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Implementation of the design thinking process approach to improve the crimping production work system: case study in one of the lathe workshop industries

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ABSTRACT
Fulfillment of orders for a product in the lathe industry often misses the processing deadline because the production process time is not well measured. One of the products produced by a lathe is crimping, this product often takes a long production process until 23.80 working hours. The purpose of this research is to identify the problems that cause the standard time for the crimping process to be high and provide the best solution for companies to reduce the standard time for the crimping production process. This research method uses the Design Thinking Process (DTP) which is divided into 5 stages, including Empathize, Define, Ideate, Prototype, and Test also called the EDIPT stage. The application of the EDIPT method also uses several methods or improvement tools. The improvements that have been made by the company are from the causes of methods, humans, and the environment. This research has resulted in a decrease in the standard time for the crimping process which originally obtained a processing time in 1 product of 1,428 minutes, while the standard time for the implementation of improvements was 1,375 minutes, so this research has succeeded in reducing the standard time in the crimping production process or reducing CSF by 3.71%.

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1. INTRODUCTION

Over time, after the world was hit by the COVID-19 pandemic, all manufacturing industries in Indonesia have started to improve [1]. The improvement of the manufacturing industry in Indonesia includes plans to fulfill requests for machine tools as spare parts for production machines [2]. However, in fulfilling orders for products produced by lathes, the deadline for the length of work is often missed because the production process time is not well measured, even though the deadline is the result of an agreement between the workshop and the customer [3]. A crimping product is a product that has a long production process and often misses the deadline [4]. The production process can take +3 working days for 1 product which includes milling¸ turning, hardening, welding, and threading processes [5].

This research was conducted at one of the industrial lathe workshops in the Yogyakarta area, Central Java, where most of the customers require machine tools for the automotive industry. The results of interviews with the company stated that the crimping production process often missed the deadline, which was 2 days longer. The measurement of the standard time for the crimping production process in current conditions or before improvements was 1,428 minutes or the equivalent of 23.80 working hours. The lathe workshop itself applies 7 working hours in 1 day so that in 1 week there are 6 working days. Therefore, the crimping production process can take approximately 3 working days. This is an obstacle in fulfilling customers so it is feared that customers will leave the company because they cannot fulfill the shipping process time to customers. One of the factors why customers cannot cooperate with suppliers is that they are too often late in deliveries that have been agreed upon by both parties [6]. The balance of delivery process time that has been mutually agreed upon according to customer needs can be called Just in Time (JIT) [7-8]. This JIT method cannot be carried out if the improvement does not involve a Kanban system or an Operational Process Map (OPM) improvement system [9], [10]. Meanwhile, this research is more directed at supporting the JIT method so that it runs well by creating talk time for each product and creating a new work design in the lathe process to produce crimping products on time.

The problem of not achieving the target time for the crimping production process is caused by many factors [11]. These problem factors are related to machines, methods, humans, and the environment. Machinery factors relate to production support tools, such as machinery and product measuring devices. The age of the machine in the lathe workshop is quite old so the machine is not able to operate optimally and other production support tools are limited [12]. The method factor relates to the work system in the turning workshop, the workshop does not yet have a work system design or Standard Operating Procedure (SOP) which results in the emergence of ineffective activities in the production process [1,13]. Factors that also affect this problem are the human factor associated with workers in the lathe workshop, work is often not thorough in measuring and calculating the number of products so rework activities occur [14-15]. Environmental factors relate to the work environment in the production area, especially noise [16]. The production area in the lathe workshop has a high noise intensity and exceeds the threshold value, which is an average intensity of 94 dBA. The noise is caused by the sound of machinery that is in operation so it can cause noise-induced deafness [17]. The environmental noise standard in the manufacturing industry has a minimum engine noise of 85 dBA [18].

