THE PDCA APPROACH WITH OEE METHODS FOR INCREASING PRODUCTIVITY IN THE GARMENT INDUSTRY

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ABSTRAK

Proses produksi industri garmen dengan produk kaos kaki pada suatu perusahaan seringkali mengalami kendala berupa penurunan produktivitas mesin. Hasil produksi masih belum dapat mencapai target produksi dan mengakibatkan terganggunya pengiriman ke pelanggan. Penelitian ini bertujuan untuk mengetahui penyebab utama yang mempengaruhi penurunan produksi dan memberikan solusi untuk meningkatkan produksi. Metode yang digunakan dalam penelitian ini adalah pendekatan Plan-Do-Check-Action (PDCA) dan metode Overall Equipment Effectiveness (OEE). Metode ini tepat dalam menganalisis peningkatan produksi dan mengukur efektivitas penggunaan peralatan dalam efisiensi produksi. Hasil dari penelitian ini dapat mengetahui penyebab utama yang mempengaruhi penurunan produksi dengan menggunakan Failure Models and Effects Analysis (FMEA), yaitu kecepatan standar berfluktuasi 336 RPN, kecepatan sedang 245 RPN, sloping creel 150 RPN, ruang mesin sempit 120 RPN, dan mesin kotor 72 RPN. Pengukuran efektivitas penggunaan peralatan ditinjau dari efisiensi produksi (OEE) sebelum perbaikan sebesar 63% dan setelah modifikasi sebesar 73%, artinya nilai OEE setelah perubahan mengalami peningkatan sebesar 8%. Hal ini dibuktikan dengan peningkatan output produksi rata-rata sebesar 112% per mesin/bulan.

***Kata Kunci**: Industri Garmen, Kaus Kaki, OEE, PDCA, Produktivitas.*

ABSTRACT

The production process of the garment industry with socks products in a company often has problems with a decrease in machine productivity. Production results still cannot reach the production target and result in disruption of delivery to customers. This study aims to determine the main causes that affect the decline in production and provide solutions to increase production. The method used in this research is the Plan-Do-Check-Action (PDCA) approach and the Overall Equipment Effectiveness (OEE) method. This method is appropriate for analyzing increased production and measuring the effectiveness of the use of equipment in production efficiency. The results of this study can determine the main causes that affect production decline using Failure Models and Effects Analysis (FMEA), namely, the standard speed fluctuates 336 RPN, medium speed 245 RPN, sloping creel 150 RPN, narrow engine room 120 RPN, and dirty engine 72 RPN. The measurement of the effectiveness of the use of equipment in terms of production efficiency (OEE) before the repair is 63% and after modification is 73%, meaning that the OEE value after the change has increased by 8%. This is evidenced by an increase in production output by 112% on an average per machine/month.

***Keywords**: Garment Industry, OEE, PDCA, Productivity, Socks.*

INTRODUCTION

The production process of the garment industry with socks products at PT Gunze Socks Indonesia (GSI) often occurs when machine productivity decreases. Production results still cannot reach the production target and result in disruption of delivery to customers. This study aims to determine the main causes that affect the decline in production and provide solutions to increase production. The method used in this study is the Plan Do Check Action (PDCA) and Overall Equipment Effectiveness (OEE) approach. One approach that can improve product quality is PDCA. The PDCA cycle is more than just a quality tool and a basic concept of continuous process improvement that is embedded in organizational culture. It is easy to understand and should be used by many people [1].

PDCA is an excellent model for the development function, as it can be adapted well for day-to-day management with individuals or teams. This model is often referred to in

business improvement in the change management process. It is very important to involve the people who carry out the development process [2]. The use of the PDCA approach and the application of the Small Group Activity (SGA) concept of eight steps of repair work to reduce the percentage of product defects [3]. Measurement of productivity in the production line can also be measured with the Objective Matrix (OMAX) in small to medium-scale manufacturing industries [4].

