ANALYSIS AND COUNTERMEASURE TO IMPROVE MACHINE EFFICIENCY BY USING OVERALL EQUIPMENT EFFECTIVENESS (OEE) METHOD

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ABSTRACT

To compete in global market, no organization will tolerate losses. Overall Equipment Effectiveness (OEE) is a novel technique to measure the effectiveness of a machine and it truly reduces complex production problems into simple and intuitive presentation of information. It considers all important measures of productivity. An attempt has been done to measure and analyze existing Overall Equipment Effectiveness (OEE) at JSC Paper Mill Sdn. Bhd. in hope to reduce unplanned downtime losses on equipment failure and tooling damage to maximize the productivity. Before obtaining the data to calculate the existing OEE value, the product or process that have the highest downtime rate need to be identified which is Toilet Tissue converting process at Converting Department. The methods used to analyze these various causes were Ishikawa diagram, Pareto Analysis, 5 Whys and 5W1H. After knowing the causes of various activities that leads to high downtime rate, then recommendations for improvements that could be used by JSC Paper Mill were ready to be made.

ABSTRAK

Untuk bersaing dalam pasaran global, tiada organisasi akan bertolak ansur dengan kerugian. *Overall Equipment Effectiveness (OEE)* adalah teknik baru untuk mengukur keberkesanan mesin dan ia dapat mengurangkan masalah pengeluaran yang kompleks ke dalam persembahan yang mudah dan intuitif maklumat. Ia menganggap semua langkah-langkah penting dalam produktiviti. Satu percubaan telah dilakukan untuk mengukur dan menganalisis *Overall Equipment Effectiveness (OEE) yang* sedia ada di JSC Paper Mill Sdn. Bhd. dengan harapan untuk mengurangkan kerugian *downtime* yang tidak dirancang akibat kegagalan peralatan dan kerosakan alat untuk memaksimumkan produktiviti. Sebelum mendapatkan data untuk mengira nilai OEE yang sedia ada, produk atau proses yang mempunyai *downtime* yang tinggi adalah Toilet Tissue Seksyen. Kaedah-kaedah yang digunakan untuk menganalisis sebab-sebab kerosakan adalah dengan menggunakan gambarajah *Ishikawa,* Analisis *Pareto, 5 Whys* dan *5W1H.* Selepas mengetahui punca aktiviti-aktiviti yang membawa kepada kadar *downtime* yang tinggi, maka cadangan untuk penambahbaikan yang boleh digunakan oleh JSC Paper Mill Sdn. Bhd. dikemukakan.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

NDA	Non-Disclosure Agreement
TPM	Total Productive Maintenance
OEE	Overall Equipment Effectiveness
TT	Toilet Tissue
JIPM	Japan Institute of Plant Maintenance
AM	Autonomous Maintenance
PM	Preventive Maintenance
OPC	Operation Process Chart
SPC	Statistical Process Control
UCL	Upper Control Limit
LCL	Lower Control Limit

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter discusses about the introduction, overall ideas and concepts to the Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE). Besides, the background of the study, problem statements, objective of the study, and scope of the study will also be described in details in the sections below.

1.2 BACKGROUND OF STUDY

Lean production system is the idea of long-term growth and value generation through the main goal, to reduce costs and improve quality through the complete elimination of waste. Lean production system is also seen as a collection of tools, tips and techniques, which has been shown to be effective to drive waste with no value added in the manufacturing process from the customer's point of view.

JSC Paper Mill Sdn. Bhd. was selected to be studied in this research. It is one of the largest tissue paper manufacturers in Malaysia with 220-250 employees and staffs. JSC exports its products to Singapore, Brunei, New Zealand, and Mauritius instead of local customers. JSC imports wood pulps from China and Indonesia. These pulps are produced into higher grade of jumbo rolls while recycled papers are used to produce lower grade of jumbo rolls. These jumbo rolls are then converted into different products of tissue papers, which are toilet tissue rolls, jumbo roll tissue, facial tissue, kitchen towel, pop-up tissue, serviettes and napkins, industrial wiping, clinical roll and centre-flow towel.

This study is conducted by choosing the toilet tissue (TT) section as a research. TT section has three shifts with 8 hours per shift, which mean the production is 24-hours-based. They highlighted that they are experiencing a high possibility of losses in the production area due to the equipment breakdown and high minor stops while operating their core products.

