Measurement of the Overall Equipment Effectiveness (OEE) and the Process Improvement on Radiator Crimping Line

Hendri, Muhammad Kholil, Bethriza Hanum, Atep Afia Hidayat

Abstract. PT SS.Tbk is a producer of several high-quality automotive components that have a market share in the country and abroad. One of the products is Radiator. The study was conducted on the crimping line because this line still has many obstacles in production. One of them is low production capacity and is not in accordance with machine standards. OEE Method is a calculation of several elements, namely Availability, Performance Efficiency, and Rate of Quality Products. The beginning of the research is to find supporting data to calculate the three elements. From the available data and through the calculation phase can produce 99% availability, performance of 50.9%, and quality rate of 99.68%. From the results of the three elements, the OEE value can be determined by multiplying the three elements and the result is 49.23%. From these results it can be seen that the element that must be improved is performance by increasing production capacity.

1. Introduction

The improvement of the manufacturing system is one of the efforts made by the company, in order to be able to respond to changes that must be controlled at all times to see market conditions in the world. To produce radiators that meet the needs of consumers abroad, quality change and improvement is very important for automotive companies to do. Various processes need to be improved starting from making components, assembly, testing, and packaging.

The general way to do this is continuous improvement, but not the real problem, due to the ineffectiveness of the system or method of measuring performance, equipment and solutions to existing problems.

The choice of improvement method is very important to see how far the method is suitable or not in the process improvement. The radiator product itself has an ongoing process, from components to packaging. Many methods are used to produce radiators that meet the standards, but these methods are not feasible to use because of high costs and long cycle times.

For this reason, process improvement requires the use of new methods aimed at obtaining appropriate and effective methods in the process of making radiators.
One method of measuring performance that is widely used by companies is "Overall Equipment Effectiveness (OEE)". OEE is a measuring tool to determine the effectiveness of the performance of the process. OEE is also an open way in terms of providing information in handling problems of a work system. OEE helps maximize the company's assets to the availability of time (Availability) in producing output (Performance) with the best product quality (Quality).

This measurement method consists of three main interrelated factors namely Availability (availability), Performance (ability), Quality (quality). With the OEE method, the authors conducted research to improve one of the processes in making radiators. The author takes the radiator crimping process that requires repairs because there is a bottleneck of all radiator making processes. OEE measurements are carried out before and after the process improvement in the radiator crimping line.

There are several factors that can cause low capacity, namely the engine itself, operator movements, poor working methods, and factory environmental conditions. The main factors that we will observe are machines and operators.

2. Formulation of the problem
The problem with line crimping in the process of making radiators is low production capacity and not in accordance with standards. OEE's ability is very good in identifying problems to the root of the problem so that the problem-solving action can be right on target. For this reason, the focus of the problem in this study is the calculation of the OEE value of the machine in the radiator crimping process and the process improvement plan which aims to increase the value of OEE so as to increase production capacity.

3. Research purposes
The objectives achieved in this study are
1. Understand and understand OEE methods and at the same time be able to apply in the world of work.
2. Obtain OEE value on the machine or equipment that has been determined by the object of research.
3. Summing up the results of OEE and knowing the relationships of OEE elements that influence each other.
4. Develop an improvement plan to increase the value of OEE.

4. Scope of problem
The scope of the study includes taking data for the purpose of calculating OEE values. The author will take the data for one month to be processed and obtained the results of OEE calculations in the radiator crimping process. After that, a process improvement plan is conducted to produce a positive OEE value. For improvement, I will first see which parts will be repaired. With this scope, it is hoped that there will be improvements to the OEE method.

5. Literature review
5.1 Total productive Maintenance (TPM)
In order to be able to compete in global competition and change rapidly, it is necessary to implement a strategy that can manage all resources in the organization appropriately, effectively and efficiently. Just in Time (JIT) and Total Quality Management (TQM) are some of the strategies that have been widely used by the industrial world and in recent times Total Productive Maintenance is present as a strategy that is believed to be capable of being a strategic quality maintenance tool.
Total Productive Maintenance stems from the premise of PM (Preventive Maintenance and Productive Maintenance) from America entering Japan and developing into a new Japanese system that became known as TPM (Total Productive Maintenance).