The new approach of this research is to use Focus Group Discussion (FGD) which is a collection of expert judgment of 5 members, to determine the value of project criteria in the Matrix diagram and risk analysis in the Failure Mode and Effects Analysis (FMEA) so that the Risk Priority Number (RPN) value is obtained according to the priority of the work. FGDs were also conducted to take 5W+2H corrective actions, the difference from other studies using only 5W+1H. In addition, this study emphasizes that all forms of improvement are consistently carried out by making SOPs for each improvement.

In general, it can be concluded that the PDCA cycle is a tool that facilitates the detection of opportunities for project improvement and development and provides the same implementation in lean manufacturing projects [4]. The PDCA is contained in a circle, and endless, allowing to consider all the implemented and applied solutions an indicator for further improvement activities [5]. Analysis of the causes of defects in p-tank and recommend countermeasures for the recurrence of p-tank defects in the assembly line of 4 divisions aluminum radiator using the PDCA method and 8 repair steps [6]. The Quality product improvement by solving product burr problems after leaving the product that comes out of the mold is of high quality with no burrs using the PDCA method in solving existing problems [7].

The use of recycled paper from cement bags (used paper) can reduce the production cost of fiber cement roofing, this research was conducted by [8]. Other research resulted in preliminary assessments in designing a complete stand-alone industrial facility using the PDCA method to manufacture injection molded parts for the automotive industry [9]. As evidenced by the implementation of Kaizen through step 8 PDCA to reduce line defects in the pasting process, by applying this method the company can minimize plate scrap by 38% compared to the plate scrap rate after repair, and the company can achieve the expected target [10]. OEE is a method that can increase productivity, and this can be measured by production activities carried out following applicable work standards [11]. The problem analysis that has been carried out using the OEE method concludes that the company must focus on improvement by increasing production scheduling and production performance of equipment/machinery and reducing product quality problems before production and during the production process [12].

Improving the bonding quality of shoes by using the Quality Control Circle (QCC) method which applies quality control tools such as check sheets, Pareto diagrams, fishbone diagrams, and 5W+1 H can reduce the expected defects. [13] [14]. The impact of torn belt problems, knowing the cause of torn conveyor belts and estimating the results of repairs from the cost side, and knowing the value of effectiveness, the right method is to use the OEE method and Fuzzy Failure Mode and Effects Analysis (FFMEA) [15]. Analyzing six major disadvantages of window film printing machines and applying FMEA and Total Productive Maintenance (TPM) methods which aim to increase the OEE value of window film printing machines [16] and Linear Acceleration (LINAC) machines in healthcare [17].

However, in this study, productivity improvement was carried out by applying the PDCA approach using several methods including Matrix diagrams, Pareto diagrams, Block diagrams, Fishbone diagrams, FMEA, and finally calculating OEE. This research is almost the same as other research, namely using the PDCA approach [3] [18] [6]. The difference in this study does not describe the 8 steps in the improvement but is more conceptualized into

the PDCA cycle so that the improvement is more sustainable. To find out the productivity that occurs, this research uses the OEE method which is part of the TPM, this research method is also almost the same as other research [19] [12] [20]. The OEE method is combined with FFMEA as a quantitative study [15], in this study the OEE method is combined with FMEA which is the result of the FGD.

RESEARCH METHODS

The material used in this research is a collection of several threads that undergo a knitting process to become a sock product. The composition of the material used is from several color threads consisting of a composition of yarn composed of 60% Acrylic Cotton, 30% Spandex, and 10% Nylon. The machine tool used in this research is a double Knitting socks machine with the Nagata D210 brand made in Japan with a total of 20 machines. The internal standard for counting socks in this company is 1 deca = 10 pairs.

Based on the phenomena described, this research uses the most appropriate type of research is mixed methods research which combines quantitative research methods and qualitative research methods to be used together [21]. The research framework can be seen in Figure 1.