Through the first visit to the company in Toilet Tissue (TT) Section, the operators were observed that they are pressing the emergency button repeatedly in short time intervals, readjusting the machine setting and toilet tissue position. Besides, the downtime of TT section is so high that the machine operating time is low. The high downtime rate is due to the machine breakdowns, frequent stoppages, and low maintenance level of machines.

All these factors lead to low output production with low machine operating time. The existing maintenance department was struggling to match the process improvements with their maintenance schedules. They have performed maintenance actions weekly and some monthly in duration of 6 months; however the results showed no significance improvements in the machinery breakdown. Based on this situation, there is a need to investigate the root cause of the breakdown and implement a more suitable method in order to further improve the process flow, which will directly benefit the whole production process.

1.3 PROBLEM STATEMENTS

Through numerous interviews and observations done in the Toilet Tissue (TT) section, there are quite a number of machine breakdown and minor stoppages cases throughout the production in every shift, which requires serious concern and improvement. To go further, there are some questions that need serious consideration. There are:

i. Which factor causes the highest downtime rate in TT section?
ii. How to increase the machine operating time as well as reduce the downtime rate?

1.4 OBJECTIVES OF STUDY

This project aims to investigate current manufacturing system in the real manufacturing industry. There are two objectives in this project, which are:

i. To propose a method to reduce or eliminate unplanned downtime losses on machine breakdowns and minor stoppages.
ii. To evaluate and propose a new solution through the Overall Equipment Effectiveness (OEE) analysis based on Total Productive Maintenance (TPM).

1.5 SCOPES OF STUDY

The first scope of study is to identify a suitable company to carry out my project. The company should be open-minded and do not resist to change. JSC Paper Mill Sdn. Bhd. is chosen instead of other manufacturing companies. The study is narrowed down to only Toilet Tissue (TT) section in the whole converting department in JSC. This is because the manager and the operators highlighted that the TT section has the highest machine breakdown cases compared to the other sections. The study is focused from machine set-up until inspection process only. Manual packing into pallet form or palletizing is not included in the study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter describes the principle of Overall Equipment Effectiveness and Total Productive Maintenance in general, and the principles behind the system. All related terms, terminology and formulas will be clearly stated.

2.2 HISTORY OF MAINTENANCE

Traditionally, maintenance is considered to be performed to repair the broken machine, and the machine is considered to be fixed, in order to correctly perform the operation properly. Maintenance tasks include re-adjust, replace parts or components, change the oil, lubrication and perform cleaning (Sullivan, 2004). Maintenance literature often presents the trend changes of the three generations before World War II had started as shown in Figure 2.1.

Maintenance of the First generation does not tend to follow any specific maintenance plan, the downtime and failure prevention are not assumed as an important issue. Basically, this means that the machine is kept operating until they fail (Mäki, 2008). Maintenance task is easy and does not require high skills, because the machine is not complicated and complex.

Thereafter, the second generation of maintenance strategies fundamental reformed. On-going war requires a lot of supplies, but manpower is still limited, which means that the machine must do more complicated tasks. Hence, when the manufacturing industry has become increasingly dependent on the machine, it is very crucial to prevent machine shutdowns. This created the first concept in 1960, the preventative maintenance. The main idea of preventive maintenance is to increase the life of the machine and keep the running costs down (Moubray, 1997).

Maintaining relationships between equipment failures and operating costs was noticed during the third generation. Reliability and machine availability is an important issue for production. Also towards Just in Time (JIT) production, where the equipment failure impacts the total supply chain (Moubray, 1997).

