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Total Productive Maintenance Policy to Increase Effectiveness and Maintenance Performance Using Overall Equipment Effectiveness

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ABSTRACT

In the manufacturing process, the machine is very important because downtime can inhibit and even stop production. We focused on the highest downtime that occurred in a particular product line and critical machine. This research contributes to overcoming and making the machine's performance and ability better. We make use the Total Productive Maintenance (TPM), which started by calculating Overall Equipment Effectiveness (OEE) and Six Big Losses. This study also provides the maintenance attempt to increase the effectiveness and to eliminate losses incurred by calculating Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR). Finally, we proposed the TPM implementation to improve the effectiveness of the machine. The result showed that the OEE has not reached the ideal value due to the low availability. Breakdown losses contributed to the biggest factor in the loss. The way to overcome the cause of breakdown losses is to increase performance maintenance, by calculating and evaluating MTBF and MTTR. This research presented the cause of the low value of OEE, provided the performance maintenance policy according to MTBF and MTTR, and proposed the TPM implementation.

1. Introduction

It is an undeniable fact that a country's economic growth is very much dependent on the success of its industrial sectors [1]. The competitive nature of the world industry enforces manufacturers to implement more advanced technologies to secure their positions against competitors [2]. The manufacturing industry remains competitive and strives to find methods to improve quality, efficiency, and productivity [3, 4]. In the meantime, the food industry growth in Indonesia is placed in the first rank due to high consumer demand. The increase in the growth of medium-large manufacturing the industry was contributed by the food industry by 15.28% in 2017 [5]. As the number of demand keeps increasing, it is logical that the competition between manufacturers is going to be incisive. Therefore, manufacturing firms need to cover various areas concerning technical, organizational and personal solutions, such as short lead-time and competitive prices to achieve excellence [1, 6]. When the service exceeds the stakeholders' expectation, it can be rated excellent [7].

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Due to the manufacturing challenges, manufacturers are forced to improve their production systems to optimize and reduce overall production costs [1]. However, these improvements cannot be achieved if the companies do not evaluate their current performance [8]. To gain competitive advantage, there are different techniques of waste reduction and performance enhancement such as Just in Time (JIT), Total Quality Management (TQM), Total Productive Maintenance (TPM), Kaizen and Lean Manufacturing (LM) [1,3, 9]. To ensure manufacturing organizations remain competitive, most of them are turning to TPM and LM to ensure seamless operations [10]. The implementation of TPM is suggested to manage the time losses [11], as proposed in this paper.

We propose the Overall Equipment Effectiveness (OEE) to measure improvement initiatives, which is the combination of the actual availability, performance efficiency and quality rate [11-13]. The OEE is the TPM metric which is used to benchmark, analyze and evaluate the productivity or the equipment effectiveness in the production process [2, 4, 13, 14]. However, productivity in such production systems depends directly on the efficiency of their operations or bottlenecks [15]. The OEE is a proven approach and a really powerful tool that can be used to perform diagnostics as well as to compare production units in different industries [3, 9]. The OEE can approve either short-term reactive actions or long-term planned actions as long as the corrective actions are structural and easy to implement [16].

The OEE can be known as a measurement of the utilization sum by observing six big losses [14]. This includes the utilization of equipment in an operational system, defects in equipment, implementation, and adjustments related to reducing the access time to machinery, short-term stops, reducing speed due to lowering the machinery function rate, wastes, and repetition of work related to lowering the quality level of the products [14]. Analyzing the six big losses in the industry provides a useful viewpoint and helps technicians and experts in making better decisions on the machineries and production line and increases the output and efficiency of the equipment [14].

The avoidance of plant shutdowns is one of the highest priorities for plant operators and plant owners [17]. Shutdowns are forced by abnormal situations, such as unexpected breakdowns due to aging or over-straining of the equipment [17]. The performance of equipment depends on the maintenance activities on the entire equipment [18]. Therefore, manufacturers provide excellent reliability and quality of their equipment at competitive prices [13]. These actions are intended to minimize the occurrence of idle time. Idle time is the non-productive time of employees or machines, or both, due to work stoppage from any cause during which an employee is still paid [3]. It is also called waiting time, allowed time, or downtime [3]. Fail in performing good maintenance practices could result in degrading the overall performance of a company [18].

It turns out that the machine or equipment plays an important role to turn input into an output. The OEE is normally used to evaluate the most problematic machines in an organization [8]. The OEE not only helps to achieve minimum breakdown and to keep the plant in a good working condition at the lowest possible cost [3] but also reveals the hidden costs associated with the efficiency of the equipment [13]. The OEE value can be increased by minimizing the breakdowns and changeover losses which are associated with the availability and by minimizing the defects and setup scraps losses which are associated with quality [15]. The machines that are in good condition will help the company in generating the quantity and quality of products in accordance with the company’s target.

