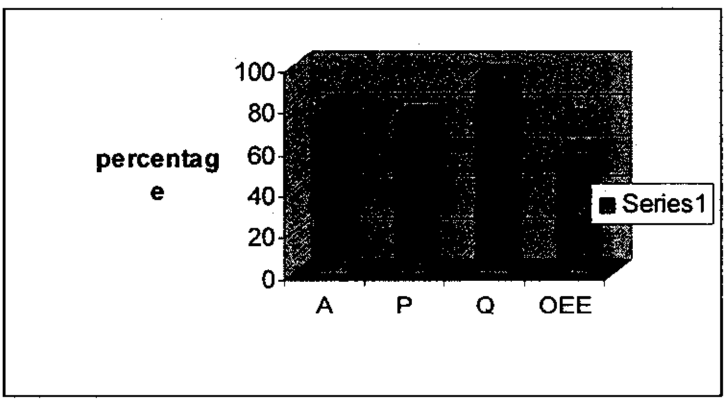
Fig 3.4 cooking machine

Before implementing autonomous maintenance and kaizen the over equipment effectiveness of the machine was as per table.

Table 3.6 OEE for Cooking Machine before Implementing Total Productivity Maintenance

Period	A	B	C	D	E	F	G	H	I	J	K	OEE
Week1	5760	420	5340	955	4385	82.1	60	50	68.4	2	96.6	54.2
Week2	5760	420	5340	890	4450	83.3	66	50	74.1	4	93.9	57.9
Week3	5760	420	5340	1050	4290	80.3	75	50	87.4	2	97.3	68.0
Week4	5760	420	5340	1010	4250	79.5	65	50	76.4	2	96.9	58.8

A = gross available time
B = planned down time
C = running time (A-B)
D = down time
E = operating time(C-D)
F = availability (E/C*100)
G = output
H = theoretical cycle time
I = performance (H*G/E*100)
J = rejects
K=quality (G-J/G*100)



OEE AVERAGE = 59.7%

Fig 3.5 Graph for Cooking Machine before Implementing TPM

3.5.1 Autonomous maintenance implementation in cooking heat machine

Minor defects by themselves seem to do no harm. Minor defects don't seem to matter at the moment. But minor defects, left unattended may affect machine performance in many ways. Minor defects are to be eliminating before implementing the autonomous table.

Table 3.7 Detail of Defects in Cooking Machine

S.NO	Details of Defects	Action Taken
1	Rotating blade damaged	New blade is fixed
2	Material leak from drum	Proper fitting and alignment
3	Oven thermostat is heat	Checking
4	Coil cable to be fixed properly	Using cable tie and corrected
5	Heating coil is damaged	Proper power using
6	Screw cover vibration	Corrected and adjustment
7	Plate cover jerk	Tighten
8	Oil filter to be cleaned	Dusts are removed
9	Oven controller short	Corrected

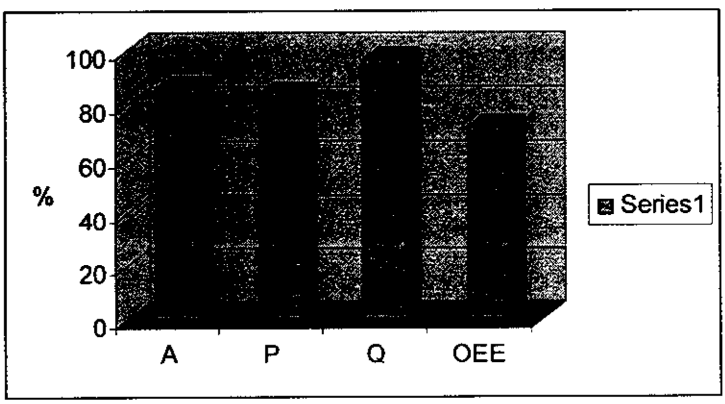
Table 3.8 Autonomous Maintenance for Cooking Machine

S. No.	criteria	Sub assembly	where	what	how	time	Res	Re mark	Freq
1	Inspect&tight	Operator panel	Front side	Elec switch	Hand	2min	operator	To avoid forced B/d	Daily
2	Inspection	Machine	Front	Lamp	Visual	1min	operator	M/c status	Daily
3	Inspection	Oven heater	Inside	Heater	Visual	2min	operator	Avoid over heating	Daily
4	Inspection	Temperature monitor	m/c inside	High temp	Temp measurer	2min	operator	Avoid high temp	Daily
5	Cleaning	Oven stay	m/c inner	Air	Clean	2min	operator	Improve operation	Week
6	Inspection	Temp panel	Inside electric panel	check	Hand	2min	Operator	Check heating system	Week
7	Inspection	Stay line	Inside m/c	Oil	Brush	10min	Operator	Stay condition	3month
8	Cleaning/ inspection	Electrical panel	Electrical lines	Hand & visual	Inside the panel	30min	Electrician	To avoid forced	6month
9	cleaning	Spindle motor	m/c left side	Fan	Dry cloth	30min	Operator	Avoid break down	6month
10	Cleaning\ inspection\ tightening	Overall machine	All area	Lubricant	Manual	8hrs	Operator	Preventive maintenance	6month

