

**The Implementation of Total Productive Maintenance (TPM) In  
Manufacturing Company**  
**A Case Study of XYZ Plastics Manufacturing Company in Nigerian.**

**BACHELOR THESIS WITHIN:** Industrial Engineering  
**NUMBER OF CREDITS:** 15  
**PROGRAMME OF STUDY:** International Business Engineering  
**AUTHOR:** Femi Gbenga - Labiji  
**TUTOR:** Henrik Ringsberg  
**BORÅS:** 2019



**HÖGSKOLAN I BORÅS**

## Table of Contents

### Acknowledgement

### Abstract

### Abbreviation

### CHAPTER 1

1. Introduction .....	6
1.1 Background .....	6
1.2 Research Question and Purpose.....	6-7
1.3 Thesis Structure.....	7

### CHAPTER 2

2. Research Methodology.....	7-8
2.1 Data Collection and Analysis.....	8-9
2.1.1 Sources of Secondary Data.....	9
2.1.2 Sources of Primary Data.....	9
2.1.3 Questionnaire.....	9-11
2.2 Ethical Consideration in Data Collection.....	11-12
2.3 Validity.....	12
2.4 Reliability.....	12-14

### CHAPTER 3

3. Frame of Reference.....	14
3.1 History of Total Productive Maintenance (TPM).....	14-15
3.2 TPM Techniques.....	15-19
3.3 The Implementation of Total Productive Maintenance (TPM).....	19-20
3.4 The factors that make implementation of TPM successful.....	20-23
3.5 The TPM Effectiveness Measurement.....	23
3.6 Roles of Production and Maintenance of TPM.....	23-25
3.7 Identification and Categorization of Barriers in TPM Implementation.....	25-26
3.8 Mapping the Focus Area.....	26
3.9 The major Manufacturing Issues.....	26-27

### CHAPTER 4

4. Case Study at XYZ Plastics Industry.....	27
4.1 History of XYZ Plastics Company.....	27-28
4.2 Company Operations.....	28-29
4.3 Initial Condition at XYZ Plastics Industry before TPM.....	29

### CHAPTER 5

5. Results and Analysis.....	29
5.1 Implementation of 5S in XYZ Plastic Industry.....	30-31
5.2 Implementation of 8 Pillars of TPM in XYZ Plastics Industry.....	31-33
5.3 Implementation of TPM Methods at XYZ Plastics Industry.....	34
5.3.1 5S.....	34
5.3.2 8 Pillars.....	34-35

### CHAPTER 6

Discussion.....	35
-----------------	----

### CHAPTER 7

Conclusion.....	36
7.1 Recommendation.....	37
7.2 Theory Conclusion.....	37

**CHAPTER 8**

References ..... 38-41

**CHAPTER 9**

Appendix .....42

**Acknowledgement**

I am really thankful to the Almighty God for making it possible. The process of writing thesis has not been an easy task but it has added value to my knowledge. Each and every activity of writing thesis has been a value adding activity. During writing my thesis, many people has supported and encouraged me with positive feedback and comments. Therefore, I would like to express my gratitude to them.

Firstly, I would like to say thank you to my supervisor Henrik Ringsberg for all his comments, support guidance and time. Your feedback was very helpful for me.

Secondly, I would like to say thank you to all the workers at XYZ Plastics Industry in Nigeria for their contribution during the empirical aspect of the research and squeezing those minutes out of your busy schedule for the responses to the questions and little chats. I would also thank my wife for her timeless understanding, patience and for her constant support.

Finally, I dedicated this thesis to the memory of my father, Theophilus Taiwo - Labiyi, who always believed in my ability to be successful in the academic arena. You are gone but your belief in me has made this journey possible.

## **Abstract**

The purpose of this thesis is to implement Total Productive Maintenance (TPM) in Nigeria Plastics Manufacturing Company.

Manufacturing companies round the world pay huge amount of money for purchasing new equipments to boost their production however nothing or little is done to achieve or obtain full output from the machine for which it is intended to do. Small losses in time or deviations from planned or calculated capability are taken as usual machine performance. But currently as a result of improved capability levels and demand of quality product at lower prices, purchasing latest machine/equipment is not a way out unless it is completely used. Total Productive Maintenance (TPM) is a method that involve everybody totally, from high management to all workers to implement a complete maintenance program for all machine/equipment during its life. This method ends up in most effectiveness of tools, equipment, virtuously improved workers, tidy up working area, neat and clean working environment.

A structure is going to be developed with the potential of evaluating the impact of implementing total productive maintenance within. By evaluating the result or outcome of Total Productive Maintenance (TPM), manufacturing companies can create sensible/smart decisions to improve the potency and standard of the machine, equipment and also the product on XYZ Plastics Manufacturing Company in Nigerian.

### **Keywords:**

5S, 8Pillars and lean

TPM: Total Productive Maintenance

PM: Productive Maintenance

JIT: Just-In-Time

TQM: Total Quality Management

OEE: Overall Equipment Effectiveness

MTTR: Mean time to repair

MTBF: Mean time between failures

## **Abbreviations**

MTBF: Mean time between failures

MTTR: Mean time to repair

OEE: Overall Equipment Effectiveness

TPM: Total Productive Maintenance

TQM: Total Quality Management

PM: Preventive Maintenance, Productive Maintenance

JIT: Just-In-Time

## **1. Introduction**

In this chapter background, research question, research purpose and thesis structure is introduced.

### **1.1 Background**

The companies all over the world try to boost their profit while not increasing the sale worth of their merchandise/products. This will solely be done by minimizing the producing price of the merchandise/products by increasing the productivity and reducing losses throughout production. Automation has contended a good role in increasing productivity however it fails if the equipment and machine isn't maintained properly (Bupe et al, 2015).

In recent companies situation material wastage and large loss of time occur within the workshop floor. The material wastage and large loss of time are as a result of unskilled or unqualified operators, maintenance personnel, processes, tooling issues and non-availability of components and materials on time. There are few different losses like rejected materials and components, quality waste, idle machines, idle workforce etc (Eti et al, 2004).

The quality connected to waste is of high importance as a result of it took all the time of the production and assembly process/method and find wasted once the products is completed.

Also, it matter in terms of time, material and therefore the hard-earned name of the firms.

There are few different invisible losses like when operating the machines against its requirement (e.g. low speed and soon), bottle necks, startup loss, within the process/method and break down of the machines. To avoid the aforementioned losses, a revolutionary idea of TPM has been adopted by several industries across the globe. The main concepts/ideas is to make lead time, defects, tolerance for waste, breakdown, accidents and inventories reduced to minimum or zero and these are becoming necessity for the production/manufacturing plant and this can be achieved by implementing TPM (Total Productive Maintenance) (Venkatesh, 2015).

Total Productive Maintenance (TPM) is analyzed and categorized in three different parts:-

Total: This implies that each individual within the company, from the floor base workers to the highest management workers. Productive: This implies no wasted activity or the manufacturing of products and services that meet or exceed customer's expectation.

Maintenance: Taking care or keeping machine and equipment in good working condition like the original form every time (Bupe et al, 2015).

The results of the thesis will shows the improvement in the processes of the firm and its goal to realize positive outcomes. It additionally proves that TPM isn't just a few production tools, implementing and maintaining TPM could be a long run method and so as to visualize massive improvement and enhancements, an organization must place effort ceaselessly (Bamber et al, 1997).

In the end, there'll be suggestions and implementation to the organization with the way to improve the organization production and also the current performance level, locating the main cause of the problem.

### **1.2 Research Question and Purpose**

How can Total Productive Maintenance (TPM) be implemented in a plastic manufacturing company.

The purpose of this thesis is to implement Total Productive Maintenance (TPM) in Nigeria Plastics Manufacturing Company.

**Limitations:** due to the facts that I conducted the case study in Nigeria, I do not have much on me (financially) to be able to travel to Nigeria often to schedule more meeting with the management and workers like operators and soon during the initiation period and to supervise the progress of the TPM implementation.

Based on this stated purpose the following research question has been formulated.

### **1.3 Thesis Structure**

The structured of the thesis is as followed:

Chapter 1: is made up of the introduction and background, that give a review of the root behind the motivation, reasons and problems which make or led the writer to research deeply into the study.

Chapter 2: is made up of the methodology of this study which was conducted as a case study.

Chapter 3: consists of the frame of reference which was surrounded by related literatures such as articles, research papers, academic books and journals.

Chapter 4: empirical findings which are presented and examine thoroughly.

Chapter 5: is made up of the results and analysis from the empirical findings and summarized it also.

Chapter 6: is made up of discussion of the study.

Lastly chapter 7: is made of the conclusion of the study.

## **2. Research Methodology**

The term research is commonly coupled to educational or academic activity, but many researchers (Saunders and Lewis, 2011; Walshaw, 2012) links research to way of life and see it as an elementary activity of everyday living. They recommend or suggest that everybody is engaged within the research method through trying to seek out solutions to issues that are perceived (Alan Johnston, 2014).

Management research thus tends to be simplest, effective and helpful in resolving organizational or operational issues within the workplace (Alan Johnston, 2014). Lee and Lings, (2008) argue that research is concerning generating information concerning what you think the globe or the world is. This is supported by Jankowicz (2005) and Quinlan, (2011) who emphasize that research is concerning making new information or knowledge which its development relies on a judgment of what is known and the way it is known.

(Harrison & Van Hoek, 2008) suggest the most effective way to collect data is by walking through the process to determine the actual component and all the stages in the process.

**Qualitative research:** is framed generally inside the socially created and advocacy/participatory theories that assert that meaning is created socially, and therefore there are multiple truths to discover (Creswell, 2003; Crotty, 1998). There are several types of qualitative research; the most important ones are grounded theory, phenomenology, case study, narrative analysis, and ethnography (Merriam, 1998). The qualitative data collected from observations, interviews, and field notes are coded, analyzed, and interpreted taking into account the context and personal values of the researcher (Creswell, 2003).

It is decided by research study that which methods best suits that study. The combination of both methods can be used if there are enough resources are available (Carr, 1994). I have selected qualitative technique and the reason for selecting this technique is that I will try to

gather deep and intensive knowledge about the concern questions. To collect the answers of “why” “what” and “how” qualitative is the appropriate method (Svenning, 2003). Due to this reason qualitative approach is more suitable to collect data. It will allow us opportunity to address new aspect of our problem and be flexible in the study. Flexibility of study makes the collection of data into interactive process which can help to raise previous unconsidered issues related to that study. We can raise and address these issues by the interaction with interviewees. As the data is obtained it can be analyzed in depth throughout the study.

**Deductive Approach:** This research is conducted by the deductive approach which means that I will try as much as possible to draw reasonable conclusions from the data collected during the interviews (survey) and questionnaires conducted, after which conclusion will be made base on their reply and behavior.

## 2.1 Data Collection and Analysis

The usage of multiple sources during this case study is compounded further by Yin (1994), when he proposed three principles of data collections for case studies:

1.) Use multiple sources of knowledge

2.) Create a case study database

3.) Maintain a chain of evidence Sampling:- constitutes the collection of real data sources from a bigger set of prospects or possibilities. It involves two interconnected components: (a) shaping the complete set of doable data sources that is mostly termed the population, and (b) selecting a specific sample of data sources from that population (Given,2008).

This bachelor thesis is research and conducted as a case study, a case study design was applied as the thesis involved an in-depth understanding of TPM on topics like the implementation plan, TPM modes, challenges and benefits of TPM implementation and finally TPM key performance indicators. A qualitative approach is used to assess the maintenance systems and to calculate OEE. Research data was collected using interviews, company records, designed questionnaires, and direct observations.

A case study approach is used as a methodology in a research because according to Yin(2003) a case study design should be considered when: (a) the focus of the study is to answer "how" and "why" question; (b) you cannot manipulate the behavior of those involved in the study; (c) you want to cover contextual conditions because you believe they are relevant to the phenomenon under case study; or (d) the boundaries are not clear between the phenomenon and context. Bryman and Bell (2007), suggested that a case study entails the detailed and intensive analysis of a single case.

As Stake (1995) observes, case study research is about the state of case study and the nature of the particular case in question. The utilization and the main reason of such research method is its power, quality and simple to use for the study particularly. Research studies in business and management are usually based on this kind of research design.