Total Productive Maintenance is a maintenance concept that involves all workers who aim to achieve effectiveness in the entire production system through productive, proactive, planned participation and maintenance activities (Suzaki Kyoshi, 1999).

TPM consists of three syllables namely:
1. **Total**
   - This indicates that TPM considers aspects and involves all existing personnel, starting from the top level to the bottom line.
2. **Productive**
   - Focusing on all efforts to carry out maintenance with production conditions running and minimize the problems that occur produced at the time of maintenance is carried out.
3. **Maintenance**
   - Means that maintaining and maintaining the equipment independently is carried out by the production operator so that the condition of the equipment remains good and maintained by cleaning it, lubricating it and paying attention.

Nakajima (1989) defines TPM as an innovative maintenance approach that optimizes equipment effectiveness, reduces breakdowns, and encourages autonomous maintenance by operators through daily activities that involve workers as a whole.

TPM is a form of good cooperation between the maintenance and production department in the organization to improve product quality, reduce waste, reduce manufacturing costs, increase equipment availability, and improve the company’s maintenance conditions.

Blancard (1997) says that TPM is a life-cycle approach that is integrated with plant maintenance. TPM can be effectively utilized by organizations to develop worker involvement at every step of the manufacturing process and maintenance of facilities to better streamline production flow, improve product quality, and reduce operating costs. Total employee involvement, autonomous maintenance by the operator, small group activities to increase reliability, maintainability, equipment productivity and continuous improvement (kaizen) are the principles covered by TPM.

5.2. **Overall Equipment Effectiveness (OEE)**

Total productive maintenance (TPM) is an original idea from Nakajima (1988) that emphasizes the utilization and involvement of human resources and preventive maintenance systems to maximize the effectiveness of equipment by involving all departments and organizational functions. Total productive maintenance is based on three interconnected concepts, namely:

1. Maximizing the effectiveness of machinery and equipment
2. Independent maintenance by workers
3. Small group activities

In this context OEE can be considered as a process of combining operation and maintenance management and resources.

TPM has two objectives namely zero breakdown and zero defect. With the reduction of the two things mentioned above, the level of use of operating equipment will increase costs and supply will decrease and further employee productivity will also increase. Of course it takes a process to achieve this and even requires a time that according to Nakajima ranges from three years depending on the size of the company. As a first step, companies need to set a budget for improving machine conditions, training employees in equipment and machinery. Actual costs depend on the initial quality of equipment and
the expertise of the maintenance staff. Once productivity increases, of course all these costs will be covered quickly.

All activities to increase the company’s work is done by minimizing input and maximizing output. Output does not only concern productivity but also better quality, lower costs, timely delivery, improved occupational safety and health, better morale and conditions and a more pleasant work environment. The relationship between input and output can be seen in Figure 1 below:

![Figure 1. Matrix The relationship between input and output in production activities (Source: Nakajima, S, 1988)](image)

In the matrix above it is evident that engineering and care are directly related to all output factors namely production, quality, cost, surrender, safety and morals. With increased automation and reduced labor, the production process shifted from manual with the hands of workers to machinery. In this position, equipment and machinery are crucial in increasing output. All of the output factors mentioned above are very much influenced by the condition of the equipment and machinery.

The purpose of TPM is to enhance the effectiveness of the equipment and optimize the output of the equipment (PQCDSSM) by trying to maintain and maintain optimal conditions with a view to avoiding machine damage, loss of speed, damage to goods in the process. All efficiencies including economic efficiency are achieved by minimizing maintenance costs, maintaining optimal equipment conditions for their useful life or in other words minimizing equipment life cycle costs. The effectiveness and minimization of equipment life cycle costs is achieved by involving all members of the organization in reducing the six big loses which reduce the effectiveness of the equipment.

Nakajima also suggested evaluating the development of the TPM because the accuracy of the production equipment data is essential to the long-term success of continuous improvement. If the data on damage to production equipment and the reasons for production losses are not understood, any activities carried out will not be able to solve the problem of the decline in operating system work. Production losses together with indirect and hidden costs make up the majority of total production costs. That is why Nakajima said OEE as a measurement that tries to reveal the hidden costs. This is one of the important contributions of OEE with the identification of hidden losses which is a big waste that is not realized.

