TPM-The Need of the Hour for the Ethiopian Textile Industry

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ABSTRACT

The primary goal of total productive maintenance (TPM) program is to change the culture of the industry maintenance policy by participation of all employees toward the maintenance system of the company. It aims to reduce unplanned stoppage, breakdowns accidents and losses obstructing equipment effectiveness. In most of Ethiopian industries maintenance is considered as evil activity. This paper is aimed at implementation of TPM in Ethiopian textile industry (KK Textile Industry PLC, Addis Ababa) is presented. This study has exploited various research methodologies by exploring their contribution toward the best triumph of the anticipated results. Relevant primary and secondary information was congregated to induce superior maintenance system for the industry. The relevant secondary data was collected from the technical manual, monthly and annual report of the industry. Information was also gathered using questionnaire and interview in structured way besides direct observation on site visit to enable the investigator to keep tracking the responses. The collected data mainly aims at assessing the existing maintenance system and the future business plan of the industry. Data analysis in the research has been conducted using appropriate tools in order to identify core problems in the specified company. Based on the analysis for various maintenance activities of the industry, some work flow and systems are developed and proposed. Finally, TPM system is developed along with its implementation and master plan for the case industry.

Keywords: Total productive maintenance, OEE, textile industry.

INTRODUCTION

New approaches in modern service and manufacturing industries have been rummaged around, developed and implemented so as to survive in the dynamic and fierce competitive system that are becoming even more complex. The need for driving down costs, integrating every activities and available resources of a company, empowering the employee to make decision, eliminating waste generated by failure across the value adding process, shortening of production lead time and delivery of quality assured services and products have been given due attention. As they are the necessity to secure a sound future within an ever changing market and to be open to all market and technology driven opportunities. To meet these needs, one of the new techniques in maintenance area that is developed in Japan to support total quality control and just-in-time is TPM. Even though, many management personnel consider maintenance as expense and evil activity, presently, there is a gradual shift in thinking as companies began to identify the role of maintenance and it is also well accepted that maintenance is one of the main potential area to use as a competitive advantage. Currently, the concept of TPM in Ethiopian manufacturing industries is the critical missing concepts in successfully achieving not only world class equipment performance, but also it is a powerful new means in improving overall industry performance.

Ethiopian textile industries are becoming incompetent in national as well as international markets. The reason

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for this may be the poor maintenance management system of the industries does not allow the industries to become more competitive. Maintenance is one of the areas to be given due consideration in modern management to increase machine productivity and to produce quality products as well. The modern business world is exploiting better mechanisms to be competitive, so the last thing the industries need is better maintenance management system, if they are to provide better product to get in their own way to develop suitable system for the success of their business.

Generally the study will focus on assessing the existing maintenance system of the KK Textile Industry PLC to investigate potential area of improvement so as to develop and implement the TPM to the best achievement of the objective.

KK Textile Industry PLC is one of modern textile industries in Ethiopia and the machineries are computerized except the one which bought from Akaki textile industries. The industry is capable of producing different items through new and computerized machineries but what is distressing is that the industry has been operating under its planned capacity due to high rate of unplanned failure. Generally, the maintenance system of the industry is based on poor integration of all functions and processes in the organization, which results in high maintenance cost, less availability and reliability of equipments, high total maintenance hour and man hour, frequent failure of machineries, low profit, low production, and low workers dissatisfactions.

As the country is having high demand of textile products, enhancing the performance of the industry through implementing well developed and organized maintenance system will not only help the industry to have efficient way of maintaining its different machineries but also it contributes its experience for the similar industries toward providing high quality product. The objectives of the research are to critically examine and investigate the problems of the existing maintenance system of the industry, to study the maintenance system of the industry, to identifying the causes of the existing problems and propose developed maintenance system and implementation model for the industry.

Scope and Limitation of the Study

The study conducted in the KK Textile Industry PLC is based on the available data, questionnaire, interview and visit. The available data is taken only for fiscal year of 2006-2007 due to poor recording and reporting system prevailing in the industry. Further more, the author couldn't find a single industry, which has experienced in the implementation of TPM in the country to share the experience for TPM development program for the industry. Hence, the authors persuaded to rely on the literature review.

Significance of the Study

The study will have significant contributions to the industry to have well established maintenance system that facilitates it to provide better services to its customer. Further more; the study can be used with small adaptation in similar Ethiopian textile industries. The study is also valuable for further and better research.

LITERATURE REVIEW

The goal of TPM focuses on improving corporate culture through improvement of human resources and plant equipment. The Japan institute of plant maintenance (JIPM) has put forward the five goals of TPM which are the minimum requirements for the TPM development (JIPM): (i) Improving equipment effectiveness. (ii) Improving maintenance efficiency and effectiveness. (iii) Early equipment management and maintenance prevention. (iv) Training to improve the skills of all people involved. (v) Involving operators in routine maintenance.

Benefits of TPM

Johansson and Nord (1999) depicted the following benefits derived from the implementation of TPM:

- Delivering the right quantity at the right time, in the right quality.
- Productivity is improved through fewer losses in the company.
- Quality is also improved as a result, that the failures and malfunctions are reduced and the order and method are focused.
- The cost are lower, because the losses, and other not value generating work are reduced.
- The delivery time can be kept better, because the production without disturbances is easier to plan.
- Environment and security are better, because leakages are tightened.
- Motivation is higher, because the responsibility and rights are delegated and the investment in the personnel is done, in the form of education.
- Plant productivity can be improved and overall plant efficiency can be enhanced by 1.5 to 2 times from the existing.
- Lower operating costs.
- Improved equipment life span.
- Better ability to satisfy customer's needs by 100%.

Further more, better understanding of the performance of their equipment can be achieved by operator through better training which lead to have better equipment performance.

Benefits of TPM for operators and maintenance personnel: (i) Increased skills through additional training, (ii) Better job satisfaction: Operators-More involvement in solving annoying equipment problems and Maintenance-More challenging work. (iii) Better job security.

Pillars of Total Productive Maintenance

The JIPM proposed a series eight pillars of TPM in a systematic way to optimize plant and equipment efficiency by crating perfect relationship between man and equipment.

The 5S

The 5S (Table 1) practice is a preparatory phase of TPM which is a technique used to establish and maintain quality environment in an organization. 5S improves safety, work efficiency, improves productivity and establishes a sense of ownership. The 5S is developed in Japan for work place organization and house keeping and represents for Japanese words: seiri, seiton, seiso, seiketsu and shitsuke which connote organization, tidiness, cleaning, standardization and discipline respectively (www.weibull.com, www.plantmaintenance.com).

Table 1. 5S nomenclature.

Japanese/ English 5S/ English 5C	Features
Seiri/ Sort/ Clear	Sort out unnecessary items form the workplace and discard them
Seiton/ Set in order/ Configure	Arrange necessary items in good order so that they can be easily picked up for use
Seisio/ Shine/ Clean and check	Clean the workplace completely to make it free from dust, dirt and clutter
Seiketsu/ Standardize/ Conformity	Maintain high standard of house keeping and workplace organization
Shitsuke/ Sustain/ Custom and practice	Train and motivate people to follow good housekeeping disciplines autonomously

Once fully implemented, the 5S process can increase morale, create positive impressions on customers, and increase efficiency and organization (Melesse Workneh and Singh, 2012; Johansson and Nord, 1999).

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Autonomous Maintenance (Jishu Hozen)

Autonomous maintenance is a unique feature of TPM that aimed at developing machine operators to become responsible for maintaining of their equipment, taking care of routine maintenance tasks, and elimination of production defects at source. These require the operator to be able to sense and find abnormality of the equipment (Robinson and Ginder, 1995). To acquire the above mentioned ability, operator should have the following basic abilities: Ability to tell normality from abnormality precisely; Accustomed to strictly keeping the rules of condition control; Ability to take quick and proper actions against the abnormality.

Kobetsu Kaizen

Kaizen is a aimed at incorporating a number of small continuous improvements to achieve and sustain zero losses with respect to minor stops, measurement and adjustments, defects and unavoidable downtimes. The key aspect of Kaizen is that it is an ongoing, never ending improvement process through eliminating losses using all techniques for Kaizen and by changing the operation process to make the job more productive, less tiring, more efficient or safer for the employee (Melesse Workneh Wakjira and Singh, 2012).