It is to also ensure that the quality of the data is good and sufficient. Since the interviews are going to be done by me it's important for this research to adapt a case study methodology as stated by Yin (1994) "to explain the complex causal links in real-life interventions".

Knight and McCabe (1997) propose that the case study gives way by which various qualitative methods can be put together, by avoiding too reliance on one single approach. Gerring, (2007) in his book "Case Study Research", stated that to refer to a work as a "case study" might mean:

(a) that the research is holistic, thick (a more or less comprehensive examination of a phenomenon).

- (b) that its method of evidence gathering is naturalistic (a real-life context).
- (c) that the research investigates the properties of a phenomenon, instance or example.
- (d) that its method is qualitative, small N.
- (e) that it utilizes a particular type of evidence (e.g., ethnographic, clinical, non experimental, non survey-based, participant-observation, process tracing, historical, textual, or field research).
- (f) that the topic is diffuse (case or context are difficult to distinguish).
- (g) that it employs triangulation ("multiple sources of evidence").
- (h) that the research investigates the properties of a single observation.

### **2.1.1 Sources of Secondary Data**

- Keywords used: I identify my papers by searching for TPM (Total Productive Maintenance) in a manufacturing company.
- More than 50 papers are identified
- I selected the papers used by checking on the papers that are recent base on their years and months.

Secondary data can be both qualitative and quantitative data. Qualitative method entails collecting data through interview and observation while quantitative method deals with numerical data when we try to carry out findings (Davies, 2007). Furthermore, we can categorized secondary data as survey, documentary and multiple sources, in addition the data can be published summaries or raw data (Saunders et al, 2009). Secondary data is also used to get deeper understanding of the study and to address the problems and challenges of the study. The secondary source was attained through the internet, books, literatures and periodicals.

### **2.1.2 Sources of Primary Data**

Primary data is an information that is directly collected from the respondents. It is also called first hand data that are sourced through observations, experiments, surveys or questionnaires and interviews by the person conducting the research (Ghauri & Grohaug, 2010). Although it takes time and it is very costly to collect, primary data is still the most appropriate for this research because information is collected directly for the specific purpose (Ghauri & Grohaug, 2010).

The author intend to obtain data directly from the source for this research. Participant observation is also used to collect data that would be further analyzed and used to fulfill the research questions.

The interviews conducted with the management, operators and also floor workers of the Plastics Manufacturing Company and the questionnaires in the form of a survey, is the main method or way of acquiring data for this bachelor's thesis. The primary sources of collecting data for this research were personal interviews with the management, operators and also floor workers of the Plastics Manufacturing Company. The author met with the management, operators and also floor workers of the Plastics Manufacturing Company to discuss the question in full details to keep and maintain a balance with the thesis written.

The full questionnaire is in Appendix 1

### **2.1.3 Questionnaire**

I have used questionnaires include 19 questions sent out to staff of XYZ Plastics Manufacturing Industry.

The main purpose of this questionnaire is to gather information for the purpose of understanding how XYZ Plastics Industry apply TPM approach within their organization. The interview exercise is intended for all employees within the company and the main objective of the interview is to obtain information that assist in assessing the operation and production-benefit analysis that is involved in TPM implementation in XYZ Plastics Industry.

### **TPM Questionnaires**

- 1.) What is company's culture?
- 2.) What is your job description?
- 3.) How do you measure production efficiency?
- 4.) What is the volume level of the products of the company?
- 5.) What is your current Lead-time?
- 6.) What are the major drivers of your business?
- 7.) What is TPM? 8.) What has motivated the company to implement TPM?
- 9.) Presently how you are implementing TPM?
- 10.) What are the outcomes?
- 11.) Where is TPM implemented in your Organization?
- 12.) What are the criteria for choosing that area?
- 13.) Explain how TPM is practicing in the company?
- 14.) How long it will take to implement TPM in the factory?
- 15.) What were the direct and indirect costs involved in the implementation of TPM?
- 16.) How much company spends on TPM?
- 17.) What tangible and intangible benefits has TPM brought to the company?
- 18.) Any Other comments on implementation of TPM?
- 19.) Was the implementation process of TPM should be continuous? (Bupe et al, 2015).

### **Interviews**

Interviews are conducted face to face.

Interviews:- are method of gathering information or opinions by asking a sequence of questions that can be either of pre-defined order (structured), unstructured, or semi-structured. The traditional interview is a personal discussion between the interviewer and the interviewee.

However, it can also be done through telephone calls or even via internet (Jupp,2006).

However the conduction of semi - structure interviews with the floor workers and the management of XYZ Plastics Industry in Nigeria.

The interviewees were allowed the opportunity to speak openly and freely without limits in order to make the interview more creditable and efficient as well as to stick to the specific research theme. The interviews in this research will be conducted at XYZ Plastics Industry in Nigeria. Coding of the interview is non-applicable in respect to the scope of the research and due to the number of interviewees. The interview will be semi-structure and in a sense 'open'. Semi-structured interviews typically have an initial question followed by probes. These kinds of interviews are typically supported the information or knowledge of, and/or the idea that the respondents have had a specific experience they will elaborate upon. In these forms of interviews, matters has typically been analyzed before the interview.

Therefore, the researcher is seeking further data or information. During a semi-structured interview, an interview schedule is developed to deal with the subject and to guide the interview, yet "without fixed wording or fixed ordering of questions" (Minichiello et al, 1995). The content of the interview is directed on matters that are foremost to the subject of the research. The way within which questioning takes place permits space for flexibility, social interaction, exploration of ideas and "provides opportunities to observe participants in the face-to-face ongoing interaction of the focus group" (De Laine, 1997). I have selected semi structured interviews method because it is most suitable method to collect first-hand information and gives freedom to interviewees on how they give answers to particular question. It also provide interviewees the opportunity to ask questions from interviewer as well and to clarify the meaning of unclear questions. Due to this reason researcher can get more deep information about the subject. Although semi structured interviews are time consuming and mostly interviewees do not want to participate in this but it gives intensive information about the particular subject.

Note that interviews should be preferred when there are clear objectives for the research, when time is limited, when there are many experiences from different people to be studied (Taylor and Bogdan, 1984). By choosing (some management, operators and some workers) who have similar activity/ occupational tasks, who encountered similar setbacks daily as a results of non implementation of TPM in their scope of work, may be thought-about and regarded as a focus group as defined.

Focus groups are group interviews of 12 to 15 people and concern a sort of organized discussion that is design and planned by the interviewer. The main aim of this method is to investigate people's views in depth and in combination with other opinions. (Stewart, Shamdasani and Rook, 2007). The interviews were conducted with maintenance personnel, machine operators and other employees in the production department. The questions are mainly focused on:

- Types of losses company mostly experienced.
- Reasons of maintenance problems.
- How much TPM concept existed in the company?
- Elements that can help in implementing TPM.

The first TPM meeting divided the XYZ plastics industry location into different areas of responsibility. For example production consisted of different areas and units and the financial department, HR offices and distribution centre had their own locations. After dividing the areas, each team chose a team leader. In many cases the person was already the manager or the head of that particular unit. As mentioned in the five levels plan, the first step of implementing TPM is to perform the initial cleaning and inspection. Executing the cleaning according to the five levels plan will bring each unit to TPM level one.

## **2.2 Ethical Consideration in Data Collection**

Ethics define what is or is not legitimate or ethical to try and do. Codes of behavior, and legal considerations in most countries can give some mounted rules and principles for researchers, and research ethics has a positive role to play within the style and conduct of human research, but it wants or needs to be seen as an integral part of the research method. Commonly control beliefs regarding research ethics embrace the importance of the protection of vulnerable populations, maintaining professional standards, safeguarding the rights and well-being of participants, risk management, and ensuring public support for research (Edwards and Skinner, 2009).

Ethical concerns would like to be thought-about in each part of the research study, not just in the research style or once the researcher receives any needed ethical clearance and authorization to begin the research. The researcher desires to think about and touch on or act upon ethical responsibilities and concerns continue throughout a project, even beyond the information or data compilation section or phase into analysis, write up and publication, (Edwards and Skinner, 2009).

### **2.3 Validity**

To ensure a balance between validity and reliability, firstly I drafted the case study questionnaire and subsequently distributed out the questionnaires to some management, floor workers and operators. Additionally, some workers were asked verbally about their opinion on TPM (Total Productive Maintenance). Some respondents took few days to answer the questionnaire while most of the respondents took some weeks to give me back the questionnaires with their answers. Some workers did not respond and some refused to participate due to their level of education. The most important phase was compiling all the responses and looked for the similar answers. According to Bryman and Bell (2007), a case study should have principles of validity, reliability and replicability.

Validity:- in interviewing refers to the formation of appropriate operational measures for the ideas or concepts being investigated (Emory & Cooper, 1991). Interviewing tries to attain construct validity through three techniques. Firstly, triangulation of interview questions is typically established within the research style or design stage by two or a lot of carefully worded questions that check up on the topic or subject matter under investigation from completely different angles. Secondly, the interview technique typically contains an inherent negative case analysis wherever, in every interview and before the subsequent, the technique expressly needs that the interviewer plan to negate rising explanations interpreted within the information or data (Dick, 1990).

Finally, the flexibleness of the approach permits the interviewer to re-evaluate and re-design each of the content and method of the interview program, therefore establishing the content validity (Sekaran, 2000 and Emory and Cooper, 1991). Validity is of various forms, but the types commonly used in traditional research are internal and external validity. Internal validity exist where there is degree of causal relationship between two or more variables. External validity on the other hand refers to degree at which the result can be generalized to certain individuals, settings, population and time (Ghuri and Gronhaug, 2010).

### **2.4 Reliability**

Reliability:- in interviewing refers to how systematically a method measures the ideas it is alleged to measure, enabling different or other researchers to do the study again and attain similar findings (Sekaran, 2000 and Emory and Cooper, 1991). Reliability is typically achieved through four tactics: Firstly, reliability is achieved through the structured method or process of interviews. Secondly, reliability is achieved through organizing a structured or process for recording, writing and deciphering information or data. Thirdly, research reliability is usually achieved through comparison of the research findings between the inquirer or interviewer and respondent or interviewee. Finally, the utilization of a planning committee to help within the style or design and administration of the interview program is another different way that reliability may be achieved (Guba & Lincoln, 1994).

To ensure validity and reliability in this research, one of the most common phenomenon that is associated with the XYZ Plastics Industry is the maintenance problem as responded by the management, operators and some floor workers. To ensure this common cause is valid, the author has been with the management, operators and floor workers within the company several times to ensure that this hypothesis was true and thereby validating the empirical findings. The author was also concerned about the stability of the data so that the responses do not fluctuate to ensure reliability and validity.

Therefore the author grouped, counted and wrote down each response different times based on the questions asked to ensure that they fall in the same category and do not fluctuate. To further ensure validity and reliability, the author often had impromptu discussions about the questions with some management and workers. This course of action was employed to ensure that what was written by some of the management and workers at XYZ Plastics Industry was not different from what they experienced at work. To ensure the validity of this thesis as much as possible, the author have chosen the right persons in the companies for interviews. By right person means, the person who has the expert knowledge about the particular aspects and to achieved high reliability in manufacturing industries the amount of unplanned downtime and shutdowns will go closer to zero. Reliability can be defined in terms of producing or operation conditions as "the chance of a machine or product will perform in a great way for a given time frame when used beneath certain operation conditions"( Blanchard, 2004). Inside that definition we address the important issues or thing troubles of reliability: function, operation situations and time (Smith, 2004). Every system that we use has a function it has to fulfil. which means the device or machine need to produce a selected quantity of products with the manufacture unique pace and fine or quality.

The operation situations outline wherein environment the device or machine has to operate: the running temperature, humidity, vibration, coping with or handling, storing and so forth. The maximum essential difficulty, time, gives us the expected life of a device or machine and the possibility it must run failure loose or free. In TPM the reliability is measured most of the time with mathematical terms: mean time between failures (MTBF). We also need another mathematical term, mean time to repair (MTTR), to calculate the total availability of the machine. In addition to the MTBF and MTTR, we also need to calculate the overall equipment effectiveness (OEE) (Blanchard, 2004).