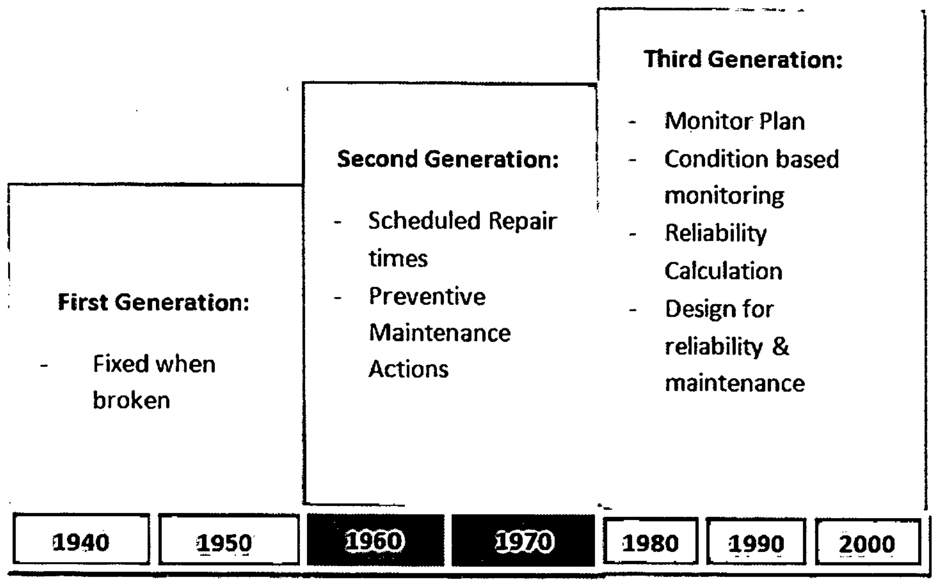

Figure 2.1: Maintenance History

2.3 TOTAL PRODUCTIVE MAINTENANCE (TPM)

TPM is one of total quality culture which followed a lot of good practice; it is through the use of lean principles to enhance their competitiveness. New tasks are made possible including equipment improvement, overhauls, training, maintenance prevention, predictive maintenance. Tasks transferred to production include simple maintainability Kaizen, cleaning, inspections, lubricant, and also adjustments. Figure 2.2 shows the schematics on how TPM shifts the maintenance task from Maintenance team to Production Department.

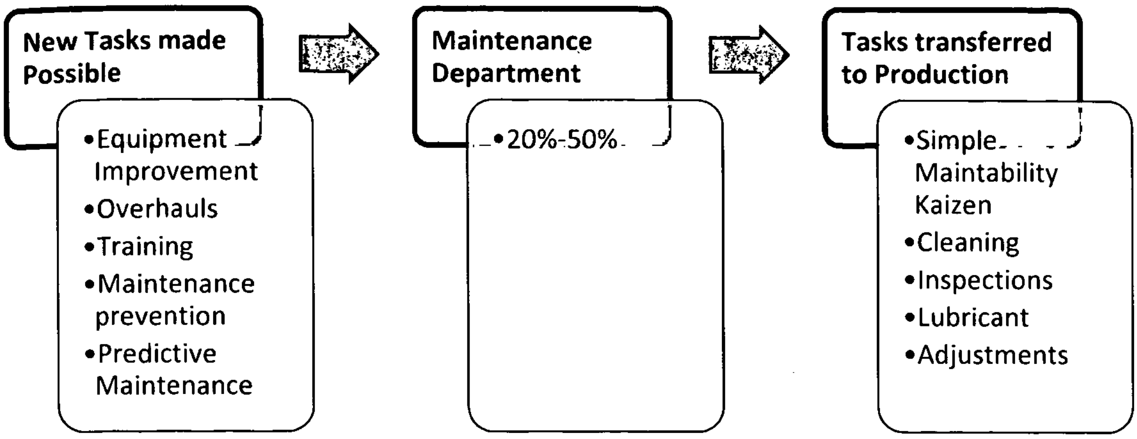

Figure 2.2: How TPM Shifts Maintenance Tasks

2.3.1 Defining TPM

According to Bamber (1998), TPM can be defined by using two kinds of approach which are either described as the Western approach and the Japanese approach.

2.3.1.1 Defining TPM through Western Approach

In western approach, the pioneer is Edward Wilmott, the managing director of Wilmott Consulting Group. However, he only defines TPM that is more likely to suit the Western manufacturing although he agrees with the Japanese five point definition. He focuses on achieving the standard performance of the Overall Effectiveness of Equipment (OEE) with total participation company-wide. There is another person who adapts the TPM definition to the Western companies, Edward Hartman. Nakajima recognized him as father of TPM in USA. Hartman (1992) indicates that TPM that was implemented permanently will improve the OEE and this will succeed with the participation of the operators (Bamber et al., 1999).

2.3.1.2 Defining TPM through Japanese Approach

This definition was given directly by JIPM and particularly, this idea was given by the JIPM very own vice chairman, Seiichi Nakajima. He is regarded and respected by a lot of TPM practitioners as the father of TPM. Five points which will include in the definition of TPM are listed below:

i. It aims to use the equipment in manufacturing to its fullest potential or the most efficient way.
ii. TPM system will spread throughout the company with the use of improvement related maintenance, preventive maintenance and maintenance prevention.
iii. TPM will totally involve every employee from the management department staff equipment operators, and equipment designers were required.
iv. Promotes and apply autonomous based productive maintenance in small group activities.