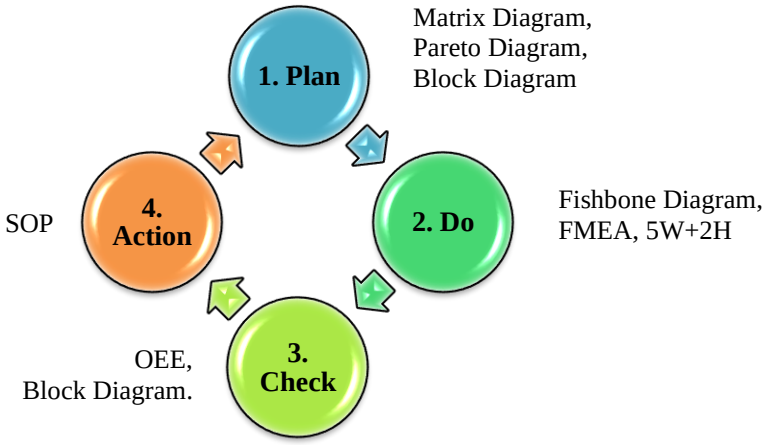


Figure 1. Research Framework [22]

Based on Figure 1, qualitative research is the Fishbone diagram and 5W+2H, while others are included in quantitative research. The steps of this research use the PDCA phase approach, and each phase of the process uses the appropriate method in the steps to take productivity measures. Data analysis techniques on the method of Matrix diagrams, Fishbone diagrams, FMEA, and 5W+2H using FGD with the number of expert judgments as many as 5 members. Data processing techniques for each stage used consist of:

Phase P – Plan

In this planning phase, research determines the productivity target of double socks. The knitting machine has determined the average productivity target of 305 deca/day, so management has set a target of a 105% increase. The methods used at this phase of the plan include:

A Matrix diagram is used to see the relationship between two or more factors. In selecting a project, the selection must be determined. Example project criteria are business benefit criteria and feasibility criteria. The scores used in this matrix diagram are a score of 9 (highly meeting the criteria), a score of 3 (there is a possibility of meeting the criteria), and a score of 1 (not meeting the criteria). It is done with FGD to get the project and work priority score [23].

A Pareto diagram is a bar graph that shows problems in order of the number of occurrences [24]. According to the Pareto diagram, a bar graph shows issues based on the

order of the number of events. The order starts from the number of problems that occur the most to those that occur the least. The graph shows the highest bar graph (far left) to the lowest chart (far right).

A Block diagram is a graph that compares multiple data categories, comparing two or more factors/items in a certain period. Each bar can reflect the calculation of a variety, a function (formula) of the category (such as the mean, sum, or standard deviation), or the sum of values from a table. In this study, there were reports before improving the production of double socks for two months.

Phase D – Do

This do phase of research aims to make quality improvements with several improvement methods, including determining the leading causes of root causes, prioritizing failure modes based on RPN, and creating a quality improvement plan. The methods used at this phase of the program include:

A Fishbone diagram is an analysis that is carried out by starting from the consequences or problems that arise and then in a structured way looking for possible causes. In general, six factors can cause deviations in business processes, namely 4M (Material, Method, Machine, Man) and 1E (Environment).

FMEA is an analysis of the organization that may decide that any RPN above 200 creates an unacceptable risk [25] [26]. FMEA is a priority failure mode based on the RPN, which is calculated by the product of the risk factor occurrence (Occ), severity (Sev), and detection (Det), which experts score with integers from 1 to 10. After there is an RPN value with the formula RPN = O x S x D, where O is the probability or frequency of failure, S is the seriousness (consequence) of failure, and D is the ability to detect failure before the impact the failure effect manifests.

5W+2H method is a structured method to generate ideas using a series of questions related to the problem or set goal. In this study, the data analysis method was obtained during the FGD in a meeting where the content of the meeting discussion determined 5W+2H with the results of mutual agreement.

Phase C – Check

This check phase research calculates the results of repairs using the OEE method and makes a Block diagram graph to compare before improvement and after improvement quickly.

