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Application Total Productive Maintenance (TPM) To Increase the Effectiveness of Engines with OEE as A Tool to Measure in the Industrial Packaging Cans

Mohamad Nasir, Haryo Tuwanggono Morrow, Erry Rimawan
Master Program in Industrial Engineering, Univeristy Mercubuana

Abstract:- Competition in the tin packaging industry is very tight so that every industry must improve the effectiveness of the machine in order to survive, compete and dominate the market. The purpose of this study is to calculate the level of effectiveness of the engine, the factors causing low effectiveness, the root of the problems encountered and the settlement related to the treatment machine in the packaging industry cans. The approach used to solve the problems is Total Productive Maintenance. Total Productive Maintenance is one of the elements of manufacturing aimed at improving the effectiveness of the machine. The main indicator is the Overall Equipment Effectiveness TPM. OEE calculation results in this study was 65.43%. Six Analysis of the dominant big losses by using Pareto diagram is setup and adjustment losses amounted to 62, 84% and reduced speed losses amounted to 29.18%. To find the root problems using techniques 5 way and further illustrated by the cause and effect diagram. The problem faced by the industry is a factor kemasankaleng machine maintenance. Implementation of Focused Improvement and Autonomous Maintenance is expected to resolve the problem and improve efektivitasmesin.

***Keywords**:- Total Productive Maintenance, Overall Equipment Effectiveness, Six Big Losses, Cause and Effect Diagram, Autonomous Maintenance, Focused Improvement.*

I. INTRODUCTION

Tin packaging company is a company that makes cans from tinplate raw material to be canned. Tin packaging business is the type of business to business, in which the product will be used by other industries. Tin packaging company in Indonesia, almost all of the Domestic Capital Company (DCI). With many industry players cans provide competition in this business is getting tougher. It can be seen from the competition in quality products, competitive prices among so many tin packaging company in Indonesia.

In the increasingly fierce competition, the main thing that should be prioritized by the tin packaging industry in order to survive, compete and market share is to improve performance in the production line. Therefore, the management of the tin packaging industry in this company leaders must know what things are able to support performance improvement in the production line. The smoothness of the company's production lines can not be separated from the company management's ability to manage resources dayaperusahaan.

Hardware is the main resource that can not be separated from the overall system resources of the company. The ability of the company in the application of a technology must be supported by the ability to maintain the equipment associated with this technology. Equipment is also related to the effectiveness of the machine so that in the long term will relate to the achievement of corporate goals.

Another factor underlying the increase in engine maintenance and quality control is a very fast changing market and the many variations of the products offered. This will automatically increase the role of maintenance / care machines and required complex equipment and adaptation technologies as well as resulting in lower production cost, and who can win the competition in quality will ensure success in the implementation of new management systems.

In order to reduce production costs, the company must operate more effectively and efficiently. Companies are required to devise strategies in various aspects of its operations in an effort to improve the efficiency and effectiveness of operations. In connection with these efforts, the company must keep a close watch their waste-waste that arises as the product defect, a large maintenance costs and so on. In this regard, a company must prioritize activities that seek quality products to be compliant with evaluate the actual performance, comparing the performance targets and handle the differences yangterjadi.

Costs arising from the quality control / quality will be enhanced to maintain a minimum so that the total costs incurred for the production of balanced outcome. Things can be done by the company is the implementation of maintenance of the machine that allowed the company reduces waste pemborosan- for their defective products, delays and congestion of machinery and production equipment interference. And this means lower costs of production processes in line with the maintenance of the quality, the establishment of a conducive teamwork and education and training for employees.

Along with changes in the environment makes maintenance and quality control require a good handling. In

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this condition needs an effective policy in production strategy, especially concerning the maintenance or quality control. Turnover condition requires equipment capacity more intensive supervision, quality control and cost control.

Total production, quality of production and maintenance of machinery in a production process is inter-related problems, as a real traditional three issues separately. Each has their own needs to grow and develop even factually there is dependence on each other. It is in the process of modern production prefers to merge so that it will obtain optimal results.

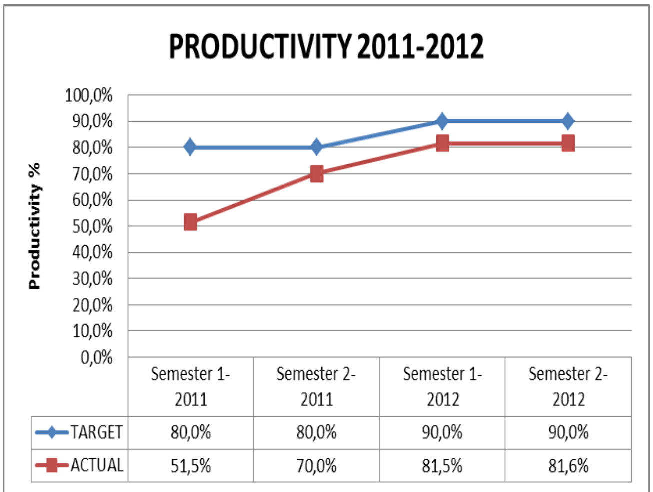

Fig 1:- Current Achievement 2011sampai productivity in 2012 as well as the target KPI Productions same period. (Source: Report of the tin packaging industry production in 2011 to 2012)

The percentage of defective products machinery General Line since 2011 to 2012 has decreased but still outside the target set. The gap between actual and target in the second half of 2012 was 0.95%

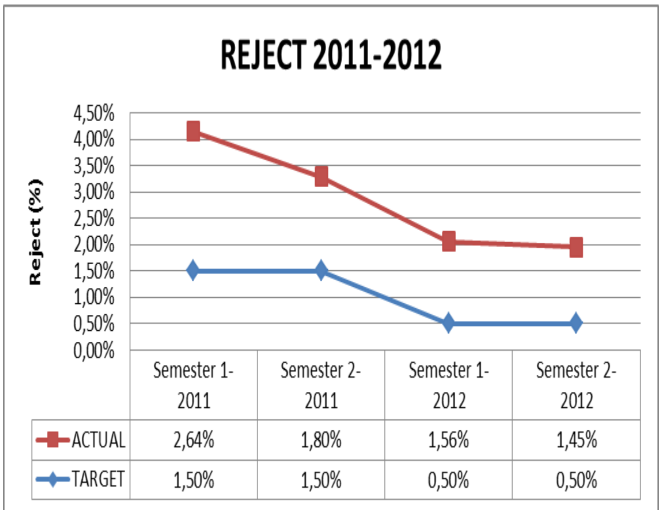

Fig 2:- Actual reject 2011sampai Achievement 2012 and targets KPI Productions same period. (Source: Industrial Production Report canned Period 2011 to 2012)

Therefore, the level of productivity and product quality based not only on the production process again, but on the performance of a production machine. For the performance of a production machine remains in good condition, there should be an optimal maintenance, such as preventive and corrective maintenance of a controlled, combining engine maintenance with the relevant sections in the production line.

Problems encountered engine parts General Line cans packaging industry is the high percentage of downtime on the machine GL1, GL2 and GL3 unplanned caused by damage to the engine suddenly, set up, change over, preparation and quality checked. During 2011 to 2012 the downtime caused by nothing material was 0.35%. And downtime caused no adalahtidak operator recorded in the report. The following table is a machine down time is the period 2011 to 2012. The gap between the target and actual downtime in the second half of 2012 was 13.51%.

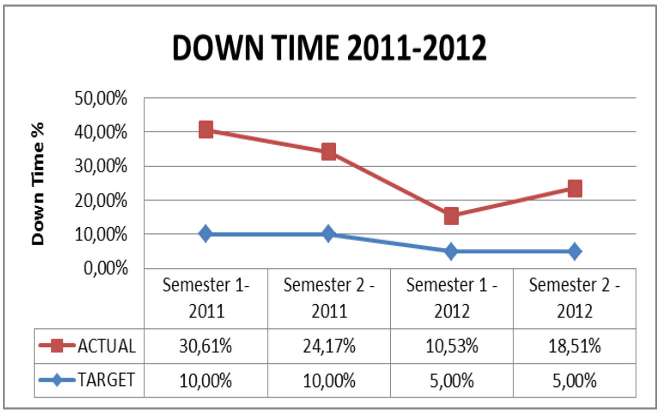

Fig 3:- charts the actual down time 2011sampai Achievement 2012 and targets KPI Engineering same period.
(Source: Production Report Period 2011 to 2012)

This resulted in the number of products produced output is less than the target set in the material that eventually shortage of customers. Another result is a quality product that is not in accordance with customer expectations will cause problems for the customer.

The cause of the problems above, among others, lack of focus and attention on the company's overall engine maintenance system. Tin packaging industry is trying to focus on improving service to customers with a focus on product delivery on time, high quality and providing services / service according to customer wishes.

