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IMPROVING PRODUCTIVITY THROUGH EVALUATION AND IMPROVEMENT OF SETUP TIME ON PIPE LASER CUTTING MACHINE USING SINGLE MINUTE EXCHANGE OF DIE (SMED) METHOD

PENINGKATAN PRODUKTIVITAS MELALUI EVALUASI DAN PERBAIKAN WAKTU SETUP PADA MESIN LASER CUTTING PIPA MENGGUNAKAN PENDEKATAN METODE SINGLE MINUTE EXCHANGE OF DIE (SMED)

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ABSTRACT
This study aims to improve setup time efficiency on a pipe laser cutting machine using the Single Minute Exchange of Die (SMED) method. Initial identification includes an analysis of the machine setup time by taking into account the Rating Factor and operator allowance. The normal setup time is 2,936.64 seconds, with an operator rating factor of 0.14. The conversion from internal to external setup resulted in a 16% decrease in setup time, but the initial improvement was not significant. Through fishbone analysis, the factors causing the high setup time were identified, and improvement solutions were proposed for management, equipment, environment, materials, machines, and methods. The second improvement was made by replacing problematic bolts, resulting in a 30% decrease in setup time. The application of SMED proved to increase process time efficiency by 30%, potentially increasing the company's productivity in pipe machining.
Keywords:Manufacture, Productivity Conversion Set Up, SMED Method

ABSTRAK
Penelitian ini bertujuan meningkatkan efisiensi waktu setup pada mesin laser cutting pipa melalui metode Single Minute Exchange of Die (SMED). Identifikasi awal mencakup analisis waktu persiapan mesin dengan memperhitungkan Faktor Rating dan allowance operator. Waktu normal untuk persiapan adalah 2.936,64 detik, dengan faktor rating operator sebesar 0,14. Konversi dari setup internal ke eksternal menghasilkan penurunan waktu setup sebesar 16%, namun perbaikan pertama belum signifikan. Melalui analisis fishbone, faktor-faktor penyebab tingginya waktu setup diidentifikasi, dan solusi perbaikan diajukan untuk manajemen, peralatan, lingkungan, material, mesin, dan metode. Perbaikan kedua dilakukan dengan mengganti baut yang bermasalah, menyebabkan penurunan waktu setup sebesar 30%. Penerapan SMED membuktikan peningkatan efisiensi waktu proses sebesar 30%, berpotensi meningkatkan produktivitas perusahaan dalam pengerjaan pipa.
Kata-kata kunci: Manufacture, Produktivitas Konversi Set Up, Metode SMED

1. INTRODUCTION

Every company is faced with the challenge of providing services that meet customer demands, with the primary goal of achieving customer satisfaction. Customer expectations focus on timely delivery according to established schedules, an aspect that is also a priority for manufacturing companies with high production levels. As the number of customers increases, speed of service becomes increasingly important, and companies need to consider various factors that can affect customer satisfaction.influencetheir productivity. Some key factors that play a significant role in this are timeset-up, process time, machine conditions, and other elements. In particular, the timeset-up and process time have a major impact on the product manufacturing cycle. To increase service speed, companies are required to be effective in minimizing lead time.set-upand processing time. This way, companies can meet customer demands more efficiently, achieve customer satisfaction, and simultaneously increase their productivity.

Currently, the automotive industry is experiencing rapid growth along with increasing consumer demand.accecoriesAutomotive companies, such as PT. Laksana Tekhnik Makmur, face significant challenges in meeting fluctuating market demand with diverse product specifications. Consumers tend to be discerning in their product selection, prioritizing size, shape, and color according to their preferences. Manufacturing companies, including PT. Laksana Tekhnik Makmur, must be able to create product variety to remain competitive. This increase in product variety impacts changes in the specifications of the production machines used. Machine setup processes become more frequent when facing the challenge of increasing product variety. Changes in product color, size, or shape add complexity to the production process and require frequent replacement of machine components to meet these demands. This results in increased production time compared to normal.