Our research is focused on the food company which has been exporting the products into Asia, Australia, and Europe. It has eight main production processes namely sieving flour, mixing, dough sheet forming, steaming, forming and cutting, frying, refrigeration, and packaging. The company produces 18 different flavor products based on large demand. The company operates in 3 shifts or 22 hours a day to meet the demand. Working continuously for 22 hours a day will have an impact on the inevitable machine breakdown. As a result, the downtime of the machine will be very high. Based on the historical data shown in Fig. 1 and Fig. 2, this research focused on line 7, particularly on WP-ATB 08 machine.

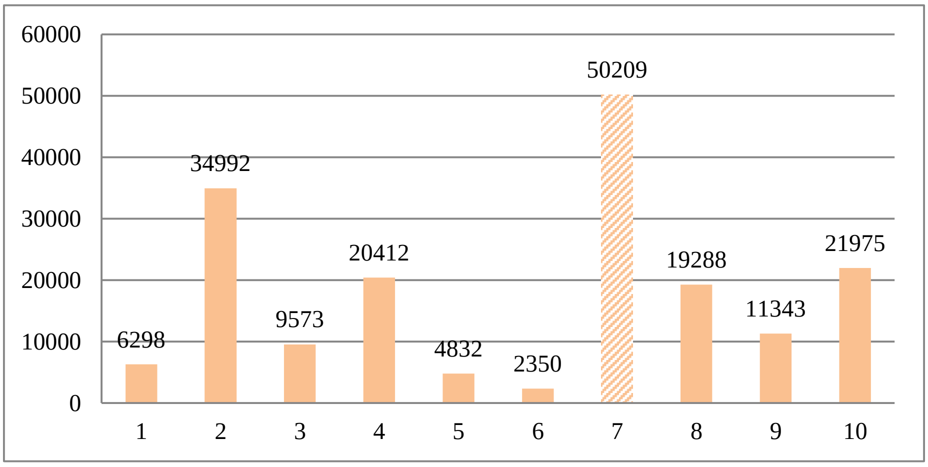

Fig. 1. *Downtime machine January-December 2017 (Minutes).*

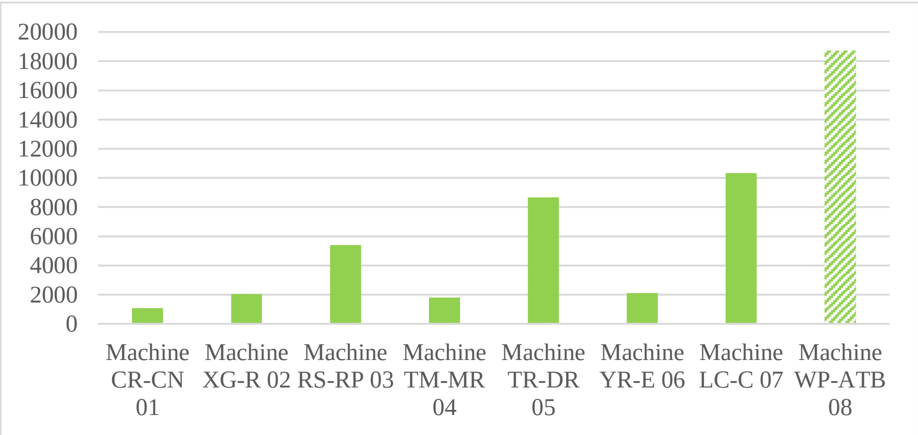

Fig. 2. *Downtime machine in Line 7.*

WP-ATB 08 machine engine is the critical unit that required maintenance to work optimally. High machine downtime indicates that the existing maintenance in the company has not been maximized so it is necessary to manage a better maintenance system. In other words, the company needs to apply the TPM. TPM is identified as a manufacturing paradigm that has undergone rapid and growing changes in Japan. The TPM approach optimizes equipment effectiveness, eliminates failure and increases maintenance autonomy involving the entire workforce. TPM generally accepts organizations in manufacturing as the most effective maintenance strategy to improve maintenance performance. Previous research showed that TPM had a direct impact on the performance improvement of production equipment [19].

This research utilizes Overall Equipment Effectiveness (OEE) which is a quantitative element of TPM as a production process analysis. The measurement of OEE can provide the ability to increase machine productivity [4]. Six major losses resulting in the production process can be analyzed with Six Big Losses [20] and followed by measuring the maintenance performance in terms of Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR) value [21].