Work system design is a principle and technique to achieve the best work system design and to create standardization of a system or method, calculate the standard time, and improve a system or method to support workers [19]. One of the tools in designing a work system is a work map which consists of 2 groups, namely local work maps and overall work maps. The local work map displays regular work activities in one workstation. This map has various types, namely left-hand and right-hand maps, as well as worker and machine maps [20]. The problem that arises is an imbalance in the production process of a product because it only burdens one process, namely the manufacturing industry process [21]. The implementation of the Design Thinking Process (DTP) in the manufacturing industry is very important to achieve the company's target of increasing production results [22]. At the same time, Design Thinking provides a solution-based approach to solving problems that occur. Well-thought design is a way of thinking and working and a set of straightforward methods. Design Thinking revolves around a deep interest in developing an understanding of the people for whom the product or service is being designed thereby helping in developing empathy with the target users [23]. Design Thinking is very useful in tackling unclear or unfamiliar problems, by reframing problems in human-centered ways, generating lots of ideas in brainstorming, and adopting a hands-on approach to prototyping and testing [24]. The DTP method used in designing wheelchairs for stroke patients is design thinking that focuses on humans, knowing user needs, and innovating according to user needs [25].

Various successful businesses in the world usually carry out the Critical Success Factor (CSF) identification process, the same as identifying how to improve process flow diagrams in the manufacturing industry, for example, the standard crimping time. CSF analysis is a method of analysis by considering several critical things in the corporate environment to define what factors influence the success and success of a company or organization and can be determined if the objectives of the organization have been identified [26]. One of the successes of research is to get a CSF value that is by the company's expectations so that productivity can increase [27].

This research will solve the problem through methods, and human and environmental factors. This is a motivation for writers to improve because these three factors are interrelated or influential and allow them to be implemented so that problems can be resolved. This is also the focus of improvement in this research on lathes with crimping production. This research cannot improve the crimping manufacturing process time so it is expected that the standard manufacturing time can be reduced so that it can reduce the CSF. CSF will be successful if, in the product manufacturing process, it can reduce production standard time by sampling 1 product in several trials [18]. The trial time for the process of making 1 product can be said to be talk time in the manufacturing industry, which is often found in sample production processes [28]. Other research in the automotive industry has conducted a design thinking process using the Just in Time method and the Kanban system [9]. Many of the automotive sectors conduct layout of the process operation map, it can even succeed in increasing its productivity by 25% [29].

This research's new approach to lathe production uses the Design Thinking Process (DTP) approach, which includes the implementation of the Empathize-Define-Ideate-Prototype-Test (EDIPT) improvement steps. Each repair step consists of several repair methods or tools combined sequentially. Several methods used include Focus Group Discussion (FGD), Inter Relationship Diagrams (IRD), OPM, and statistical tests at the data processing stage so that the improvement methodology will be structured and conceptualized. The purpose of this research is to identify the problems that cause the standard time for the crimping process to be high and provide the best solution for companies to reduce the standard time for the crimping production process. The contribution that can be obtained from this research for academic researchers is to train them to think critically and develop their knowledge regarding work system design in the same industry. The benefit of practice in the lathe workshop industry is that information is obtained that current working conditions can cause waste of activity and work time, and high noise can cause deafness due to noise. Apart from that, by implementing the design thought process, all stakeholders must be able to think about how to find the best solution to reduce the wastage of time in crimping on lathe machines.

2. MATERIALS AND METHODS

This research is a type of mixed-method research between qualitative and quantitative data. This type of qualitative research is based on the results of expert discussions at FGD meetings [30], IRD, and reference documents from previous studies. Quantitative research is based on numbers or observational and statistical values. Quantitative data was collected by measuring time 10 times both before and after improvements to crimping production. Data processing was carried out using statistical uniformity tests and data adequacy tests, and this research used Minitab 18 software to test data normality using the Kolmogorov-Smirnov normality test method. Then, to determine the CSP, first calculate the Cycle Time (CT), Normal Time (NT), and Standard Time (ST).

This study uses the DTP method which is divided into 5 stages, including Empathize, Define, Ideate, Prototype, and Test also called the EDIPT stage [31]. The stages of this research can be seen in Figure 1.