Kobetsu Kaizen ten step development are: Step 1-Select model equipment/line/process, Step 2-Organize project team, Step 3-Grasp present losses, Step 4-Kaizen theme and goal setting, Step 5-Mapping out Kaizen plan, Step 6-Mapping out and evaluation of analysis and countermeasures, Step 7-Implementation of Kaizen, Step 8-Confirm effects, Step 9-Taking measures to prevent recurrence and Step 10-Horizontal replicate.

Planned Maintenance

The planned maintenance aims to increase mean time between failures, reduce mean time to repair, and reduce maintenance cost. There are two basic activities carried out in planned maintenance system to have trouble free machines and equipments producing defect free products for total customer satisfaction: Maintenance activities, and Kaizen activities.

Planned maintenance has eight activities conducted by maintenance department (Robinson and Ginder, 1995) viz., support and guidance to autonomous maintenance, zero failure activities, planned maintenance structure, lubrication management, spare parts management, maintenance cost management, predictive maintenance and diagnostic method, and enhancement of maintenance technology and skill.

Standardization of maintenance activities:

Maintenance activities ought to be standardized for several reasons.

- The diverse maintenance activities.
- Maintenance techniques and skills take a long time to master.
- Maintenance work is generally less efficient than production work because it is essentially non repetitive and requires length preparation and large margins for error.

Quality Maintenance

The purpose of quality maintenance is to produce defect free products to maintain the product quality through eliminating non conformance so as to satisfy the demand of the customer. The JIPM define quality maintenance as activities that are to set equipment conditions that preclude quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of products (JIPM).

Training

One of the obvious reasons for training is that the employee can't do something that the job requires to be done. There is some skill they have yet to perfect or acquire, or some knowledge they are lacking that keeps them from doing a completely satisfactory job.

This reasons enough to make training a necessity. Training is an integral part of TPM. Training the operators and the maintenance workers helps to achieve zero breakdowns as many breakdowns are a result of lack of skill (Johansson and Nord, 1999).

Office TPM

This pillar involves other functions of the organization to focus on improving productivity, bringing better efficiency in administrative function and eliminating losses. The aim of office TPM is to make the production system efficient through the entire organizational activity. Office TPM addresses twelve major losses. They are - Processing loss; Cost loss including in areas such as procurement, accounts, marketing, sales leading to high inventories; Communication loss; Idle loss; Setup loss; Accuracy loss; Office equipment breakdown; Communication channel breakdown, telephone and fax lines; Time spent on retrieval of information; Non availability of correct on line stock status; Customer complaints due to logistics; Expenses on emergency dispatches/ purchases.

2.2.8 Safety, Health and Environment

The basic principle of safety, health and environment is to minimize the number of accidents, health problems and damage to the environment. This pillar plays a great role in the other pillars that addresses workplace organization and discipline, regular inspections and servicing, and standardization of work procedures.

Case Study: KK Textile Industry

Short History of the Industry

KK Textile Industry PLC was established over twenty years ago, a pioneer in the private sector of textile industry of Ethiopia.

Current business activities and lines of operation:

Trading and Distribution: Import and distribution of yarns, blankets, tires, food items, electrodes, pipes and industrial raw materials; and export of textile products especially cotton blankets, and agricultural products.

Manufacturing: Dyed, acrylic yarn, and blankets of different quality, size, design, and color.

Maintenance System of the Industry

Maintenance system of the blanket factory

The maintenance system of the industry is according to the skill of the maintenance personnel. The maintenance department of the industry has no manual. The researcher's tried to find the problem that the industry does not have the manuals, the answer found was the equipment vendor's didn't give enough material. The maintenance personnel just changes the items which failed by the operation after the failure occurs. There is no analysis done to find the causes and the effect of the failure.

Some of the maintenance plan of the industry contains cleaning and making minor inspection on the machineries. The plans are not based on the maintenance manuals due to unavailability. The maintenance system the company uses is almost 85% breakdown type and very small percentage about 15% lubrication and change of oils. The maintenance system of the company doesn't allow the operators to change any items before it break.

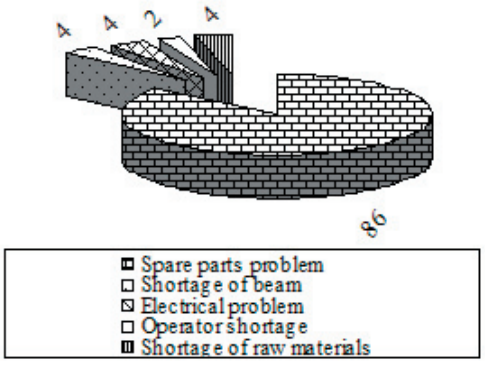


Figure 1. The causes of idle time distribution.

Table 2. Sample of monthly production of blanket (June to November, 2007).

Months	Production (Pieces)
June	20967
July	27817
August	24954
September	28550
October	29217
November	28848

Table 3. Production and the waste products (June to November, 2007).

Months	Production (Kg)	Waste (Kg)	Percent
June	91928.8	13227	14.38
July	78372.6	12615	16.09
August	80286.8	11918.4	14.84
September	68958.1	8601	12.47
October	82927.8	11171.7	13.47
November	63251.6	8202	12.47

In current situation around 9 machines failed and stopped operation out of 15 machines. All machines stopped by the problem of spare parts and this shows that the maintenance system of the company doesn't follow the correct maintenance procedure and due to the machines are out of operation the company is loosing its profit. The idle time records show that 86 percent of the idle time is due to the shortage of spare parts and the other minor causes are shown in the Figure 1. Table 2 shows the production of the new and old blanket factories during the last six months. Table 3 shows the production and the waste products from June to November, 2007. Table 4 shows the defect types recorded from June to November, 2007.

Table 4. Defect types recorded (June to November, 2007).

Salvage	Loom pantor	Raising	Cutting waste	Total (Kg)
June				
4154	383.5	7303.5	1386	13227
July				
4235.5	538.5	6587.5	1253.5	12615
August				
4039	518.5	5936.5	1424.4	11918.4
September				
3371	639.5	3461.5	1129	8601
October				
3913.1	743.3	5399.5	1115.8	11171.7
November				
3081.9	684.6	3496.5	939	8202

Overall equipment effectiveness

Overall equipment efficiency (OEE) is a tool that combines multiple manufacturing issues and data points to provide information about the process. It is an all inclusive benchmarking tool that serves to gauge the various subcomponents of the manufacturing process (i.e., availability, performance and quality)- and used to measure actual improvements on 5S, lean manufacturing, TPM, Kaizen and six sigma. When using OEE with these management systems the benefits become tangible and noteworthy (www.plantmaintenance.com).

After all factors are taken into account, the OEE result is converted (transmuted) in percentage. The results (in %), therefore, can be regarded as a preview of the existing production efficiency of a particular line, cell or machine.

Having the right metrics, OEE provides a window to analyze out of the ordinary issues and gives you an established framework for improving the whole manufacturing process.

OEE = Actual output ÷ Theoretical maximum output

or, OEE = Availability ratio × Performance ratio × Quality ratio

Availability ratio-the share of the actual production time and the planned production time.

Availability = [Operation time (Scheduled time available–Downtime) ÷ Scheduled time available] × 100%

Performance ratio-Loss of production due to underutilization of the machinery. In other words, losses are incurred when the equipment is not run with full speed. Short, unregistered, stops may affect the performance ratio as well.

Performance ratio=Processed amount×Ideal cycle time÷Operation time

Quality ratio- The amount of the production that has to be discharged or scrapped.

Quality ratio=Amount good÷Total amount produced

It is a significant performance indicator in TPM which enables one to know how much the equipment is utilized to the fullest. A high level of equipment effectiveness can be achieved only when all three rates are high.

As it has been delineated previously, the method distinguishes the six big loss types, and three key performance measurements: availability, performance rate and quality rate that combines into one consolidated metric. To find the overall equipment efficiency of the textile industry, identifying the six major losses of the machines was the first stride by organizing under three key factors. And then data pertinent to those losses was collected for randomly selected machineries. The major losses that are identified and the OEE of the selected machineries presented as follows.