To overcome the problems of the machine necessary measures to support improve engine performance by the application of Total Productive Maintenance (TPM). This is in line with several previous studies that states that the TPM method to increase Overall Equipment Effectiveness (OEE). Several previous studies TPM (Almenazel, 2010, p. 522; Ottosson, 2009, p. 48; Hegde et al, 2009, p. 32; Imani et al, 2011, p.5) states that the TPM will increase the effectiveness of the machine, improve communication, and teamwork.

II. LITERATURE REVIEW

A. *system PemeliharaanMesin*

➢ *Management and Maintenance*

According Wiremen (2003, p.60) states that twenty years ago, executive management focused on increasing profits in a short period of time, at the expense of physical assets. Companies that best practice to develop planning strategies, build strength, and completeness of the organization. One area of concern of the company is a function of maintenance / asset management. Treatment is very important that the company be konpetitif in pasardunia.

If the maintenance function be a contributing factor in increasing konpetitif companies in order to survive, management must change the way towards maintenance. If this malakukan management, the company has a strong maintenance team, it contributes to the profits. So the management will focus on maintenance organizations.

➢ *Equipment service level*

Equipment service level is an indicator of the amount of time in which the equipment available to the service of production and operation. Total equipment service level is closely linked to the cost of care, and determine the type of maintenance that followed. Based Wireman (2003, p. 14), there are five maintenance philosophy is:

1. ReactiveMaintenance.
2. *CorrectiveMaintenance,*
3. PreventiveMaintenance.
4. PredictiveMaintenance.
5. MaintenancePrevention.

B. *Total Productive Maintenance (TPM)*

➢ *DefinisiTPM*

According to the Japanese Institute of Plant Engineers (jipe) in Sharma et al. (2006, hal.262) TPM is defined a team-based maintenance strategies to maximize the effectiveness of the equipment by setting the overall productive maintenance system includes all equipment into use, extend the life of equipment associated with the planning, use and maintenance as well as the involvement of everyone, starting from the top executive management to the production operator. This explains a relationship of synergy of all functions of the organization and make productive maintenance TPM through motivational management and small group activities are voluntary. TPM requires organiasasi horizontal type structure with minimal levels of authority instead of the vertical type with many tahapanotorisasi.

Opinion Nakajima (1988) in Sharma et al. (2006, p 262) states that there are five elements of the TPM concept is;

1. TPM aims to maximize the effectiveness of the equipment
2. TPM establishes a system of maintenance equipment sunguh- really selamadipakai
3. TPM implemented by many departments in sebuahperusahaan
4. TPM involves every employee, from top management to employees at shoopfloor
5. TPM is an aggressive strategy focused on significant improvement in function and design of production equipment.

Citing Nakajima (1998) in Sharma et al. (2006, p 262) the word "total" in the TPM have the following meanings:

1. *TotalEffectiveness.*
2. *TotalMaintenance,*
3. *TotalParticipation.*

According to Wireman (2005, p. 179) states that the definition of the TPM is not only the activities of maintenance or improvement program but is an operational philosophy where everyone in the company understands that the individual performance impact on the capacity of the equipment.

Opinion Borris (2006, p. 4) the definition of the practice of engineering TPM is a good and simple. TPM requires root-cause analysis solution. Good at hospital environment and environmental equipment service, both require that ensures failure does not happen again. And the expected result is the impact to customers and profits. TPM version explains that fits on the development of modern industry and can adapt to several types of equipment not only in industrial alatberat.

➢ *TujuanTPM*

MDG Goal to eliminate all equipment losses of pengoperation this case to ensure that the overall equipment efficiency (OEE) maximum. Eliminating these losses is the responsibility of each department. Therefore, the TPM is an operational philosophy. All departments have an impact on utilization in the handling of equipment, all parts of the TPM program.

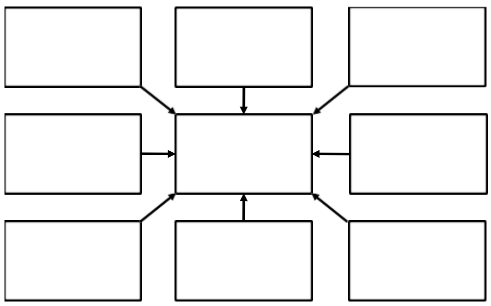

Fig 4:- Illustration of the philosophy of TPM (Source: Wireman (2005, p. 180))

Shown in Figure 4 all departments should focus on how the impact on the equipment. This image as illustrated process of Total Quality Management (TQM), TQM focus on the product, but TPM focus on equipment. If a company's success with TQM methods, it is usually successful with TPM process.

If TPM is operational philosophy, have specific goals and objectives. Interest TPM (also called pillars of TPM) and four supporting initiatives. That goal is the continuous improvement of the effectiveness of the equipment. An enterprise wants and make sure that companies in the world have the same equipment or process for poduk kind, which produces the maximum. In other words, a competitor that has a low cost producer, will win and leave the company's competitors yanglain.

Now Low cost producer in a competitive market is determined by how to organize work and focus on getting more output with the same assets with competitors. This is the focus of filosofiTPM.

TPM philosophy is supported by four activities *improvement*

1. Improvements effective treatment danefisiensi
2. Focus on the management of the equipment from the early design and maintenance prevention
3. Training to enhance the ability of personnel whichengages
4. Involving operators in daily equipment maintenance

➢ *eight PilarTPM*

Based Borris (2006, p. 7) states now TPM is a summary of eight different sections called eight pillars of TPM. Each pillar has a different area of responsibility but each area of overlap. Eighth pillars are:

1. *Initial PhaseMaintenance*
2. *Health danSafety*
3. *Education andTraining*
4. *AutonomousMaintenance*
5. *Planned Maintenance*
6. *QualityMaintenance*
7. *focused Improvement*
8. *Supportsystems*

Fig 5:- Eight pillars of TPM (Source: Borris (2006, p 8))

➢ *TimTPM*

Based on Wilson (2002, p. 266) The most fundamental concept of TPM is the TPM team. There are several teams that are in the plant consists of a production operator, maintenance and engineering. As operator who operates the machine, set up and maintenance of manufacturing assets in the department or area (Figure 5), everyone supported each other in suatuperusahaan.

The team focused on the conditions and performance of the plant, *tooling*, And the work environment.

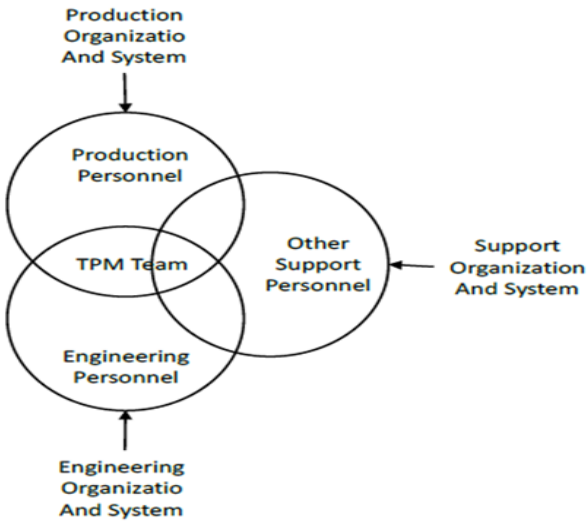

Fig 6:- Membership TPM Team
(Source: Wilson (2002, p. 266))

TPM is essential Tim involve the production and maintenance personnel. Failures and problems in plant and machinery will be identified and solved by looking in terms of production and engineering side, if approved laludilaksanakan practical solutions.

C. *Overall Equipment Effectiveness (OEE)*

Opinion Wireman (2005, p.182) is OEE is a benchmark for some of the TPM. If the real goal of TPM is the continuous improvement of OEE, it makes OEE as the main indicator in the implementation of TPM. OEE is the product of equipment availability, performanace efficiency, and quality rate.

OEE indicator-based flexible because it can be used daily, weekly, and even monthly. OEE is an indicator of the strength of this very necessary for a company that started the initiative TPM. The weakness of the OEE does not exist, except for one application. OEE is a measure of the effectiveness of the machine and not to the effectiveness of all the factories, department, or company. OEE calculation originally performed by operators and maintenance people to assess the development of engine repair. It is difficult at the factory level. To be effective, this indicator should focus on orientasimesin.

Opinion Borris (2006, p.28) TPM indicator is to measure overall equipment effectiveness (OEE). OEE is a breakdown of equipment which is not only derived from production losses, but also running below capacity, and produce the results that defects have a negative impact. To make sure a machine is ready to run and can manufacture products according to standards on maximum results and machinery used in good condition. This measure with OEE TPM.

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OEE is the result of the multiplication of availability, performance, and quality.

OEE = availability x performance x quality (2.1)

➢ *Equipmen tAvailability*

Based Borris (2006, p.29) states availabiliy is a comparison of the amount of time of the equipment can produce a good running of the total can be running. According to Nakajima (1988, p 22) availability is the ratio of operating time downtime shared outside loading time. In the mathematical formula as follows:

$$\text{Availability} = \frac{\text{Operating time}}{\text{Loading time}} = \frac{\text{Loading time} - \text{down time}}{\text{Loading time}}$$

Management and decide the definition of the term downtime and make procedures counting down time. It must match the industry standard. It would be very useful if it can be traced individually, it helps to look for the root cause breakdown. How much time it takes to test, check, setup, wait for results, waiting for engineers, operators wait, wait for the product, the production run, change over, and peralatandowntime.