The OEE method has a systematic calculation process to identify all productivity losses in streamlining resources and increasing production performance, the OEE method is also a comprehensive measurement of how well it performs within a given design capacity [11]. The operating conditions of the machine/production equipment will not be displayed accurately if it is only based on the calculation of one factor, such as performance efficiency. But the other six factors in the six significant new disadvantages are small downtimes calculated from the efficiency of the machine/equipment performance. The six factors in the six significant losses must be included in the OEE calculation. The actual condition of the machine/equipment can be seen accurately [12] during the OEE formula:

$$\text{Availability Ratio (\%)} = \frac{(\text{Processing Housr} - \text{Downtime})}{\text{Processing Hours}} \text{ x } 100\% \quad (1)$$

$$\text{Performance Efficiency (\%)} \frac{\text{CPO Produced}}{\text{Extraction Capacity}} x\ 100\% \quad (2)$$

$$\text{Quality Rate (\%)} = \frac{\text{Good CPO}}{\text{CPO Produced}} x\ 100\% \quad (3)$$

$$\text{OEE (\%)} = \text{Avability Ratio x Performance Efficiency x Quality Rate} \quad (4)$$

Block Diagram is a graph that compares multiple data categories, comparing two or more factors/items in a certain period. This block diagram aims to compare the results of OEE calculations, both before and after improvements.

Phase A – Action

Standard Operational Procedure (SOP) is the data analysis technique in this research is to document every action before and after the improvement of the SOP [27]. In this study, the conditions of the observations or revisions are recorded in SOPs, One Point Lesson (OPL), and Work Instructions (WI). This is done so that all forms of rules or instructions can be socialized among employees so that new employees will understand the procedures that already exist in the company.

RESULTS AND DISCUSSION

The FGD was conducted by the management team and 5 expert teams. The analysis was conducted to determine the main criteria in the improvement project (Matrix diagram), the real cause (Fishbone diagram), FMEA, and 5W+2H to make improvements. The following characteristics of experts can be seen in Table 1.

Phase P – Plan

At this planning stage, several findings were obtained by calculating the Matrix diagram before improvements were made. The findings also on the defects of Pareto diagrams and Block diagrams can be identified thoroughly. The results of processing the Matrix diagram data from the FGD meeting, then to get the priority of project work, the data is entered into Microsoft Excel, it will produce Table 2.

Table 1. Characteristics of Expert Judgment

	Age (years)	Work Experience (years)	Position	Special Skill	Remarks
Expert 1	52	18	Board of Director	Sustainability Development	Internal
Expert 2	49	23	General Manager	Lean Manufacturing	External
Expert 3	47	15	Production Manager	VSM, TPM, QCC	External
Expert 4	45	18	Maintenance Manager	TPM, OEE	External
Expert 5	42	13	Spesialis	PDCA, DMAIC, Kaizen	Consultan

Table 2. Matrix Diagram of Project Criteria

No	Project	Project Criteria							
		High Impact			Easy to Fix				
		Financial Advantage	Customer Satisfaction	Efficiency Up	Degree of difficulty	Success	Processing Fee	Total Score	Priority
1	Reduce Dirty Machine	3	3	3	3	9	9	30	2
2	Reduce Yarn Break	1	3	9	9	3	1	26	3
3	Reduce Complain	3	9	1	3	3	1	20	4
4	Over Production	1	1	3	1	3	3	12	5
5	Increase Productivity	9	9	9	9	9	9	54	1

After determining the matrix diagram to determine the priority of improvement, the next step is to create a Pareto chart. For details, see Figure 2.