6. Research Methodology
Research methodology is a procedure that contains clear stages that are arranged systematically in the research process. Each stage and section determines the next stage so it must be passed carefully.

7. Place and Time of the Research
The study was conducted at PT. Selamat Sempurna Radiator Tbk (ADR Group) especially in the crimping radiator line, which is located at Jalan Kamal No. 88 North Jakarta. The study was conducted for one month, from 1 May 2015 to 31 May 2015.

8. Object of the Research
PT. Selamat Sempurna tbk is an Autopart Manufacturing company whose production is in the form of car radiators. The main subject of this research is to find OEE in the crimping line and make improvements so that the OEE value is better than before.

9. Preliminary Studies
are needed to further examine what will be the problem. Preliminary studies consist of literature studies and direct observations in the field.

9.1 Method of Collecting Data
Data collection method is a way of procuring primary and secondary data for research purposes. In general, data collection, both primary and secondary, can be divided into several ways, namely:
Data collection methods used in carrying out this research are:
1. Primary Data is data obtained from direct observation and research in the field. The collection of primary data is done by observing directly in the factory and asking for information and interviewing employees directly involved in the operational process. The data obtained included data regarding production results and a description of the production process.
2. Secondary data is data that is not directly observed by researchers. This data is company documentation, past research results and other data.
3. Data collected will be used later in data processing. Data collected includes:
   a. Company production data
   b. Loading Time
   c. Operating Time
   d. Process Time
   e. Defect Amount
   f. Planned Downtime
   g. The type of machine used and some time the damage.

9.2 Data Processing
is performed by the Overall Equipment Effectiveness (OEE) method with the following steps:
1. Availability
   is a comparison between the actual operating time (actual operating time) and the loading time (planed operating time).
2. Performance Efficiency
   is the ratio of the quantity of products produced multiplied by the ideal cycle time to the time available to carry out the production process (operating time)
3. Quality Rate
   The determination of the value of this quality product is measured by the ability of a machine to produce a production that meets the quality standards that have been standardized by the company.
4. Overall Equipment Effectiveness (OEE)
   After the Availability, Performance and Quality rate values on the crimping machine are obtained, the OEE value calculation is used to determine the effectiveness of the machine.
5. Defining the real problem is done using a Cause and Effect Diagram.

9.3 Analysis and Problem Solving
Analyzing the results of data processing to find out how much the change in the level of effectiveness of the use of production machines and to obtain a solution of existing problems, including:
1. Analysis of OEE calculations
2. Analysis of Cause and Effect Diagrams
3. Evaluation and Proposed problem solving

\[ \text{Start} \]
\[ \text{↓} \]
\[ \text{Study} \]
\[ \text{↓} \]
\[ \text{Problem Identification} \]
\[ \text{↓} \]
\[ \text{Problem Formulation} \]
1. Overall Equipment Effectiveness
2. Process Improvement in Crimping Radiator Line
\[ \text{↓} \]
Research Objectives
1. Finding out the OEE Result and Analyzing the Result
2. Planning Maintenance for OEE Value Improvement
\[ \text{↓} \]
Field Study
\[ \text{↓} \]
Literature Review
\[ \text{↓} \]
Methodology Construct
\[ \text{↓} \]
Collecting and Processing the Data
\[ \text{↓} \]
Result and Analysis
\[ \text{↓} \]
Conclusion and Suggestion

9.4 Data Collection and Processing
To calculate the OEE value, data is needed in accordance with the formulas in finding OEE values. Data obtained directly in the field (production line) for one month. For data collection carried out in April 2015.

The data includes several items, as follows

1. Data downtime
   Downtime is the time that should have been used in the production process but because of damage to the machine resulting in the production does not match as it should. Process failure on the machine is a loss that results in no product output. Downtime data can be seen in table 1.

| NO. | Date           | Availability | Down Time |
|-----|----------------|--------------|-----------|
| 1   | 01 April 2015  | 22           | 0.5       |
| 2   | 20 April 2015  | 22           | 3.5       |
| 3   | 27 April 2015  | 22           | 1.38      |

Source: PT. Selamat Sempurna Tbk
2. Data Planned Production Downtime
   is the planned time in the production unit where the machine stops operating, including
downtime needed for planned maintenance and management activities (e.g., morning meetings).