Material troubleshooting where losses came from a group that will be addressed / resolved. Supposedly performance analysis is based on the availability for weekly or total availability issue. TPM interested in maximizing production and every person in the company responsible for this.

An argument explains that for routine quality test run is to show a lack of confidence about the performance of the engine. The machine is not reliable, do not trust the reliability of the engine, or other reasons. TPM purpose is to avoid unnecessary tests, all problems should be resolved.

TPM is taknik cross-function, not maintenance techniques. Is a good cooperation between maintenance and production operators closest to the product. The aim is to improve the total productivity of the equipment, not only care alone. Losses can occur due to bad schedule or losses due to set up and test.

losses others due to change over the product. Eg change over the product A to product B, it was confirmed that the product B can be run on this line. After stopping the product A, then the machine stops and cause downtime also change over from product A to product B. To reduce down time change over need for cooperation between maintenance and production operators to shorten changeover time.

➢ *Performance Equipment*

If road equipment with output lower than capacity, it means it has little equipment problem. Equipment road at half the speed that equates to 50% of downtime. According Nakjima (1988, p 23) Performance efficiency is the product of the net operation rate and operating speed rate. In the mathematical formula is as follows:

$$\text{Performance efficiency} = \frac{\text{processed amount x actual cycle time}}{\text{operating time}} \times \frac{\text{ideal cycle time}}{\text{actual cycle time}} = \frac{\text{processed amount x ideal cycle time}}{\text{operating time}}$$

➢ *Quality Product*

Opinion Borris (2006, p.31) states that if the quality of the product is less than 100%, there is a problem. If the low quality / product fails to get to the customer, this means not only the risk of production down but losing customers. If the engine fails to produce the goods according to the standard, it will often do tests to catch the earlier failure. Interest 100% always bisadicapai.

The definition of the product quality is the ratio between the number of products that can be received by the total number of products have been manufactured (including products that can not be accepted). According to Nakajima (1988, p 25) quality rate of product in the mathematical formula as follows:

$$\text{Rate of quality product} = \frac{\text{processed amount} - \text{defect amount}}{\text{processed amount}}$$

According to McKone et al. (1996) in Wakjina and Singh (2012, p.29) mentions the TPM standard is as follows:

availability > 90%
- *PerformanceEfficiency* > 95%
- *qualityproduct* > 99%

So the ideal OEE is> 85% as a world class performance.

D. Six BigLosses

TPM key objective is to eliminate or minimize all losses associated with manufacturing systems to improve OEE. In the early stages of TPM initiative focused on eliminating six big losses, which resulted in a low OEE this case according to Gupta et al., 2001 in Ahuja and Khamba (2008, p. 724). Six Big losses include:

1. *Equipmentfailure*
2. *Set up and adjustmentloss*
3. *Idling and minorstoppage*
4. *Reduced speed*
5. *Defect in process*
6. *Redued yield*

TPM aims to increase OEE by eliminating the root causes of losses. OEE calculation is affected by the six major losses (each with six big losses) as shown below:

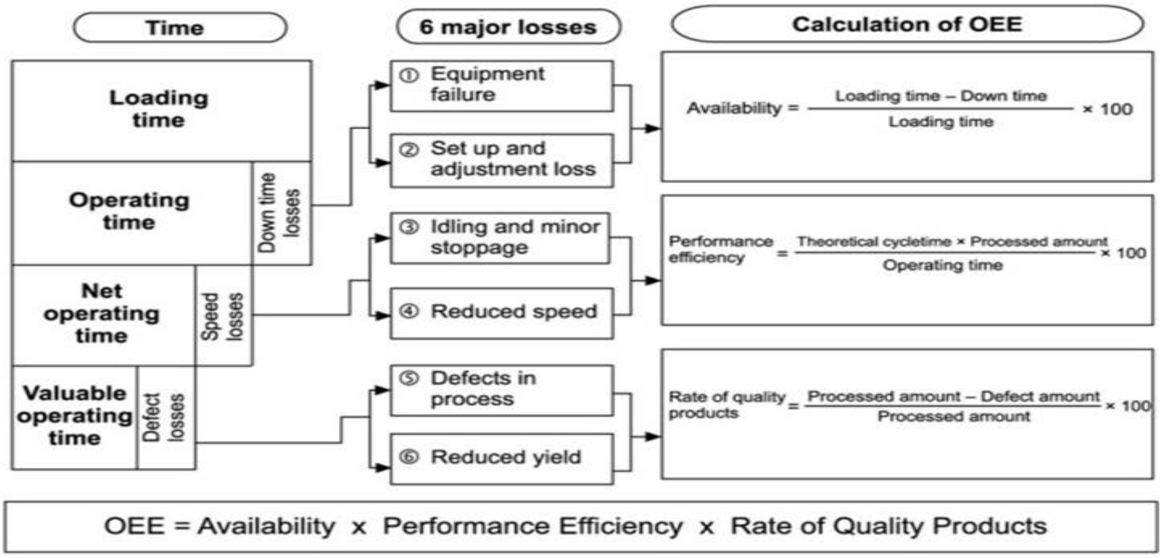

Fig 7:- Six big losses
(Source: Ahuja and Khamba (2008, p.17))

In Scdanibbio (2008, p. 6) by Nakajima has identified six types of losses related to equipment, commonly called the Six Big Losses. In detail will be described below.

➢ *EquipmentFailure / Breakdwon*

Damage to machinery / equipment is an improvement equipment that has not been previously scheduled waktuyangdiserapolehkerugianiniterlihatdariseberapa of the time is wasted due to damage to the equipment / machinery production. In the category of downtime losses which absorbs some time the production process (loading time). The disadvantage of this breakdown will result in time wasted resulting in losses for the company due to reduced volumeproduksi.

➢ *Set up and AdjustmentLoss*

Set up and adjustment losses an absorption time for installation, adjustment and parameter adjustment of the machine to obtain the desired specifications at the first began to produce certain components. Also the time required for the activities to replace a type of product to the next product type for the next production. In other words the total needed the non-producing machine in order to change their equipment (dies) for the following product types to be produced a product suitable for further processing.

➢ *Idling and Minor Stoppages (Losses Due to Operate Without Burden Nor Due to Stop a moment)*

idling is the equipment operates without producing a product or in other words the process air. Idling losses due to operating without a load and equipment / machinery to operate without generating products. Minor stoppages losses is equipment pausing appear if external factors resulting in equipment / machine stops repeatedly.

Idling and minor stoppages the losses due to the cessation of the equipment because of delays in the supply of materials or absence of carriers available although WIP. These problems are often overlooked as the elimination of unwanted products corresponding problems encountered, so that zero idling and minor stoppages being a primary goal. Both of these losses are part contributing to the speed looses.

➢ *ReducedSpeed*

Reduced speed a loss that occurs due to equipment operated under the standard speed. Is the difference between design speed with the actual operating speed. The reason for the difference in speed can be problems of mechanical, electrical, or any quality problems. The decline in production speed arise if the actual operating speed is smaller than the speed of the machine that has been designed to operate in normal speed. The decline in the pace of production, among others caused by:

a. Designed engine speed can not be achieved because of the change in the type of product or material that is incompatible with the equipment / machinery which is used
b. Production speed equipment / machinery decreased due to operator not knowing how many normal speed equipment / machinery actually be met
c. Deliberately reduced production speed to prevent problems on the equipment / machinery and the quality of the product if it is produced at production speed lebihtinggi.

➢ *DefectinProcess (KerugiankarenaProdukCacat maupunkarenaKerjaProdukDiprosesUlang)*

Defect in process is time wasted to produce defective products and defective products generated will result in the loss of material, reducing the amount of production, increase production waste and rework costs. Losses due to rework including labor costs and time required to process and rework or repair the defective product. Only a small amount but this condition could cause greater problems.

- *Reduced Yield (Losses Start Time Production to Achieve Stable Production Conditions)*

Reduced yieled is the material losses incurred during the time required by the equipment / machinery untukmenghasilkanprodukbarudengankualitasproduk which had been expected. Losses incurred depending on factors such as the state of unstable operation, improper handling, and installation of equipment / machinery, molds (dies), or the operator does not understand the activities of the production process.

According to a book written Davis Wilson (2002, p. 364) explains that to maximize the effectiveness of the equipment means that the best means to restore the capital assets of the business. To improve the effectiveness of the machinery and equipment used must be measured and reduced losses during machine operation. TPM can eliminate the six big losses, it is the fokusTPM.

E. Techniques PerbaikanKualitas

In the book by Goetsch and Davis (2013, p.245) states that employees within an organization in any department, employees can use several techniques favorable quality improvement and the company will be able to survive by using the techniques earlier. In the implementation of quality engineering technique was between employees and management melakukancross-function.