Production process effectiveness becomes difficult to achieve, primarily due to the frequency and length of machine setup times required. Companies, including those focused on efforts to reduce machine setup time. Currently, machine setup times reach 30 minutes, which is not in line with the increasing consumer demand. The long setup time results in many component parts being unmanufactured. Therefore, the target in this study is to reduce setup time by 30% to 50%, with the hope of reducing the number of component parts being unmanufactured. This is expected to increase machine production capacity and overcome the resulting problems. In the literature, the rapid growth of the automotive industry and increasing consumer demand have been highlighted, underscoring the importance of responding to diverse consumer needs in achieving competitive advantage. Increasing consumer demand in the automotive industry emphasizes the need for adaptation and efficiency in the production process. The concept of product variety complexity and its impact on changes in machine specifications. Increased product variety can cause challenges in the production process, including more frequent machine setup changes.

The SMED method is an effective approach in reducing machine setup time. SMED can reduce setup time to one minute or less, with a positive impact on production flexibility and efficiency. The successful implementation of SMED in the manufacturing industry, especially in addressing changes in product specifications and increasing productivity. The application of SMED is also associated with labor reduction, increased production time efficiency, and reduced production costs. The positive impact of setup time reduction on production efficiency. Setup time reduction has been shown to increase productivity and optimize resource use. The implementation of SMED can involve challenges, but Febianti provides insight into strategies to overcome these obstacles. This provides a valuable perspective to understand the critical factors that need to be considered during SMED implementation. The need for performance evaluation after SMED implementation. This study provides insight into success metrics that can be used to measure the impact of SMED implementation.

2. METHOD

Method SMED (Single Minute of Exchange Die), considered a highly relevant approach, has become an effective solution in reducing machine setup time. The implementation of the SMED method has proven effective in reducing setup time, as well as providing additional benefits such as reduced labor, increased production time efficiency, reduced production costs, and elimination of potential errors during machine setup.

SMED, stands forSingle-Minute Exchange of Die, stems from problems that arise in production activities where each machine requires a setup process, whether for running production for the first time or for changes in production. Before the SMED concept emerged, the time required for set-up was very long, which in the end is not economical for the company because it can cause bottlenecks which resulted in production losses. In the period 1950-1969 in Japan, Shigeo Shingo came up with the concept of SMED after reflecting on the challenges in overcoming bottlenecks on car bodymolding presses, particularly regarding the length of changeover times. Shingo, after consulting with various companies including Toyota, identified that bottleneck This is due to time change over, especially on large production.Lot sizeeconomically calculated based on the comparison between production time and delivery time change over, where the time required to stop production of one product and start production of the next is considered equally important. If the changeover time is too long, it will cause production losses and significantly increase production costs. Therefore, SMED is proposed to address this problem by reducing setup times to one minute or less for more efficient and economical production.

The SMED method consists of three stages which are described as follows:

1. First Stage: DifferentiatingSetUp Internal And SetUp External

a. Using the Checklist (Checklist): Prepare a checklist that includes steps to setup internal and external setup.

b. Checking Machine Performance and Function: Evaluate machine performance when it is not operating.(setup internal).

c. Improve the Work System andPart-partOthers: Identify and improve work systems and other components that affect time.setup.

2. Step Two: ConvertingSetUp Internal become External Setup

a. Preparing Good Operational Conditions: Ensure that the operational conditions of the machine and the working environment support the external setup.

b. Perform Function Standardization: Standardize the steps and functions that can be changed from setup internal to the external setup to produce a 30%-50% reduction in setup time.

3. Stage Three: Improving All Aspects of OperationsSetUp

a. Involves a thorough analysis of each of the previous basic operations.

b. Standardization efforts are made to streamline basic procedures in operations.setup internal And external.

c. Focus on improving all aspects that can affect timesetup, identifying and addressing factors that may slow down the process.

These three stages form a systematic approach to redesigning and improving the efficiency of the machine setup process, with the primary goal of reducing setup time and increasing productivity. The first stage identifies the differences between internal and external setups, and the second stage focuses on converting setup internal to external, and the third stage improves critical aspects of the setup operation.