3. Production Set-up Time Data
   is the time required to produce one product after another product has been completed. The
time needed to carry out the machine setup starts from the machine stops until the next
production process.

9.4.1 Availability
   is the ratio of the operation time to loading time. The availability value is calculated using the
following formula:

   \[ \text{Availability} = \frac{\text{Operating Time}}{\text{Loading Time}} \times 100\% \]

9.4.2 Performance Efficiency
   is the multiplication between the operation speed rate and the net operation rate, or the ratio of the
quality of the product produced multiplied by the ideal cycle time to the time available to carry out the
production process (operation time).

9.4.3 Ideal cycle time
   is a standard cycle time that can be achieved under normal circumstances. Total
production can be produced under normal conditions is 50 pcs/hour in one flow (in one flow there is
a set of machines), for PT. Selamat Sempurna has three flow (three sets of machines). So that the total
is 150 pcs/hour. Whereas the ideal cycle time is 1 hour / 80pcs (one flow) for three flows is 1 hour /
240 pcs = 0.0041 pcs/hour.

   \[ \text{Performance Efficiency} = \frac{\text{Processed Amount} \times \text{Ideal Cycle Time}}{\text{Operating Time}} \times 100\% \]

9.4.4 Rate of Quality Product
   is comparing the ratio of the number of good products to the number of products processed.

   \[ \text{Rate of Quality Product} = \frac{\text{Processed Amount} - \text{Defect Amount}}{\text{Processed Amount}} \times 100\% \]

9.4.5 Overall Equipment Effectiveness (OEE)
   is used to find out the effectiveness and productivity of the production process on the crimping line at
PT. Selamat Sentosa Tbk.

OEE calculation is the product of Availability, performance efficiency, and product quality rate.

\[ OEE = \text{Availability} \times \text{Rate of Quality Product} \times 100\% \]

10. Results and Analysis
10.1 Results of Data Collection and Calculation
The results of calculations of several supporters of OEE such as availability, performance efficiency,
and rate of product quality can be explained as follows.
10.1.1 Availability Value
Obtained from the production process time compared with the planned process time. 100% availability can be interpreted as the production process always runs in time in accordance with the planned time (there is never a down time). In the production of crimping, several important things can be produced as follows:

10.1.2 Performance Efficiency Value
Interpreted as the ability to maximize the acceleration of production. If the value of performance efficiency is 100%, then the process has been running at maximum speed (theoretically, based on the ideal cycle time and total production. In the production of crimping can be seen that the value is very low because there are several things as follows.

1. For the processed amount does not match the ideal conditions. This can be seen the actual condition of the total production produced under normal conditions 50 pcs / hour. Ideally with normal conditions, the machine can produce 80 pcs / hour.
2. For the conditions of production as shown in table 4.6, low performance efficiency values can be produced. Almost all grades in April were low. The lowest was on April 4, 2015 because the lowest production yield was 763 pcs.
3. From these results must be immediately considered and analyzed how it can occur and solutions to increase that value. The author will focus on this problem and will plan improvements that must be made to increase the value of performance efficiency.

From these results it can be analyzed how much time is needed for crimping one radiator so that it can also be calculated how many hours it is produced. This is to compare with the ideal time so that the time difference is obtained which must be shortened again. For the calculation will be discussed further in the discussion about the improvement plan.

10.1.3 Rate of Quality Product
Product quality is determined based on the number of production, OK products and NG or nonstandard product results. In the table can be seen as follows.

1. The rate of quality product reaches 100% if there is no "NG" or nonstandard item on that date. This must be maintained because it will benefit the company.
2. The lowest rate of quality product on April 30, 2015 because of the highest number of rejects produced was 40 pcs from the production of 2815 pcs. This must be considered why the results of the highest reject. From the production data, it can be seen that there are many rejects because the tank broke. This must be further analyzed by checking the size of the tank against the core, or improper machine settings.