The basic techniques of quality that can be used among other things Pareto Chart, Diagram Cause and Effect (Cause and Effect Diagram), sheets of checks (Check Sheet), Histogram, diagram deployment (Scatter diagram), flowcharts (Run Chart, and map control (control chart), and analysis of process capability. but that will be described in a review of the literature is not all, just dealing with topics that will be discussed, including the techniques used are pareto diagrams and causality (cause and effect diagram). Where such techniques have utility that can stand alone as well as mutual help between one technique yanglain.

- *Pareto Charts*

Pareto diagram first introduced by an expert on the Italian economy is Alfredo Pareto (1848-1923). Pareto diagram is a drawing that sort of classification data from left to right from the biggest to the smallest. This helps to solving the most important problems to be resolved (the highest rank) and up to unnecessary problems resolved (the lowest rank). Pareto diagram can also identify the most important issues of quality improvement efforts and provide guidance on priorities allocate resources to resolve the problem.

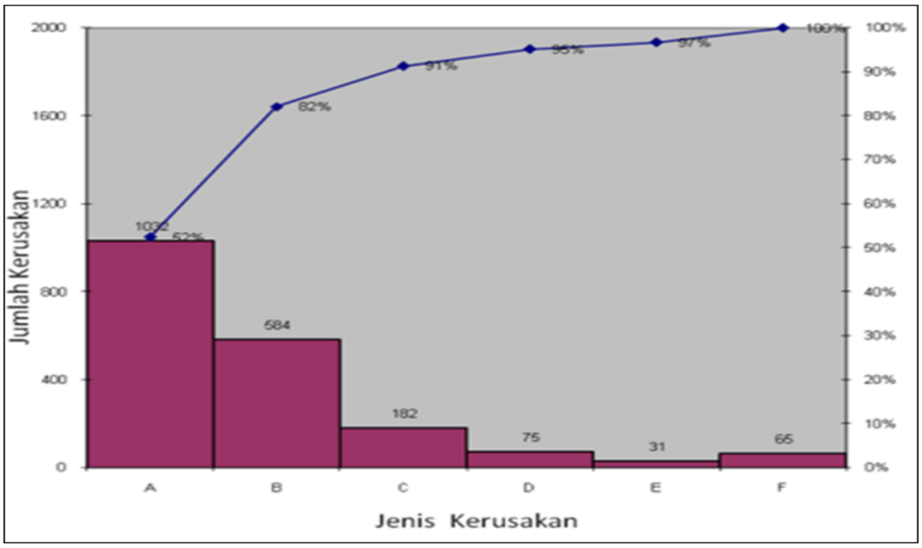

Fig 8:- Pareto Charts
(Source: Goetsch and Davis (2013, p. 246))

Pareto diagram also can also be used to compare the conditions of the process, for example mismatch process before and after the corrective action on the process. The Pareto Principle is a formula of 20:80, which is 20% of quality problems caused losses sebesar80%.

Use of the Pareto diagram is a process that never ends, for example from the image above, the target refinement is the problem A. If successful improvement program in the future then the target refinement is the problem B. Similarly, subsequent to the C, D and so on so that repairs made secaramenyeluruh ,

- Cause and EffectDiagram

Cause and effect diagram also called causal diagram developed by Dr. Kaoru Ishikawa in 1943, so it is often called the Ishikawa diagram. Ishikawa diagram outlines and symbols showing the relationship between the result and the cause of a problem. The diagram is used to determine the effects of problems to further remedial action taken. Of these consequences then searched several possible causes. The cause of this problem comes from various sources, for example, human, material, machine, method, environment and measurement.

From some of the above causes can be reduced to some sources smaller and detailed, for example, can be derived from human concern, skill, thoroughness and education. To search for various causes can be reached by brainstorming involving all parts involved in the process. To find the root cause of the problem using the technique of asking for trouble as much as five times the so-called five way.

Besides being used to find the main cause of the problem, cause and effect diagrams can also be used to find the cause of a minor who is part of penyebabutama.

III. RESEARCH METHODOLOGY

In detail the purpose of research titled Proposed Implementation of TPM in order Increasing the Effectiveness OEE Machine as a Measure Tool in the tin packaging industry are as follows:

1. To know and analyze the extent of engine maintenance is done now with the expected level of effectiveness of the machine tin packaging industry.
2. To find and cultivate several factors that affect the menggunakaan OEE calculation and analysis of six biglosses
3. To determine the actual root of the problem that occurred in GeneralLine.
4. As management guidelines to direct the entire organization in the tin packaging industry towards improving OEE by application of TPM in order to compete, survive danberkembang.
5. 3.1 Research Variables

According Sugiyono (2007, p. 33) the relationship between one variable with other variables in the study were divided into:

1. *Independent variable* (Independent variables) are variables that affect other variables (dependent variable). The independent variable in this study is the rate Availability, Performance Rate and Quality Rate.
2. *Dependent variable* (The dependent variable) is a variable that is influenced by other variables (independent variable). Dependent variable in this research is the Overall Equipment Effectiveness (OEE).

➢ *Problem Formulation and Determining Objectives*

The next research step is identifying the problem. Problems encountered later identified to assess alternative solutions. Issues to be discussed is how to increase the effectiveness of the machine. This is done by identifying the factors that caused the engine failure and provide suggestions as an initial step TPM implementation on the tin packaging industry. After the Problem Formulation stages of research is to determine statement of research goals.

➢ *Method of collecting data*

According to Tika (2006, p. 57) states the research data collected consist of primary data and secondary data. The method used in the data collection process research are as follows:

1. Methods of data collection through Depatemen report Production, Engineering (Maintenance), and QA and PPIC.
2. Observation, conducted to obtain data relating to the time machine breaks down time, set up, vacancy occurs, and some other things related to the equipment / machinery used in the production process. The study was conducted by observing and researching the mechanical condition of the research sites directly through yangtersedia parameters.
3. Interview, the interview conducted this study to the Operational Head, Engineering / Maintenance, QA and PPIC to obtain primary data on the practice of program implementation and maintenance of more detailed data yangberkenaan with the implementation of corporate policies in the field of operations.

➢ *Processing and analysis of data*

Stage of data processing and analysis conducted this study are:

1. Overall calculation EquipmentEffectiveness
2. Calculation six biglosses
3. Analyzing the data by using Pareto diagram.

The results of data processing is used to analyze the extent of the effective use of production machines and also to obtain settlement of problem issues such as:

1. analysis perhitunganOEE
2. Analysis of six biglosses
3. analysis paretodiagram
4. Analysis of the cause and effectdiagram
5. Proposed troubleshooting is done based on a literature review and processing as well as analisisdata.

Based on the analysis and description of the results of the measurement of Overall Equipment Effectiveness (OEE) a number of conclusions. Having obtained some conclusions then given beberapasaran.

IV. DATA DANANALISIS

A. Production Process

In carrying out the process of the production of tin packaging industry, part

General Line # 3 is divided into several phases:

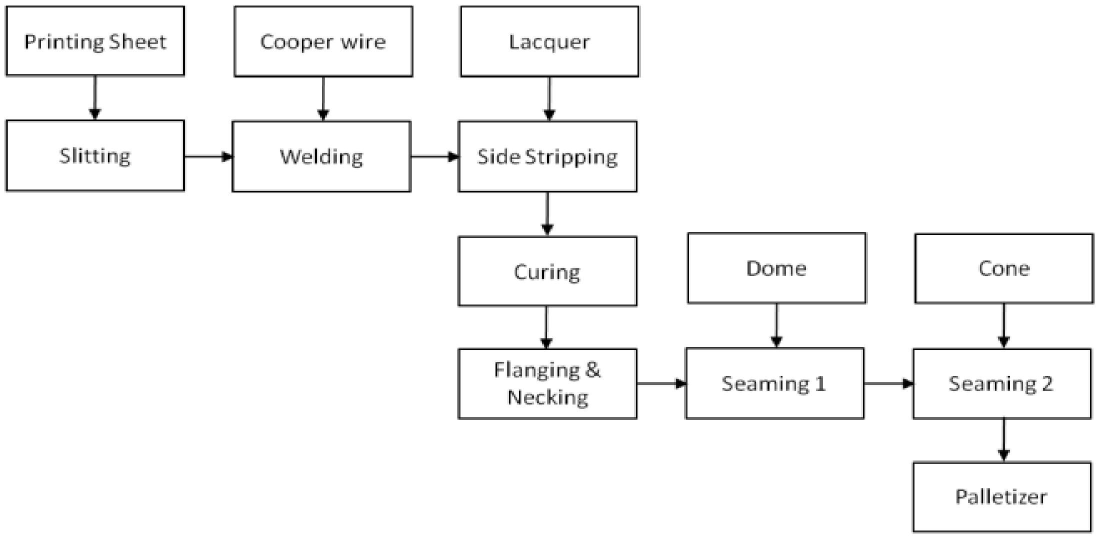

Fig 9:- Production Process Flow Chart (Source: Secondary data are processed)