2. Literature Review

2.1. Manufacturing Performance and Evolution of TPM

Previous research in the manufacturing system shown that a good strategy or policy is required to improve maintenance performance [22]. The assumption of the TPM method is to maintain machines in the state of productivity [12]. In this context, we make use of the method and measurement of TPM, 5S and OEE implementation. TPM has a strong positive impact on various dimensions of manufacturing performance [22]. Furthermore, OEE is a very important measure in providing information about wasted time and production [22].

2.2. Total Productive Maintenance (TPM)

TPM involves all workers through small group activities [23]. TPM is a comprehensive maintenance system that includes preventive maintenance to prevent loss and waste [19]. In implementing TPM, 8 pillars are needed, namely, eight autonomous maintenance focused improvement, planned maintenance, quality maintenance, education and training, safety, health and environment, TPM office and development management [24].

There are two basic activities in maintenance, namely cleaning and inspection. The motto of the TPM is as follows [22]:

Seiri (Sort)
Activities that remove all items that are in the workplace are not required for the current production operation or in the form of records.

- Seiton (Set in Order)
  Activities that organize and label the required products are easy to find and use.

- Seiso (Shine)
  Activities are undertaken by removing undue objects in the workplace such as clean floors, appliances, and workstations to prevent contamination.

- Seiketsu (Standardize)
  Activities that maintain the results achieved in the previous 3-s and standardize for ongoing improvement.

- Shitsuke (Sustain)
  Establish standards for 5S practices such as fostering the discipline and personal habits of employees.

After implementing the TPM program then the company can implement TPM with the following steps [23]:

- Stage of Preparation
  - Top management announced the decision to introduce TPM.
  - Conduct lessons and campaigns in order to introduce TPM.
  - Implement basic TPM policy and objectives.
  - Create a master schedule to further develop TPM.
- Implementation Stage Preparation.
  - Start holding tight TPM.
- Implementation of TPM.
  - Implementation of Stage Preparation.
  - Carry out an autonomy maintenance program.
  - Implement a maintenance program scheduled for the maintenance department.
  - Conduct training to improve operational and maintenance skills.
  - First, build an equipment management program.
- Stages of Consolidation.
  - Improve existing TPM implementation and raise TPM level.

2.3. Overall Equipment Effectiveness (OEE)

The concept of Overall Equipment Effectiveness (OEE) was first written in 1989 from a book entitled TPM Development Program: Implementing Total Productive Maintenance and was updated by Seiichi Nakajima of Japan Institute of Plant Maintenance [25]. Measurement is an essential requirement of continuous improvement processes [26]. OEE is one of the measurements that can be used to measure good performance in a factory, and the measurement is done to find out the effectiveness of the machine [27].

The previous study tried to enrich the OEE with statistical analysis, simulation modeling, temporal performance expression model, a didactic approach, Overall Resource Effectiveness (ORE), and Valve Diagnosis System (VDS) [6, 10, 12, 16, 17, 18, 28]. Previous research revealed the linkage of OEE implementation with TPM and LM as the most critical factors [10]. Another study also found that human errors in maintenance have a significant positive relationship with OEE [18]. A simulation study has been conducted to evaluate the effectiveness of the production system using OEE before and after introducing improvement initiatives [12]. A temporal performance expression model and a didactic approach enriched the OEE due to the need for adaptive assistance systems [6, 16]. The impact of the worker, equipment, and raw material onto the manufacturing system is considered while calculating OEE alongside ORE [28]. More specifically, another study tried to improve OEE value by detecting and forecasting gradual increasing valves' faults while making use of the VDS [17].

The OEE has been utilized with various improvement techniques to address several issues. TPM has been exploited to reduce idle time in the machining process industry [3, 13, 15]. Another study strived to improve the availability issue using cellular layout and Single Minute Exchange of Dies (SMED) [9]. Other research addressed the downtime and root causes of failures in bottleneck equipment using the Failure Mode and Effects Analysis (FMEA) approach [4].

The formulas for calculating the OEE are as follows [22]:

$$Availability(A) = \frac{Loading\ Time - Downtime}{Loading\ Time} x\ 100\ . \quad (1)$$

$$Performance(P) = \frac{Theoritical\ Cycle\ Time\ x\ Processes\ Amount}{operating\ time} x100\ . \quad (2)$$

$$Quality(Q) = \frac{Processed\ Amount - Defect\ Amount}{Processed\ Amount} x100\ . \quad (3)$$

$$OEE = (A)(P)(Q)\ . \quad (4)$$

2.4. Six Big Losses

Six big losses cause the ineffective machine, such as [20]:

– Breakdown Losses
This loss is coming under the downtime losses. This type of loss is occurring due to the failure of parts, which causes the stop of production and these can be measured by the time consumed to repair or replace the part.