- Equipment failure loss: In the industry the highest loss that hinders the efficiency of the machineries is equipment failure loss.
- Setup and adjustment loss: This loss occurs mainly at the shift and rest time of the operators. Frequently, it is observed that the machineries are not operational at this time to prepare for the ensuing operation.
- Startup loss: In the industry at the beginning of the machine there is small time loss to warm up the machine.
- Minor stoppage and idling loss: The minor stoppage loss is the one in which minor trouble causes the machine to refrain from operation. When breakage occurs during operation on weaving machine and transpalet machine, unplanned stoppage for cleaning and lubrication is one of the minor stoppage and idling loss occur on the factory.
- Speed loss: The weaving machines maximum designed speed is 450rpm but the machines are running with the speed of 280rpm.
- Defect and rework loss: The defects in the blanket factory are not re worked but discarded as

Table 5. Sample data of wearing machines available in the department.

Total number weaving machines	Number of machines in operation/day	Planned production (m)	Maximum production	Availability (%)
15	6	1515	557	40
15	6	1515	575	40
15	6	1515	530	46
15	6	1515	554	46
15	6	1515	607	40
15	6	1515	418	40
15	6	1515	648	40
15	6	1515	637	40
15	6	1515	482	40
15	6	1515	275	40

waste but in the acrylic yarn factory most defects are sold by lower price. In general the defects are likely to be considered as waste which should be disposed of.

Calculating overall equipment effectiveness:

Some of the data pertinent to the above loss are difficult to obtain, since the industry doesn't apply the OEE concepts in evaluating the performance of the machines at the individual level. It has been attempted to gather some relevant data to estimate the OEE of the typical machinery.

Availability:

The availability is the ratio of time needed for operating the equipment to the time actually consumed for operation and it is expressed as:

Availability= Actual running time÷Scheduled running time (1)

From the observations and few recorded data to calculate the availability of the machine, the researcher has treated the weaving machines as a whole as one machine and considered the available machines in that departments. Therefore accordingly the available machines on the days are collected and recorded in the Table 5.

Unplanned stoppage means the period during which the line is stopped due to equipment failure, setup, adjustment, and change over and so forth. To find the availability of the machines, equipment failure loss of ten days is collected and shown in Table 5.

Performance rate:

It is expressed as:

Performance rate=Speed operating rate×Net operating rate (2)

To find the performance rate for the machines, the collected data (Table 6) indicates that the scheduled speed of the machineries is 280rpm. The quality section performed calculations to find the performance of the machines. Table 6 shows the performance of weaving machine.

Table 6. Performance of the weaving machine.

Average rpm	Average picks/cm	Average time (minutes)	Average weft breakage	Average warp breakage	Calculate production (m)	Average actual production	Average actual effect (%)
280	8.1	30	4.4	2	10.37	8.2	79
280	8.1	30	4.8	2.2	10.37	8.2	79
280	8.1	30	4.5	2	10.5	8.75	83

According to the records the average performance rate of the pantor loom (weaving machine) is 80%.

Quality is fitness to use or exceeding customer satisfaction and so on. In the case industry the quality parameters are defined in two factories that is blanket and acrylic yarn factory. The quality problems in the blanket factory arise from different reasons. But recorded data shows that the main reason for poor quality product is negligence of operators.

Table 7. Yearly production plan of 2005/06.

Type of product	Production plan (Kg)	Actual production(Kg)
100gm yarn	1381200	480602.4
250gm yarn	3222800	2745921
250gm millage	0	12900.25

Table 8. Yearly production plan of 2006/07.

Type of product	Production plan (Kg)	Actual production (Kg)	Actual/ Planned (%)
100gm yarn	706500	144700	20
250gm yarn	1468500	1591329	108
250gm millage	0	4900	-

Table 9. Sample data of type and amount of defects in three years.

2004/05	2005/06	2006/07	Total
Defect type:			
Bar mark:			
569.64	413.2	376.05	1358.89
Died cut:			
689.56	470.16	335.96	1495.68
Shrinkage:			
325.85	248.8	67.05	641.7
1585.05	1132.16	779.06	

Quality rate=Output-Waste ÷ Total output (3)

From the Table 6 the quality rate of the machine is 85%. Therefore, the OEE of the weaving machine is obtained by multiplying the above three factors and the result is $0.85 \times 0.8 \times 0.4 = 0.272$

The calculated OEE of the machines shows that the poor OEE attributes to poor availability of the machines. The company can easily identify the causes of the loss which inhibit the overall equipment efficiency using this method.

3.2.3 Maintenance area of acrylic yarn factory

Acrylic yarn factory is one part of company and its main products are different color yarns. During the research period the researcher found that most of the machineries in the factory are working and there was no recorded data available to assess the past data. The data

available to assess the production and quality of the factory are shown in Tables 7-9. The sample data of the yarn production and the average waste taken from the monthly report of five months is as shown in the Table 9.

3.3 Problem Areas in KK Textile Industry PLC

3.3.1 Allotting the maintenance activities to the operator in both acrylic yarn and blanket factories

In industry all maintenance activities are only done by maintenance division which encompasses maintenance foreman. Deterioration prevention based on fixed interval of time and restoration of the equipment are the basic activities of the maintenance division of the industry. The purpose is to achieve industry goals through the implementation of operator initiated daily maintenance consisting of cleaning, adjustment, and regular inspections, as well as improvement activities. And the maintenance division also needs to participate only in inspection and restoration of equipment which requires high skill and specialization.

The proposed activities that the operators and the maintenance division should do are revealed as follows.

- The operator's of blanket and acrylic yarn factories duty should be:

(i) Restoration of minor deterioration of the machineries: (a) Restoration of some mechanical part failure. (b) Restoration of oil, mechanical drive and electrical system deterioration.

(ii) Establishing basic conditions for all the machines in the department: (a) Cleaning for weaving, warping, raising, and other machines they operate. (ii)

Retightening of loose parts on the above mentioned machineries.

(iii) Keep operating condition for Obem dyeing machine, weaving boilers and other machines: (a) Operating properly. (b) Proper loading based on the capacity of the machines.

(iv) Accomplishing minor inspection for the equipments and machines: (a) Appearance inspection for the machines listed above. (b) Noise, vibration etc. tracking while operating by understanding irregularities for internal deterioration by the five senses. (c) Reporting the condition of the equipment immediately for further investigation if it is required.

- The maintenance personnel's of the two factories duty should be:

(i) Execution of time based maintenance for all the machines in the industry: (a) Prepare annual, monthly and weekly maintenance plan for the weaving, raising, and other machineries in the industry. (b) Perform the above plans accordingly.

(ii) Standardization of following points: (a) Standardization of replacement for every machinery in the industry. (b) Standardization of maintenance activities and methods for every machinery in the industry. (c) Standardization of inspection methods for all machines.

(iii) Providing training to the operators in both acrylic and blanket factories.

(iv) Diagnosing failure mode and effect analysis when failure occurs in any machine within the industry.

(v) Prevent recurrence of failure that has occurred in routine operation.

(vi) Discover potential failures (fatigue, faults and equipment weaknesses) of priority equipment.

3.3.2 Standardization of maintenance activities

In the industry it is observed that, most of maintenance activities are executed without the base of standards. The following area is proposed for the industry to be standardized to have consistent maintenance system (Appendix 1).

Executing training to develop the maintenance skill of the maintenance personnel and operators on industry

It is proposed that, the industry need to focus on providing continuous training to all of its operators to increase the life and availability of the equipment. The following points picked out from the study that some of the skills that operators of the company need to acquire are:

- Ability to detect causal abnormalities.
- Ability to perform minor inspection and restoration and more.

The training provided to the maintenance men focuses on developing them as a teacher and leaders in the maintenance field. They should act in close cooperation with operators. Some of the skills that the maintenance men of both factories should have include:

- Ability to prepare and train operators in both factories.
- Ability to promptly discover causes when ever a failure occurs for machineries.
- Ability to make the repairs and checking of equipment before handing it over.
- Ability to trace the causes of failure.