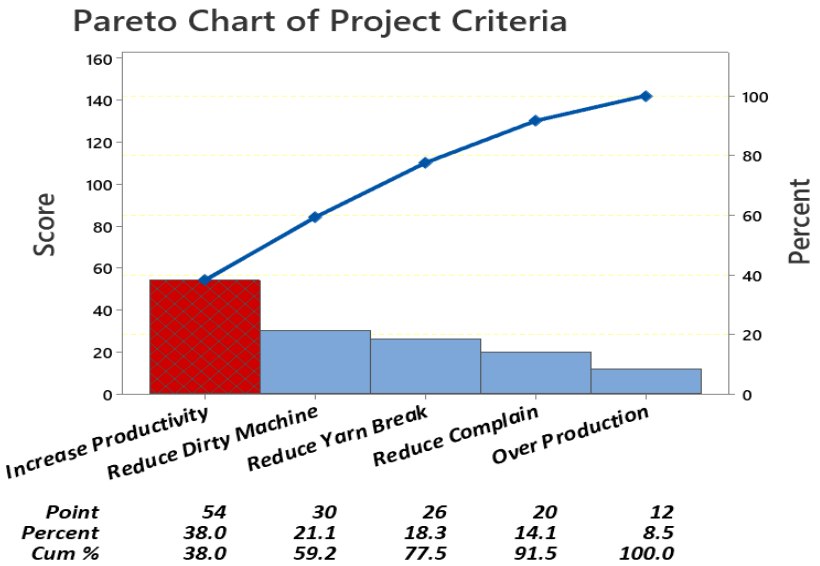


Figure 2. Project Criteria

Figure 2 shows that the Increase Productivity project is the most Pareto project or problem. After knowing that there is a problem with decreasing productivity, the next step can make a Block diagram. The next step is to check the production of the Knitting machine for a month or a day. For more details, see Figure 3.

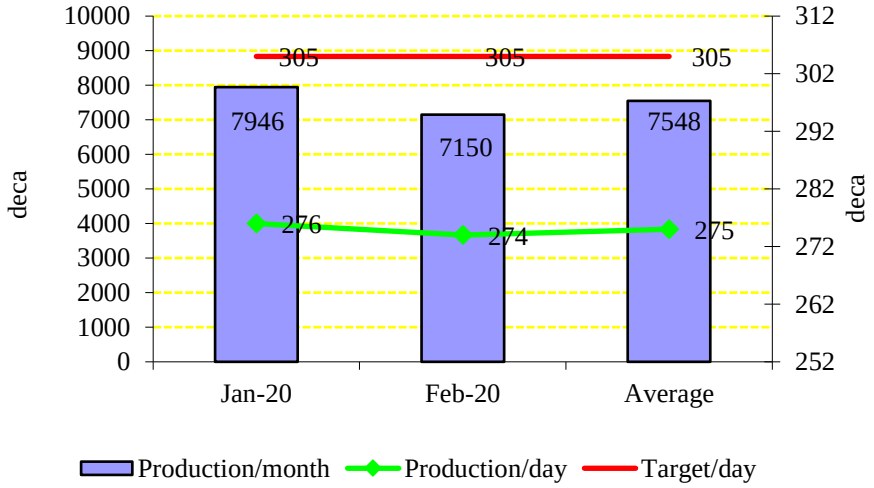


Figure 3. Production Results of Double Type Knitting Before Improvement

Figure 3 shows that the average production/day of 275 deca is far from the target of 305 deca, so management has set a target of a 105% increase.

Phase D – Do

We have used several methods to find the leading cause at this do phase, analyze the risk value, and plan corrective actions for defects. The results can be explained in several methods:

Based on the results of Fishbone diagram meetings with operators and leaders using brainstorming and why-why analysis, the main factors causing the root of the problem were obtained. The next step from the results of the Fishbone diagram is to use Microsoft Visio software, and it will look like Figure 4.