– Setup and Adjustment Losses
This is also coming under the downtime losses. This type of loss occurs during the change in the production process such as change of section, change operating condition, start the different shifts, and change of product and many more.

– Idle and Minor Stoppage
This loss comes under the speed losses, meaning the output is smaller than the target. This loss is caused by jamming or machine idling.

– Reduced Speed Losses
Reduced Speed Loss is caused by a decreasing speed which means the machine does not operate at its original operating speed.

– Rework Losses
These losses are due to the defective product and the rework has to be done to remove the defects and follow the standard specification.

– Yield / Scrap Losses
These losses are due to wasted raw material.

2.5. Mean Time between Failure and Mean Time to Repair

Mean Time Between Failures (MTBF) is defined as the average expected time that the next failure will occur after a failure [21]. Mean Time To Repair (MTTR) is defined as the average time to repair or to fix the component [21].

The formulas for calculating MTBF and MTTR are as follows [29]:

$$MTBF = \frac{Sum\ of\ equipment\ uptime\ of\ all\ machine}{of\ failures\ of\ all\ machines}. \quad (5)$$

$$MTTR = \frac{Sum\ of\ repair\ time\ of\ all\ machines}{of\ failures\ of\ all\ machines}. \quad (6)$$

3. Research Methodology

In this study, we use primary data and secondary data as shown in Fig. 3. Primary data were obtained by interviewing, observing the production process and monitoring the machine or equipment. The interview process was done by asking directly to the related stakeholders at the company. We observed the production process on the production line and found that a particular machine or equipment was interrupted during the production process. Secondary data were obtained through historical data for one year (January-December 2017), such as downtime, the amount of production, the number of defects, non-productive time, the amount of damage to the machine, the standard repair time, product prices, component costs, and labor costs.

The calculation process begins by finding OEE values consisting of availability, performance, and quality values. We compare these three values with world-class standard values to see the most significant factor. After that, we calculate the six big losses to find out the big mistakes that caused and have an impact on availability, performance, and quality. As for availability factor, it consists of breakdown losses and setup and adjustment losses, while performance factor consists of idling and minor stoppage and reduced speed losses, and quality factor consists of rework loss and yield or scrap losses.

When it comes to the machine maintenance policy, it was carried out as an effort to overcome the problem of low OEE values that did not reach world-class standards. This policy was focused on the six dominant big factors and causes the ineffective of the machine.

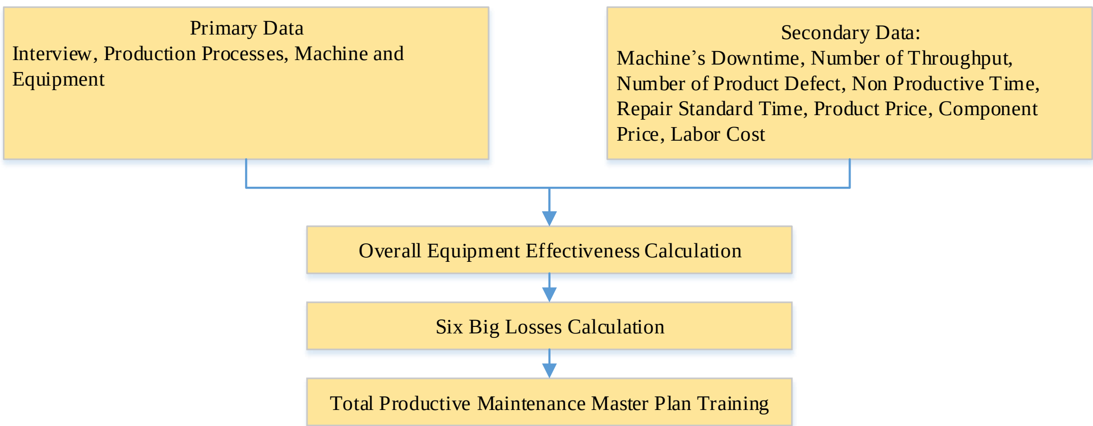

Fig. 3. *Research methodology.*

4. Result and Discussion

4.1. Overall Equipment Effectiveness (OEE) Calculation

The measurements of OEE on the WP-ATB 08 machine are shown in Table 1. Table 1 represents the average availability value of 82.56% with values ranging from 65.22%-87.35%. The average performance value is 90.83%, ranging from 65.22%-87.35%, and the average quality value is 95.04%, ranging between 91.15%-97.67%.