1. *Slitting.* In preparation for this raw material began with the preparation on slitter machine. The raw material is cut tinplate 1st lane in operation slitter machine. And kemudin cut lines in operation 2nd slitter machine. The quality of the note is the squareness of the results of the piece. No cacatvisual.
2. *Welding.* Welding process is started on the process of forming a can body called the forming process. In the next stage is a welding process that connects the left and right sides of the tin. The quality of the welding process is observed at maturity welding results. Average cans should not exist cacatvisual sebelah.Tidak high.
3. *Side Stripping.* Side stripping process is the process of lacquer on the side of the can that finish in welding. The aim is to protect the tin side stripping of rust. The quality of the note is the side stripebubble
4. *Curing. curing*is the drying process after the cans were given side stripping. The aim of the can dry on the side stripe into the prosesberikutnya.
5. *Flanging and necking. flanging*is the process of formation of aerosol cans lip bottom side before replacing the dome (lid down). Necking process is the formation of the upper neck before aerosol cans mounted cone (lid on). The quality of the note is a visual disability, height and width flanging / necking.
6. *Seaming # 1. Seaming # 1*is the installation of a dome in aerosol cans. Which is considered high quality is nominal, seamer long, thick seamer, body hook and cover hook and diameterdome.
7. *Seaming # 2. Seaming # 2*is a cone installation process on aerosol cans. Which is considered high quality is nominal, seamer long, thick seamer, body hook and cover hook and diametercone.
8. *Palletizer.* Palletizer process is the process of packing the aerosol can be packaged in a palette. At the time of packing to consider is the quality of the visuals.

B. Research data

The research data is the data collected to be used as research material. These data consist of data relating to the capacity and time to operate the machine. And a data output that includes good and defective results.

➢ *Data relating denganMesin*

Machines that become the object of research is the engine of General Line # 3 with a production capacity of 4031-8633 cans / hour, commonly called Unit per Hour (UPH). The machine operates 2 shifts for 6 days per week.

➢ *Time data relating to the production process*

Data analysis time required for the effectiveness of the equipment / machinery for the production of which is the time of damage to the equipment / machinery, the time required to perform the settings and change over the period January to December 2013.

Some of the factors that cause the machine downtime on the machine General Line # 3 in 2013 were:

1. *mechanical Breakdown* (MBD), the time taken to repair because of the mechanical components of the engine failure. This usually occurs because of engine failure while operating.
2. *electrical Breakdown* (EBD), the time taken to repair because of the failed component electricalmesin.
3. *set up* is set processing parameters to start running the engine at the start of the shift or after engine repair. This is to ensure that the product specifications of the customer are met. Finish the set up of the machine can be runningnormal.
4. *Change Over*, The time used to change the product specification to product yanglain.
5. *Preparation* & Quality Check, namely the preparation of the box, material, pallets and others at the beginning of the shift as well as checking the quality of tin cans in the first production yangdihasilkan.

Actual data product yield and number of defects that occur from January to Desember2013

month	production Output (pcs)	Yield losses (pcs)	Rework & Reject (pcs)	Good Product (Pcs)
January	923.024	551	6.277	916.196
February	310.603	131	1.688	308.784
March	944.534	630	5.957	937.947
April	1,142,619	758	9.606	1,132,255
may	1,059,538	785	10.649	1,048,104
June	1,369,042	965	13.846	1,354,231
July	1,361,849	969	13.883	1,346,997
Aug	1,073,033	510	19.642	1,052,881
Sept	1,017,505	740	13.763	1,003,002
Oct	1,045,041	858	17.784	1,026,399
November	934.317	676	12.888	920.753
dec	994.372	779	10.327	983.266
Total	12,175,477	8.352	136.310	12,030,815

Table 1:- Production Data Period from January to December, 2013.

From the above calculations showed that the availability rate is the lowest in July 2013 amounted to 67.78%, the highest availability rate in March 2013 amounted to 84.88% and the average availability rate during January to December 2013 was 76.49%

C. Effectiveness Calculation Equipment / Machinery (OEE)

To analyze the effectiveness of the equipment / machinery used the data relating to the production process, equipment maintenance, data on the number of production and flawed data. In addition to the above data analysis also analyzes availability rate, the analysis of performance rate and quality analysis rate.

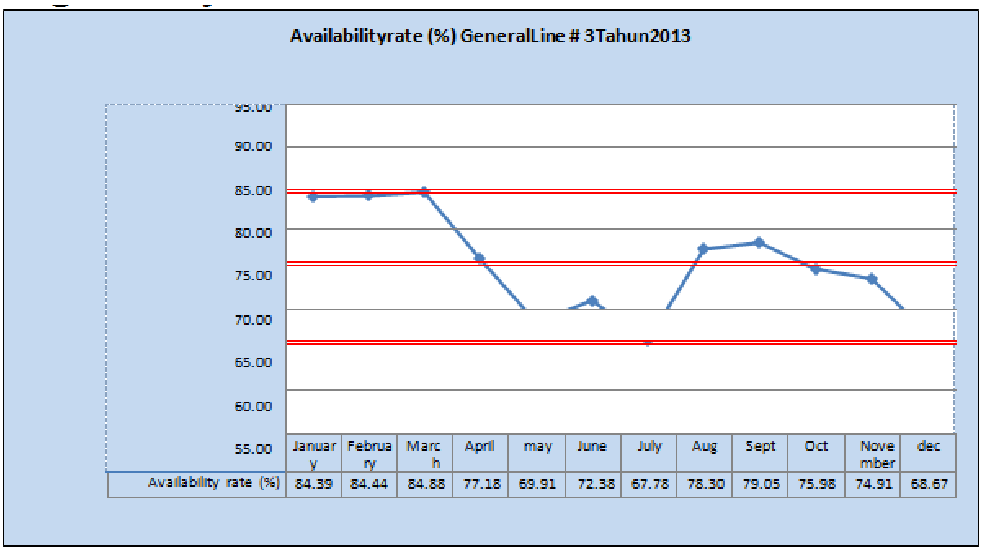

Fig 10:- Availability Rate Graph
(Source: Secondary data are processed)

❖ *Performance calculation rate Equipment*

➢ *Calculation of Availability RatePeralatanProduksi*

availability rate menunjukkantingkatanketersediaan or readiness machinery / equipment produksiuntukdigunakan in the production process. a mesinatauperalatan production with level *availability rate* high indicates that the equipment / mesintersebutselalu in condition ready with if anytime used.

Based on the data it can be calculated downtime availability value rate. Below is the data for calculating the availability rate on a production machine General Line # 3.

Some of the steps are as follows:

1. Determining the amount of time available within one month, hours of work each month in hours. For machinery General Line # 3 hours each month is 525jam.
2. Calculating time no schedule of the machine that the machine is not because the production schedule of

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bagianPPIC.

3. Calculating planned maintenance time is the time required by Engineering to perform a scheduled engine maintenance. For machinery General Line # 3 is 14 hours per month.
4. Calculating downtime downtime and consists of mechanical, electrical downtime, set-up and adjustment, change over, preparation and cekkualitas.
5. Determining the time of the operation by using the formula operation time equal to the time burdens downtimelosses.
6. Calculating the level of availability rate with an explanation as above.

month	Total (hour)	No Schedule (hour)	Planned Maintenance (hour)	Loading Time (hour)	Down Time (hour)					Operating time (hour)	Availability rate (%)
					MBD	EBD	set up	change over	Preparation and Quality Check		
January	525	267.60	14	243.40	0:00	0:00	9.75	11:25	17:00	205.40	84.39
February	525	454.75	14	56.25	0:00	0:00	2:00	1:00	5.75	47.50	84.44
March	525	259.65	14	251.35	0:00	1.75	14:50	11:00	10.75	213.35	84.88
April	525	167.00	14	344.00	10:25	6:50	27.50	11.75	22:50	265.50	77.18
may	525	182.00	14	329.00	19.75	0:00	36.00	16:00	27.25	230.00	69.91
June	525	94.75	14	416.25	4:00	12:00	49.70	16:50	32.75	301.30	72.38
July	525	83.50	14	427.50	7:00	1.75	64.25	20:00	44.75	289.75	67.78
Aug	525	232.25	14	278.75	0:00	0:00	14:50	13:00	33.00	218.25	78.30
Sept	525	233.00	14	278.00	2:25	1:00	16:50	17:00	21:50	219.75	79.05
Oct	525	204.00	14	307.00	2:00	2:00	26.50	17:25	26.00	233.25	75.98
November	525	231.00	14	280.00	6:50	6.75	23:00	14:00	20:00	209.75	74.91
Dec	525	220.70	14	290.30	8.75	3:25	37.00	17:00	24.95	199.35	68.67
Average											76.49

Table 2:- Analysis of Monthly Averages Availability Rate Year 2013
(Source: Secondary data are processed)

➢ Production

performance rate is the ratio of the quantity of products produced with the ideal cycle time to time available to carry out the production process. Or the ratio between the actual output with the number of products that can be produced.