Table 3.9 OEE for Cooking Machine after Implementing Total Productive Maintenance

period	A	B	C	D	E	F	G	H	I	J	K	OEE
Week1	5760	420	5340	730	4610	86.3	80	50	86.7	2	97.2	72.7
Week2	5760	420	5340	670	4670	87.4	76	50	81.3	3	96.5	70.7
Week3	5760	420	5340	720	4620	86.5	82	50	88.5	1	98.6	75.4
Week4	5760	420	5340	720	4620	86.5	77	50	83.3	2	97.3	70.4

A = gross available time
B = planned down time
C = running time (A-B)
D = down time
E = operating time(C-D)
F = availability (E/C*100)
G = output
H = theoretical cycle time
I = performance (H*G/E*100)
J = rejects
K =quality (G-J/G*100)



OEE average 72.4%

Fig 3.6 Graph for Cooking Machine after Implementing TPM

3.6 STUDY ABOUT THE INCLINDE CONVEYOR MACHINE

Before entering in to the packaging process operation like mixing, grinding, powdering and cooking etc. are to be done for moving, inlet hoping, loading in inclined conveyor machine. These operations are noted as key operations this is an automatic operation. A numerical control display unit is attached with this conveyor for guiding the items to move proper direction.

This operation fixes the load and start the machine, then the load moves in proper direction for doing operation as per the correct direction. According to the requirement the operator keeps on changing the programs in the monitor.

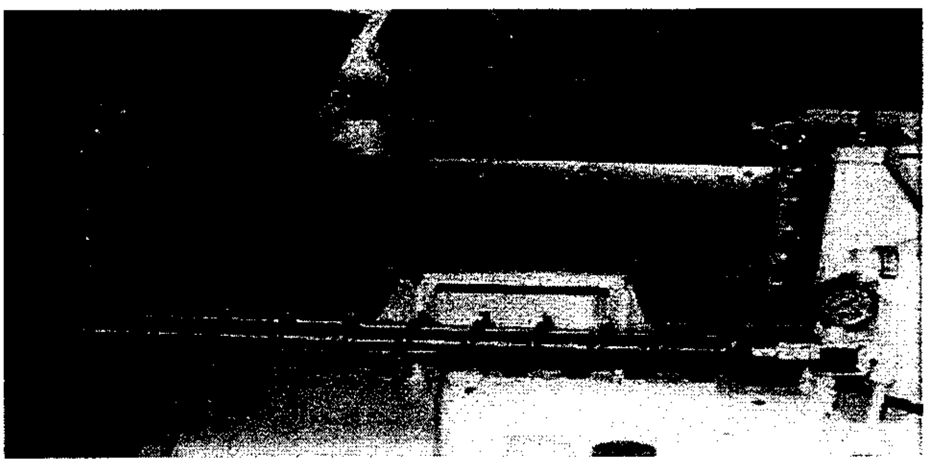


Fig 3.7 Inclined Conveyor Machine

3.6.1Autonomous Maintenance Implementation in Inclined Conveyor Machine

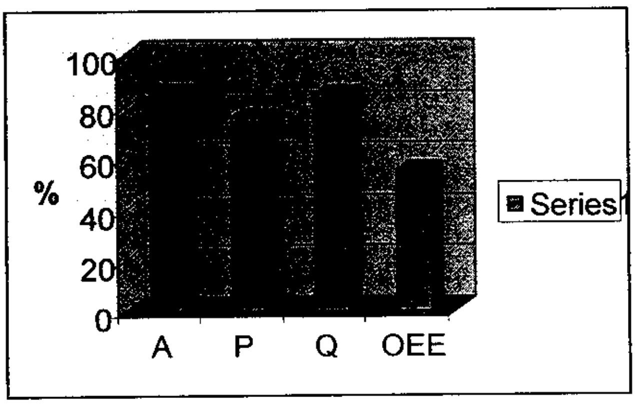
There are three categories of defects:

1. critical defects
2. major defects
3. minor defects

Table 3.10 OEE for Conveyor Machine before Implementing Total Productive Maintenance

period	A	B	C	D	E	F	G	H	I	J	K	OEE
Week1	8450	540	8000	1050	6950	86.8%	90	60	77.6%	12	89.8%	60.5%
Week2	8450	540	8000	1080	6920	86.5%	86	60	74.5%	5	85.6%	55.7%
Week3	8450	540	8000	1240	6760	84.5%	80	60	71.2%	13	79.4%	48.6%
Week4	8450	540	8000	1430	6570	82.1%	89	60	78.8%	13	84.5%	54.6%