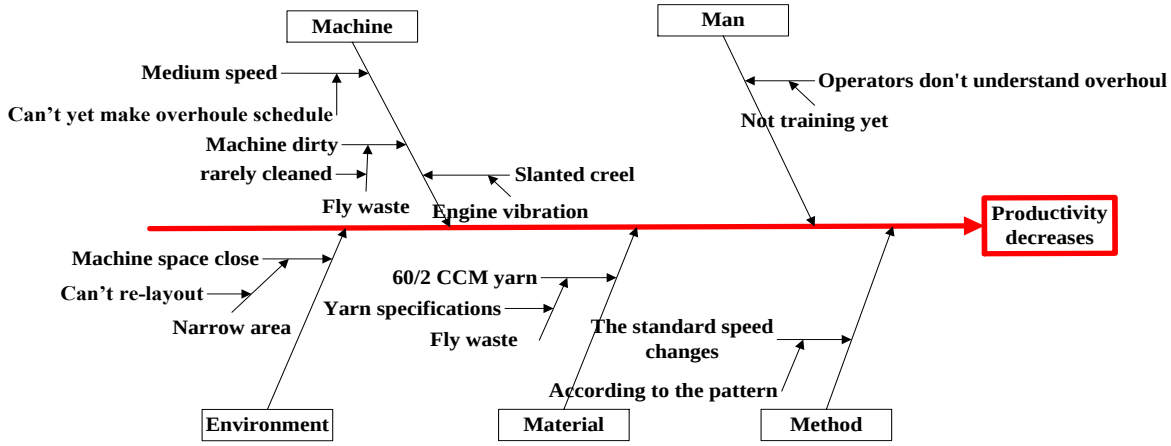


Figure 4. Fishbone Diagram of Productivity Decreases

Based on the FMEA meeting results in the FGD activity, which consisted of 5 members (expert judgments) from the Leader specialist level to the Director who had the capacity as an expert judgment in determining FMEA scores. Several factors that cause the decline in production productivity using a causal diagram and the FMEA method so that corrective steps can be taken [28]. The results can be seen in Table 3.

Table 3. FMEA Analysis of Productivity Decreases

Potential Failure Mode	Sev	Potential Failure Effects	Occ	Potential Cause of Failure	Det	RPN	Rank
Medium speed	5	Production down	7	It can't yet make a schedule overhaul	7	245	2
Machine dirty	4	Machine stop	6	The amount of fly waste	3	72	5
Slanted creel	6	Yarn break	5	Machine vibration	5	150	3
Machine space close	5	Ineffective	6	Narrow area	4	120	4
The standard speed changes	6	Production down	7	According to the pattern	8	336	1

Table 4. Determine 5W+2H for Planning Improvement

No	What	Why	How	Who	When	Where	How Much
	What is the problem?	Why should it be dealt with?	How to deal with it?	Who is in charge?	When will it be implemented?	Where is it carried out?	How much will it cost
1	The standard speed changes	Production will drop	Set speed 9 = 250 rpm (RIB style)	Edys	March 23, 2020	R&D computer	-
2	Medium speed	Production will drop	Make a schedule overhaul	Firman	April 1, 2020	Machine double Knitting	Rp 5,650,000
3	Slanted creel	Stuck threads often break	Resetting slanted creel	Herpriyatna	April 15, 2020	Machine back area	-
4	Machine space close	It's not effective to change the basket often	Setting space between machines 72cm	Warsito	April 26, 2020	Machine double Knitting	Rp 3,000,000
5	Machine dirty	Clog, and the machine will stop	Make a machine cleaning schedule	Mindoro	April 28, 2020	Machine double Knitting	-

Table 3 shows that the highest value of the RPN results is the main priority for improvement. there are 5 main causes of problems or obstacles to the decrease in socks production, based on the results of the FGD meeting by expert judgments. After determining the FMEA, the 5W+2H meeting was continued by selecting a plan to increase productivity on the double knitting machine with several contributing factors. Productivity improvement techniques and corrective actions can be seen in Table 4.