MTBF:- Mean time between failures (MTBF) presents us the average time between failures. The larger the MTBF, the more reliable our machine is. But when we are calculating the failure occurrence we always have to remember that the result which we get is only an estimation and the formula for MTBF is assuming that the failure rate is constant (Nicholas, 1998).

The mean time between failures will be calculated with the following formula:

$$MTBF = TOTAL\ RUNNING\ TIME \div NUMBER\ OF\ FAILURES$$

Mean time to repair (MTTR) measures the time that has been spent on repairing the machine. This can tell us information about the quality of the maintenance work. Like, how skilled our repairs personnel are, the level of difficulty in the maintenance work and the

availability of the spare parts (Blanchard, 2004). When we are interested to calculate the total availability we can combine these two formulas as follows: (Smith, 2004).

$$AVAILABILITY = MTBF / (MTBF + MTTR)$$

Overall equipment effectiveness (OEE) measures the improvement of the TPM by providing the rate of improvement. This will be calculated by using the following formula:

$$OEE = A \times P \times Q$$

The availability in this case is:

$$A = (TOTAL LIFESPAN - DOWNTIME) / TOTAL LIFESPAN$$

The total lifespan is the lifetime that the designer or the manufacturer has set for the machine. The downtime is the time when the machine is not working as a result of a breakdown, setup and maintenance.

The performance rate is calculated by using the formula:

$$P = \frac{OUTPUT \times ACTUAL CYCLE TIME}{LOADING TIME - DOWNTIME} \times \frac{IDEAL CYCLE TIME}{ACTUAL CYCLE TIME}$$

where, output tells the number of products produced, ideal cycle time tells the designed time needed to produce one product and actual cycle time is the time used to produce one product in practice.

The quality rate uses the following formula:

$$Q = \frac{QUALITY DEFECTS + STARTUP DEFECTS + REWORK}{INPUT} - INPUT$$

Input tells the number of products produced and defects comprise the products that do not pass the quality control. When improving the OEE there is an increase in both the production performance and quality. Production plants using just in time (JIT) and total quality management (TQM) manufacturing and TPM have found OEE measurements extremely useful for them (Nicholas, 1998).

### 3. Frame of Reference

Under this section of the research, the author was keen on finding published related academic materials in the field of logistics and supply chain management industry that has specific references on Total Productive Maintenance (TPM). The data mining search for these published materials included the internet, academic books and literatures, journals, thesis and articles written by scholars and academics with interest in the field of Total Productive Maintenance (TPM). Through these collections of published materials, the author believes a hypothesis could be drawn on the research.

#### 3.1 History of Total Productive Maintenance (TPM)

The idea of TPM originated in Japan's production industries, at first with the aim of eliminating production losses because of limitations with TQM method for production operations is attributable with the process ideas of TPM and seeing the procedure applied to many plants in Japan; the key idea being autonomous maintenance. TPM is a major departure from the "you operate, I maintain" philosophy (Eti et al, 2004).

TPM advanced from TQM, which evolved as a right away result of Dr. W. Edwards Deming's have an effect on Japanese industry. Dr. Deming commenced his work in Japan rapidly after world war 11. As a statistician, Dr. Deming initially started out to reveal the Japanese how to use statistical analysis in manufacturing and a way to use the ensuing data to manipulate or control quality in the course of manufacturing. The preliminary statistical procedures and the ensuing best control principles fueled by the Japanese work ethic became a way of lifestyles for Japanese industry (Eti et al, 2004; Suzuki, 1992).

This new manufacturing concept eventually became known as Total quality management (TQM). When the issues of plant maintenance were examined as a component of the TQM (Total Quality Management) program, a number of the overall ideas didn't appear to suit or work well within the maintenance setting. preventative maintenance (PM) procedures had been in existence for period of some time and PM was practiced in most plants. By using PM techniques, maintenance schedules designed to maintain and keep machines operational were developed (Eti et al, 2004; Suzuki, 1992).

However, this method typically resulted in machines being over-serviced in an effort to enhance production. The thought was typically "if a little oil is good, a lot should be better." Manufacturer's maintenance plan or schedules had to be followed to the letter with very little thought on the realistic needs of the machine. There was very little or no involvement of the machine operator within the maintenance program and maintenance personnel had little coaching and instruction further than what was contained in usually inadequate maintenance manuals (Eti et al, 2004; Suzuki, 1992).

The need to go more than simply planning maintenance in accordance with manufacturer's recommendations as a way of productivity improvement and quality product was quickly recognized by those firms that were committed to the TQM programs. To resolve this drawback and still adhere to the TQM ideas modification were created to the initial TQM ideas and it's called TPM (Total Productive Maintenance) and these modifications elevated maintenance to the standard (Eti et al, 2004; Suzuki, 1992).

Seiichi Nakajima, an officer with the Institute of Plant protection or maintenance in Japan is credited with defining the concepts of TPM and seeing it applied in loads of plants in Japan. The first broadly attended TPM convention held within the United States befell in 1990. Today, numerous consulting corporations routinely offer TPM meetings as well as provide consulting and coordination offerings or services for organizations wishing to begin a TPM application of their plants (Jack Roberts, 1997).

### **3.2 TPM Techniques**


TPM (Total Productive maintenance) is one of a lean tool, a maintenance program which gives a totally new approach for maintaining plant and equipment. This maintenance program is used for increasing the efficiency of the machines and the processes. TPM gives a way for excellent planning, organizing, monitoring and controlling practices through its 5S foundation methodology and unique eight-pillars (Suzuki, 1992; Venkatesh, 2015). Figure 1 shows TPM 5S foundation

**TPM -Total Productive Maintenance**

**5S Definition**

5'S represents **5 Japanese Disciplines** for maintaining a **Visual** workplace.

<b>Seiri</b>	- Sort (Organize)
<b>Seiton</b>	- Simplify (Visibility)
<b>Seiso</b>	- Sweep (Cleanliness)
<b>Seiketsu</b>	- Standardize (Adherence)
<b>Shitsuke</b>	- Self-discipline (Sustain)



TPM 5S Foundation by (Venkatesh, 2015).

### Explanation of Five Level of TPM

The TPM can be divided into five different steps or levels.

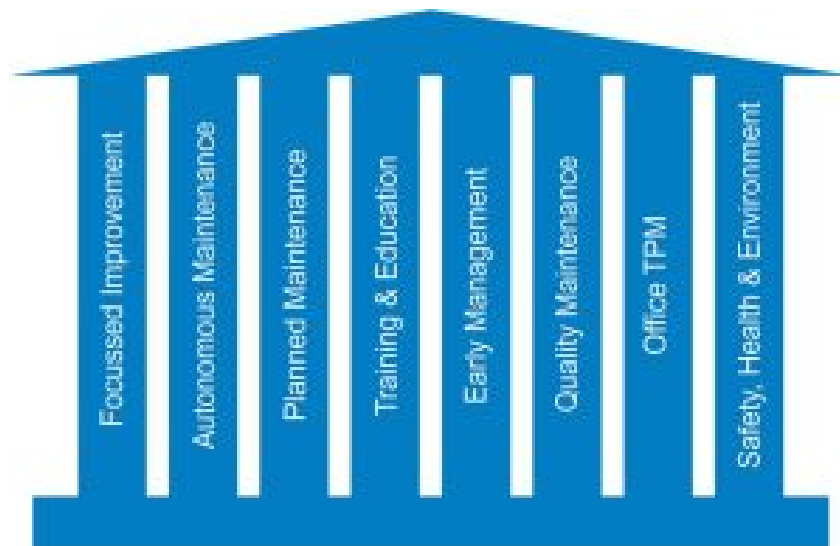
**Level 1:** At the first level initial cleaning and inspection is performed. The aim of level or step one is to increase the efficiency of the machines and find problems, which have not been found before. Unnecessary items and equipment are also removed and general cleaning is performed to clear away the dirt and dust (Venkatesh, 2015).

**Level 2:** At the second level all the sources of contamination, dirt and oil, are eliminated. The places which are difficult to clean and inspect are relocated or re-assembled to allow access (Venkatesh,2015).

**Level 3:** The third level introduces standards for cleaning, lubricating and maintenance. They are to make sure that the cleaning is performed effectively. Problem areas are taken into closer look to pinpoint the places where lubrication has been inefficient and insufficient. The process will also be documented for auditing purposes, where we have the situation before the cleaning and after the cleaning. This is an easy way to realize the positive changes achieved by TPM (Venkatesh,2015).

**Level 4:** At the fourth level the personnel will be trained and advised in the basic functions and controls of the machines they use. This will make sure that they are able to perform easy maintenance tasks on their own and they are aware of the functions of the machine they are working with (Venkatesh,2015).

**Level 5:** The fifth level sums up the standards and learning acquired by training at the third and fourth level and it is time that the operator starts to perform the basic inspection and maintenance task autonomously. At this stage we take photographs of the final results and the pictures will be compared to with photographs taken at the earlier stages. Comparing the pictures is very easy and straight forward method used to document the achievements of the TPM project (Venkatesh,2015). Figure 2 shows 8pillars of TPM



Eight pillars of TPM by (Suzuki, 1992;Venkatesh, 2015).

#### **Explanation of Eight Pillars of TPM**

To begin applying TPM ideas to plant maintenance activities, the whole workforce should initial be convinced that higher level management is committed to the program. The primary step during this effort is to either employ or appoint a TPM planner or organizer. It's the responsibility of the planner or organizer to sell the TPM ideas to the workforce through an enlightenment and educational program. To try and do an intensive job of teaching and convincing the workforce that TPM is simply not another "program of the month," can take time, maybe a year or more than (Jack Roberts, 1997; Suzuki, 1992; Venkatesh, 2015).

TPM implementation includes the following eight pillars:

- 1.) Autonomous maintenance
- 2.) Focused improvement
- 3.) Planned maintenance
- 4.) Operating and maintenance skills training
- 5.) Early management
- 6.) Quality maintenance
- 7.) TPM in administrative and support departments
- 8.) Building a safe, environmentally friendly system (Suzuki,1992;Venkatesh,2015).

See table 1

#### **Table 1:- 8 pillars of TPM**

### 1.) AUTONOMOUS MAINTENANCE

- Step 1 Perform initial cleaning and inspection
- Step 2 Eliminate contamination sources and cleaning specifications
- Step 3 Establish checking standards and cleaning specification
- Step 4 Conduct general equipment inspection
- Step 5 Perform general process inspection
- Step 6 Systematic autonomous maintenance
- Step 7 Practice full self-management (Suzuki, 1992; Venkatesh, 2015).

### 2.) FOCUSED IMPROVEMENT

- Step 1 Select improvement topic
- Step 2 Understand situation
- Step 3 Expose and eliminate abnormalities
- Step 4 Analyze causes
- Step 5 Plan improvement
- Step 6 Implement improvement
- Step 7 Check results
- Step 8 Consolidate gains (Suzuki, 1992; Venkatesh, 2015).

### 3.) PLANNED MAINTENANCE

- Step 1 Evaluate equipment and understand situation
- Step 2 Reverse deterioration and correct weakness
- Step 3 Build an information management system
- Step 4 Build a periodic maintenance system
- Step 5 Build a predictive maintenance system
- Step 6 Evaluate the planned maintenance system  
(Suzuki, 1992; Venkatesh, 2015).

### 4.) OPERATING AND MAINTENANCE SKILLS TRAINING

- Step 1 Evaluate the current training program and set policy and priority strategies
- Step 2 Design a program for improving operating and maintenance skills
- Step 3 Implement operating and maintenance skills training
- Step 4 Design and develop a skill-development system
- Step 5 Foster an environment that encourages self-development
- Step 6 Evaluate the activities and plan for the future (Suzuki, 1992; Venkatesh, 2015).

### 5.) EARLY MANAGEMENT

- Step 1 Investigate and analyze the existing situation
- Step 2 Establish an early management system
- Step 3 Debug the new system and provide training
- Step 4 Apply the new system comprehensively  
(Suzuki, 1992; Venkatesh, 2015).