10.1.4 OEE Value
is obtained from the data that has been calculated it can be seen that the results are mostly still lacking or below standard. This is because the performance efficiency results are still low. From this we will analyze the causes of the low performance efficiency results.

10.1.5 Maintenance Plan
Because OEE results are low, improvements must be made to obtain OEE values that are in accordance with the standards. The focus of improvements is on performance efficiency, which results are very low. The causes of low performance results need to be analyzed. There are several factors that affect performance, namely machine, human, process layout. The research will be done by calculating the cycle time from the crimping process from the engine to the handling system. All movements will be calculated with the aim of whether there is a long movement on the engine or handling system that requires a lot of time.

Problems that arise if the handling time is long so that it will affect production results. So the movement of the operator must be considered and the layout of the process also considered.
So the line for repairing crimping is as follows
1. For layout changed again by bringing the side crimp machine closer to the crimp machine. When viewed by the operator in handling long enough because the core distance between the machines is quite far, which is about 180 cm. For this reason, to avoid the long handling side machine side crimp closer to the core and crimping machines.
2. Using conveyors for movement of cores so that the operator does not need to make a movement to take cores in a pallet. With the core conveyors coming by itself the funds will shorten the handling operator.

11. Conclusion
From the results of the study we can get the following conclusions:
1. Overall Equipment Effectiveness is the most powerful tool to find out problems in a company because OEE overcomes problems to the root of the problem.
2. The research that has been carried out produces values from several variables of OEE namely availability (an average of 99%), rate of product (an average of 99.68%), and performance efficiency (an average of 50.9%). From these results it can be seen that the performance efficiency results are not good so there is a need for improvement plans.
3. From the three variables above, an OEE value can be generated, which is the multiplication of the three variables. For the results of OEE itself is 49.23%. So it can be concluded that if one variable value is low it will produce a low value as well. In other words, the three variables affect each other. So to produce a good OEE value and in accordance with the standards, all three variables must produce a good value.
4. Improvement plans regarding productivity or performance effectiveness are changes in the layout of the crimping process by bringing the sidecrimp machine closer to the crimping machine with the aim of shortening handling so as to produce a shorter cycle time that will improve production results.
5. The other proposal is the manufacture of conveyors for the running of the core so that handling can be reduced.

12. Recommendations
From the results of the research and during the research process, there are a number of suggestions, namely:
1. Research is still simple and with tools as it is. For the future, research uses adequate and sophisticated tools so that results are more accurate.
2. With this final project, it is expected that what has been read by the reader can be applied in the workplace because OEE is very useful for improving the quality of a company.

References
[1] Assauri, S (2004) *Manajemen Produksi*, Lembaga Penerbit Fakultas Ekonomi Universitas Indonesia, Jakarta
[2] Catena, Marco and Alessandro Persona, *Accelerated TPM* by Simulatic Dept of Management and Engineering University of Padova, Italy
[3] Gasperz, Vincent (1991) *Statistical Process Control Management Business Total* PT.Gramedia Pustaka Utama Jakarta
[4] J.R Tony Arnold,Stepea(2004) *Introduction to Material Management*, Pearson Prentice Hall
[5] Kiyoshi Suzuki, *Tantangan Industri Manufactur.*
[6] Kiyoshi Suzuki, *The New Manufacturing Challenge Technique for Continues Improvement*, The Free Press New York., 1987.
[7] Nicolo Belavendram (1996) *Quality by Design*, Prentice Hall
[8] Peter S Pande Neuman,Cavanaugh (2002) *The Six Sigma Way Team Field Book*, McGraw Hill
[9] Rahmay Nurcahyo (2008) *Presentasi kelas TQM*, Salemba
[10] Wauters, Francis and Jean Mathot (2002), *OEE (Overall Equipment Effectiveness, ABB Inc.*
[11] Wignjosoebroto, Sritomo, *Pengantar Teknik dan Manajemen Industri*, Prima Printing., Surabaya, 2003.

[12] Williamson, Robert (2004) *Don’t Be Misled by OEE*, Strategic Work System Inc.

[13] Williamson, Robert M (2006) *Using Overall Equipment Effectiveness : The Metric and The Measures*, Columbus.