Table 1. *Availability, performance, and quality value.*

Month	Availability (%)	Performance (%)	Quality (%)
January	*71,77*	*97,17*	*91,15*
February	*85,90*	*90,51*	*96,57*
March	*86,43*	*99,43*	*96,74*
April	*87,35*	*85,47*	*97,67*
May	*83,33*	*84,66*	*95,15*
June	*65,22*	*89,65*	*85,98*
July	*84,21*	*92,24*	*96,87*
August	*86,00*	*93,90*	*96,12*
September	*84,04*	*88,82*	*96,23*
October	*84,39*	*91,59*	*96,08*
November	*86,00*	*92,08*	*96,02*
December	*86,11*	*84,40*	*95,91*
Average	*82,56*	*90,83*	*95,04*

Based on Table 1, it will be known the value of the effectiveness of the machine, as shown in Table 2 and Fig. 3.

$$OEE(\%) = (Availability\ Rate)(Performance\ Rate)(Quality\ Rate)$$
$$= (82.56\%)(90.83\%)(95.04\%) = 71.27\%\,.$$

Table 2. *Overall equipment effectiveness value.*

Overall Equipment Effectiveness Factors	Actual Value (%)	World Class Standard (%)
Availability	*82,56*	*≥90*
Performance	*90,83*	*≥95*
Quality	*95,04*	*≥99*
Overall Equipment Effectiveness (OEE)	*71,27*	*≥85*

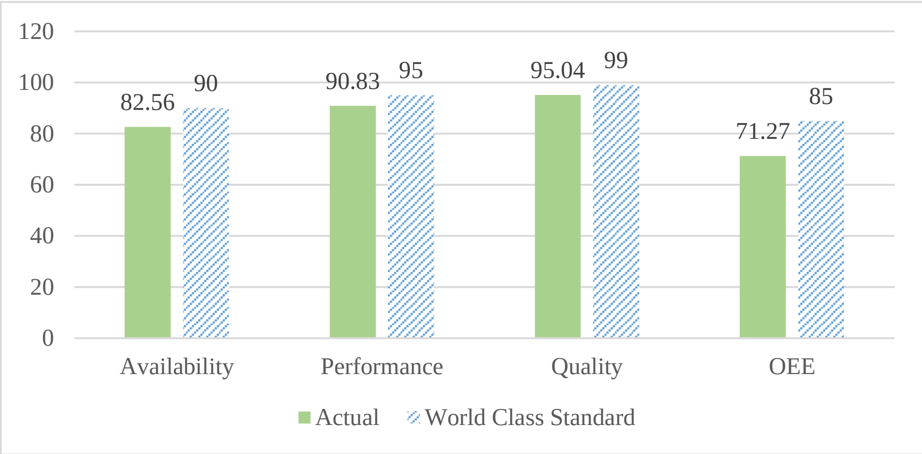

Fig. 4. *Overall equipment effectiveness value (%).*

Table 2 and Fig. 4 show that the WP-ATB 08 machine is not effective. It can be seen that the OEE value does not reach the world-class standard. Fig. 4 also shows that the low availability value (82.56%) indicates that the machine is working appropriately. The availability factor is the farthest factor from its world-class standard in terms of percentage (7.44%). It turns out that the availability factor contributes the most to the low OEE value, and we extract the corresponding six big losses to know the ultimate causes.

4.2. Six Big Losses Calculation

Six Big Losses is an attempt to identify the factors that provide the greatest loss to equipment, as shown in Table 3 and Fig. 5. Every factor in Six Big Losses provides information regarding downtime losses, speed losses, and quality losses. Based on Table 3, the value of breakdown losses is 11.67% and indicates that the company needs proper maintenance to overcome the breakdown.