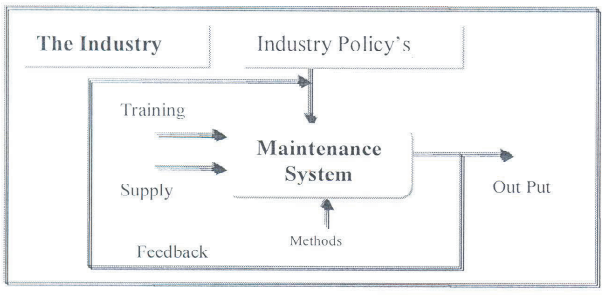


Figure: 3.6. Simplified Maintenance System Model

Figure 2. Simplified maintenance system model.

Proposed area of computerization for the industry

Areas that many textile industries are now turning their attention are toward developing and using computer programs geared toward control of

the maintenance organization. In light of this, it is proposed that the industry need to force itself toward exploitation of the benefits from these eras technology to survive through cost effective solution to most of its problems.

Improving the maintenance workflow

No functions that are proposed in the above will be effective unless a workflow is developed for planning and scheduling maintenance work. Once established, this workflow must be followed consistently if significant results are to be expected. The maintenance workflow model proposed for the industry shown in Figure 2 is developed by taking the maintenance activities as a system that has an input and out put. Since maintenance system is a complex system, irrespective of its function and size. Internally, it is composed of interrelated and interdependent parts. Externally to the maintenance system, there are components that impact on and/or are impacted by the organization. All are interconnected and affect other systems to varying degrees. Distinguish between activities moving into the system and those moving out of the system were the first step in modeling the work flow. This way of looking at the maintenance system enables to incorporate all constituent parts that will assist in planning and coordinating recourses and activities.

Further more, feedback the results of the out put in to the maintenance system is also considered as a vital element for future development of the system. The input and out put that are considered for the maintenance activities of the industry are shown in Figure 2.

The main activities in maintenance system are planning, scheduling and execution of all practical maintenance work requests within their required completion dates. This work will include all breakdown and preventive maintenance tasks and corrective work. Planning consists of planning the actual work activities and the resource needs, such as tools, materials and work skills for the maintenance task. Where as scheduling is the assignment of numerous planned jobs into a defined period of time to optimize the use of the resources. Execution of the maintenance task consists of such activities as installation, inspection, modification, restoration and repair of the equipments.

As it has been delineated in the previous sections, the maintenance activities of the industry are not well equipped with training and work standards. The proposed model incorporates training, autonomous maintenance, improvement concepts and standardization of the maintenance activities that makes the model far better than the existing system. In model the operators in both factories involve in minor inspections, more over training is provided for them to have know how of their equipment. The maintenance men are also trained to reduce the repair mistakes and to prepare them to teach and lead the operators with better knowledge. This simple proposed model is sustainable if and only if a industry implements the TPM system since the central core of the TPM system is to integrate every activities of a industry with maintenance department as well as involving the operators in maintenance activities.

Overall TPM Development Program for the Industry

The implementation of TPM in the industry is intended to be carried out devising the implementation steps systematically by breaking down each activities of the appropriate pillars of TPM and leveling them according to their priority. It is supposed that full implementation of TPM program of the industry will take minimum 42 months. And also, the three years of the program is partitioned into six implementation levels which they will have six months of equal interval. In each level, the required implementation steps for each activity of the selected pillars of TPM

executed according to their precedence. The target is set for each level and the results are measured against it. If the implementation of that level is successfully succeeded, the immediate level will be started to be implemented. But, if it fails, a thorough investigation carried out to discover the causes of the failure so as to use for the upcoming practice and the process of the achievement keeps on until it becomes satisfactory. The proposed execution model of the implementation process is shown in Appendix A. Before the launching of the implementation model there is preparatory step. In this step the commitments of top management and necessary budget will be allocated. An overview of TPM and committee will be formed for each TPM pillars. It takes six months to perform such activity.

TPM implementation plan

This section endowed with developed steps that are required to implement TPM system in KK Textile Industry PLC. However, the scope of this developed implementation plan is that it is not exhaustive which entail iterative process and multidisciplinary team for effective implementation plan.

Introductory step (step zero)

The introductory step of TPM implementation plan used to make commitment of top management, and to allocate the necessary budget for the implementation. In this step the TPM committee is established and any introductory lesson should be given step by step. Finally the introductory step should be evaluated according to the questions prepared to asses it.

1. Announce top management of textile industry decision to introduce TPM:

- Did top management of textile industry make an announcement to implement TPM?
- Is the announcement made in the board of directors of industry meetings?
- Is the announcement made in meeting of textile industry general manager, finance manager, administration manager, commercial manager production and technique manager of the industry?
- Have the TPM lectures for corporate managers such as productions managers, quality control and marketing managers been planned?
- Is publicity given to the top management decision to implement TPM through industry bulletin?
- Is presentation made for the purpose and prospective effects of TPM to president in a case where TPM introduction has decided by industry business department?
- Is owner of the industry an advocator for TPM?

Is it decided to spend money and time for achieving improvement of equipment and human psychological constitution through TPM in the industry?

Has declaration of introduction been ever made by operators of the machine?

2. Introductory education and campaign of TPM:

- Is the purpose of TPM implementation understood by all levels of the employees in the industry?
- Did top management such as textile manager and others participate in PM excellent plant award winners lecture?
- Did top management of the industry participate in TPM lectures for the management?
- Did top management participate in TPM executives' course?
- Did managers of different departments in the industry participate in TPM manager's course?
- Did supervisors and operators participate in TPM training courses for the production field leaders?
- Did team leaders participate in TPM training courses for the production field leaders of the industry?
- Have the employees been educated using TPM video and slides?
- Is the education disseminated by production

field leaders to the ordinary employees?
- Is campaigning of TPM done using posters, slogans etc in the industry?
- Is sufficient budget secured from industry top management for introductory education?
- Did the top management of the industry take initiative in receiving the education?
- Did the top management arrange the education at each level of hierarchy in the industry?
- Did the top management of the industry evaluate the progress of education?

3. Establishing TPM promoting organization and pilot organizations model:
- Has the TPM committee been organized to promote TPM throughout the textile industry?
- Does TPM promoting committee have a promotion office and full time personnel?
- Are subcommittees organized by theme to be tackled and "Kobetsu-Kaizen" project teams for the followings: (i) Public relations for the whole industry? (ii) Education and training for the operators in the industry? (iii) "Kebetsu-Kaizen"? (iv) "Jishu Hozen"? (v) Planned maintenance? (vi) Safety hygienic and environmental factors?
- Are chiefs and managers of different departments in the industry are TPM committee members?
- Is TPM promotion organization and its personnel allocation done by top management of the industry?
- Do the following committees of the industry held meetings once in a month: (i) TPM promotion committee in the industry? (ii) Section promotion committee in the industry? (iii) Subcommittee of the "Kobetsu Kaizen"? (iv) Subcommittee of "Jishu Hozen"? (v) Subcommittee of "planned maintenance"? (vi) Subcommittee of "initial production and flow control"? (vii) Subcommittee of "Hinshitsu Hozen"? (viii) Subcommittee of "office improvement"? (vii) Subcommittee of "education and training"? (ix) Subcommittee of "safety and environmental factors"?

Setting basic policies and target for TPM (Establish basic TPM policies and goals):
- Is the TPM integration into the basic business policy of the industry or corporate mid/long term business plan clarified?
- Is the ideal condition clarified by each working level of the industry?
- Has the time needed for reaching PM excellent award been predicted for the industry?
- Are the TPM targets decided for the followings in the industry: (i) Failure reduction percentage? (ii) Overall equipment efficiency?
- Is the PM award screening level compared with the benchmark to predict the achievement and estimate cost to effect for the industry?
- Have the basic business policy or mid/long term business plan, cost management of the industry with TPM activities and targets of the industry been adjusted?
- Is the TPM basic policy confirmed and applied satisfactorily in the lower level of the industry?