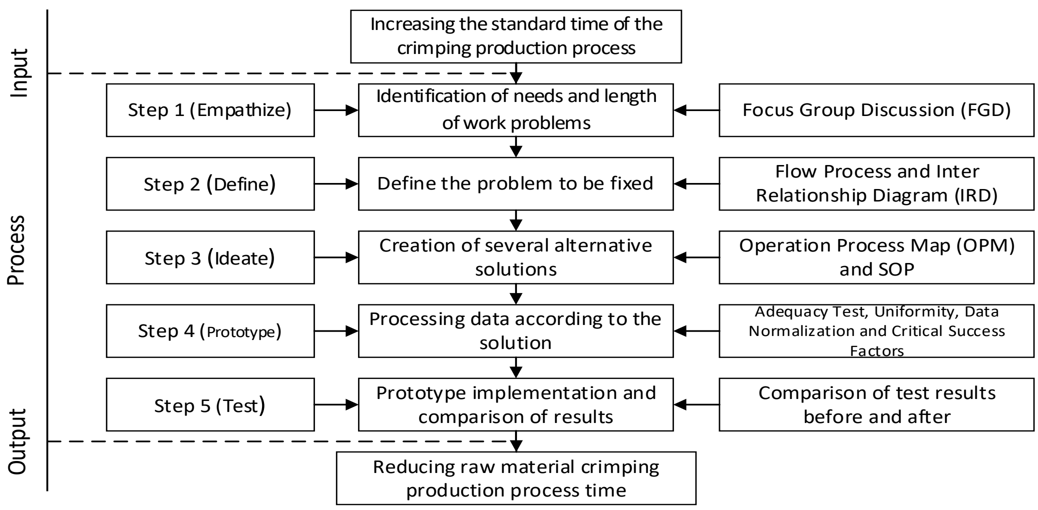

Figure 1. Research Framework

Based on Figure 1, the first stage in this research step is the Empathize stage, which determines the identification of needs and problems that have occurred so far using the role and participation of stakeholders through FGDs. The FGD members from the 5 expert judgments can be seen in Table 1.

Table 1. Member Focus Group Discussion (FGD)

Expert	Position	Age (years)	Experience (years)	Competency skill	Remarks
1	PPIC Manager	46	15	Cost down, Planning, Simulation, and Mapping operation	Internal
2	Production Manager	51	24	Lean Six Sigma, DMAIC, Design thinking, Mapping operation	Internal
3	Maintenance Manager	43	13	Machine learning, IOT, TPM, and OEE	Internal
4	Director	52	21	Cost down, HSE, Operational management	Internal
5	Machine Technician	48	17	Simulation, Machine learning, and Corrective action	Consultant

The second stage is the Define stage, where at this stage it determines the problem to be improved using the crimping manufacturing flow process on a lathe. Then these problems are identified using Inter Relationship Diagram (IRD) [32]. This IRD serves as a tool that identifies in detail the cause-and-effect relationships of a complex problem. Therefore, the use of the IRD instrument in this study serves to explain the cause-and-effect relationships of interrelated problems [33]. The problem in the lathe workshop is the length of time it takes to work on the production process so it often has an impact on fulfilling orders past the agreed deadline. The length of time to process an order is caused by the production process time which is not measured properly. Hence, the formulation of the problem in this research is about how to reduce the standard time for the crimping production process. The next stage, the third stage is called the Ideate stage, where at this stage an alternative solution is created that has been planned to fix the problem of increasing the standard time for the crimping production process. At this stage, the time measurement is also carried out 10 times either before improvement or after improvement. The measurement uses a stopwatch time measurement method and uses earplugs while production workers work in the machining area.

Furthermore, the fourth stage is the prototype stage, where the data that has been collected will be processed for several tests including uniformity tests and data adequacy tests. A data uniformity test is a technique of testing data to find out whether the data used is uniform or not [34]. The research data is said to be uniform if the average value of the subgroups is not outside the Upper Control Limit (UCL) and Lower Control Limit (LCL).

$$\text{Average Standard (AS)} = \frac{1}{n}\sum_{i-1}^{n} |Xi - X\dot{b}ar| \tag{1}$$

$$\text{UCL} = \text{Xbar} + \text{AS} \tag{2}$$

$$\text{LCL} = \text{Xbar} - \text{AS} \tag{3}$$

The normality test is a technique for testing statistical data to determine whether the data used is normally distributed or not. This study used the Minitab 18 software to test the normality of the data using the Kolmogorov-Smirnov normality test method. If the results of this test explain that the P-value is greater than 0.05 then the data is said to be normally distributed.