Rate performance analyzes intended to determine the extent to which the efficiency of equipment / machines used for the production process. This analysis includes the following phases.

1. Calculating the cycle time period (c / t) theoretically to produce a can that is C / T 0.417 seconds to cans of 104 mm and a C / T 0.893 seconds for the 276 mm cans. Cycle time in General Line # 3 ranges from 0.417 seconds to 0,893detik.
2. Calculating the amount of production for each period (January to Desember2013)
3. Calculating the average operating time of the engine General Line # 3 is used in the production process.
4. Analyzing the performance rate for each period using data in bawahini.

month	Cycle time (Second)	Production output (pcs)	Operating Time (hour)	Performance Rate (%)
January	0717	923.024	205.40	89.50
February	0466	310.603	46.50	86.46
March	0705	944.534	213.35	86.70
April	0728	1,142,619	265.00	87.19
may	0663	1,059,538	230.10	84.80
June	0668	1,369,042	301.30	84.31
July	0655	1,361,849	289.75	85.52
Aug	0.636	1,073,033	218.25	86.86
Sept	0674	1,017,505	219.75	86.69
Oct	0698	1,045,041	233.25	86.87
November	0697	934.317	209.00	86.55
Dec	0629	994.372	199.35	87.09
Average				86.55

Table 3:- Analysis of Average Monthly Performance Rate Year 2013
(Source: Secondary data are processed)

From the above data are at the lowest rate performance buan May 2013 aitu 84.31%. Performance

The highest rate in January 2013 was 89.50%. And the average performance rate in the period January to December 2013 adalah86,55%.

month	Availability rate (%)	Performance Rate (%)	Quality rate (%)	OEE (%)
January	84.39	89.50	99.26	74.97
February	84.44	86.46	99.41	72.59
March	84.88	86.70	99.30	73.08
April	77.18	87.19	99.09	66.69
may	69.91	84.80	98.92	58.64
June	72.38	84.31	98.92	60.37
July	67.78	85.52	98.91	57.33
Aug	78.30	86.86	98.12	66.73
Sept	79.05	86.69	98.57	67.55
Oct	75.98	86.87	98.22	64.82
November	74.91	86.55	98.55	63.90
Dec	68.67	87.09	98.88	59.14
Average	76.49	86.55	98.85	65.43

Table 5:- Calculation Results Monthly Averages OEE Year 2013

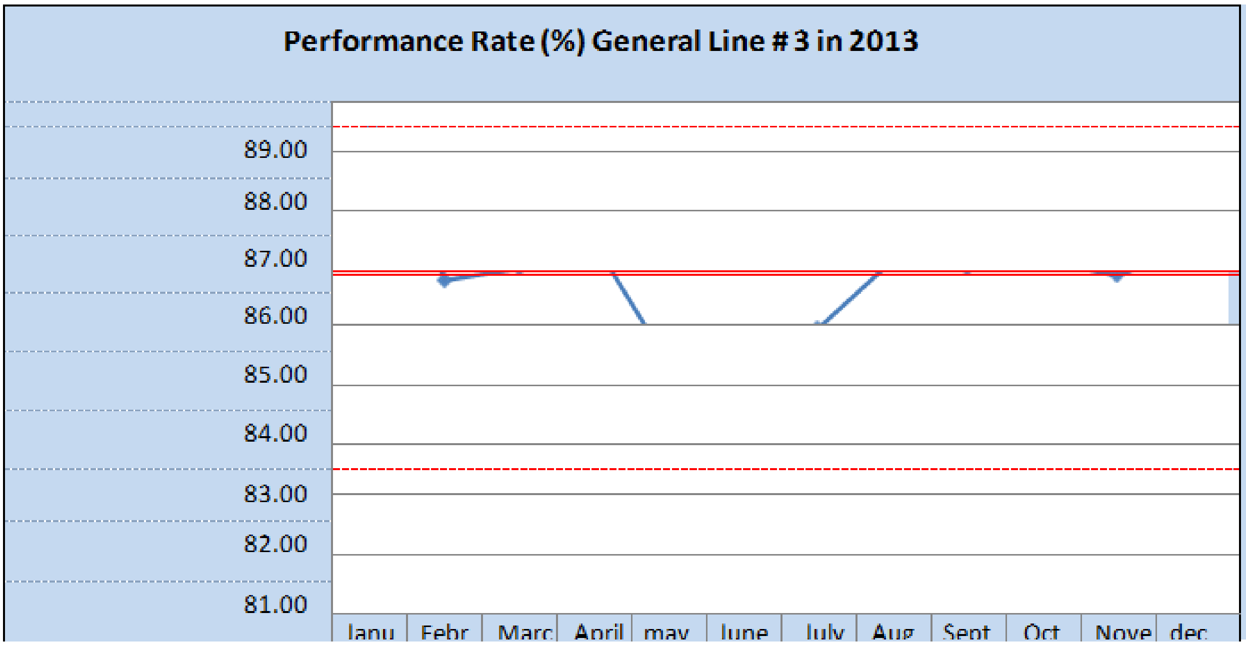

Fig 11:- Graph Performance Rate

➢ *Calculation of Quality Rate Production Equipment*

Quality rate is the ratio that indicates the ability of the equipment to produce products that comply with the standards already set. Based on data from the reports of production losses can be calculated quality value rate. Below is the formula for calculating the value of quality rate on machinery General Line # 3.

From the results of the calculations in Table 4.5 indicates that the level of product quality tin cans in the packaging industry average at 98.85% figure (using machine General Line # 3). Quality lowest rate occurred in August 2013 in the amount of 98.12% rate and best quality is the month of February 2013 yaitu99,41%.

month	Production output (pcs)	Yield losses (pcs)	Rework and Reject (pcs)	Good Product (pcs)	Quality rate (%)
January	923.024	551	6.277	916.196	99.26
February	310.603	131	1.688	308.784	99.41
March	944.534	630	5.957	937.947	99.30
April	1,142,619	758	9.606	1,132,255	99.09
may	1,059,538	785	10.649	1,048,104	98.92
June	1,369,042	965	13.846	1,354,231	98.92
July	1,361,849	969	13.883	1,346,997	98.91
Aug	1,073,033	510	19.642	1,052,881	98.12

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Sept	1,017,505	740	13.763	1,003,002	98.57
Oct	1,045,041	858	17.784	1,026,399	98.22
November	934.317	676	12.888	920.753	98.55
Dec	994.372	779	10.327	983.266	98.88
Average					98.85

Table 4:- Analysis of Average Monthly Quality Rate in 2013
(Source: Secondary data are processed)

The graph illustrates the quality rate the quality during 2013, can be seen in Figure 12.

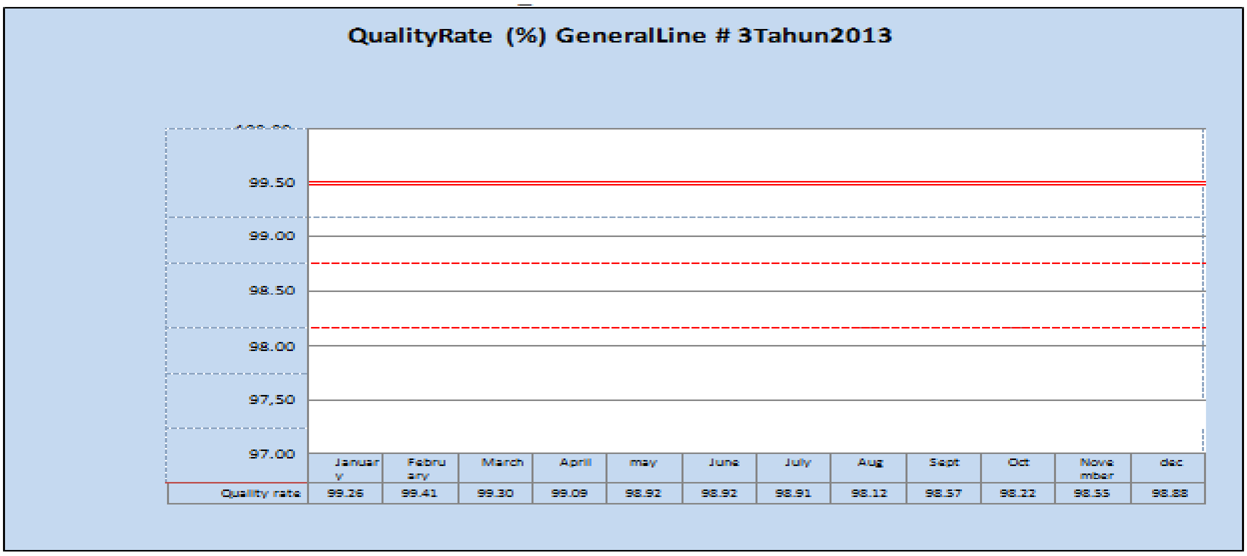

Fig 12:- Graph Quality Rate

Three stages of analysis is the analysis of availability rate, performance rate and quality rate has passed, the next stage is to quantify the effectiveness of each period of production equipment General machine Line # 3 with the following formula:

OEE = availability rate x performance rate x quality rate

month	Availabilit y rate (%)	performance nce Rate (%)	Quality rate (%)	OEE (%)
January	84.39	89.50	99.26	74.97
February	84.44	86.46	99.41	72.59
March	84.88	86.70	99.30	73.08
April	77.18	87.19	99.09	66.69
may	69.91	84.80	98.92	58.64
June	72.38	84.31	98.92	60.37
July	67.78	85.52	98.91	57.33
Aug	78.30	86.86	98.12	66.73
Sept	79.05	86.69	98.57	67.55
Oct	75.98	86.87	98.22	64.82
November	74.91	86.55	98.55	63.90
dec	68.67	87.09	98.88	59.14
Average	76.49	86.55	98.85	65.43

Table 5:- Calculation Results Monthly Averages OEE Year 2013

(Source: Secondary data are processed)

From the calculation of OEE in Table 5. obtained as follows:

1. The results of calculation of OEE highest value in January 2013 amounted to 74.97% influenced by the value of 84.39% availability rate, performance and quality rate of 89.50% rate99,26%
2. Instead calculation of OEE lowest value occurred in July 2013 amounted to 57.33%, it is influenced by the availability rate of 67.78%, 85.52% rate performance and quality rate98,91%.
3. On average OEE during the period January to December 2013 were as follows 65.43%, it is influenced by the average availability rate of 76.49%, 86.55% rate performance and quality rate98,85%.
4. OEE analysis of the data it can be concluded that the value of OEE in General Line # 3 can be categorized in sub-standard conditions of world class manufacturing. OEE value can be regarded world class company manufacturing with the following criteria: availabiltiy rate of greater than 90%, the performance rate greater than 95%, quality rate of greater than 99% and greater OEE dari85%.

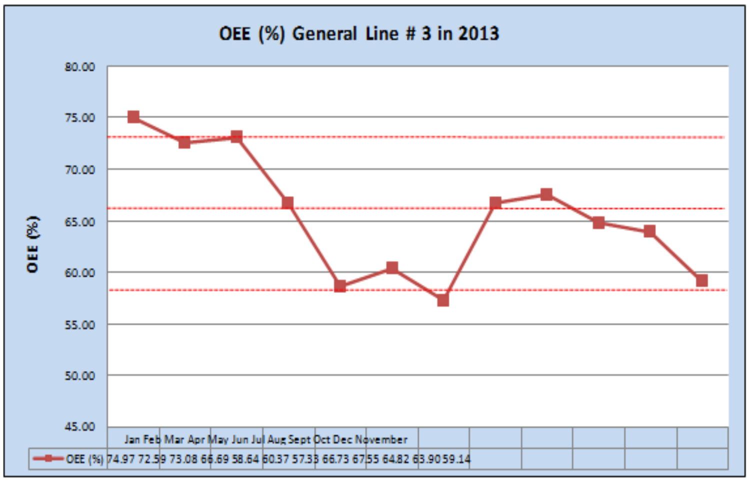

Fig 13:- The graph Overall Equipment Effectiveness

D. Calculation Six BigLosses

TPM aims to increase OEE by eliminating the root causes of losses. Calculation of the percentage of the six big losses as in the detailed description below.

➢ *Equipment Failure / Breakdown*

The percentage of the effectiveness of the machine is lost due to equipment failure can be calculated with the following formula:

$$\text{Equipment failure} = \frac{\text{Total equipment failure}}{\text{Loading Time}} \times 100\%$$

equipment failure The highest was in May 2013 by 6.00%. Lowest equipment failure occurred in January, February and August 2013 amounted to 0%, and average equipment failure during the period of 2013 amounted to 2.40%.

➢ *set up and Adjustmentloss*

Set up the percentage of downtime and loss adjustment is sebagaiberikut:

$$\text{Set up \& Adjustment} = \frac{\text{Total set up \& adjustment time}}{\text{Loading Time}} \times 100\%$$

Tin packaging industry in the monthly report said change over the time spent on replacing or adjusting equipment (dies) for the following product types to be produced a product suitable for further processing.

Set up and adjustement percentage of the highest lossses occurred in July 2013 amounted to 30.18%. Set up and adjustment lows reached in March amounted to 14.42%. And the average set-up and adjustment during 2013 was sebesar21,11%.

➢ *Idling and MinorStoppages*

Idle and minor stoppages the machine Genral Line # 3 during 2013 was 0%. There is no record of the material shortage downtime / delay and operator problems.

➢ *ReducedSpeed*

Reduced speed of the percentage of losses can be calculated with the following formula:

$$\text{Reduced speed losses} = \frac{\text{Operating time} - (\text{ideal cycle time x Total Product})}{\text{Loading Time}} \times 100\%$$

➢ *Process DefectLosses*

To determine the percentage of rework and defects losses can be used as follows:

$$\text{Rework \& Reject Losses} = \frac{\text{ideal cycle time x (rework \& reject)}}{\text{loading time}} \times 100\%$$

➢ *ReducedYield*

$$\text{Reduced Yield} = \frac{\text{ideal cycle time x (reduced yield)}}{\text{loading time}} \text{X } 100\%$$

In order for a maximum equipment effectiveness means the best means to restore the capital assets of the business. To improve the effectiveness of the machinery and equipment used must be measured and reduced losses during machine operation. TPM can eliminate the six big losses that are the focus of this case. Below is a resume six big losses in the General Line # 3

E. Pareto Charts

Data from the six big losses made Pareto diagram determines the priorities for improvement in Genral Line # 3. That the largest percentage of the six big losses in the categories set up and adjustment losses amounted to 62.84%, then the category of reduced speed losses amounted to 29.18%, 7.76% equipment failure losses, rework and reject losses of 0.21% and reduced yield of 0.01% Last idle and minor STOPPAGE 0%. Having made the cumulative percentage table is then created Pareto diagram as below.

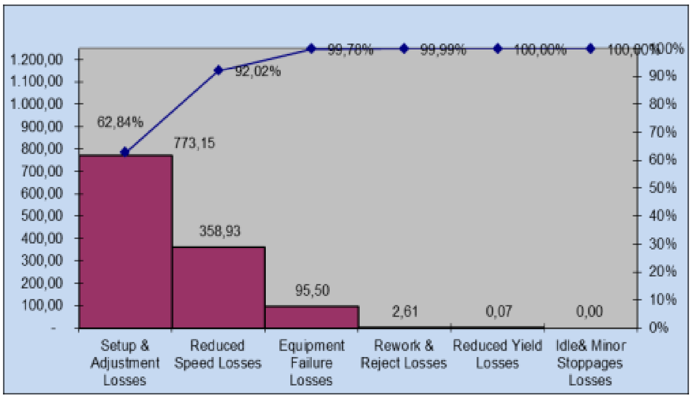

Fig 14:- Six Big Losses (Pareto Diagram)

In Figure 14 illustrates that the cumulative percentage of> 80% at six big losses is a category set up and adjustment losses amounted to 62.84% and reduced speed losses amounted to 29.18%.

Based on the Pareto diagram of the six big losses, the losses above the attention and focus on improvement in the packaging industry can and will do troubleshooting on the discussion.

V. DISCUSSION

❖ *Main Findings*

The main finding in this study is included the discovery of OEE and six big losses which will be described below.

First, the average OEE machinery General Line # 3 during the period January to December 2013 was approximately 65%. OEE is the lowest in July around 57% and the highest in January by 75%. The amount of availability, performance and quality product comparable to a high rate and low OEE during 2013.

Second, the order of the percentage of the category of the largest six big losses in the engine General Line # 3 is as follows: set up and adjustment losses, reduced speed losses, equipment failure, losses, rework and reject losses, and reduced yield, as well as idle and minor stoppages.

Analysis of the cause of the six big factors that lead to low losses in the engine effectiveness OEE calculation is done by using a cause and effect diagram. The analysis carried out will be more efficient if it is only applied to the factors of six big losses are dominant as the Pareto diagram above 80% that had been made that is set up and adjustment losses and reduced speed losses. Melalui this diagram can be known causes of high set-up and adjustment losse and the losses reduced speed in lebihterperinci.

Analysis of influential factors to find the main cause of six big losses need to do a qualitative analysis of the karaketeristik man, machine, material danmethod.

A. Cause and Effect Diagram Set-up and Adjustment for Losses

Finding the root of the real problem that occurred in the General Line # 3 with an analysis of cause and effect diagram to set up and adjustment losses. All set-up and adjustment time is the time for adjustment and also time spent on activities replace one product to the next product type for the next production process. Using techniques Rev 5 questions is as below.

1. *Man* (Human). Lack of skill and competence of the operator of machinery and equipment as set up and adjustment.

a. Why operatorkurang skill and competence?

Because training is conducted ineffective

b. Why training is not effective? because tidakada *schedule*

c. Why is not there a schedule? material tidakada

d. No matter why?