5. TPM master plan:
- Is the promotion organization in the industry established?
- Do adequate numbers of over lapping small groups in hierarchical system and promotion secretariat exist in the organization?
- Have the policy, targets and achievement goals been set?
- Are the following activities being exercised in the industry: (i) TPM news? (ii) Contest using activities status board? (iii) Provision for presentation of activities? (iv) Organization of Kaizen teams? (v) Selection of Kaizen theme? (vi) Establishment of planned maintenance system? (vii) Management of lubricant and spare parts? (viii) Establishing the initial production and flow control? (ix) Standardization of process methods? (x) 3M (man, machine, material) analysis? (xi) FME and PM analysis? (xii)

Simplification of accounting related procedures? (xiii) Kaizen of production management system? (xiv) Development of warehouse and storage management? (xv) Safety inspection manual? (xvi) Daily safety management activities? (xvii) Establishing education system? (xviii) Individual ability development? (xix) Maintenance skill training? (xx) Support for "Jishu Hozen" activities?

TPM kickoff:

- Is the announcement of TPM introduction made to all employees in the industry?
- Is it confirmed if every employee in the industry agrees with the top management policy of TPM?
- Is any event to commemorate the occasion planned when all the employees in the industry agree with the decision of the top management to completely eliminate 16 major losses of the industry?
- Is the right environment created in the industry where every employee of the industry agrees with the top management policy of TPM implementation?
- Is the morale of all employees in the industry heightens to an extent where they can challenge the ultimate end aggressively?
- Are the presentations made on these topics: (i) TPM basic policy to be applied in the industry? (ii) TPM target for the industry? (iii) TPM development master plan of the industry? (iv) Repetition of decision making by top management of the industry? (v) Declaration of challenging PM excellent award by the representative of the employees of the industry?
- Has the top management of the industry attended the kickoff meeting to reconfirm the declaration of TPM introduction?
- Are encouragement speeches by guests from similar textile and other industries organized?
- Are the customers of the industry, affiliated companies and cooperative companies invited to the event?
- Has the introductory TPM education been finished before kickoff day?
- Has the necessary arrangements made in advance concerning the events which will be held on the kickoff day?
- Has the round tour of production floor been made to ask the forefront operators whether end purpose of TPM introduction been fully understood?

Table 10. Introductory education conducted to the section head.

Sections Heads	No. of Person
Administration head	1
Finance manager	1
Production and technique manager	1
Productivity improvement and quality head	1
Marketing and sales head	1
Maintenance and technical department head	3
Blanket production head	1
Store head	1
Spare parts store head	1

Step 1: Declaration by board of directors and general manager to introduce TPM in the industry.

The commitment of the top management of the industry is indispensable for rapid promotion of TPM. In this step the following activities should be conducted: (i) Meeting conducted by the board of director of the industry to announce that the implementation of TPM is decided. (ii) To prepare a schedule for training the managers of the industry.

Step 2: Introductory education and campaign of TPM.

After the declarations is made the introductory education to the managers and to all employees of the industry conducted according to the plan scheduled by the top managers. Initially, the introductory education is presented to each head divisions of the

industry that are on the hierarchy (Table 10). Next, the training will be presented by the section heads, which are already trained, to each of the second level of managers under their section. The training conducted down the level in the similar manner.

Finally, a maximum of a three day seminar need to be opened to the entire employee and should teach the employee the future direction of the industry. This campaign targets to help the sections head to create some understanding about the TPM and to support them not to have difficulty while implementing TPM. And also, the seminar helps the employee to have some insight about the purpose of TPM.

Step 3: Establishing TPM promotional organization.

For the successful implementation of TPM in textile industry, creating small group from top management to the first line worker or operators of the machines is formed for the industry. Leaders of individual groups are members of a small group at the next higher level of the organization to link the different groups and enhance vertical and horizontal communication. In addition to the small group function, the following team should also be created.

TPM planning team: This team is responsible for planning and prioritizing each activities of the TPM implementation in the industry.

TPM implementation team: This team is responsible for developing and executing each activities of the TPM program in the industry which is already planned.

Step 4: Setting basic policy and targets for TPM in the industry.

Each department in the industry set the policy and the target for their department for 3 to 5 years a head taking the policy and targets of the industry as their input as well as based on the condition of the department.

Step 5: Selecting model equipments for kaizen activity.

This is selecting model equipments with the highest priority. The prioritization is based on equipment safety, reliability, quality, etc. The more the equipment safety, reliability and quality is less, the more it is prioritize. These equipments selected from each type of model and function by small group which is formed.

Step 6: Follow up the result.

The last part of the introduction step is announcing the implementation of TPM in the industry in a ceremony in which all employees of the industry participate. In this ceremony supportive company, supplier and affiliated company are invited to create consciousness in their mind that better intimacy is needed based on quality. During the ceremony, proclaiming the major TPM activities that are executed in the coming three years presented along with its master plan. This stage is a transformation stage where the total implementation of TPM executed and conducted if providing the introductory TPM education to all employees is completed.

Level-1: TPM Implementation

The following activities of the selected pillars of TPM are carried out in this level.

- Autonomous maintenance activity: (i) Provide basic training to operators of the industry about safety, and equipment structure and functions of machines such as weaving, raising, stitching beam winder and so on. (ii) Make cleaning plan for each parts of the above mentioned machines. (iii) Removing unnecessary articles around the above machineries of the industry. (iv) The initial clean up include fiber dust, oil, etc. and has to be removed and minor defects of the machineries should be detected by touching for example the belt and other components of weaving machine.
- Planned maintenance activity: (i) Executing operation of the selected model equipment from each department. One weaving machine, raising, O beam and so on. This step includes: (a) Running of the

selected machine. (b) Developing the early discovery of interior situation and rapid report remedy system of the machine. (ii) Executing breakdown maintenance system: (a) Performing to restore the unplanned failure of the selected machine. (b) Identifying frequently observed unplanned breakdown of the machine. (c) Identify equipment where frequent breakdown occur and carried out like gripper head and belt, (d) Determine and track the frequency of the unplanned failure.

- Training: (i) Setting policy and priority measures to train the operators in the industry. The industry should set the basic training policy and measuring matrices suiting it and put the aims of the training in terms of developing the maintenance men, operator and fostering personnel efficiency in office work. (ii) Establish training system for the maintenance men in all textile machineries. (iii) Establish training system for the operators of the machines such as weaving, raising, stitching etc. (iv) Establish training calendar for the operators of the machines in industry.
- Improvement activity: (i) Select model from both factories that produces many loses: weaving machine. (ii) Organize the project teams to investigate major losses. (iii) The manager of the technique and production department is the leader, i.e. department manager for department model and the section manager for section model. (iv) Group and confirm the present losses. Find sufficient data also. (v) Setting improvement theme and goal. (vi) Set up Kaizen theme based on results of present status survey. (vii) Set challenging goals and periods by zero loss concepts. (viii) Assign staff for each loss.
- TPM office: Providing awareness about office TPM to all support departments such as quality control, and marketing departments of the industry.
- Safety, health and environment: (i) Constitute a committee from section heads such as weaving section, raising, stitching and others and workers headed by technical manger. (ii) As part of the initial cleaning, detect and correct any problems that might affect safety or the environment. In case of acrylic yarn factory the waste water treatment is installed for minimizing environmental safety.

Level-2: TPM Implementation

- Autonomous maintenance activity: In this step hard to access area should be improved and causes of forced deterioration should be eliminated from the machineries of the industry. Taking action at the source of problems observed in level one of autonomous maintenance. This action includes avoiding of recurrence of the accumulation of fiber dusts on the equipments by solving the problem at the foundation and eliminating the causes. In this second level of the autonomous maintenance implementation, temporary procedures or manual for cleaning, lubrication, retightening and checkups developed.
- Planned maintenance activity: In this level of the planned maintenance implementation, the above level will be continued to be executed for the additionally selected weaving machines in this level. And also the following activities accomplished for the success of the implementation.

(i) Executing preventive maintenance system: (a) Identifying equipment where preventive maintenance is to be carried out viz., rapier, belt, lateral cutter, positive cutters, gears etc.(b) Develop check list of preventive maintenance inspection for the above mentioned parts.(c) Determine preventive maintenance interval for the above equipments of the industry.(d) Developing daily maintenance system for the above mentioned equipments: (i) Cleaning, addressing latent defects and (ii) Daily inspection for deterioration. (e) Execute preventive maintenance

(ii) Executing condition based maintenance system for the machines in the textile industry: (a) Identifying equipment where condition based maintenance is to be carried out: Electrical system for timing of operation should be monitored. (b) Select the parameter to be measured for condition monitoring: Sound, temperature, visualizing the appearance of the belts gripper head and other

components. (c) Identify instruments required for condition based maintenance. (d) Execute condition based maintenance.