### 6.) QUALITY MAINTENANCE

- Step 1 Prepare quality assurance (QA) matrix
- Step 2 Prepare production-input condition analysis table
- Step 3 Prepare problem chart
- Step 4 Evaluate seriousness of problem using failure-mode-effect analysis (FMEA)

Step 5 Use phenomenon-mechanism(P-M) analysis to track down causes of problem  
Step 6 Assess impact of proposed counter measure using FMEA  
Step 7 Implement improvement Step 8 Review production-input conditions  
Step 9 Consolidate and confirm check points  
Step 10 prepare a quality component control table and assure quality through strict condition control (Suzuki,1992;Venkatesh, 2015).

#### 7.) ADMINISTRATIVE AND SUPPORT DEPARTMENTS

Step 1 Increase work efficiency through focused improvement  
Step 2 Build a system of administrative autonomous maintenance  
Step 3 Improve administrative capacity through education and training  
Step 4 Create an efficient staffing system  
Step 5 Develop a work evaluation system(Suzuki,1992;Venkatesh, 2015).

#### 8.) BUILDING A SAFE, ENVIRONMENTALLY FRIENDLY SYSTEM

Step 1 Promote safety awareness in conjunction with autonomous maintenance  
Step 2 Prevent accidents that originate in behavior by making people safety-conscious  
Step 3 Prevent accidents that originate in equipment (Suzuki 1992;Venkatesh, 2015).

### 3.3 The Implementation of Total Productive Maintenance (TPM)

The TPM program can be implemented in four major phases (Nakajima, 1988; Park and Han, 2001), as follows:

#### Phase 1

**Preparation** - in this section the management at the highest or top-level has the responsibility to announce the choice to introduce the TPM program and to organize an acceptable environment. A program is developed so as to: cut back losses of equipment, create an autonomous maintenance program, improve internal control and supply the staff (managers and operators) with coaching and education (Ademir et al, 2015; Nakajima,1988; Park and Han, 2001 ).

#### Phase 2

**Preliminary implementation** - the operators are concerned within the maintenance activities and also the main skills and competencies are provided to the entire workers. However, before the individual employee begins, an idea to spot initial tasks and to develop procedures is elaborate by the managers (Ademir et al, 2015; Nakajima, 1988; Park and Han, 2001).

#### Phase 3

**TPM implementation** - the main focus here is to enhance equipment effectiveness by means that of specific techniques. During this part the operators are concerned in the autonomous maintenance program, requiring improvement of their ability levels (Ademir et al, 2015; Nakajima, 1988; Park and Han, 2001).

#### Phase 4

**Stabilization** - at this stage the organization shall continue the TPM program by using of continuous improvement method. During this section, the upkeep or maintenance goals are

incorporated to the business strategy. Checking of results continuously and additionally the reassurance that TPM skills may be reached by designation the group's performance. In every section of the program there are many steps to be developed and roles to be fulfilled by top managers, midlevel management, engineers, maintenance technicians and operators, making the TPM implementation method to be advanced (Ademir et al, 2015; Nakajima, 1988; Park and Han, 2001).

On the way to decide the principle actions to be taken in a TPM program, in every segment, the employer needs a commercial enterprise undertaking and a strategic plan (Park and Han, 2001). In line with (Eti et al, (2004), a better planning of maintenance schedules implies in lesser effort wasted.

### **3.4 The factors that make implementation of TPM successful**

There are some structure factors that can influence the success of any program implementation in an industries (Fu et al, 2006) and (Sola and Xavier, 2007). For example in the area of maintenance the main critical success factor (CSF) for TPM implementation are presented as follows:

**1.) Education and training:** there is no hesitation that personnel that are highly qualified are vital to the performance of any organization. In maintenance management, the success of the organization during a TPM implementation programs depends on competencies of the staff or employees toward the task, highlight Ahuja and Khamba (2008).

According to Panneerselyam (2012), training and education for every workers or employees at all levels within the organization could be a key success issue for TPM implementation. Relating to the maintenance department, individuals are the foremost necessary resource, as a result they manage, plan, supervise and execute all maintenance practices (Alsyouf, 2009).

An educational and training program is crucial to transfer maintenance tasks to operations and also the educational background of the corporate or company personnel may or can seriously have an effect on the speed of TPM implementation (Sun et al, 2003).

The corporation has the duty to sell or promote continuous learning so that it will assist the TPM implementation (Park and Han, 2001).

Among the foremost contributions of personnel qualification are: productiveness improvement, requirements of quality fulfillment, reduction of failures, accidents and injuries, and the appearance of latest ideas in an effort to enhance the activities continuously (Ademir et al, 2015).

**2.) Working in teams:** According to Santandreu-Mascarell et al (2013), employees or individuals within the organization who are ready to work in groups or teams have the subsequent characteristics: they are committed to their work, request for information and new opportunities, and are ready to take risks in an innovative ventures. Excessive stage of collaboration among employees and work unit within an agency or organization is the maximum important aspect to enhance management practices and operational performance ( Baird et al, 2011). Specially in TPM applications, all personnel inside an organization inclusive of operators, renovation or maintenance employees, supervisors, schedules and upper management, must be included in a group, highlight Sun et al, (2003).

Park and Han (2001) emphasize that human beings, mainly operators, preservation or maintenance technicians, engineers, designers and planners, all ought to work as a group

with a view to maximize the general effectiveness of equipment, through creative solutions for operational issues.

**3.) Preparation and planning:** At the strategic level of the organization, the management at the top level is liable for making and preparing an appropriate atmosphere and surrounding ready for TPM implementation. A strategic set up may be a basic demand and demands each external and internal analysis (Park and Han, 2001).

The first analysis consists of: markets, competitors, clients, tendencies, opportunities and threats; the second evaluation incorporates: evaluation of business enterprise strengths, weak point and assets. TPM dreams will be blanketed or included in the marketing strategy (Ahuja and Khamba, 2008).

According to Lasim and Ramayah (2010) an understanding of maintenance as a strategic decision can or may eliminate any potential of deterioration equipment, stoppages and breakdown, failures and can also contribute to extend or increase the morale of the groups. Even as TPM is a strategic method, the primary impact on its implementation takes place at the plant stage requiring sturdy integration among the sectors. Therefore, TPM practices need to be incorporated to the organization approach if you want to reap a world magnificence maintenance fame (Sharma et al, 2006).

Managers should encompass a plan to: sell TPM activities; lessen the gadget or equipment losses; create an self sufficient maintenance application; preserve exceptional manage or quality control ; broaden preventive and predictive renovation in addition to improve maintenance skills by way of schooling or training and education (Chan et al, 2005; Park and Han, 2001).

**4.) Top management commitment:** Any action in a corporation or an organization, that include maintenance management, depends on the commitment of high or top management. The maintenance strategy ought to be incorporated to the manufacturing and corporate strategy so as to be competitive more (Alsyouf,2009).

It is reported that firms focused on competitive strategy tend to invest a lot in infrastructure like employee or worker empowerment and development of management programs (Ward et al, 2007).

In this direction, high or top management plays a vital role to make sure that TPM goals and objectives are in aligned with the general and overall goals and objectives of the business (Lazim and Ramayah, 2010).

The alignment of business strategy and operations strategy may or can verify the success performance of the organization (Shavarini et al, 2013). Effectiveness of performance measurement systems is associated with top management support (Tung et al, 2011). Park and Han (2001) state that top management support is required in 2 ways: to overcome issues because of the cross-functional impact of TPM; and to produce adequate resources as well as time, money and people. Managers can make contributions in the direction of a hit or successful TPM implementations by way of several attitudes which include selling cultural modifications, casting off obstacles associated with middle-degree or level control and promoting inter-branch synergy within the company or organization (Ahuja and Khamba, 2008). People within the organization must be convinced that the upper-level management is committed to the program (Sun et al, 2003). This is important to ensure the involvement of the staff (Ademir et al, 2015). The morale of production operators and maintenance personnel depends on management support (Chan et al, 2005). Top management commitment is important to promote motivation inside the business enterprise and to create recognition of the genuine capacity of the TPM philosophy (Panneerselvam, 2012).

**5.) Resistance to change:** In the TPM implementation system the personnel can resist the adoption of recent upkeep practices for specific motives. Chan et al (2005) have mentioned that employees could be: skeptical approximately the operator's capacity to practice, or fearing that TPM would possibly growth their workload, or in confrontation with the division of labor. Ahuja and Khamba (2008) have expressed that middle management may resist offering authorization and recognition to bottom-level operators, as a result of concern of losing the respect and authority. Poduval et al (2013) have stressed that workers may view themselves as they only belong to the departments within which they work and to not the organization, indicating lack of alignment with the organization mission and goals. As for adjustments or changes in production practices, an important component to be found or observed is the practices lifecycle. Some practices applied based on employees tendencies- e.g. shared imaginative and prescient, employee involvement, education and training, and so forth. Had been found to last longer inside agencies or organization (Kuula et al, 2012). When new practices like TPM are implemented during a plant, personnel development for the new job responsibilities is fundamental to alter the staff's mind facing the new established order (Ademir et al, 2015).

**6.) Change in culture:** A study disbursed in large and medium-sized organizations shows that culture modification or change has been the most obstacle for TPM implementation (Aspinwall and Elgharib, 2013). Organizational culture is defined inside the literature because the values and beliefs that organizational members share and might form the firm strategic orientations (Naranjo-Valencia et al, 2011). On its turn, organizational way of life is related to the firm performance measures and, as highlighted through Prajogo and McDermott (2011), although one cultural side may be relevant in poignant performance, each cultural dimension has its importance within the firm performance. Thus, relating to the implementation of a management system, a modification or change management method contributes to better performance (Ronnenberg et al, 2011). As the culture of the organization is top-down, higher or top managers play a vital role in terms of leadership so as to alter the present organization culture(Ademir et al, 2015). According to Poduval et al (2013), the organization changes only if the top manager is willing to change. Panneerselvam (2012) points out that a company wants radical transformation in its culture to establish the workers involvement toward TPM implementation, and such action should be motivated by the highest or top management as an amendment or change agent. In the case of TPM implementation, organizational exchange or change is related to the dedication from both management and employees (Hansson et al, 2003; Bamber et al, 1999).

**7.) Employee involvement:** In the expression TPM, the word "Total" means employee involvement, as defined by (Nakajima, 1988). In fact, the issue in implementing a TPM program is that the quality of getting commitment and involvement from staff and therefore the participative approach may be a primal key to its success (Arca and Prado, 2008). Panneerselvam (2012) highlights that the most effective approach to make sure that employees are fully involved is by involving the staff by: getting their views and ideas during the program implementation; providing an encouraging safe work; stimulating a sense of ownership; developing a system of worker empowerment; recognizing employees efforts and enhancing competencies toward their functions.

**8.) Monitoring result:** The measurement is an important requirement of the continuous improvement process. The main goal of TPM is to maximize equipment effectiveness and, therefore, it is measured in terms of the OEE (Overall Equipment Effectiveness) index, which is used to assess availability, performance rate and quality rate from six types of equipment

losses: breakdown losses; set-up and adjustment losses; reduced speed losses; minor/idling losses; reduced yield losses; defect/rework losses (Sharma et al, 2006).

**9.) Effective communication:** Panneerselvam (2012) states the importance and relevance of managers effectively communicate to the staff, the importance and advantages of the TPM program to the working personnel. In the same direction, Ahuja and Khamba (2008) highlight the importance of structure and multilevel communication to all or any workers so as to propagate the TPM advantages and edges and also the basic principles of the program. Alsyof (2009) emphasizes the need to show the impact of maintenance on organizations performance. Park and Han (2001) state that a frequent communication method across the organization might lead to nice and great involvement, cooperation and commitment among employees.

### **3.5 The TPM Effectiveness Measurement**

Measurement is a crucial demand of continuous improvement processes. It is necessary to establish acceptable metrics for purpose of measurement. From a generic perspective, TPM can be defined in terms of overall equipment effectiveness (OEE) that successively will be thought-about a combination of the operation maintenance, equipment management, and obtainable or available resources ( Chan et al, 2005). The purpose of TPM is to maximize system effectiveness, and the OEE is used as a degree (Waeyenbergh and Pintelon 2002). In step with Nakajima (1988), OEE measurement is an effective way of analyzing the efficiency of a system or an included manufacturing system.