A = gross available time
B = planned down time
C = running time (A-B)
D = down time
E = operating time(C-D)
F = availability (E/C*100)
G = output
H = theoretical cycle time
I = performance (H*G/E*100)
J = rejects
K = quality (G-J/G*100)



OEE average= 54.8%

Fig 3.8 Graph for Conveyor Machine before Implementing TPM

Table 3.11 Detail of Defects in Conveyor Machine

S.NO	Details of Defects	Action Taken
1	Master plate threads are spoiled	New blade is fixed
2	Tool change position noise	Proper fitting and alignment
3	Chip conveyor rubber plate not corrected	New plate is fixed
4	Cleaning air leak	Replaced new hose
5	Fixture setting time more	eliminated
6	Screw cover vibration	Corrected and adjustment
7	Plate cover jerk	Tighten
8	New door cover is needed	Door cover changed
9	Rust in spindle	Corrected

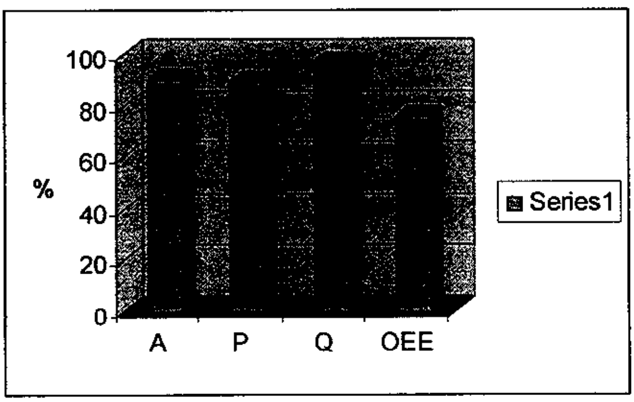
Table 3.12 Autonomous Maintenance Check list for Conveyor Machine

criteria	Sub ass	where	what	How	time	res	remark	freq
inspection	machine	front	lamp	Visual	2min	operator	check	daily
inspection	Conveyor M/c	M/c inside	check	Visual	2min	operator	avoid	daily
cleaning	machine	overall	check	Hand	30min	mechan ic	maintenance	week
Inspect & tightening	Moving load	front	Conveyor	Hand	2min	operator	Avoid force	daily
inspection	motor	M/c back side	noise	Ear	2min	operator	avoid	Daily
tightening	Electric panel	inside	Electrical lines	Hand	30min	electrici an	avoid	3mon th
Inspection	moving belt	Outside M/c	conveyor	Hand	10min	operator	check	Week
Cleaning/ inspection/ tightening	Overall M/c	All area	lubricant	Manual	8hrs	Mech & elect	Preventive maintenance	6mon t

Table 3.13 OEE for Conveyor Machine after Implementing Total Productive Maintenance

Period	A	B	C	D	E	F	G	H	I	J	K	OEE
Week1	8450	550	7950	820	7130	89.6%	108	60	90.5	4	97.1	78.8
Week2	8450	550	7950	790	7160	90.1%	106	60	88.8	5	96.3	77.0
Week3	8450	550	7950	810	7140	89.8%	110	60	92.7	3	98.4	72.4
Week4	8450	550	7950	740	7210	90.6%	104	60	86.5	2	97.3	76.2

A = gross available time
B = planned down time
C = running time (A-B)
D = down time
E = operating time(C-D)
F = availability (E/C*100)
G = output
H = theoretical cycle time
I = performance (H*G/E*100)
J = rejects
K = quality (G-J/G*100)



OEE average= 76.1%

Fig 3.9 Graph for Conveyor Machine after Implementing TPM

CHAPTER 4

RESULTS AND DISCUSSION

Total productive maintenance methods changed the maintenance culture of selvi food product industry. Minor defect and down time loss in mixer machine were eliminated with help of autonomous maintenance activity.

OEE values before & after implementation of TPM methods

S.NO	Before implementing TPM Methods	After implementing TPM methods
1	Mixer machine the OEE=65.3%	Mixer machine the OEE=65.3%
2	Cooking machine the OEE=59.7%	Cooking machine the OEE=72.4%
3	Conveyor machine the OEE=54.8%	Conveyor machine the OEE=76.1%

The autonomous maintenance is successfully implemented and due to that breakdowns are rectified.

CHAPTER 5

CONCLUSIONS

Today, with competition in industry at an all time high, TPM might be the only thing that stands between success and failure for some companies. The developed methodology has an aim to bring, concerning the creation of competitive advantages, exploitation increase of mechanical equipment of a company. It can be adapted to work not transportation, and in Varity of other situations.

- Increase of productivity, via reduction of downtime loss
- Product quality improved
- Improvement for healthier and safer work environment.

After the implementation of autonomous maintenance the following benefits are achieved.

- Prevention of accidents
- Increase in the machine life
- Consistency in product quality
- Break down reduction.

CHAPTER 6

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