(iii) Introducing performance indicator for weaving machines in the industry: (a) Improvement in OEE. (b) Total maintenance cost. (c) Cost of breakdown, preventive and predictive maintenances in a percentage of the total maintenance cost.

- Training: After the first level of training implementation carried out, implement the following activities. (i) Implement the training system for the employees of the industry. (ii) Evaluate the activities of the training system. While implementing the training system, the following tasks should be done: (i) Training of instructors for maintenance skill. (ii) Operation skills upgrade training for operator. (a) Provide training for skill upgrade to correct operation, as required. (b) Provide training for skill upgrade needed for minor inspection and routine restoration. (iii) Provide maintenance skill training to leaders of small circles in the operating sector by instructors. (iv) Provide maintenance skill training to all maintenance men by instructors.
- Improvement activity: (i) Mapping out the improvement plan and evaluation of analysis. (ii) Plan the analysis and counter measuring system for the above identified losses. And also, prepare procedures for implementing. (iii) Implementation of improvement activity. (iv) To replicate the system implement PDCA cycle.
- TPM office: Initial clean up of every offices of the industry: (a) Removal of unnecessary articles. (b) Clean dirt, dust and strains in the work place. (c) Identify all documents in lockers and desks. (d) Classify documents in accordance with nature of work.
- Safety, health and environment: (i) Include key safety procedures in provisional cleaning and checking standards. (ii) Conduct safety training to the people. The aim of the training is to create hazard awareness.

Level-3: TPM Implementation

- Autonomous maintenance activity: (i) Tentative standards of cleaning will be set for the machines. For example three times a day for weaving machine. (ii) Mastering the inspection skill of the operators of all machines.
- Planned maintenance activity: The following actions are also employed for further improvement of the system. (i) Keeping and using maintenance records for the selected weaving, raising and other machine: (a) Identify the type of maintenance required. (b) Develop the form of maintenance records. (c) Identify the contacts of the maintenance report. (d) Ensure all the required information included in the record. (e) Make sure the maintenance report well kept. (f) Make sure the recorded information used or input the various maintenance activity for continuous improvement. (ii) Executing operation: Standardizing the operation method. (iii) Executing breakdown maintenance: (a) Seek a solution for minimizing the above identified unplanned breakdown and implement the system. (b) Prepare procedures and manuals for breakdown maintenance execution. (c) Carry out replacement method and adopt a system. (iv) Executing preventive maintenance system for weaving machines: (a) Measure performance of PM program. (b) Standardize equipment PM execution method. (v) Executing condition based maintenance system: (a) Set the fixed time condition monitoring system. (b) Set the criteria for unscheduled check. (vi) Executing preventive maintenance system: (a) Evaluate the performance of PM. (b) Improve the PM system. (c) Implement PDCA activity cycle.
- Training: Understand the right method of cleaning, lubrication and inspection of the machineries in textile industry.
- Improvement activity: Improve the losses and set conditions of operation.
- TPM office: (i) Fault finding work in the offices: (a) Survey the condition of work to expose the faults. (b) Remove the faults. (ii) Improve the problems

observed in the above step: Aimed at reducing or eliminating office work flow stagnation.

• Safety, health and environment: Working more on building trouble free equipment and creating safe and pleasant work place.

Level-4: TPM Implementation

The process of executing the TPM implementation for the whole equipment is performed as per the above implementation steps. Additionally, the following activities are included in this level.

• Autonomous maintenance activity: General inspection: to understand the structures functions and principles of equipment in textile industry and learn their optimal conditions: (i) Train the operators of the machines in the industry how to carry out the inspection. (ii) Find and restore slight defects through general inspection like the breakage of belts in weaving machine. (iii) Evaluate inspection skills provided in the previous levels and provide training in deficiency areas. (iv) Advance the inspection system.

• Planned maintenance activity: (i) Executing condition based maintenance system: (a) Train maintenance personal on use of condition monitoring instruments. (b) Measure the performance of the condition based maintenance system. (ii) Automate maintenance system: (a) To identify the areas that need computerization, conduct a study. (b) Critically review prevailing systems and procedures.

• Improvement activity: (i) Horizontally replicate the technique for other weaving machines. (ii) Do analytical and improvement techniques for the rest of the machines

• Training: (i) Train the operators of the weaving, and other machines for the causes of abnormal conditions. (ii) Train the operators to replace parts. (iii) Train the operators about the quality products.

• Safety and environmental activities: Address safety in the following areas: Heat, Equipment load, Vibration and excessive load, Problem during operation.

• Quality maintenance: (i) Revise standard of products. (ii) Identify waste.

Step-5: TPM Implementation

• Autonomous maintenance: (i) Autonomous inspection: To maintain the machineries of the industry deterioration and restoration condition implemented in levels 1-4. (a) Review cleanup, lubrication and general inspection criteria for the machines in the industry. (b) Preparation and implementation of autonomous inspection checks sheets for the machineries in the industry. (c) Review equipment and human factors; clarity abnormal conditions. (d) Maintain optimal equipment conditions once restoration is restored through general inspection. (ii) Work place organization: (a) Organize the surrounding of machinery. (b) Reducing material searching time by organizing material around the equipment and workplace. (c) Identification of very important parts and produce to be accessible every where. (iii) Standardize the work place of the industry.

• Planned maintenance: (i) Automate the operation system: (a) Identify the activities of the next operation. (b) Identify types of reports required. (c) Improve the previous activities of CM. (ii) Automate maintenance system: (a) Simplify the work procedure based on the above study conducted in level four of the TPM implementation process. (b) Critically study hardware and software. (c) Measure performance of the software and hardware. (d) Train the maintenance personnel on use of the system. (e) Implement the system.

• Improvement activity: Give the following points due consideration: (a) Preliminary hazard analysis.

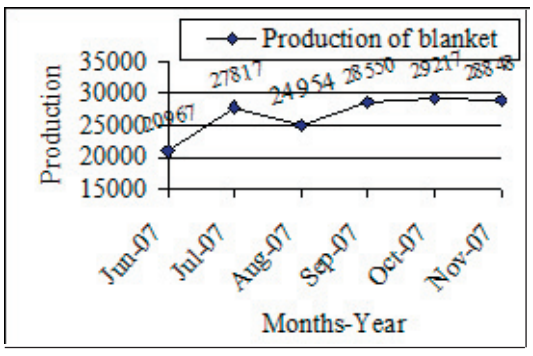


Figure 3. Monthly production of blanket.

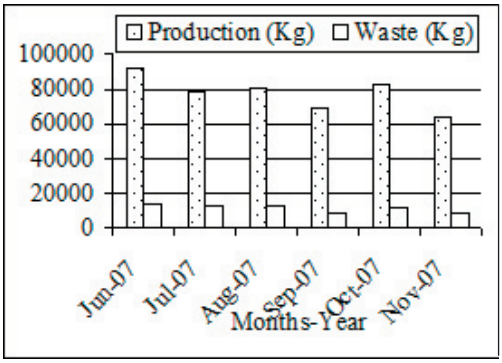


Figure 4. Production and waste report of the six months.

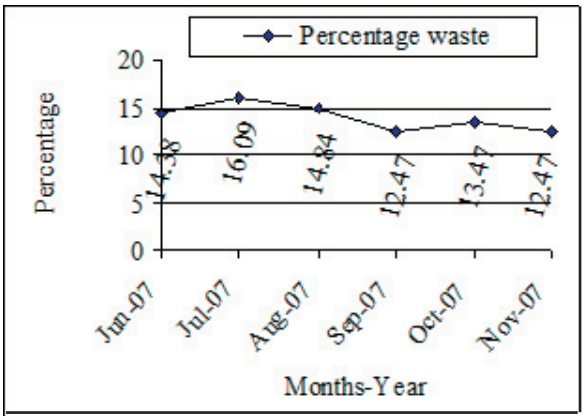


Figure 5. Percentage waste of the six months.