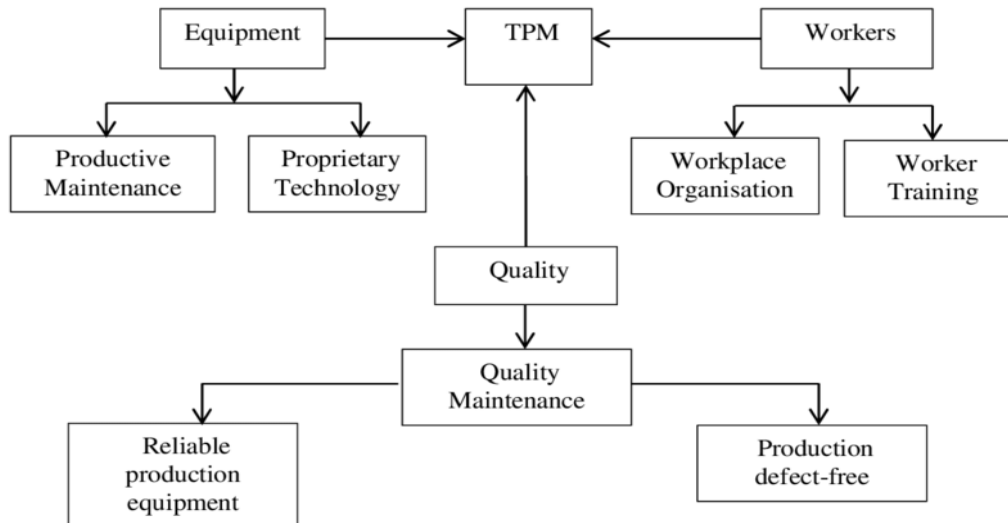
It is far a characteristic of availability, overall performance rate, and best rate. Definitely, the three dimensions are measures of the device or equipment losses. Nakajima (1988) defined the losses into six major categories as follows:

- 1.) Breakdown losses
- 2.) Set-up and adjustment losses
- 3.) Minor/idling stoppage losses
- 4.) Reduced speed losses
- 5.) Defect/rework losses
- 6.) Start-up losses (Chan et al, 2005).

### **3.6 Roles of Production and Maintenance of TPM**

TPM could be a synergistic relationship among all organizational functions, notably between production and maintenance. This aims for continuous improvement of product quality, as well as operational potency and capability assurance. An efficient TPM depends on each production and maintenance activities (Chan et al, 2005).

Also Yamashina (1995) stated that no matter how good the way plants are equipped with advanced manufacturing techniques, it is perpetually the operators, not managers or systems, who have an effect on the plant's performance. In this affiliation, operators ought to participate in the maintenance operator by being responsible for the reduction or prevention of degradation or deterioration and figure 3 show the supporting elements of TPM.



The key supporting element of TPM (Chan et al, 2005).

The operators central role in equipment operation, condition, and maintenance should be acknowledged. The co-operative effort permits maintenance personnel to focus their energies on tasks requiring their technical experience and to learn about and use additional refined techniques for advanced manufacturing (Chan et al, 2005).

Operators and maintenance personnel must reach mutual understanding and share responsibility for equipment (Jostes and Helms, 1994; Lawrence, 1999; Ben-Daya and Duffuaa, 1995). In fact, everyone concerned with equipment must co-operate with and understand the role of everyone else (Co et al, 1998).

Operators need to do the following:

- Hold basic equipment situations (cleaning, lubrication, bolting); preserve and maintain working situations (proper operation and visible inspection).

- Find out deterioration, mainly via visual inspection and early identity of signs of abnormalities for the duration of operation.

- Decorate talents together with device operation, set-up, and adjustment, as well as visual inspection (Chan et al, 2005).

### 3.7 Identification and Categorization of Barriers in TPM Implementation

TPM is an innovative approach to maintenance that holds the potential for enhancing effectiveness of production facilities. It demands important modification of labour culture and radical restructuring of labour. Introducing TPM in operations situated in developing countries could be a major challenge as a result of the surroundings and environment is usually traditional and unfavourable to the transformation (Tsang and Chan, 2000). In recent years, several firms have tried to implement TPM programs, but less than 10 percent reach this implementation (Mora, 2002).

Further, Hartmann (2000) has confirmed that each second try of TPM implementation has resulted in failure. Before the adoption and implementation of TPM, it's significantly necessary to foresee the barriers related to it. Hence, it becomes essential to review and analyze the barriers inhibiting the TPM implementation. On the idea of literature analysis and interactions with the managers (maintenance and production) and academicians, a huge range of barriers are classified into totally different classes in order that their intensity may be computed with no problem.

These barriers are grouped into five categories:

- 1.) Behavioural Barrier
- 2.) Human and Cultural Barrier
- 3.) Strategic Barrier
- 4.) Operational Barrier
- 5.) Technical Barrier

1.) Behavioural Barrier:- these barriers are related to the human being working in the organization and it is caused by:

- Lack of top management commitment
- Employee resistance
- Lack of clear vision
- Lack of job security
- Poor coordination between maintenance and production department

2.) Human and Cultural Barrier:- these barriers are related to the culture prevailing in the organization which significantly affects the working of human resources within the organization and it is caused by:

- Lack of motivation
- Lack of coordination
- Inability to change organizational culture
- Unwillingness of human resources to adopt TPM
- Less empowerment to take decisions

3.) Strategic Barrier:- these barriers are related to the strategic decision of the TPM implementation. Strategic planning of TPM implementation is imperative as it provides a framework for proactive decision-making to evaluate performance continuously and also to what could go wrong, determine significant risks and implement strategies to deal with those risks (Raj and Attri, 2010) and it is caused by:

- Ineffective long term planning
- Non-clarity of organizational objectives
- Non-clarity of organizational policy about TPM programs
- Failure to allow sufficient time for evolution
- Poor structure to support TPM initiatives

4.) Operational Barrier:- these barriers are related to operation procedures of maintenance and it is caused by:

- Lack of standard operating procedure
- Absence of preventive maintenance schedules
- Poor workplace environments
- Inadequate use of tool, techniques and methodologies
- Lack of follow up of progress of TPM initiatives

5.) Technical Barrier:- these barriers are related to the knowledge of the TPM concepts and principles and it is caused by:

- Lack of technical knowledge
- Less educated workforce
- Lack of training and education
- Lack of understanding of TPM concepts and principles
- Absence of computerized maintenance management systems (CMMS) (Attri et al, 2013).

### 3.8 Mapping the Focus Area

In order to quickly understand the current situation or procedures in the production lines and to get accustomed to the people and products, the author of this thesis interviewed the Managers, supervisors, operating personnel's, processing personnel's, quality personnel's

The full questionnaire is in Appendix 1

and discussed the five focus areas for TPM implementation which are :

1. To check how the level of their initial clean and inspection is performed.
2. To check how the level all the sources of contamination, dirt and oil, are eliminated.
3. Introduces standards for cleaning, lubricating and maintenance.
4. The personnel's will be trained and advised in the basic functions and controls of the machines they use.
5. To sum up the standards and learning acquired by training at the third and fourth level and it is time that the operators start to perform the basic inspection and maintenance task autonomously.

Training for safety and maintenance prevent accidents and enable the employee to take greater responsibility for their work. Process working and standards reduce the amount of defects and rework. A clean and well-organized office and production site ensure a safe and functional working place. And also explained to them that although TPM requires time and investments, it is worth the efforts when considering the benefits that can be achieved with it.

### 3.9 Manufacturing Issues

Below are the factors that hold back the implementation of TPM within the XYZ Plastics company.

**1.) The cost of TPM Implementation:** Not having enough money in disposition is one in all the key barriers in implementation and adoption of TPM among an organization. The main concern about applying TPM, like every other productivity improvement initiative among an organization is that it may need huge amount of money to pay for professional that we initiate and implement the TPM concepts. The teaching and instruction given to the individuals that will utilize these techniques needs money. In some cases, production of an organization could also be stopped i.e. if the machine or plant layouts got to be modified for free/smooth flow of material, then the production has to stop. In the case of providing the teaching and instruction to individuals production ought to stop.

**2.) Misapplication:** Due to the fact that the current manufacturing market is incredibly competitive, the company is suspending/delaying TPM with unpredictable future certainties, which cause decreasing or reduction in manufacturing performance. So as to continue to exist or carry on, managers have choose to adopt the TPM idea as soon as possible. In XYZ Plastics Industry case, there are many places in the company where you can store raw material and waste, for the manufacturing process to become much easier and faster, due to the facts that everything is not properly arrange, it takes longer time to find material to used for each machine, because the company were in rush of being lean, cause misapplication of many lean manufacturing tools which resulted in many failures.

**3.) Cost Drivers:** In other to increase the profit, it's essential to recognize and ranking the components that generate costs in the company. Once finding these components, each of the cost saving exercises and TPM application that put in force waste elimination and performance improvement can be accomplished. The extent of implementation of TPM and different manufacturing practices that modify the effective lean depends on the plant size; plant age and therefore the extent of individuals interest are the factors of successful or

failure of TPM application. The size of a plant is a vital issue that determines whether or not an organization can do a successful TPM application.

**4.) Employee Involvement/Human Factors:** The application and productive adoption of TPM will solely be sustained in structured manner if and only if workers involved are concerned. Here in XYZ Plastics Industry just only the senior management is aware of the TPM methodology. Since the information would have remained among the boundary of simply one or two of individuals, mainly the seniors, ensuing into no correct/proper implementation.

**5.) Complex Manufacturing Parts:** The plastics that XYZ Plastics Industry manufacture are of various shapes and sizes, therefore to manufacture these plastics with different shapes and sizes the machine have to be compelled to set each day with completely different program and fixtures. As a result of that the machines aren't functioning with their full specifications and stay idle throughout the time of setting a new part for manufacturing.

**6.) Organizational Culture:** The creation of a collateral Organizational culture is the most vital platform for the successful and booming implementation of TPM.

**7.) Miscellaneous:**

- Operators are not doing daily maintenance of the machine, which results in a breakdown of machines very often.
- Most of the time wasted in setting the fixtures.
- If any of the worker is absent from work, the production or operation on that machine will be stops because there is nobody to replace the absent worker.
- No morning meetings (necessary for daily production planning).
- No checklist, working instruction, and instructions for maintenance of the machine. Operators did not know how to do the maintenance.
- No proper sorting of tools in the work place area.
- No one is cleaning the workplace, which makes the working area messy because of which finding the tools or fixtures are difficult or time-consuming.
- The material of one machine is lying on the area of another machine.
- Operators do not have knowledge of 5S, TPM or any other lean manufacturing techniques.

#### **4. Case Study at XYZ Plastics Industry**

The empirical of this thesis is presented in this chapter. During this study, primary data is collected through semi-structured interviews as earlier asserted and supported by actual observation of the total production maintenance in the plastics manufacturing industries in Ibadan, Nigeria. Managers, supervisors, operating personnel's, processing personnel's, quality personnel's were interviewed and observed. The plastics industries used in this study will be referred to as "XYZ industries" further on, as I could not acquire or obtain outright permission to use their actual name as at the time of this document or report. It could sometimes be called the XYZ plastics industries or plastics industries depending on the flow of the write up.

##### **4.1 History of XYZ Plastics Company**

XYZ plastics industries is an outstanding participant in the Nigerian plastic sector. one hundred percent Nigerian owned, XYZ Plastics has been producing plastic, family gadgets, household items, garden furniture, kitchenware, industrial products and plastics packaging materials like coolers and soon in Nigeria for over 25 years, meeting the worldwide requirements /international standards. XYZ plastic products are made with up to date

substances to fulfil environmental requirements. Enduring paperwork and high-quality construction make their merchandise comfortable durable and sturdy. Their first-rate products are available in numerous design and shade or color options. colourings stay colourful even after years of tough use. Their high-quality furniture is primary inside the enterprise or business and their chairs are extraordinary for all activities such as: convention rooms, churches, inns, café, reception areas, schooling rooms and workplaces. Their design choice grows everyday in an effort to offer you simplest and the excellent with various options of designs to the Nigerian public and the whole of West Africa. Their product are famous all over the use of a these days, our products have accomplished a pervasive presence that proves the staying power of appropriate design. Their Chairs are of natural shapes, easy and easy form sculpted to match the frame. Anything you need, whether to make your growing church congregation greater comfortable, starting a rental service carrier business, beginning a new faculty or day care, placing an elegant contact or touch on your reception place, workplace or garden, they stand as a progressing accomplice.