Table 3. *Six big losses value.*

Six Big Losses Factors	
Downtime Losses	
Breakdown Losses (%)	*11,67*
Setup and Adjustment Losses (%)	*5,76*
Speed Losses	
Idle and Minor Stoppage (%)	*4,11*
Reduced Speed Losses (%)	*7,62*
Quality Losses	
Rework Losses (%)	*0,67*
Yield/Scrap Losses (%)	*2,87*

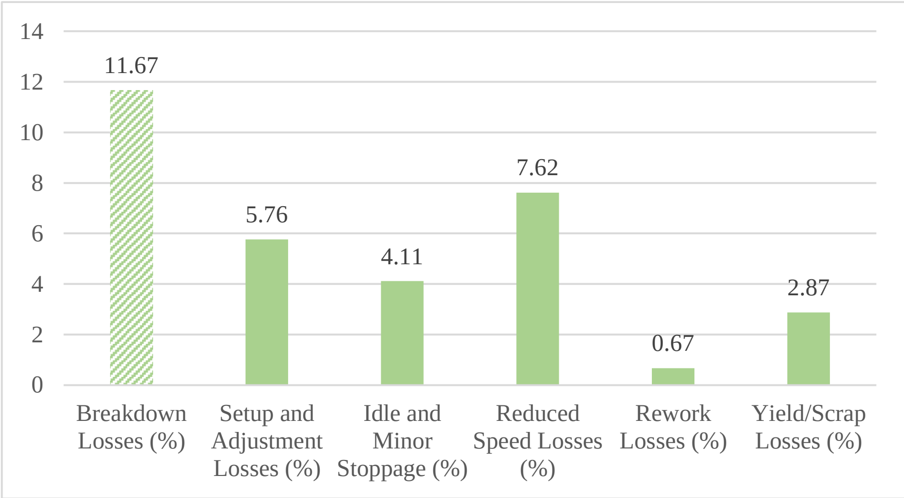

Fig. 5. *Six big losses value.*

4.3. Mean Time between Failure and Mean Time to Repair Calculation

Both the Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR) values are shown in Table 4. This calculation provides the time between machine breakdown and repair time required by the company when breakdown occurs. MTBF is 2317 minutes, indicates the machine breakdown reaches 53 times a year. The result shows the MTTR value is 289 minutes, represents the machine breakdown occurs as much as 53 times a year.

Table 4. *Mean time between failure and mean time to repair (minutes).*

Month	MTBF	MTTR
January	*1073*	*273*
February	*2010*	*194*
March	*4045*	*510*
April	*2044*	*165*
May	*934*	*129*
June	*439*	*148*
July	*1971*	*259*
August	*2683*	*275*
September	*3933*	*411*
October	*2633*	*370*
November	*4025*	*463*
December	*2015*	*273*
Average	*2317*	*289*

4.4. Work Process of WP-ATB 08 Machine

Fig. 6 shows an overview of the working process of the WP-ATB 08 machine that often experiences high downtime and many failures in comparison with other machines. The detail working process on the machine is as follows:

WP-ATB 08 machine is located on line number 7 and is utilized as packaging area. This machine is in charge of cutting the necessary seasonings package during the production process of instant noodles. To carry out the work process of the engine, the spice is removed first from the box and is glued with another spice riddle. After that, the spice is placed on the guide roller to be pulled towards the cutter through the spice ring and feeder roller. In the cutting process, there are sensors to detect any wrongdoing. After that, the process goes to the chute that is assisted by the pusher lock to put on the instant noodles above the earrings before heading for cartooning and shipping to the finished material warehouse. The breakdown that often happens is on the cutter, censors (noodle and spice) and pusher lock, particularly on the belt. The malfunction of the component often stops the main operation. In the machine, there is also a switch panel and alarm lamp that serves as a signal when mistakes happened. The information that often appears on the panel switch as an error such as:

- Error 1 (Pitch too short)
  That means the pitch size on the spice detected by the spice sensor is too short. The spice pitch here means the connecting area between one spice with another that will be cut.

- Error 2 (Pitch too long)
  This means that the pitch size on the spice detected by the spice sensor is too long.

- Error 3 (Cutter not protruded)
  This means the cutter in the problem so it should be sanitized and repaired.

- Error 4 (Alarm for Pusher Lock)
  This means the pusher lock or on the belt does not rotate.

- Error 5 (Alarm for Warning)
  This means there is a mistake to be aware of it.