(b) Fault hazard analysis. (c) Mean time between failures. (d) Fault tree analysis. (e) Failure mode and effect analysis.

- Quality maintenance: (i) Waste elimination should be practiced. (ii) Analyze the activities that will contribute to the final product.
- Safety and environmental activities: (i) Identify different pollutants. (ii) Identify areas of pollution. (iii) Give hazard awareness training.
- Office TPM: (i) Check stores of files and documents. (ii) Clean the storage areas and set

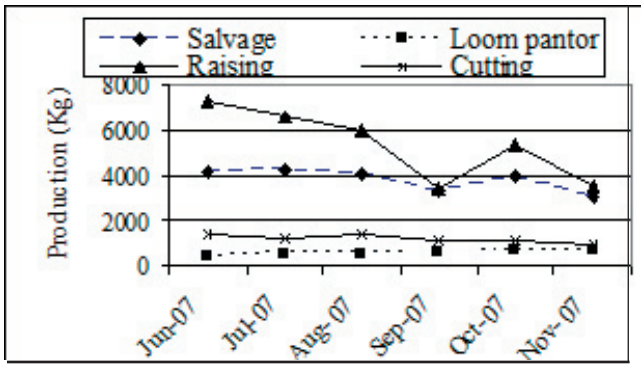


Figure 6. Comparative analysis of the types of defects in blanket.

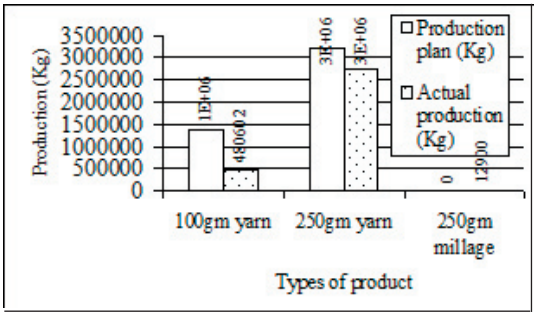


Figure 7. Annual production plan and actual production of acrylic yarn factory in 2005/2006 year.

standard time table for cleaning.

- Training: (i) Make the operators practice to estimate failure causes. (ii) Make the operators to assist in overhauling.

Level-6: TPM Implementation

- Autonomous maintenance: (i) Standardization: ensuring maintenance and management of these activities (level 1-5) and at expanding the operator roles to work related to the equipment and areas around it. (a) Standard work criteria. (b) Data record standards. (c) Spare parts management. (ii) All out autonomous maintenance management.

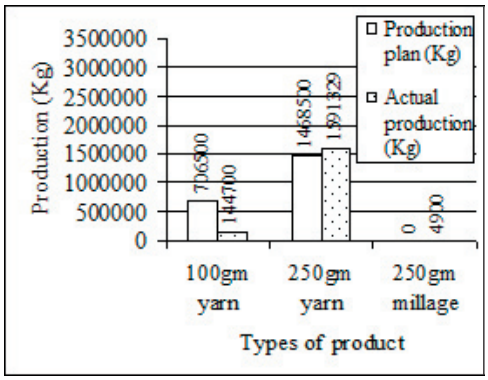


Figure 8. Annual production plan and actual production of acrylic yarn factory in 2006/2007 year.

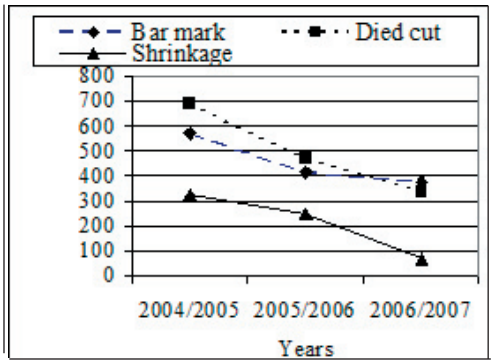


Figure 9. Type and amount of defects in three years.

• Planned maintenance: Automate the operation system: (a) Based on the above study, initially review the type of hardware and software available in the market. (b) Measure the performance of the system. (c) Train the maintenance men and the operator in the use of the system. (d) Implement the system.

• Improvement activity: (i) Clarify the phenomenon of the weaving machine selected. (ii) Practice industrial engineering techniques.

• Quality maintenance: (i) Remove unnecessary motions in the industry shop floor. (ii) Remove the process which don't add value to the product. (iii) Apply just in time manufacturing process to minimize inventory cost.

• Office TPM: (i) Clear the emergency passages and set standard to check them. (ii) Allocate articles in correct place.

• Safety and environmental factors: (i) Give one point lesson to employees of the industry. (ii) Encourage the participation in the activities.

• Training: (i) Upgrade maintenance and operation skill. (ii) Increase the technological power of diagnosing equipment.

Data Analysis

Data analysis of blanket factory

The required data are not available especially to asses the maintenance effectiveness of the industry, but few related data are collected to asses the over all performance and problem areas of the industry. As it can be analyzed from the Table 2 which shows the monthly production of blanket the production of the factory is about to decrease as indicated in the Figure 3. This is caused by different problems of the company. One of the problems assessed is the unplanned stoppages of the machineries caused by the shortage of spare parts. When we think of production we have to think the health of the machineries first. Otherwise the unplanned stoppage is expecting situation.

The other situation analyzed from the data collected is the amount of waste (Figure 4). In this case it is difficult to analyze the amount of waste in Kg with the previous month waste, because it is proportional to the amount of product. Therefore the researcher's realized the percentage of waste.

Figure 5 reveals that the wastage is not in increasing rate. This is not to show that the company should be satisfied by the result but still it has to perform much to decrease the amount of waste scientifically.

Data collected and tabulated in Table 4 shows that there are four types of defects in the process of blanket. Figure 6 shows comparative analysis of the types of defects in blanket.

Data analysis of acrylic yarn factory

Figures 7-8 shows annual production plan and actual production of acrylic yarn factory in 2005/2006 and 2006/2007 years. Figure 9 shows type and amount of defects in three years.

• Defect: Bar mark, Cause: Improper loading, Over loading, Stick misallocation, Over loading the stick.

• Defect: Cutting, Cause: Improper detaching the package, Carelessness in unloading, Carelessness in loading.

• Defect: Shade variation, Cause: Raw material problem, Non uniform in quality, Mixed yarn, Low quality yarn, Poor supervisor, Color incompatibility, Operator negligence.

• Defect: Shrinkage, Cause: Improper Loading and Stick misallocation.

RESULTS AND DISCUSSION

Some of the problems observed during the study are listed as follows:

• The industry doesn't have any maintenance record and during the study it was difficult to get data of each machine. In TPM concept the machineries

should have their own history and records. This aids the industry to perform the maintenance operation smoothly.

- The above problems lead the company even to spend more money for maintenance and also high down time. Unplanned stoppages are also high and many machines are stopped by the shortage of the spare parts.
- From the observations and interviews there is lack of good management system and the workers of the industry compare their payment with the other similar industries in that area. This causes the workers to become highly dissatisfied. The operators of the machine are not interested to handle the machines with care.
- The results found from the waste report of the acrylic yarn factory indicate that most of the defects are caused by the negligence of the workers and their carelessness.
- The maintenance personnel do not have theoretical background to investigate the problem and to remove it from the source.
- From the planned maintenance point of view the industry policy is not based on preventing the occurrence of failure. When the equipment breaks they fix it. Here the problem is not only changing the equipment or maintaining the equipment to its original working condition but also it may cause the other equipments to fail.
- Concerning the autonomous maintenance much to be done to shift the maintenance concept from maintenance department to the production department. The equipment operators should be given training on basic inspection and cleaning methods of the equipment.
- As an industry policy training has no consideration for the employees. Without training and education we cannot increase the skill of the workers.
- The result of observation shows the office arrangement is not inviting the managers to control the process and the filing system is not adequate for the controlling of the process.
- Concerning safety and environmental factors the industry has good attempt on environmental pollution by purifying the polluted water by different mechanisms. Even though the environmental safety is satisfactory the attempt should be done on the safety of the workers in the two factories. The chemical in the acrylic factory and the dusts in the blanket factories are causing series problem on the workers. But still the observer did not observe any worker who wears safety goggle or material.
- Kobetsu Kaizen (continuous improvement) concept has not been applied by the industry.
- During the study the researcher's observed that no one is attempting toward the improvement in any aspect.
- As it was discussed earlier quality maintenance is not issue of the industry. To talk about the quality of maintenance work we have to talk first about the effective maintenance.
- Concerning shop safety, some safety equipments like fire fighting systems are installed in the factory but still training on how to operate and use is lacking in the industry.