3. RESULTS AND DISCUSSION

Before performing operations on the laser machinecuttingPipe, the initial step taken is to carry out the preparation process. Previous researchers have observed and recorded the time required for each stage of laser machine preparation.cuttingpipe. Observations were conducted five times for each preparation stage, and the observation data are presented in Table 1. The following is the average time recorded for each preparation stage, based on five observations:

Table 1
IdentificationInternal / External Setup

No	Activity	Place	Time(s)	Internal Setup	External Setup
1	Checking Machine Cleanliness	Machine	46	✔	
2	CheckingChain Cable And Cable Duct	Machine	120	✔	
3	Checking for water leaks	Machine	78	✔	
4	Checking for Air Leaks	Machine	76	✔	
5	Checking for Oil Leaks	Machine	73	✔	
6	CheckingSledding Machine	Machine	96	✔	
7	CheckingOil Lubricant	Machine	108	✔	
8	Checking Engine Sound	Machine	120	✔	
9	Checking the Lens andNozzel	Machine	92	✔	
10	CheckingControl Panel	Machine	87	✔	
11	Checking the Air Regulator	Machine	90	✔	
12	Taking Nitrogen Gas	Storage Gas	120	✔	
13	Nitrogen Gas Replacement	Machine	120	✔	
14	Taking Oxygen Gas	Storage Gas	60	✔	
15	Oxygen Gas Replacement	Machine	60	✔	
16	Pipe Material Selection and Selection	Pipe Rack	180	✔	
17	Installation of Pipe Materials	Machine	90	✔	
18	Setting Model	Machine	960	✔	
Total Time			2.576		

Taking the above preparation data into account, the standard time can be calculated by taking the Rating Factor into account. The Rating Factor table can be found in Table 1. Therefore, the normal time for the preparation can be calculated as follows:

$$Wn = Ws \times (1 + Rf)$$
$$= 2.576 \times 1,14$$
$$= 2.936,64$$

Table 2
Determination Rating Factor for Operators Set up

No	Factor	Class/Emblem	Mark
1	Skills(skill)	Good Skill (C1)	+0,06
2	Business (effort)	Good Effort	+0,05
3	Condition (condition)	Good (C)	+0,02
4	Consistent (consistency)	Good (C)	+0,01
Total			0,14

Tolerance size (allowance) operators on the machine can be seen in Table 3.

Table 3.
Determination of Standard Machine Operator Allowance

No	Factor	Class	Allowance %
1	Operator's Personal Needs	Man	1,8
2	Energy Expended (Male)	Currently	8,0
3	Work Attitude	Standing on two feet	2,0
4	Work Movement	Normal	0,0
5	Eye Fatigue	Discontinuous view	3,0
6	Workplace temperature conditions	Normal	2,5
7	Atmospheric Conditions	Enough	1,5
8	Good environmental conditions	Quite Noisy	1,5
Total			18,5

Therefore, the standard time for processing setup is:

Wb = Wn x (1+ All)
= 2.936,64 x 1,185
= 5,432.78 seconds
= 90 Minutes

Table 4
Conversions Internal Become External Setup

No	Activity	Place	Time(s)	Internal Setup	External Setup
1	Checking Machine Cleanliness	Machine	46	✔	
2	Checking Chain Cable And Cable Duct	Machine	120	✔	
3	Checking for water leaks	Machine	78		✔
4	Checking for Air Leaks	Machine	76		✔
5	Checking for Oil Leaks	Machine	73		✔
6	CheckingSledding Machine	Machine	96	✔	
7	Checking Oil Lubricant	Machine	108	✔	
8	Checking Engine Sound	Machine	120	✔	
9	Checking the Lens and Nozzle	Machine	92	✔	
10	CheckingControl Panel	Machine	87	✔	
11	Checking the Air Regulator	Machine	90	✔	
12	Taking Nitrogen Gas	Storage Gas	120		✔
13	Nitrogen Gas Installation	Machine	120	✔	
14	Taking Oxygen Gas	Storage Gas	60		✔
15	Oxygen Gas Replacement	Machine	60	✔	
16	Pipe Material Selection and Selection	Pipe Rack	180	✔	
17	Installation of Pipe Materials	Machine	90	✔	
18	Setting Model	Machine	960	✔	
Total Time			2.576	2.169	407