By assimilating all the five points above, Nakajima (1988) summarized this by defining TPM as: "Productive maintenance involves total participation as well as optimizing effectiveness of equipment and establishing a system of preventive maintenance thoroughly".

2.3.2 TPM Pillars

In TPM, there are eight pillars TPM that was said by Ahuja and Kamba (2008). By putting all these pillars in place, TPM will efficiently work and will definitely help any companies to achieve their strategic objectives. These eight pillars of TPM are depicted in Figure 2.3.

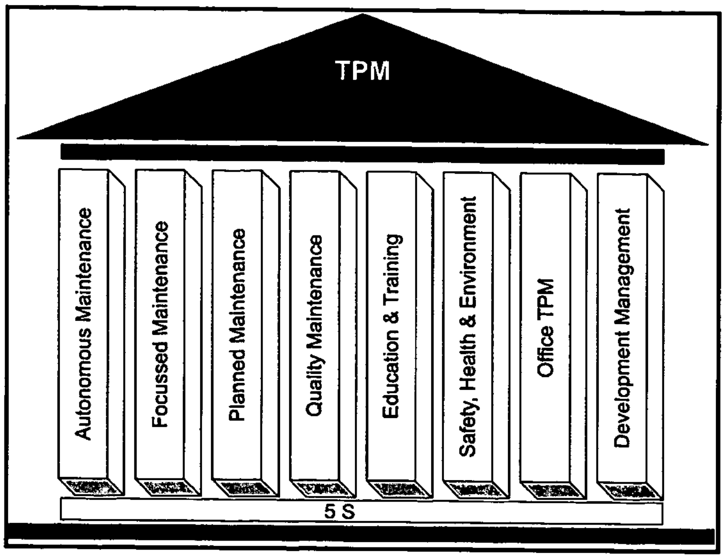

Figure 2.3: Eight Pillars Approach for TPM as suggested by JPIM

(Source: Asian Composites Manufacturing Sdn. Bhd., 2011).

The implementation for all the companies will be different from each other because TPM are not defined as a solid fact to be followed. Nevertheless, it is only as a guideline to companies. Different background and profile will determine on how TPM will be carried out in each company. Throughout many discussions within the industries in the western countries, there is only one thing that was mentioned repeatedly, that is the participation of all employees or usually known as autonomous maintenance.

2.3.3 Autonomous Maintenance (AM)

An establishment of AM is very important in TPM implementation. It is always recognized as the backbone of TPM. AM is an activity where everyone participates in improving and maintaining the reliability and efficiency of the equipments. Maintenance section is the one responsible for restoring and servicing the equipment. Operators need to maintain their equipments by performing daily checks of lubrication, pressures, and gauges. These require the operator to perceive and find abnormal equipment (JPIM solution). To achieve the above capabilities, operators should have the following basic capabilities:

i. Able to distinguish between normal and abnormalities accurately.
ii. Accustomed to the rules of the controlled conditions strictly.
iii. The ability to take measures rapidly and appropriately against abnormal.

2.3.4 Preventive Maintenance (PM)

According to Chan et al. (2005), productive maintenance is the evolution from preventive maintenance. It originated in the US and was adopted by the Japanese in 1951. It can be thought as physical checks on the equipments and if needed, the machine will be given a service to prolong its life and keep it in good condition. Maximizing equipment productivity is the common goal for the models used in PM planning and production scheduling.

However, equipment failure is usually treated as a random event and it might as well be ignored by production scheduling models. Machine failure probability may be increased by delayed PM because of trying to satisfy demands in production. These conflict can be solved by working out the PM planning and production scheduling problem independently.

2.3.5 Differences between PM and TPM

There are some big differences between traditional PM in US with TPM and all that can be verified by listing the characteristics of TPM. In TPM, maximum production efficiency improvement is the end. To achieve this, TPM was designed to avoid the downtime caused by the Six Big Losses. However, in traditional US-styled PM, they focused on equipment specialists. With this approach, the maximum production efficiency improvement cannot be achieved as in TPM (Chan et al., 2005).

The other thing in TPM is the AM which indicates that operators should know about their own equipment and know how to preserve them. This will ensure that the equipment should be in the mint condition and will operate at its maximum potential while running in production. On the other hand, in PM, maintenance is carried out by the maintenance workers and it is not the work for the operators to know and preserve their own equipments (Chan et al., 2005).

2.4 SIX BIG LOSSES

Six big losses describe the most common causes of losses in today's manufacturing environment. The main goal of TPM and OEE program is to reduce or eliminate these losses. The following table lists the six big losses directly related to the OEE loss category.