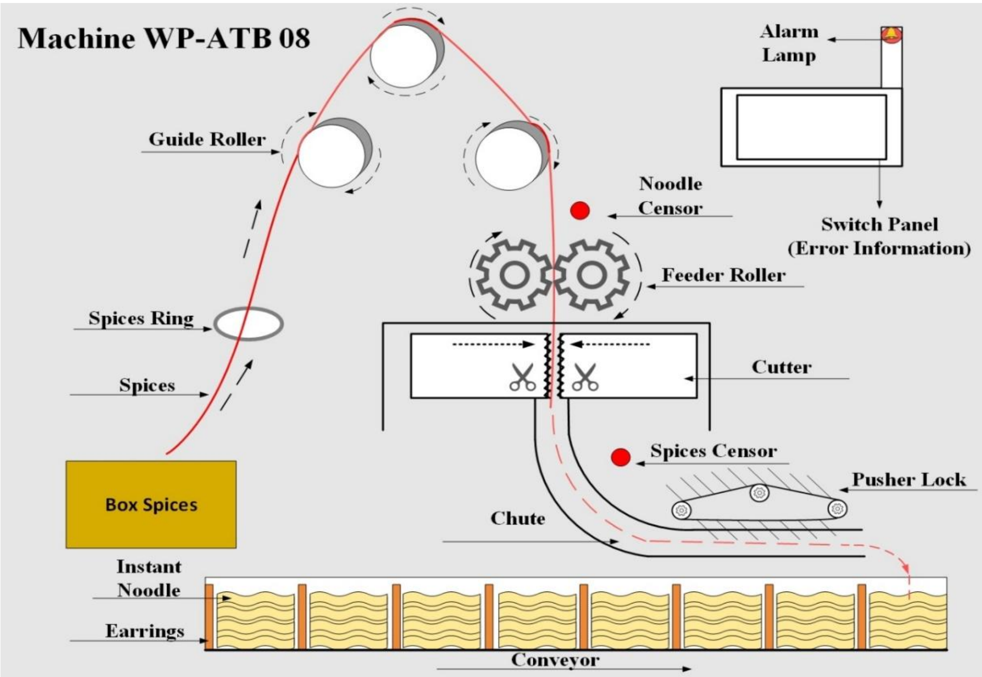

Fig. 6. *Work process of WP-ATB 08 machine.*

4.5. Proposed Implementation of TPM

The responsibility of each maintenance employee is to identify, monitor and remove causes of waste: breakdowns, little downtimes, work below a nominal performance, retooling of a machine and inadequate quality [12]. Previous research has proven that it is important that before a full OEE implementation, the management team needs to ensure an understanding of the stoppages and loss classifications as well as ensuring data accuracy so that the activities improve equipment efficiency [10].

As for increasing the effectiveness of the required TPM implementation by implementing 8 pillars:

- Autonomous Maintenance: At this stage, the technical team will provide knowledge to operators and assistant operators in WP-ATB 08. Operators will gain an understanding of machine maintenance, machine safety and basic activities of the machine. The activities consist of: operators and assistant operators can run the machine properly, clean the machine regularly, and know the machine inspection periodically, alongside with the first step when a machine malfunction occurs.
- Focused Improvement: At this stage, all personnel or workers from the operator level to the top management are responsible for tackling the problems in WP-ATB 08. To tackle the problem, it starts from small group activities (a group consisting of several operators) in constructing a report on the problem that will be used as topics of discussion.
- Planned Maintenance: This stage aims to monitor the malfunction components in the machine. Maintenance can be done to components such as a cutter, censors and pusher lock. The company can also convert the preventive maintenance policy from periodic maintenance to routine maintenance.
- Quality Maintenance: At this stage, the activity is to plan a maintenance system that provides a high-quality product and is free of defects (zero defect). At this stage, the engineering team can discuss with Quality Control regarding the product quality issues. Standard operation procedure should be properly written and the maintenance personnel must understand the maintenance activities [18].
- Education and Training: At this stage, the personnel or workers will be equipped with knowledge of the machine. The previous study highlighted the awareness training, a clear operators’ role definition, knowledge of equipment losses and basic equipment handling were some of the factors that organizations will need to develop before the implementation of OEE [10]. A managerial person must ensure all the maintenance personnel has undergone proper training on maintenance activities [18]. This would improve their knowledge, skill, and ability which helps them to make a correct decision when doing maintenance activities [18]. Later, we also arrange the training schedule to increase the ability and technique in handling the problem of the machine.
- Safety, health, and environment: At this stage, all personnel or workers will be provided with knowledge about safety, health and the environment. This knowledge includes an evacuation route when an emergency occurs, using personal protective equipment when entering production areas such as head coverings, masks, shoes, and work clothes. Another knowledge might be maintaining environmental hygiene during production areas such as not carrying cosmetics or foreign objects that violate the rules of the company's operational standards.
- Office TPM: At this stage, an office is designed for the TPM department to facilitate administrative activities that identify and eliminate losses to support manufacturing operations. This stage is done by running Autonomous Maintenance, Focused Improvement, Planned Maintenance, and Quality Maintenance.
- Development Management: At this stage, the company can develop TPM as a topic to be discussed regularly at every meeting in the company's activities.