CONCLUSION

The study aims initially at scrutinizing the maintenance system of the industry and categorically concluded that the high rate of unplanned failure reigns in the industry. This can be attributed to the condition of equipment, due to negligence of the operator and shortage of spare parts. The underprivileged preventive maintenance system of the industry is also contributed to this effect. The line of investigation winds up that the effect of not involving the operator in minor inspection and restoration of equipment escalates unexpected number of failures which challenges to maintain the proactive maintenance program.

The study also supports that the industry is losing its expensive machines for the fact that it is using rebuilt and low quality spare parts for the maintenance activities with out inspecting their condition due to lack of work standards. Rarely, providing training to the operators, inspectors and mechanics also contributes to the deterioration of the equipment due to operator' mistakes and improper repair. As a result, the line of investigation further experienced that the industry is experiencing loads of loss. It can be concluded that the industry may phase out unless some sustainable actions are implemented.

In order to alleviate the current situations of the maintenance system a typical model (Appendix B) has been proposed based on the above findings. The model emphasizes three concepts of the modern era which are inevitable to implement in any day to day activities, in addition to the four major duties of maintenance; inspection management, failure management, work management, and spare part management. The concepts rely on the continuous improvement, empowering the employee and standardizing every activity to minimize the time of execution. And the model can be applicable to the transport and manufacturing industries with some adaptation.

The study also develops the implementation of TPM system to preserve the results of the above model since the central core of the TPM system is to integrate every activities of a industry with maintenance department as well as involving the operators in maintenance activities. The proposed implementation process executed devising the implementation steps systematically by breaking down each activities of the pillars of TPM and leveling them according to their priority.

RECOMMENDATIONS

The following recommendations are forwarded for the industry and related Ethiopian industries that are executing maintenance work in their day to day activity.

- Maintenance activity shouldn't be considered any more as a separate and isolated function that makes repairs which is evil activities and that leads to high expense. Rather, it should be considered as the main potential area to use as a competitive advantage. Otherwise, higher cost will be incurred after the equipments deteriorate which directly affects the competitiveness of an industry.
- The factories should involve achieving the industry goal through the implementation of operator initiated daily maintenance consisting of cleaning, adjustment, and regular inspections, as well as improvement activities and minor restoration of equipment. And the maintenance men should only participate in inspection and restoration of equipment which requires high skill and specialization.
- Empowering the operators and maintenance men through training should be given due attention and conducted in sustainable manner to maximize the efficiency of the equipment in eliminating the operators' mistake and improper repair. Especially, the operator should be trained to pinpoint small signs of troubles when ever anything out of the ordinary occurs and to be able to operate in the proper way.
- The industries need to introduce Kaizen them the concept of continues improvement. In this concept the major losses are identified and the plan is accomplished to eliminate them at the source.
- The industries should implement the OEE as a performance indicator to track the efficiency of equipment in order to achieve higher target.
- It is foreseeable to standardize the diverse maintenance activities from routine maintenance and inspection to repair which cannot be performed

effectively if individuals are left to carry out in any way they like. It is indispensable for the industry to have comprehensive maintenance standards and manuals which concentrate and unify the past experience and technology of the industry.

- Through implementing the TPM the whole industry can be integrated together to one target for higher competitiveness in the dynamic environment. Hence, the industries should benefit from the concept of TPM to bring the employee toward the objectives of the industry.
- Implementing TPM in the various levels would help the industry to completely change the culture of its employee.
- Executing the TPM implementation in Ethiopian industries should be given attention to be competitive in the global market.

REFERENCES

http://www.plantmaintenance.com/maintenance_articles_rcm.shtml

http://www.weibull.com/SystemRelWeb/preventive_maintenance.htm

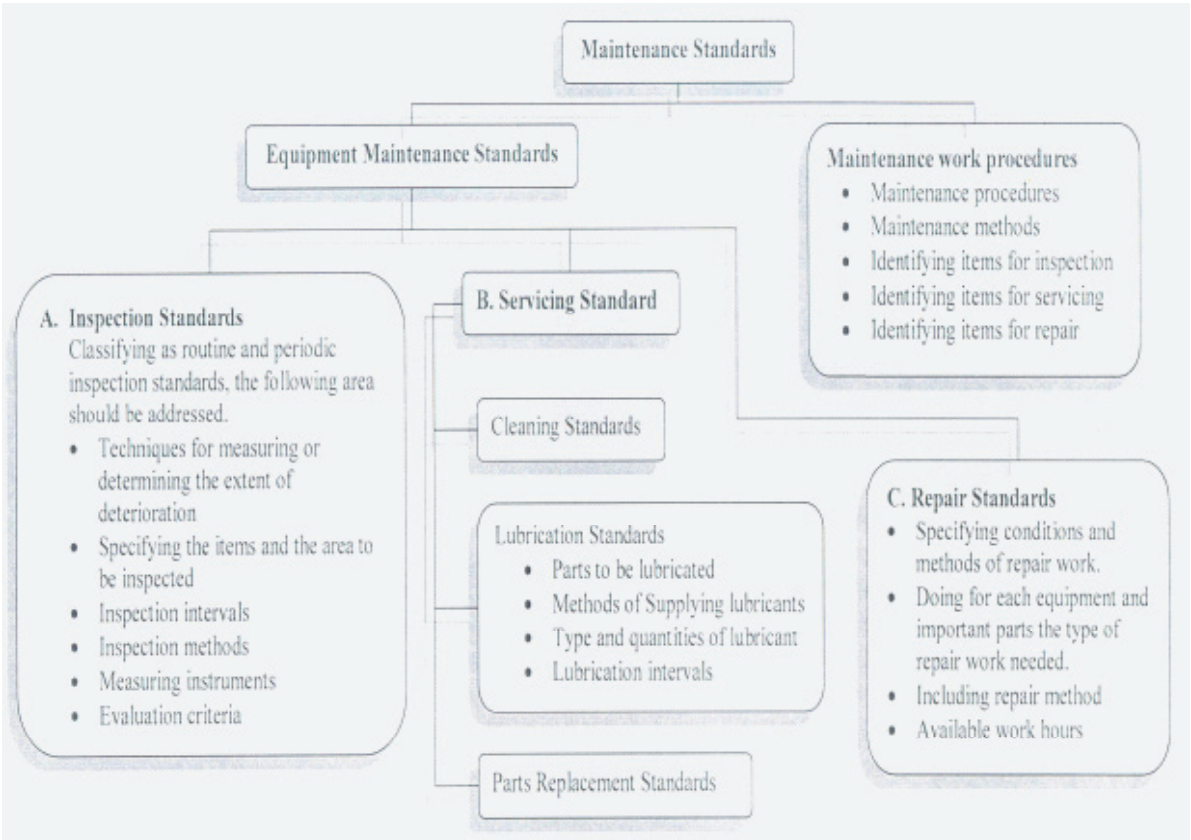
Japan Institute of Plant Maintenance (JIPM). **TPM for Every Operator (Shopfloor Series)**. Cambridge, Mass.: Productivity Press.

Johansson, B. and Nord, C. (1999). TPM-one Way to Increased Competitiveness. Examples from a Medium-sized Company, Swedish.

Melesse Workneh and Singh, A.P. (2012). Total Productive Maintenance: A Case Study in Manufacturing Industry, *Global Journal of Researches in Engineering, Industrial Engineering* **12:**: 25-32.

Robinson, C.J. and Ginder, A.P. (1995). **Implementing TPM: The North American Experience**, Productivity Press, Portland, OR.

Appendix 1. Proposed area of standardization for the case industry.



Appendix B. Proposed model of maintenance work flows