Table 2.1: OEE Categories

Six Big Loss Category	OEE Loss Category	Event Examples	Comment
Breakdowns / Equipment Failures	Down Time Loss	• Tooling Failures • Unplanned Maintenance • General Breakdowns • Equipment Failure	Data should be charted and tabulated to apply the Root Cause Analysis.
Setup and Adjustments	Down Time Loss	• Setup/Changeover • Material Shortages • Operator Shortages • Major Adjustments • Warm-Up Time	Single Minute Exchange of Die (SMED) could be used to reduce time loss.
Idling/ Minor Stoppages	Speed Loss	• Obstructed Product Flow • Component Jams • Misfeeds • Sensor Blocked • Delivery Blocked • Cleaning/Checking	Do not require maintenance personnel and automated recording is required for data to the Cycle Time Analysis.
Reduced Speed	Speed Loss	• Rough Running • Under Nameplate Capacity • Under Design Capacity • Equipment Wear • Operator Inefficiency	Cycle Time Analysis could also be used to reduce this loss.
Quality/ Start-up Rejects	Quality Loss	• Scrap • Rework • In-Process Damage • In-Process Expiration • Incorrect Assembly	May be due to improper setup, warm-up period, etc. These causes could be determined after the patterns are discovered in the products.
Quality/ Production Rejects	Quality Loss	• Scrap • Rework • In-Process Damage • In-Process Expiration • Incorrect Assembly	Rejects during steady-state production.

2.5 OVERALL EQUIPMENT EFFECTIVENESS (OEE)

OEE is a combination of data points and manufacturing problems, in order to provide information about the tool to the process. This is an all-inclusive benchmarking tool used to measure each subcomponent (i.e., availability, performance and quality) of the manufacturing process, as well as to measure the actual 5S improvement, Lean Manufacturing, TPM, Kaizen, and Six Sigma. When using OEE with these management systems, the benefits become tangible and noteworthy.

Manufacturing efficiency and effectiveness are always the buzzwords in the world. The efficiency and effectiveness of an organization is directly proportional to the prolific industries. Overall equipment effectiveness (OEE) is a measure of the level by Seiichi Nakajima in the 1960's to access and indicate how efficiently a manufacturing operation is utilized. OEE is a performance index, which indicates the current status of the production with the minimum calculation. It also helps to measure losses, noting that the corrective measures can be taken to reduce them. Effective use of men, machines, materials and methods will lead to higher productivity (Relkar and Nandukar, 2012).

OEE measurement is a simple tool that will help measure the effectiveness of the equipments (Elevli, 2010). It needs only the most important and common sources of productivity loss, which are used as a key performance indicator for providing success and lean production efforts. The benefit of using this particular measurement tools is that it cannot be manipulated.

OEE = Actual output / Theoretical maximum output (2-1)

OEE = Availability x Performance x Quality (2-2)

2.5.1 Benefits of OEE

OEE's biggest advantage is that it allows the company through the application of a single and easy-to-understand formula where, there is a separate business functions. OEE is to make the right management decisions to date the most effective benchmark tool. TPM not only increase efficiency and productivity, which have a positive impact on employees; but especially in their work morale and motivation too. Since the machine is personalized, every worker has a better knowledge and understanding of their field of work, they are proud and pleased with the work they give out. There has also been collaboration between management staff and team work environment with small fluctuations to increase coverage.

Improve productivity to reduce the cost, when we cut unnecessary movement of persons, transport and waiting time. It is also important not to exceed the real needs, because inventory will allow the right amount of money, then this will generate more investment in the growth of the product. This is the minimum number of the products that should have flaws and there should not be unscheduled production because they will again add up the cost.

2.5.2 Availability

Taking into account the loss of availability of downtime, which comprises a time planned production stops any activity significantly length (usually a few minutes - for a time sufficient to log the event as traceability). For examples, machine failures, material shortages and conversion time. Switching time is contained in the analysis, because it is along the time form. Since it is impossible to eliminate the conversion time, however, it can be reduced. The rest of the available time is referred to the operation time:

Availability = Operating Time / Planned Production Time (2-3)

2.5.3 Performance

Taking into account the loss of speed of performance, which is included in the runtime, causes the process is less than the maximum possible speed for any factor operation. The rest of the available time is called the net operating time.

Performance = Ideal Cycle Time / (Operating Time / Total Pieces) (2-4)