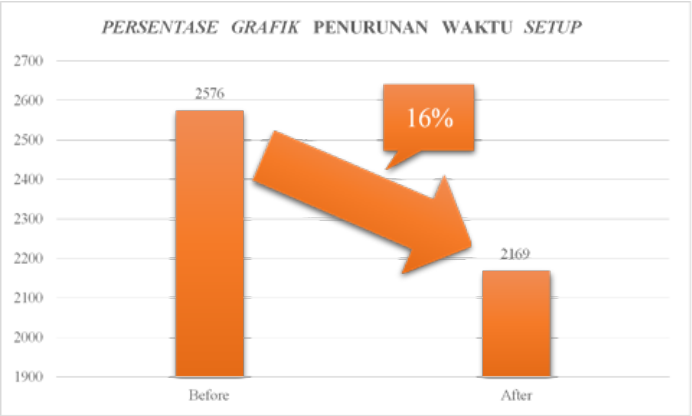

Figure 1
Percentage GraphTime Decrease Setup

From the processinternal conversionthe externalin the preparation, there is a reduction in timesetup from 2,576 seconds to 2,169 seconds.Graphicstime decreasesetup can be found in Figure 1. Fromgraphit can be seen that the timesetup experienced a decrease of 16%.

The results of the suggested improvements turned out to have an insignificant difference from the standard time set by the company. This was caused by a number of operator tasks in setup Time-consuming machines, as well as suboptimal equipment use by operators. This situation can be further improved by reducing operator time and increasing equipment efficiency, through improvements in various aspects of operations.setup.

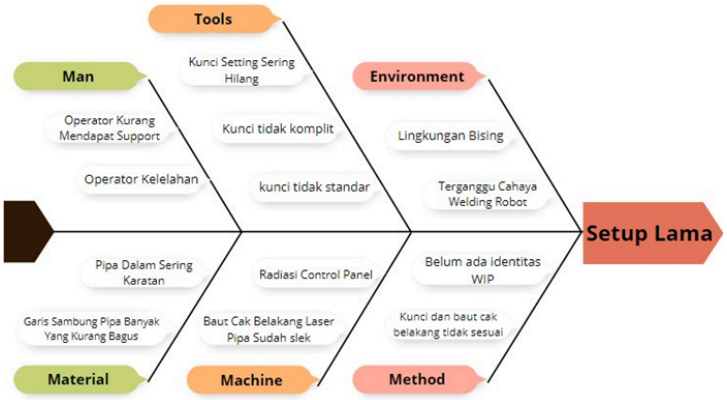

Figure 2 Diagram fishbone

By referring to the diagram fishbone In Figure 2 above, several factors contribute to high preparation times on production machines. These factors include:

Table 5
Details and Solutions

Factor	Condition	Solution
Man	Lack of implementation of 5R	Hold socialization and training sessions on the importance and how to implement 5R to operators. Use concrete examples of the benefits that can be gained through implementing 5R.
Tools	Incomplete setting equipment Setting equipment is often lost	Create a good record keeping system for each machine setting equipment. Use clear labeling on each setting tool to facilitate identification and checking availability.
Environment	UV light from the Control Panel monitor is irritating to the eyes.	Install filter anti-UV on the monitorControl Panel to reduce light exposureUV to the eyes This filter can help filter out most of the rays.UV which is emitted by the monitor.
Material	Imprecision of the basic material of the pipe connection Many of the inner pipes are rusty	Conduct a quality audit on the pipe materials provided by suppliers. Do your research and evaluation to suppliers to ensure their compliance with standard quality. Manage materials well to avoid storing materials for long periods before use. Prioritize the use of existing materials to avoid waste and accumulation.
Machine	Rear bolt of laser machinecutting Some of the pipes are leaking and some of the bolts are missing	Routine Inspection and Replacement: Perform regular checks on the bolts on the rear of the engine. Set a regular replacement schedule to prevent the possibility of loose or missing bolts. Bolt Documentation and Identification: Create documentation of the type, size, and number of bolts used on the rear axle of the machine. Identify each bolt clearly so you can easily find and replace it if necessary.
Method	The use of non-standard key tools during the setting process causes an increase in time.setup required.	Ensure that all employees involved in the setup process know to use the assigned key tool and not change it for setup on another machine. Monitor the use of the key tool during the setting process.

Factor	Condition	Solution
	There has been no identification of work in progress(WIP) in the pipe laser cutting process.	Evaluate whether the established key tools have been

Suggestions for replacing problematic L-type bolts measuring M6 x 25, M6 x 80, and bolt locksdouble thread on the machinelaser cutting pipe.