Companies can also apply 5S to help improve their effectiveness in the following ways:

– Seiri (Sort)
At this stage, the activities include removing or eliminating unused or cluttered items or components. As the boxes are scattered or not neatly arranged in the packaging area.

– Seiton (Set in Order)
At this stage, the activities include constructing bags of scrap instant noodles and facilitating the operator to remove them.

– Seiso (Shine)
At this stage, the activities contain the equipment arrangement which is used to clean the packaging area, such as a broom, a cloth, and a cleaning liquid.

– Seiketsu (Standardize)
After successfully applying the previous 3s concept, then it is important to maintain and update the running activities.

– Shitsuke (Sustain)
At this stage, the discipline and habits play an important role in the packaging area. Discipline can be assisted by a reward and punishment system.

After the TPM program is running, the company can improve by following these steps:

– Preparation Step
At this stage, the company decides to build and develop the TPM. This step is usually delivered by top management to their workers at least in terms of providing a training schedule. By step, we proposed the master plan training as shown in Table 5 and Table 6. The workers will be trained once a month or adjusted time set by the company itself. The training is conducted by the top leaders as the trainers and start from the Factory Manager, Head of Supervisor and Manager covering seven topics. The trainers are further assigned to deliver the topics to the lower level management gradually.

– Implementation of Stage Preparation
At this stage, the company not only ensures the training schedule is in progress but also creates and labels each machine according to the breakdown properties.

– Implementation of TPM
At this stage, the company continues calculating the OEE to each machine, along with six big losses, while still providing the training to all their workers.

– Stages of Consolidation
At this stage, the company continues evaluating the existing TPM program and TPM Department. Supervision on the maintenance activities is very important too [6]. The management needs to constantly engage with the shop floor and help remove the implementation barriers faced by them [10].

Table 5. *TPM master plan training (Month 1-3).*

Training Topics	**TPM Master Plan Training**											
	Month 1			**Month 2**				**Month 3**				
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Definitions and Work Steps of TPM	*F*	*H*	*S*									
Basic Concept of TPM				*F*	*H*	*S*						
Philosphy and Purpose of TPM							*F*	*H*	*S*			
Application of TPM's 8 Pilar										*F*	*H*	*S*
Applications of 5s												
TPM Toolkit (OEE and Six Big Losses)												
TPM's Role on Company Productivity												

Table 6. *TPM master plan training (Month 4-6).*

Training Topics	*TPM Master Plan Training*											
	Month 4				*Month 5*				*Month 6*			
	13	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*
Definitions and Work Steps of TPM										*O*	*A*	*W*
Basic Concept of TPM												
Philosphy and Purpose of TPM												
Application of TPM's 8 Pilar												
Applications of 5s	*F*	*H*	*S*									
TPM Toolkit (OEE and Six Big Losses)				*F*	*H*	*S*						
TPM's Role on Company Productivity							*F*	*H*	*S*			

F= Factory manager, Head of Supervisor, and Manager
H= Head of Section Supervisor
S= Section Supervisor and Assistant
O= Operator
A= Assistant Operator
W= Worker

5. Conclusions

Overall Equipment Effectiveness (OEE) value for WP-ATB 08 machine on line 7 in the packaging area was 71.27%, with availability, performance, and quality value are 82.56%, 90.83%, 95.04% respectively. This OEE value does not yet reach the world-class standard value (85%) and the lowest value is the availability factor in terms of percentage disparity from its individual world-class standard (7.44%). Therefore we go deeper into the particular six big losses on the machine, such as breakdown losses (11.67%), setup and adjustment losses (5.76%), speed losses on idle and minor stoppage (4.11%), reduced speed losses (7.62%), rework losses (0.67%), and scrap losses (2.87%). We discover the highest contribution to the low OEE value is breakdown losses. In handling breakdown losses, we provide the information about the MTBF and MTTR are equal to 2313 minutes and 289 minutes, respectively. Furthermore, we also propose the company apply the 8 pillars of TPM and 5S to increase the effectiveness. Further research can be carried out towards the Predictive OEE to provide management and control with more insights on the status of the manufacturing [2]. The thing that should be bear in every researcher's mind is the OEE always necessitates accuracy in the collected data [14]. Reliable performance measurement is important to motivate and to sustain the organizations in increasing the competitiveness and profitability of their manufacturing operations [8]. Further study can discuss the feasibility study [30] or human resource motivation [31] in implementing TPM Master Plan training.

The feasibility study could examine the employees time consuming to study and the availability improvement after the training. The previous study also suggests considering the demand uncertainty factor [32] which could be combined with the feasibility study.

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