Next, do a data adequacy test to determine whether the amount of data collected is sufficient for the data requirements. Research method for data adequacy test [35]. Testing this data uses a 95% confidence level, so the value of k = 2, and the level of accuracy is 5%, so the value of s is 0.05.

$$N^1 = \left[\frac{\frac{K}{S}\sqrt{N\sum Xi^2 - (\sum Xi)^2}}{\sum Xi}\right]^2 \tag{4}$$

A known amount of data $\sum X$, squared amount $(\sum X)^2$, squared sum$\sum X^2$, level of confidence/accuracy $\frac{K}{S}$, the amount of data (N). If N[1] < N then the data is sufficient and vice versa.
Then determine the CSF by calculating the Cycle Time (CT), Normal Time (NT), and Standard Time (ST). Cycle Time (CT) is the time required to complete an activity process from start to finish. Cycle time is the time required by the operator to complete one job [35].

$$\mathrm{CT} = \frac{\sum \mathrm{X_i}}{\mathrm{N}} \tag{5}$$

Normal Time is the time required to complete an activity process under normal or reasonable circumstances. Normal time is the normal working time in a situation and the duration is according to the skill of the operator when completing a job [36]. The normal time can be found by calculating the adjustment factor (p). The method used for the adjustment factor is the Westinghouse method which consists of aspects of conditions, consistency, skill, and effort. This is because the Westinghouse method includes more detailed aspects of the assessment and each has its adjustment value [35].

$$NT = \mathrm{CT} \times \mathrm{p} \tag{6}$$

Standard Time (ST) is the actual time needed by the operator to complete a job. The standard time can be found by calculating the allowance factor (α). The leeway factor consists of 8 aspects, namely the energy expended, work attitude, work movement, eye fatigue, workplace temperature conditions, atmospheric conditions, good environmental conditions, and personal needs [36].

$$\mathrm{ST} = \mathrm{NT} \times (1 + \mathrm{a}) \tag{7}$$

The last research step is the Test stage, where at this stage it compares the results of the research before and after the improvement. The purpose of this test phase is to find out the success of the research that has been done by comparing the results of the research.

3. RESULTS

The results of this research can be presented in this section starting from the results of each stage of improvement to the discussion of each stage of research both before and after improvement.

3.1 Step 1 Emphasize

In this section, we will discuss the results of the FGD with expert judgment [37], starting from who the members of the FGD were, what was discussed at the meeting and what were the inputs from the FGD team in improving the standard time increase in the crimping process. The first stage in this research step is the Empathize stage, namely determining the identification of needs and problems that have occurred so far using the role and participation of stakeholders through FGD. The experts who took part in this forum were 5 experts internally from the company and externally from outside the company. This FGD discussed the operational map of the crimping process before repairs and Non-Value-Added (NVA) process parts that could be removed, proposals for improvements, and the creation of SOPs. Making a cause-and-effect analysis using the Inter Relationship Design (IRD) method and providing corrective steps for activities that allow the company to improve [32]. Re-creating the flow of the crimping production process and creating Standard Operational Procedures that have not been owned by the company so far. Apart from that, the FGD team also determined the allowance factor and the adjustment factor in the steps before and after the improvement.

3.2 Step 2 Define

The results at this stage to determine the problem are done by making a crimping production process flow before improvement. In the crimping production process, there are three main stages, namely bottle pelorus, manufacture of mild steel bottle crimping heads, and manufacture of bottle crimping bodies. Some of the derivative activities of the three main parts can be eliminated to save the flow of the crimping production process. The process flow before the improvement can be seen in Figure 2.