## **4.2 Company Operations**

The different specialization area of the company gives it competitive edge in Nigeria and the whole of West Africa and get better as they increase their range of service and products. It is important to mention that each specialist groups strive to come up with excellent solutions for tasks in their respective field. This is so because different department are allowed to focus on what they do best, and as result gain more knowledge, ability to develop new ideas.

To carry out their service effectively and efficiently to meet the various demands of customer the company has distributing centers in different locations in Nigeria and the whole of West Africa.

Their different specialization area in plastics production are:- plastics furniture and plastics household items.

Plastics furniture: pioneers in plastic furniture manufacturing in Nigeria with most variations in colours with single and multi colour combinations, the durability of their products is unparalleled in the market. Their cabinets and drawers are widely used in offices and homes and their constant visits to International Trade shows help bring the latest and best global designs to Nigeria and west Africa as a whole.

Plastics household items: their plastics household items was among the first brands to enter the household goods market in Nigeria and generations of Nigerians know the brand for value and durability, they manufacture a lot of household items with the latest models with extensive colour choices and no household is considered complete without their brand of products.

Corporate Branding: They are the first and indigenous plastic manufacturing company that is into the manufacture of printed promotional items such as chairs, tables, disposable cups/power packs/plastic containers, coolers e.t.c for promotions, events and social engagements.

Their tremendous array of promotional objects together with chairs, tables, coolers, disposable cups/plastic bins e.t.c combined with powerful emblem/creative message can create a unexpected impact on emblem image and their international class machine can produce exceptional color, form, size and design of printed promotional products which

includes furnishings (chairs & tables), packaging materials (disposable plastic containers/power packs/cups, coolers and to customers flavor and specs.

Their customers base cuts throughout company establishments, multinationals, Fast Moving Consumer Goods (FMCGS) and Small & Medium Scale entrepreneurs (SMEs).

### **4.3 Initial Condition at XYZ Plastics Industry before TPM**

Case study has been presented in this sections and this are mine findings:

When starting the project, the floors of the distribution centre were cleaned once every two weeks by external cleaning services and a cleaner emptied the trashcans from the offices, wiped the floors and dust briefly. The machines did not have any plans for lubrication so they were run until something broke down.

The floors did not have any markings for the areas reserved for forklift traffic and soon. The areas where to leave incoming and outgoing goods where not fully planned either. The drivers of the trucks bringing and picking up goods were walking freely in the warehouse, areas and units. This was both a safety risk and cause of unnecessary disturbance for the workers.

The layout of the industry should also be reorganized to meet the changed demands: there were large amounts of incoming goods on pallets; there was traffic on the packing table and a growing number of small items arriving from the production on trolleys. So called “dead corners” should be utilized to store cleaning supplies, tool and packing material. There were also extra closets, cupboards and shelves which were not needed for filling the space. Changes in documentation regulation also allowed a big part of the stored picking orders to be thrown away.

The main target of the TPM project would be to bring the levels involve in TPM implementation from level one to level five. This would require maintenance plans for the forklifts, printers and other essential machines used at the industry for production and soon. The floors should be painted to guide in which areas pallets would be stored, where the main truck traffic should be and which places should not be blocked or where to be extra careful when driving.

The layout of the industry should be reorganized and cleaned. Offices, the incoming goods area, production area, warehouse and packing area would have their own tidying plans and a team responsible for conducting the procedures. The reorganized entrance area would keep the unwanted material or truck personnel out of the working area and more space would be cleared to store the incoming goods. The work process would be analyzed to cut down unnecessary movements in the production areas, warehouse and operation areas and soon. The production area, warehouse and the office would also be cleared from all the unnecessary furniture, folders, tools and other useless items.

During the initial cleaning, problem areas, faulty machines and other insufficiencies should be listed and later dealt with. This means that some worn parts would be replaced and needed supplies would be acquired. Before reaching the fifth level of TPM all the listed faults should be fixed. Issues which are either too expensive or are not worth repairing should be analyzed to find out if there is any other way to deal with the problem.

## **5. Results and Analysis**

XYZ Plastics Manufacturing Industry has been evaluated base on 5S and 8pillars of TPM (Total Productive Maintenance).

## 5.1 Implementation of 5S in XYZ Plastic Industry

**Step 1: Promotion:** The whole workers contributed to the adoption of such technique. work force is aware of the thought/idea of the technique and benefits.

- Numerous lecture and shows are given to the workers to make them perceive and understand what TPM is and the way to implement it, the primary step is to build and work on its foundation i.e. 5S.
- An interview of the workers has been taken to grasp/know the extent of their understanding of TPM.
- The questionnaires are created to aware them concerning TPM.
- The 5S methodology system flow chart is placed on manufacturing notice board as a district of promotion and makes operators understand how to implement it.

**Step 2: Initial 5S Audit:** To develop a specific 5S improvement plan and set up in the area where it is needed.

- To develop an area specific 5S improvement plan Key Techniques: Audit Sheets, Fixed point photography.
- Internal audits are created to look for and divide the areas to implement the TPM
- Possession is given to operators at the place wherever they're operating. They have to take care of the 5S methodology in their area and space.
- Prizes, Incentives are going to be given to workers, that maintains it.
- Internal audits are created to see whether or not operators are following the TPM methodology or not.

**Step 3: Sort:** Divide things in three categories: Return, Hold and Rid . Get rid of things, that isn't required.

- The area next to machine is currently divide things in three categories: Return, Rid and Hold. Eliminate things that don't seem to be required.
- Coolant tanks are lying within the machine shop, wherever they're taking the unnecessary space and making it tough for workers to have a free movement. The tank is currently hold on at the selected place assigned for tanks.

**Step 4: Set in Order:** Look for a place for everything and put everything in its place. Organizing, arranging, and storing material, equipment and information.

- Proper places are assigned for each machine to put its raw material. Earlier raw- material of one machine was lying on area of other machine because of which the area becomes messed up and it became hard for operator to work there.
- Materials were not properly arranged at the raw-material area. Now the materials are arranged properly, now there is enough space to put more material.
- Some metal and material were lying inside the shop floor. The metal and material are taken out from the shop floor and kept at the raw material area. Now there is enough empty space for other things to do here. Quality racks can be placed here which will help the shop to be more organized.

**Step 5: Shine:** Cleaning the workplace and maintaining it. Establishing preventive measures to produce ongoing cleanliness.

- The shop was not cleaned as the materials is lying everywhere. The materials are properly arranged and the shop is cleaned. Now it is easy to move around the shop.

**Step 6: Standardize:** Make up the rules, follow and implement them.

- No operator was filling the real time update within the software that makes it hard to know what is going on within the machine. Real time updates show the current operation of the machine. There are totally different colors assign for every activity within the software and

it's connected through computer network (LAN) to workplace PCs. For e.g. black color is for offline, red is for stopped, blue is for setting, green is for in-cycle, brown is for breakdown, purple is for maintenance, etc. Currently operators are filling the real time details/update within the software, so that every operators or workers can see on-line the operation that is going on within the machine. Operators don't seem to be filling details throughout tooling, maintenance, etc. within the software earlier however currently we are able to see the various colors within the software for the real time position or status of the machine.

- Employee's details don't seem to be displayed on the notice board. It was difficult to look for proper data and information of the workers as their phone number and email addresses are difficult to look for. The workers details are displayed on the notice board with all their details like phone number, name, designation, email address, etc.

**Step 7: Sustain:** Frequently apply the quality/standard and build a habit of maintaining the right procedure. The Supervisor has given the responsibility to check-up whether or not the operators are following the quality and standard or not, If they're not following then it supervisors responsibility to let and make them follow it.

- Suggestion system stating that whoever offers the most effective suggestion are given reward.

## 5.2 Implementation of 8 Pillars of TPM in XYZ Plastics Industry

### 1.) Autonomous Maintenance

**Approach:** operators had been educated and given instruction by the third party engineer that is good within the maintenance of machines. A checklist is made ready for maintenance purpose. So from now on following the listing is obligatory for all the operators. It's a responsibility of supervisor to make sure that each operator is following the checklist every time and day.

- Possession of a machine is given to every operator of the machine within which he's operating. This changes the operator outlook and mindset towards the machine.

- To clean some of the small part of the machine, air pressure is being used to clean it. The suggestion has been given to buy air pressure (vacuum cleaner) so that the dirt can be removed from the small part of the machine.

- A checklist is created for daily, weekly, monthly and yearly maintenance of the machines. So from now on the operators have each a reminder and a record of what require to be done. For more of advanced maintenance there are clear directions and instructions on the simplest and best ways to undertake the operation.

**Outcomes:** operators become well-versed and anxious regarding the condition of equipment they use on each day. They are familiar with the condition of the equipment before they use it and also they know how long it'll last.

- The operators become more expert as they gain an understanding of the final and general operating and working of the machine therefore achieving the multi-skilling objective of a lean organization.

- Machines operate at their optimum level as a result of the fundamental maintenance like cleanup, adjustment of bolts and lubrication is being done more often.

- Due to the daily maintenance, the issues/problem are known well before and corrected before they are going out of control resulting in the key breakdown of equipment/apparatus.

- Maintenance Engineering employees are freed-up to perform the upper levels of maintenance activities on important and sensitive equipment's so reducing the downtime of system (David Gitachu, 2017).

## **2.) Focused Improvement**

One of the examples of focus improvement: is implementing the quality rack in the work floor. The legs of the rack were bends due to the too much weight of materials put on the shelves. The rack legs are now fixed properly, by attaching iron rods with the leg which made the shelves much stronger to be able to lift more weight, but the solution is not permanent. The main permanent solution is to replaced it by new racks which is more stronger.

Second example of focus improvement: is changing the chain that hold the engine that is use to grind the recycle plastics to the wall, because it's not strong again which is making the engine to be shaking when it is working and it is replace by new and more stronger chain to be able to hold the engine very well.

Third example of focus improvement: is the stairs taking a lot of space in the work floor. It is reduce by cutting it in a way that there will be enough free space to keep other product, machine and material.

## **3.) Planned Maintenance**

**Approach:** all the operators, technicians and engineers of the work floor of the maintenance department are given training every month for preventive maintenance.

- All the engineers and operators of the maintenance department, must work together to do predictive maintenance.

- Training must be given to the operators that we shown them the area of the equipments and machines, that are liable to failure so that they can notified maintenance department about the failure in advance. So that maintenance department can take corrective measure or action before resulting to major breakdown of the machines or equipments (Ranteshwar et al, 2012).

**Outcomes:** by continuously programming maintenance activities, the amount of breakdowns step by step decreases and this then will increase the capability for productive activities.

- Maintenance is made on Saturdays or Sundays or once the assembly floor is free or not full of activity .

Production functions will continue with their activities with none interruption due to the facts that they know when maintenance activities will commence or will be done.

- Capital investments in machinery are reduced because the machines are maintained frequently and may be utilized to its fullest potential.

- Expensive machine components don't have to be place available in stock as there's full control and management of different classes of components (David Gitachu, 2017).

## **4.) Quality Maintenance**

**Approach:** the condition is examine and measured thoroughly in a lot of time to confirm that measured values are within standard values measure to avoid defects. The transition of measured values is watched through charts to predict probability of defects occurring and to check counter measure earlier.

- Preparation of quality assurance matrix and usage (David Gitachu, 2017).

**Outcomes:** it will cut back the cost of quality, as quality losses waste, rework, client complaints and also the time of checking up the quality will be minimized.

- it'll cut back cost by catching defects at the initial stage because it is costly and unreliable to discover defects through review later. This happens as a result of the errors are caught

before they move down the number of work that needs to be done to correct them(David Gitachu, 2017).

### **5.) Education and Training**

**Approach:** continuous improvement is feasible solely through improving constantly the knowledge and skills of the individuals at different levels. To maximize the plant potency and to minimize the defects training must be given to the workers involved.