Table 4 shows that all the main causes of the problem of declining productivity can be seen in what kind of action must be followed up, and the PIC and the time for processing it can also be determined. The remedial action above requires a repair fee of Rp 8,650,000, but

the cost proposal has been approved by the management. The details of the costs incurred consist of overtime costs for technicians and operators during machine overhaul of Rp 5,650,000 per 3 months per machine and overtime costs for technicians to shift machines or machine re-layout according to the repair plan that has been carried out amounting to Rp 3,000,000 per 3 months per machine. Increasing the capacity of supporting machines requires high costs so the management expects a comprehensive and comprehensive feasibility study that calculates supply chain costs and actual productivity [29].

Phase C – Check

After getting the improvement plan, the next step is to carry out an OEE by collecting supporting data in OEE data processing and Block diagram. The results of data processing using Microsoft Excel show that: Below is a table where the data is obtained from production results, and other data entered into Microsoft Excel. More details can be seen in Table 5.

Table 5. Comparison of OEE Calculation Results

No	Parameters	Before Improvement			After Improvement			Remarks
		Jan 2020	Feb 2020	Average Before	Mei 2020	Jun 2020	Average After	
1	Processing hours (hours)	696	624	660	600	720	660	
2	Downtime (hours)	76	67	72	35	39	37	
3	CPO produced (deca)	7,946	7,548	7,747	7,650	9,330	8,490	
4	Net Processing hours	620	557	589	565	681	623	
5	Installed capacity (deca/hour)	16	16	16	16	16	16	
6	Production capacity (deca)	9,920	8,912	9,424	9,040	10,896	9,968	
7	Extraction capacity (deca)	10,912	9,803	10,366	9,944	11,985	10,965	
8	Target Oil Extraction Rate (%)	10	10	10	10	10	10	
9	Good CPO (deca)	7,561	7,293	7,427	7,562	9,286	8,424	
10	Availability Ratio (%)	89	89	89	94	95	95	(1)
11	Performance Efficiency (%)	72	77	75	77	78	78	(2)
12	Quality Rate (%)	95	99	97	99	99	99	(3)
13	OEE (%)	61	68	65	72	73	73	(4)

Table 5 shows that to calculate OEE, it is necessary to know the Availability Ratio, Performance Efficiency, and Quality rate. The next step is to make a graph with a bar chart. The aim is to compare the results of OEE calculations, both before and after improvement. More details can be seen in Figure 5.

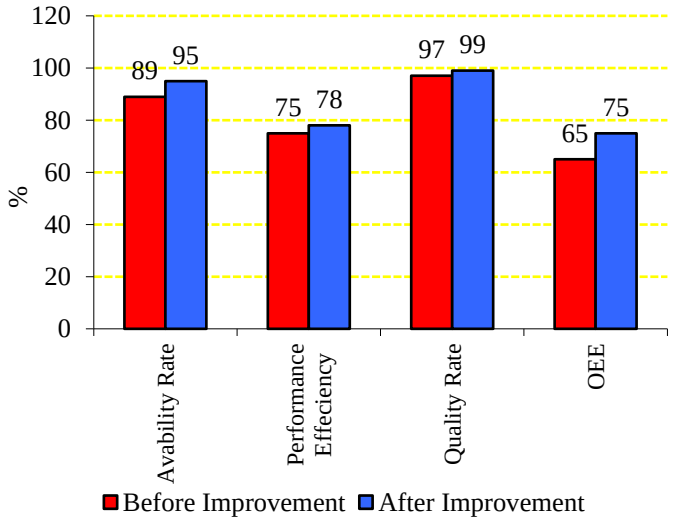


Figure 5. OEE Calculation Results Before and After Improvement

Figure 5 shows that the Availability Ratio after improvement is 95%. In comparison, the target is 90%, Performance Efficiency after the improvement is 78% while the target is 95%, Quality Rate after improvement is 99% while the target is 99%, and OEE after the improvement is 73% while 85% target. The OEE results in this study have not yet reached the mark due to the performance of this double Knitting machine in different conditions, so it needs more intensive handling or maintenance of the device. In terms of production every day, the average engine reaches an increase. For details, see Figure 6.