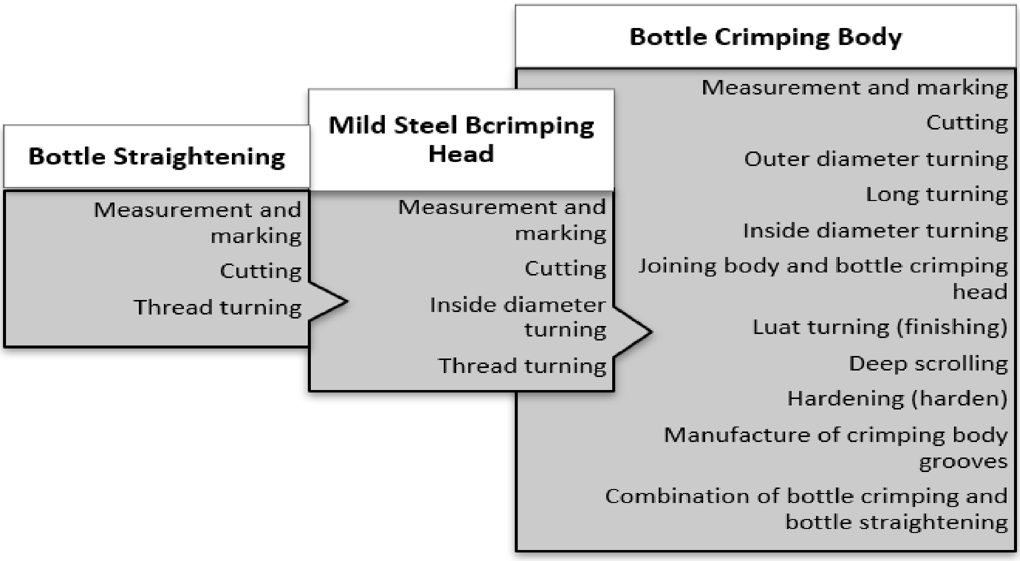

Figure 2. The flow of the crimping process before the improvement

Based on Figure 2, the researcher observed that several processes did not have added value because measuring, marking, and cutting were carried out twice. This is not effective because it can increase the time of the crimping production process. Any work that is repeated will not be effective, therefore there must be the elimination of the same work so that an effective and efficient processing time will be created [38]. Improvements consisting of measuring, marking, and cutting can be carried out at the beginning of the process when designing the crimping material settings on the lathe. New lathes can create patterns in machine settings, so that material does not need to go in and out of the machine tool.

The next step is to produce a causal diagram using the IRD method, where the problem starts from the activities below as the cause of the problem and the upward arrow direction is the result of the causes arising from the problem [32]. The causal diagram can be seen in Figure 3.