Image. 3 Build L Uk. M6x25

Figure 4: L-bolt, size M6x80

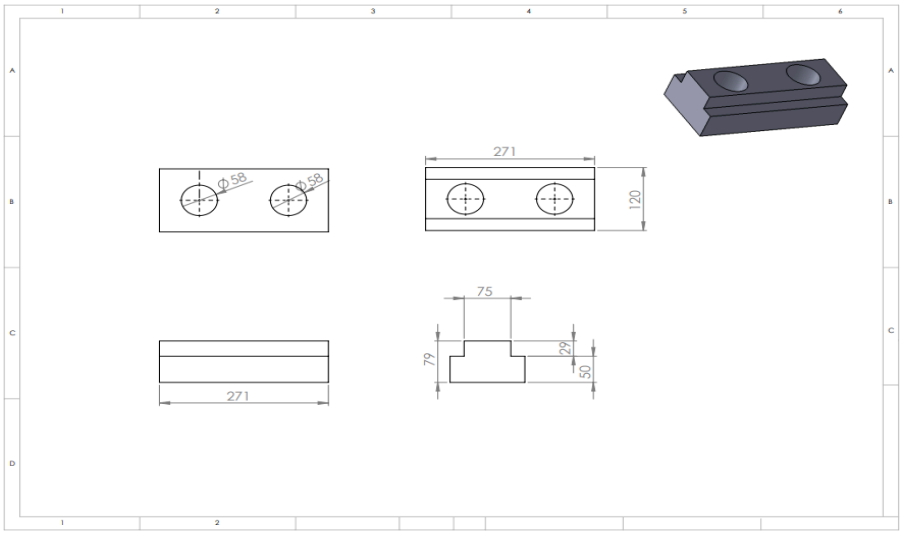

Figure 5. Bolt lockdouble thread

Table 6
Conversion internal & external setup2nd fix

No	Activity	Place	Time(s)	Internal Setup	External Setup	Description of Changes
1	Checking Machine Cleanliness	Machine	46	✔		
2	CheckingChain Cable And Cable Duct	Machine	120	✔		
3	Checking for water leaks	Machine	78		✔	Done while the operator is checking the machine on the other side
4	Checking for Air Leaks	Machine	76		✔	
5	Checking for Oil Leaks	Machine	73		✔	
6	Checking the Machine Sliding	Machine	96	✔		
7	CheckingOil Lubricant	Machine	108	✔		
8	Checking Engine Sound	Machine	120	✔		
9	Checking the Lens andNozzel	Machine	92	✔		
10	CheckingContro l Panel	Machine	87	✔		
11	Checking the Air Regulator	Machine	90	✔		
12	Taking Nitrogen Gas	Storage Gas	120		✔	It is done when the operator checks the engine sound andsetting model size
13	Nitrogen Gas Installation	Machine	120		✔	
14	Taking Oxygen Gas	Storage Gas	60		✔	
15	Oxygen Gas Replacement	Machine	60		✔	
16	Pipe Material Selection and Selection	Pipe Rack	180		✔	

No	Activity	Place	Time(s)	Internal Setup	External Setup	Description of Changes
17	Installation of Pipe Materials	Machine	90	✔		
18	Setting Model	Machine	960	✔		
Total Time			2.576	1809	767	

Decline percentage time setup laser cuttingThe pipe after the second repair can be seen in Figure 6.

Figure 6
PercentageTime DecreaseSetup Laser Cutting Pipe

4. CONCLUSION

Based on the analysis of time improvement setup on the machinelaser cutting pipes by applying the SMED method, the results show an increase in the speed of timesetup. With timesetup which is more efficient, the processing time on the machine can be minimized, so that the machine's laser cutting pipe is increased. Here are the overall results of the time improvement setup on the machinelaser cutting pipe by changing timesetup internal become external setup:

Table 7
Summary of Results Conversion Setup

Machine	Before	After	Percentage
Laser Cutting Pippa	2.576	1.809	30%

From the data that has been presented, it can be seen that the reduction in timesetup on the machinelaser cutting the pipe is very significant. This reduction in setup time has the potential to have a positive impact on processing time on the machine.laser cutting pipes, making the process time more efficient and faster.

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