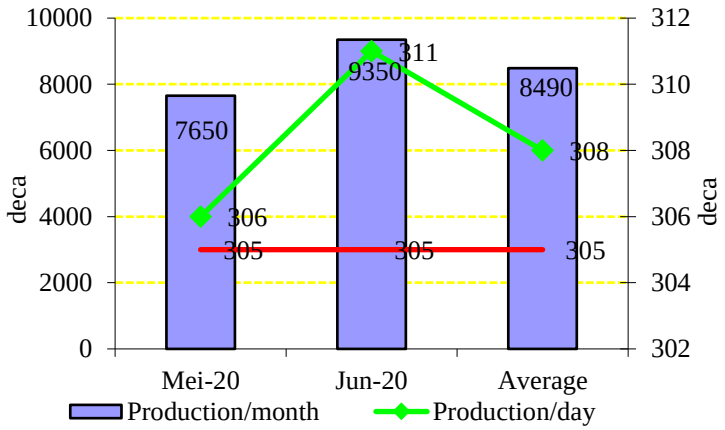


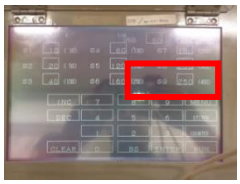
Figure 6. Production Results of Double Type Knitting After Improvement

Figure 6 shows that the average production/day of 309 deca/day exceeds the target of 305 de-ca/day, so getting an achievement of 112% or 34 deca/day, this achievement exceeds the original target of 110%. Meanwhile for the cal-culation of saving cost or efficiency = 34 deca/ day x 10 pairs/deka x 30 days/month x 0.8 $/pairs x 14,500 Rp/$ = Rp 118,320,000/month and Break Even Point (BEP) = 0 ,07 months = 2 days.

Phase A – Action

The SOP is socialized to all employees. The SOP is intended so that the employee can know and make corrective and consistent improvements. This becomes the basis for process control that can increase production. The SOP to increase the production in double Knitting Machines can be seen in Table 6.

Table 6. SOP for Increasing Productivity

No	Figure/information of the improvement	Remarks
1		Before improvement, speed varies for RIB style (S9 = 230 rpm) and after modification, is sped up for RIB style (S9 = 250 rpm). PIC is a Merchandiser and set up speed at the time of making new socks articles.
2	Schedule Overhaul (OH), three months/machine, PIC Technician + Operator	High speed due to: typical Tention Device (TD) sound, slider needle doesn't break often, middle jack doesn't break often, verge bit is stable.
3		Straight creel (Gomu's creel & Straight yarn, unbreakable yarn & no yarn snag/fall).

Continued Table 6. SOP for Increasing Productivity

No	Figure/information of the improvement	Remarks
4		Increased machines space, narrow engine spacing 70-75 cm, 20 horsepower basket capacity, reduced sock weighing and loss time.
5	Make a schedule of cleaning machine for every article and color change of socks.	Machines are maintained with a machine cleaning schedule: every article of socks and color change of socks, twice every week: smooth yarn and smooth socks.

CONCLUSION AND SUGGESTION

The conclusion that can be drawn from this research is that the results of this study can determine the leading causes that affect the decline in production using FMEA, namely the standard speed fluctuates by 336 RPN, moderate rate of 245 RPN, tilted creel of 150 RPN, tight engine space of 120 RPN and gross engine of 72 RPN.

The results of measuring the effectiveness of using equipment in terms of production efficiency or OEE before improvement are 63% and after improvement are 73%, meaning that the OEE value after improvement increases by 8%. This is evidenced by the rise in production output by 112% on average per machine per month. The theoretical implications of the results of this study are expected to provide an overview and information about the problem, the causes that occur, provide an alternative to increase production in socks in detail, and know the prevention of machine damage. The practical implications of the results of this study can be used as a reference for interested parties to research the same or similar problems.

Further research is suggested by Management to improve the production process that affects the efficiency and quality of products and is environmentally friendly so that the company gains profits by integrating the TPM method with Lean and Green Manufacturing.

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