Because material belumdibuat basic training.

2. *Machine* (machine). checking parametermesin

seamer when set up and adjustment is relatively long.

a. Why a relatively long time? many it emtooling that in setting

b. Why are so many items *tooling* that *settings*?

tooling nonstandard

c. Why nonstandard tooling? Because the supply of spare parts tooling tidakada

d. Why tooling no stock? Karenaimport

require a relatively long time.

When the set-up and adjustment of the welding machine is difficult to get the parameters yangdiharapkan

a. Why is it difficult mendapatkanparameter?

Setting the running time

b. Why when running? Between low and high speed kualitasberbeda
c. Why different quality? machine kurangstandar
d. Why less standard? Many replaced with a different material with yangawal.

3. *Material.* Material dome between one supplier with another having a different quality spec that requires special treatment when setting seamer

a. Why different specifications? Following spesifikasipemasok
b. Why follow the specifications of the supplier? Require a relatively long time for developing new product
c. Why require a relatively long time? Not to adadrawing
d. Why there is no drawing? Because the new model requires a process that reltiflama.

4. *method* (Method of work). Frequency setting and change over height. This resulted in a total time of settinglama

a. Why high-frequency setting? Schedule frequently changing
b. Why schedule often changes? Following *customer*
c. Why follow the customer? No buffer stock
d. Why no buffer stock? Not to be standardized

After the data each known cause and then proceed to draw a cause and effcet diagram as in bawahini.

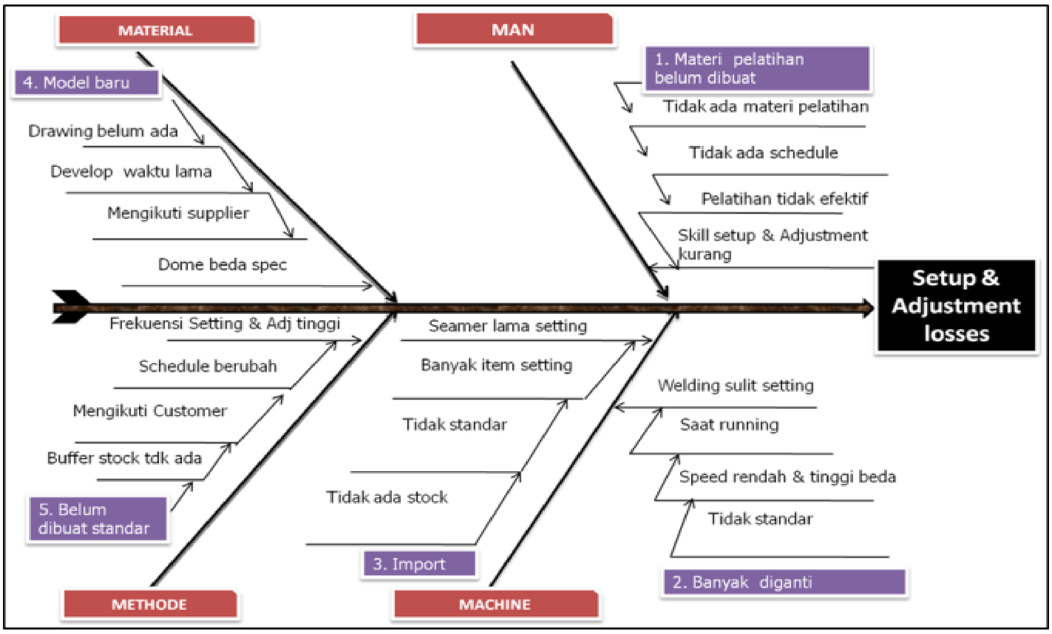

Fig 15:- Cause and Effect Diagram to Set up & Adjustment losses

B. Cause and Effect Diagram for Reduced speed losses

Some of the factors that affect the speed reduced losses are:

1. *Man* (Manuasia). Spirit *operator* for *improvement* Low engine.

a. Why the low improvement spirit? Target *improvement* KPI has not made bagiperusahaan
b. Why not be a KPI? Not available *measurre* as a reference
c. Why is there no reference? Not to dilakukankajian
d. Why not do the study? Not to be a priority by the operator maupunmanajemen

2. *Machine* (Engine). The following are factors that affect the engine speed reduced losses. Cans jammed in the necking process so that the machine should be turned off and jalanlagi

a. Why is jammed? necking chuckkotor
b. Why necking chuck dirty? Lacquer is still wet from the curing process tidaksempurna
c. Why the curing process is not perfect? heat tidakmerata
d. Why heat unevenly? Temperature adjustment and less precise speed so that the engine speed lowered so runningnormal machine.

Cans jammed in forming

a. Why jammed in forming? Body blank down tidakrata
b. Why disks down an uneven body? Stand *of body* it is not in accordance with
c. Why the holder body does not fit? The house was broken bolt
d. Why the house was broken bolt? No bolts are standard engine, so the engine speed so as not terjadimacet lowered.

3. Material. Sheet printing material mudahscratch causes the machine running at slow speed

a. Why is the scratch? Quality printingsheet inconsistent
b. Why quality is not consistent? Sistemcontrol *incoming* The low one
c. Why the low control incoming system? CoA from suppliers tidakdikirim
d. Why not post? Outgoing supplier does not control

4. Method (Method of work). Maintenance schedules are not followed olehEngineering

a. Why not followed by Engineering? Operator concerned engine running
b. Why are concerned with running? Operator reach production targets
c. Why chase the target? Because the machine is often a problem

d. Why does the machine is often a problem? Due to improvements made temporary, so engine peroduksi road with a speed that tidakmaksimal.

After the data each known cause and then proceed to draw a cause and effcet diagram as in bawahini.

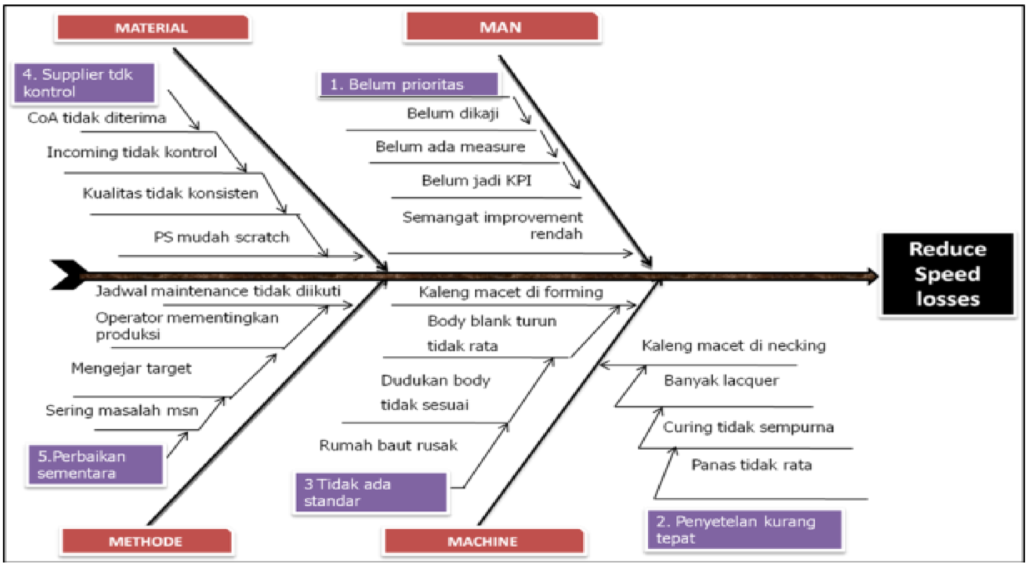

Fig 16:- Cause and effect diagram for the reduced speed losses

VI. CONCLUSION

The results of analysis and calculation of OEE in machinery General Line # 3 tin packaging industry, several conclusions can be drawn as follows:

1. Measurement of the effectiveness of the machine by using Overall Equipment Effectiveness (OEE) in the packaging industry cans in the machine General Line # 3 that the calculation starts from January to December 2013 resulted in an average value of 65.43%, it is influenced by the average 76.49% availability rate, performance rate of 86.55%, and the quality rate98,85%.
2. Factors affecting the analysis OEE with six big losses in the engine General Line # 3 is equipment failure, losses of 2.40%, set-up and adjustment losses of 21.11%, idle and minor stoppages 0%, reduced speed losses 10.25% , rework and reject losses of 0.07%, and reduced yield losses0%.
3. Based on the analysis of Pareto diagram on the machine General Line # 3, there are two main things that contributed losses of more than 80% that is set up and adjustment speed losses and reduced losses. The roots of the main problems that occur to set up and adjustment losses and reduced speed losses are mainly due to engine maintenance system that tidaksesuai.
4. Tin packaging industry production part of General Line # 3 can apply the implementation of Total Productive Maintenance (TPM) as a pilot project it is seen from the terms of the company to implement TPM. The pillars TPMyang proposed is Autonomous Maintenance program (AM) and the program Focused Improvement (FI).

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