Training to Supervisor: there should be monthly training for the quality department regarding quality check of tools. Tools should be calibrated periodically so that the tools give the correct result.

- Educating them how to use measuring instruments, equipment and soon. Training to Operators: 100 percent visual inspection training must be given to the operators, to check all the necessary gadgets.

- Operators must be educated on how to use measuring instruments and equipments.

- The supervisor should teach operators regarding problem that can occur during production.

Training to Managers: at the managerial levels, managers also learn the TPM skills so as to become competent mentors to their juniors as well as be involved in coaching programs.

**Outcomes:** by training and educating the employees it will increase their skills and performance all through the organization, and it's important for the success of TPM implementation. The effect of other pillars will not be sustainable and known without training and education.

### **6.) Office TPM (Administrative and Support Department)**

**Approach:** rejected quantities must be written by operators on daily basis in their daily production report, in order that time needed for obtaining information for daily rejection from quality department is reduced/minimized.

- Maintenance department need to follow the maintenance rules and regulation and carry out the maintenance activity of the machine as per the dates and time mention within the company's computer software for maintenance.

**Outcomes:** in as much as the administrative department are able to improve their processing procedures of ordering, then the material will get to the work-floor in a perfect way which will have a positive effect on the workflow.

- If they paid the suppliers on time, they will have the capability to provide the services in a very nice way.

### **7.) Safety, Health and Environment**

**Approach:** there should be a sufficient number of fire extinguishers all over the work floor.

- Training should be given to every employee how to use the fire extinguisher in case of emergency.

- They should remove rings, chain or any loose clothes which might have chances to stick on the machine while working.

- Training for fire prevention and fire -fighting, personal surviving techniques, personal safety and social responsibilities, and elementary first aid should be given to every employee.

- Management is also given suggestion to conduct test for the workers twice in a year.

- Workers are advised to maintain cleanliness of toilets, regular cleaning is also done.

- The employees should know what to do in case of emergency? What should be the exit plan?

## 5.3 Implementation of TPM Methods at XYZ Plastics Industry

### 5.3.1 5S

**Description:** creating a work environment that is clean and well organized.

**How Does It Help:** eliminate anything that is not needed at work-place

- Organize the remaining items
- Clean and organized work place
- Create standards for above three activities
- Ensure they are regularly applied

### 5.3.2 8Pillars

#### Autonomous Maintenance

**Description:** Places responsibility to operator for carrying out basic maintenance of machine such as cleaning, lubricating, and inspection.

**How Does It Help:** gives operators the ownership of their equipment.

- Operator becomes more skilled by knowing more about its equipment.
- Identifies rising issues before they become failures
- A machine becomes more reliable as it is well-cleaned and lubricated

#### Focused Improvement

**Description:** use of small group of cross-functional teams work together for improvement activities

**How Does It Help:** combines the collective talents of a factory for continuous improvement

- Repeating problems are identified and resolved.
- It improves problem solving capabilities of the employees.

#### Planned Maintenance

**Description:** schedules maintenance task based on the historic failure rate of equipment or machines.

**How Does It Help:** maintenance can be scheduled when there is no or less production.

- By controlling wear-prone and failure – prone parts, it reduces inventory
- It reduces instances of unplanned stop time.

#### Quality Maintenance

**Description:** design error detection and prevention into production processes so as to reduce defects.

**How Does It Help:** it targets quality issues with improvement projects mainly focused on removing root cause of defects.

- Reduces number of defective parts.
- Reduces inspection cost by finding defects early.

#### Education and Training

**Description:** fill in knowledge gaps and skills through training and educating workers.

**How Does It Help:** operators gain the skills to maintain equipment and identify problems.

- Maintenance people learn techniques for proactive and preventative maintenance.

#### Office TPM

**Description:** apply TPM principles to administrative functions within an organization.

**How Does It Help:** support functions understand the benefits of TPM and extend it beyond the plant floor by finding waste in administrative functions.

- Helps in production through improved administrative operations such as Order processing, procurement and scheduling.

## **Health, Safety, and Environment**

**Description:** providing safe and healthy working environment without any accidents and injuries.

**How Does It Help:** elimination of harmful conditions, safety risks, resulting in a safer workplace.

- Gives accident-free workplace

## **6 Discussion**

All the location within the industry was reorganized and the cleaning standards were established. The initial cleaning brought up issues which needed to be replaced and fixed. The new layout ensured that the truck drivers were not disturbing the workers anymore and a lot of space was cleared for the incoming pallets. Altogether, the new blueprint was able to utilize the previously non-occupied corners more effectively and the industry could have a larger potential for growth.

The implementation of the new cleaning standards did encounter some resistance. The job description of operators, storage and production workers did not contain any regular cleaning before. Due to this, a couple of workers were worried if they would have enough time to follow the new plans. Some of the workers have had their own desk for a long time and they have been performing cleaning within their own space. Earlier some workers felt that they were doing most of the cleaning, so after implementing the standards the workload was been divided more evenly and no one had the feeling that they are the only one responsible.

When thinking about the main focus of the TPM in the production units, it is mostly focused on the machines, the level of maintenance that the workers would perform would be only to keep the machines clean, so therefore intensive training was given to the workers both from the theoretical and practical side on how to keep the machine clean and soon but our purpose was not to train the workers to become fully qualified engineers.

Historical data required for calculating MTTR and MTBF does not exist before and I introduced it to them which they found useful. The OEE calculations would have been possible but doing this would not bring the needed information. The forklifts run a couple of meters and are stopped when picking up the goods. They are not even wanted to run all the time. When calculating OEE for machines like this, the rate would not tell the real situation of the machine availability.

The list of faults was examined and all the issues that were worth repairing were fixed and new investments were made. A few of the points, like the brand new working desks and the repairing the uneven floors would become too expensive to fix at the time and they were left out.

In total, the project was a success. The work processes were optimized and the new layout along with the cleaning working environment was a positive change. The total capacity for the received goods was increased and the machines were working well and there was more space to fit in the incoming goods and pallets. New tapings on the back room shelves were easier to read for the workers. New signs and markings structured the storage room, production room and less time was spent on searching the wanted items.

## 7 Conclusion

Base on the purpose of this thesis: Implementation of Total Productive Maintenance (TPM) in Nigeria Plastics Manufacturing Company and the research question of this thesis: How can Total Productive Maintenance (TPM) be implemented in a plastic manufacturing company. The following conclusion were drawn:

To implement TPM in a company or an organization the whole facility not a production line workers alone however conjointly with all the department within the organization need to put their effort to implement TPM. If anyone of the department won't follow TPM the whole organization will utterly lost on what they're looking for development. The success of TPM altogether depends on the company nature, particularly the processes that an organization closely-held and desires to implement TPM on them.

These are the some of the conclusion derived from implementation of TPM in XYZ Plastics Industry:

- The TPM success is determined by pillars like 5S, Autonomous Maintenance, Focused Improvement, Planned maintenance, Quality maintenance, Education and Training, Office TPM, and Safety, Health, & Environment.
- The implementation of TPM in a proper way can minimize rework and minimize losses to or below suitable levels. It will facilitate the increment in efficiency and profitability, which will help the organization to be able to compete in the business world.
- TPM can be used as a tool to enhance OEE.
- Approaches and outcomes for each pillar is discussed and proposed. Some of the examples are made to show how it makes work easier and faster. The success of these approaches is totally depends on the nature of the employees of the organization.
- To improve the productivity of the plant a proposed work floor layout and proposed workplace area is suggested which can increase the plant efficiency.
- The main factors for TPM implementation are employees involvement and top management support. The company can achieve its goal through the proper implementation of operator initiated daily maintenance consisting of cleaning, adjustment, and regular inspections along with the improvement activities and minor overhaul and repair of the equipment's.

The financial benefits achieved with this project are hard to measure. We could try to calculate the lead time. Or we could measure the times spend on each working process now and earlier. What is more difficult is to put a price tag on safety. The new chairs will add cost but it will pay back its price when the worker has less sick days. Clean and tidy working place is much pleasant to work in. But it will also be better for the workers health, especially in the working place where we got people who suffer from allergies and illnesses, such as asthma. TPM has been used in manufacturing and production units already for a long time but most of the Nigeria manufacturing industries do not know about TPM. This meant that the implementation of TPM in most of the manufacturing environment Nigeria was going to be a challenge, if not impossible. Due to the lack of knowledge of how to repair and maintain the machines, cleaning, safety and efficiency issues.

The TPM implementation brought positive changes to the entire XYZ plastics manufacturing industry and it can be concluded that a world class TPM implementation is possible with continual support at all the levels along with necessary resources.

## **7.1 Recommendation**

I recommend that the management of XYZ Plastics Manufacturing Industry should increase or raise the level of education on the job advert of their floor staff e.g. operators, cleaners and soon, at least to secondary level when they are posting the job for recruiting purpose, so that they can be able to read and write English to basic level.

Because during my interview period with majority of the floor staff, I found out that they lack basic educational level which make writing and communicating in English difficult for them, and also difficult for them to read the machine and equipment manual to be able to follow the instruction on how to clean, repair and maintain the machine and equipment.

## **7.2 Theory Conclusion**

Due to the facts that implementation of TPM (Total Productive Maintenance) was a success in XYZ Plastics Manufacturing Industry, I will employ all the staff to continually support the implementation of TPM at all levels during their day to day activities at work, because TPM implementation is a continuous process and they need to work on it together as a team.

## 8. References

- Alan, J. (2014), *Rigour in Research: Theory in The Research Approach*, YSJ Business School, York St John University, York, UK, Vol. 26 No.3.
- Ademir, S., Piechnicki A., Vanderley H. and Sola, F.T. (2015), "Decisionmaking towards achieving world-class total productive maintenance", *International Journal of Operations & Production Management*, Vol. 35 Iss 12 pp. 1594 - 1621.
- Ahuja, I.P.S. and Khamba, J.S. (2008), "Strategies and success factors for overcoming challenges in TPM implementation in Indian manufacturing industry", *Journal of Quality in Maintenance Engineering*, Vol. 14 No. 2, pp. 123-147.
- Alsyouf, I. (2009), "Maintenance practices in Swedish industries: survey results", *Int. J. Production Economics*, Vol. 121 No. 1, pp. 212-223.
- Aspinwall, E. and Elgharib, M. (2013), "TPM implementation in large and medium size organisations", *Journal of Manufacturing Technology Management*, Vol. 24 No. 5, pp. 688-710.
- Arca, J.G. and Prado, J.C. (2008), "Personnel participation as a key factor for success in maintenance program implementation: a case study", *International Journal of Productivity and Performance Management*, Vol. 57 No. 3, pp. 247-258.
- Alan, H. and Remko, H. (2008). *Logistics Management and Strategy (Competing through the supply chain)* 3rd edition. Prentice Hall, Financial Times.
- Bryman, A. and Bell, E. (2011), *Business Research Methods*, 3rd ed., Oxford University Press, Oxford.
- Bryman, A. and Bell, E. (2007), *Business Research Methods*, 2nd edition Oxford University Press.
- Blanchard, B. S. (2004), *Logistics Engineering and Management Sixth Edition*. United States of America: Pearson Education Inc.
- Baird, K., Hu, K.J. and Reeve, R. (2011), "The relationships between organizational culture, total quality management practices and operational performance", *International Journal of Operations & Production Management*, Vol. 31 No. 7, pp. 789-814.
- Bamber, C.J., Sharp, J.M. and Hides, M.T. (1999), "Factors affecting successful implementation of total productive maintenance: a UK manufacturing case study perspective", *Journal of Quality in Maintenance Engineering*, Vol. 5 No. 3, pp. 162-181.
- Ben, D. M. and Duffuaa, S.O. (1995), "Maintenance and quality", *The missing link. Journal of Quality in Maintenance Engineering*, Vol. 1 No.1, pp. 20–26.
- Bupe, G., Mwanza and Charles, M.(2015), "Design of a total productive maintenance model for effective implementation: Case study of a chemical manufacturing company," *Faculty of Engineering and the Built Environment, University of Johannesburg, Johannesburg, South Africa*.
- Creswell, J. W. (2003), *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Thousand Oaks, CA: Sage.
- Crotty, M. (1998), *The foundations of social research: Meaning and perspective in the research process*. London, England: Sage.
- Carr, L.T. (1994), "The strengths and weaknesses of quantitative and qualitative research: what method for nursing" *Journal of advanced nursing*.
- Chan, F. T. S., H. C. W. Lau, R. W. L. Ip, H. K. Chan, and S. Kong (2005), "Implementation of Total Productive Maintenance: A Case Study." *International Journal of Production Economics*, Vol. 95 No.1, pp. 71–94.

Co, H.C., Patuwo, B.E. and Hu, M.Y. (1998), "The human factor in advanced manufacturing technology adoption, an empirical analysis." *International Journal of Operations and Production Management*, Vol.18 No.1, pp. 87–106.

Davies, M. B. (2007), *Doing a Successful Research Project; Using Qualitative or Quantitative Methods*, (1st ed.). Houndmills: Palgrave MacMillan.

De Laine (1997), *Ethnography: Theory and Applications in Health Research*, Sydney.

Dick (1990), *Convergent Interviewing (Version 3)*. Interchange, Brisbane.

David, G. (2017), "TPM pillars- Eight pillars of Total Productive Maintenance"

Edwards and James, S. (2009), *Research ethics for sport management*. Pages 77-98.

Emory and Cooper, D. (1991), *Business Research Methods*. Irwin, Homewood, IL.

Eti, M.C., Ogaji, S.O.T. and Probert, S.D. (2004), "Implementing total productive maintenance in Nigerian manufacturing industries", *Applied Energy*, Vol. 79 No. 4, pp. 385-401.

Fu, H.-P., Ho, Y.-C., Chen, R.C.Y., Chang, T.-H. and Chien, P.H. (2006), "Factors affecting the adoption of electronic marketplaces", *International Journal of Operations & Production Management*, Vol. 26 No. 12, pp. 1301-1324.

Gill, J. and Johnson, P. (2010), *Research Methods for Managers*, 4th ed., Sage, London.

Ghuri, P. and Gronhaug, K. (2010), *Research Methods in Business Studies*, 4th ed., PrenticeHall, Harlow.

Guba, G. and Lincoln, Y.S. (1994), *Competing paradigms in qualitative research*.

Denzin, N.K. and Lincoln, Y.S. (1994), *Handbook of qualitative research*, Sage, Thousand Oaks.

Gerring, J. (2007), *Case Study Research: Principles and Practices*. New York: Cambridge University Press.

Given, L.M. (2008), *The SAGE Encyclopedia of Qualitative Research Methods*. SAGE Publications, Inc.

Hansson, J., Backlund, F. and Lycke, L. (2003), "Managing commitment: increasing the odds for successful implementation of TQM, TPM or RCM", *International Journal of Quality & Reliability Management*, Vol. 20 No. 9, pp. 993-1008.

Jack, R. (1997), "Total Productive Maintenance (TPM)".

Jankowicz, A.D. (2005), *Business Research Projects*, 4th ed., Cengage Learning, Stamford, CT.

Jupp, V. (2006), *The SAGE Dictionary of Social Research*.

Jostes, R.S. and Helms, M.M. (1994), "Total productive maintenance and its link to total quality management". *Work Study*, Vol. 43 No.7, pp 18–20.

Knight, D. and McCabe, D. (1997), "How would you measure something like that?" *Quality in Retail Bank*, *Journal of Management Studies*, 34 (3).

Kuula, M., Putkiranta, A. and Toivanen, J. (2012), "Coping with the change: a longitudinal study into the changing manufacturing practices", *International Journal of Operations & Production Management*, Vol. 32 No. 2, pp. 106-120.

Laws, Harper and Marcus (2003), *Research Development: A Practical Guide*, Sage.

Levy, S. (1988), *Information technologies in universities: An institutional case study*. Unpublished doctoral dissertation, Northern Arizona University, Flagstaff.

Lee, N. and Lings, I. (2008), *Doing Business Research: A Guide to Theory and Practice*, Sage, London.

Lazim, H.M. and Ramayah, T. (2010), "Maintenance strategy in Malaysian manufacturing companies: a total productive maintenance (TPM) approach", *Business Strategy Series*, Vol. 11 No. 6, pp. 387-396.

Lawrence, J.J. (1999), "Use mathematical modeling to give your TPM implementation effort an extra boost". *Journal of Quality in Maintenance Engineering*, Vol. 5 No.1, pp 62–69.

Mora, E. (2002), "The Right Ingredients for a Successful TPM or Lean Implementation".

Matthews, B. and Ross, L. (2010), *Research Methods: A Practical Guide for the Social Sciences*, Longman, Harlow.

Merriam, S. B. (1998), *Qualitative research and case studies applications in education*. San Francisco, CA: Jossey-Bass.

Minichiello, Aroni, R., Timewell, E. and Alexander, L. (1995), *In-Depth Interviewing: Principles, Techniques, Analysis*, (2nd ed.) Longman, Melbourne.

Naranjo-Valencia, J.C., Jiménez-Jiménez, D. and Sanz-Valle, R. (2011), "Innovation or imitation? The role of organizational culture", *Management Decision*, Vol. 49 No. 1, pp. 55-72.

Nicholas, J. (1998), *Competitive Manufacturing Management*. United States of America: McGraw-Hill.

Poduval, P.S., Pramod, V.R. and Raj, J.V.P. (2013), "Barriers in TPM implementation in industries", *International Journal of Scientific & Technology Research*, Vol. 2 No. 5, pp. 28-33.

Prajogo, D.I. and McDermott, C.M. (2011), "The relationship between multidimensional organizational culture and performance", *International Journal of Operations & Production Management*, Vol. 31 No. 7, pp. 712-735.

Park, K.S. and Han, S.W. (2001), "TPM – total productive maintenance: impact on competitiveness and a framework for successful implementation", *Human Factors and Ergonomics in Manufacturing*, Vol. 11 No. 4, pp. 321-338.

Panneerselvam, M.K. (2012), "TPM implementation to invigorate manufacturing performance: an Indian industrial rubric", *International Journal of Scientific & Engineering Research*, Vol. 3 No. 6, pp. 1-10.

Pius, C. A. (2007), "Development of an Impact Assessment Framework for Lean Manufacturing within SMEs," *School of Applied Sciences, Department of Manufacturing, Cranfield University, United Kingdom*.

Quinlan, C. (2011), *Business Research Methods*, Cengage Learning, Stamford, CT.

Rajesh, A., Sandeep G. and Nikhil (2013), "A graph theoretic approach to evaluate the intensity of barriers in the implementation of total productive maintenance (TPM)." *International Journal of Production Research*.

Ronnenberg, S.K., Graham, M.E. and Mahmoodi, F. (2011), "The important role of change management in environmental management system implementation", *International Journal of Operations & Production Management*, Vol. 31 No. 6, pp. 631-647.

Ranteshwar, S., Ashish, M. G., Dhaval, B. S. and Sanjay, D. (2012), "Total Productive Maintenance (TPM)," *Institute of Technology, Nirma University, Ahmedabad, India*.

Saunders, M. and Lewis, P. (2011), *Doing Research in Business and Management: An Essential Guide to Planning Your Project*, Prentice-Hall, Harlow.

Stake and Richard, E. (1995), *The art of Case Study Research*, Thousand Oaks, Calif; London: Sage.

Svenning and Conny (2003), *Metodboken*, 5th edition. Lorentz fölag. Eslöv.

Saunders, Lewis and Thornhill (2012), *Research Methods for Business Students*. Pearson.

Saunders, Philip, L. and Adrian, T. (2009), *Research Methods for Business Students*. Pearson.

Steward, Shamdasani and Rock (2007), *Studying Intimate Matters: Engaging Methodological Challenges in Studies on...*

Smith, A.M. and Hinchcliffe G. R. (2004), *RCM: Gateway to World Class Maintenance*. United States of America: Elsevier Inc.

Suzuki, T. (1992), *TPM in process industries*. New York, NY: Productivity Press.

Sola, A.V.H. and Xavier, A.A.P. (2007), "Organizational human factors as barriers to energy efficiency in electrical motors systems in industry", *Energy Policy*, Vol. 35 No. 11, pp. 5784-5794.

Sun, H., Yam, R. and Wai-Keung, N. (2003), "The implementation and evaluation of total productive maintenance (TPM) – an action case study in a Hong Kong manufacturing company", *Int. J. Adv. Manuf. Technol.*, Vol. 22 Nos 3-4, pp. 224-228.

Santandreu-Mascarell, C., Garzon, D. and Knorr, H. (2013), "Entrepreneurial and innovative competences, are they the same?", *Management Decision*, Vol. 51 No. 5, pp. 1084-1095.

Sharma, R.K., Kumar, D. and Kumar, P. (2006), "Manufacturing excellence through TPM implementation: a practical analysis", *Industrial Management & Data Systems*, Vol. 106 No. 2, pp. 256-280.

Shavarini, S.K., Salimian, H., Nazemi, J. and Alborzi, M. (2013), "Operations strategy and business strategy alignment model (case of Iranian industries)", *International Journal of Operations & Production Management*, Vol. 33 No. 9, pp. 1108-1130.

Taylor and Bodgan (1984), *Introduction to qualitative research methods*, Wiley.

Tung, A., Baird, K. and Schoch, H.P. (2011), "Factors influencing the effectiveness of performance measurement systems", *International Journal of Operations & Production Management*, Vol. 31 No. 12, pp. 1287-1310.

Tsang, Albert, H.C. and Chan, P.K. (2000), "TPM implementation in China: a case study", *International Journal of Quality & Reliability Management*, Vol. 17 No. 2, pp. 144-157.

Venkatesh, J. (2015), "An Introduction to Total Productive Maintenance (TPM)".

Walshaw, M. (2012), *Getting to Grips with Doctoral Research*, Palgrave Macmillan, London.

Ward, P.T., McCreery, J.K. and Anand, G. (2007), "Business strategies and manufacturing decisions – an empirical examination of linkages", *International Journal of Operations & Production Management*, Vol. 27 No. 9, pp. 951-973.

Waeyenbergh, G. and Pintelon, L. (2002), A framework for maintenance concept development. *International Journal of Production Economics*, Vol. 77 No.3, pp 299–313.

Yin, R. (2003), *Case study research: Design and methods (3rd Ed.)*. Thousand Oaks, CA: Sage Publishing.

Yin, R. (1994), *Case study research: Design and methods (2nd Ed.)*. Thousand Oaks, CA: Sage Publishing.

Yin, R. (1984), *Case study research: Design and methods (1st Ed.)*. Beverly Hills, CA: Sage Publishing.

Yamashina, H. (1995), Japanese manufacturing strategy and the role of total productive maintenance. *Journal of Quality in Maintenance Engineering*, Vol. 1 No.1, pp 27–38.

## 9. Appendix

### A

#### **Total Productive Maintenance (TPM) Methodology Questionnaires**

The main purpose of this questionnaire is to gather information for the purpose of understanding how XYZ Plastics Industry apply TPM approach within their organization. The interview exercise is intended for all employees within the company and the main objective of the interview is to obtain information that assist in assessing the operation and production-benefit analysis that is involved in TPM implementation in XYZ Plastics Industry.

#### TPM Questionnaires

- 1.) What is company's culture?
- 2.) What is your job description?
- 3.) How do you measure production efficiency?
- 4.) What is the volume level of the products of the company?
- 5.) What is your current Lead-time?
- 6.) What are the major drivers of your business?
- 7.) What is TPM?
- 8.) What has motivated the company to implement TPM?
- 9.) Presently how you are implementing TPM?
- 10.) What are the outcomes?
- 11.) Where is TPM implemented in your Organization?
- 12.) What are the criteria for choosing that area?
- 13.) Explain how TPM is practicing in the company?
- 14.) How long it will take to implement TPM in the factory?
- 15.) What were the direct and indirect costs involved in the implementation of TPM?
- 16.) How much company spends on TPM?
- 17.) What tangible and intangible benefits has TPM brought to the company?
- 18.) Any Other comments on implementation of TPM?
- 19.) Was the implementation process of TPM should be continuous?(Bupe et al, 2015).