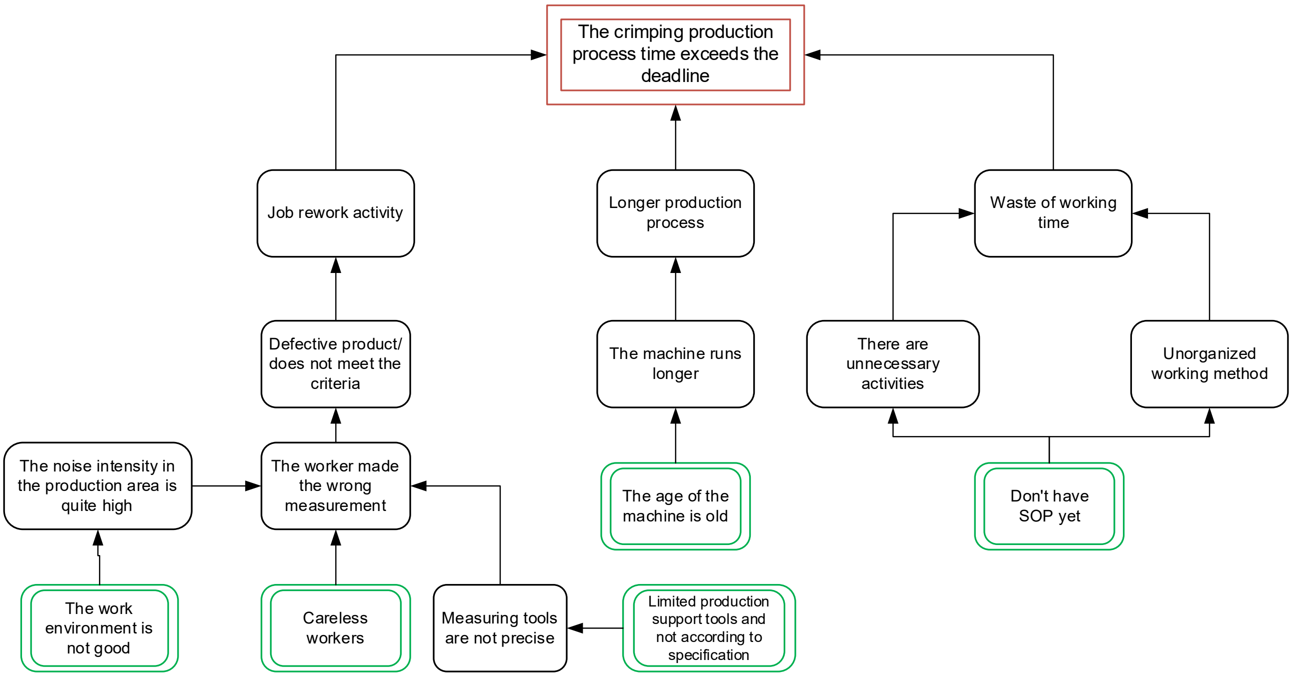

Figure 3. Inter Relationship Design Diagram

Based on Figure 3, the causes of the problems contained in the green line must be corrected immediately, but this research has limitations due to a conflict with company policy. The causes of the problem of increasing the standard time for the crimping process on lathes can be seen in Table 2.

Table 2. Results and Improvement Proposals from IRD

No	Cause of Problem	Improvement Steps	Completion Target	Status
1	Don't have SOP yet	Make SOP according to the results of the production process mapping trial	June 20, 2023	Closed
2	The age of the machine is old	Machine renewal proposal	July 1, 2024	Open
3	Limited production support tools and not according to specification	Inventory of equipment that does not comply with specifications and make improvement proposals	December 28, 2023	Open
4	Careless workers	Re-examination and supervision during the inspection and measurement process as well as providing training to workers related to SOP and safety	July 1, 2023	Closed
5	The work environment is not good	The noise is caused by the sound of machinery so production workers use earplugs to reduce noise	August 1, 2023	Closed

Based on Table 2, several improvements have open status because the company is still considering the proposal that the author has submitted to the company [39]. However, in the approval process, there are obstacles the company considers the investment policy of purchasing equipment, which of course must prepare a budget for the coming year.

3.3 Step 3 Ideate

The result of the research improvement at this stage is the design of a new work system using the Operation Process Map (OPM) using stopwatch equipment and the use of earplugs while production workers work in the machining area. The time for the process of making crimping on a lathe either before improvement or after improvement with the new process flow can be seen in Table 3.

Table 3. Operation Process Map Measurement

Activities	No	Before Improvement	Times (minutes)	No	After Improvement	Times (minutes)
Bottle straightener	1	Measurement and Marking	1.43			
	2	Cutting	3.15			
	3	Thread Turning	150.25	1	Thread Turning	150.20
Bottle Crimping Head Mild Steel	4	Measurement and Marking	2.80			
	5	Cutting	4.00			
	6	Outer Diameter Turning	25.30	2	Outer Diameter Turning	25.32
	7	Thread Turning	5.28	3	Thread Turning	6.12
Bottle Crimping Body VCN 150	8	Measurement and Marking	2.17			
	9	Cutting	4.20			
	10	Outer Diameter Turning	26.15	4	Outer Diameter Turning	25.15
	11	Long Turning	6.41	5	Long Turning	6.25
	12	Inside Diameter Turning	70.10	6	Inside Diameter Turning	68.44
	13	Joining Bodies and Bottle Crimping Heads	20.00	7	Joining Bodies and Bottle Crimping Heads	20.26
	14	External Turning (Finishing)	180.25	8	External Turning (Finishing)	180.30
	15	Deep Scrolling	60.50	9	Deep Scrolling	58.13
	16	Hardening	93.10	10	Hardening	90.48
	17	Manufacture of crimping body grooves	240.80	11	Manufacture of crimping body grooves	240.14
	18	Combination of Bottle Crimping and Bottle Straightener	3.45	12	Combination of Bottle Crimping and Bottle Straightener	4.00
Amount		18	899.75		12	876.65

Based on Table 3, the new or post-improvement process flow can reduce the number of crimping activities, which was originally 18 activities, to 12 activities. The crimping process time was reduced from

899.75 minutes to 876.65, meaning that there was a decrease in processing time of 23.10 minutes. The results of the improvement in the crimping manufacturing process time are presented in a Standard Operating Procedure (SOP) as a guideline for the crimping production work system can be seen in Figure 4.

Based on Figure 4, the new work order, work area, and person in charge of each activity must be able to carry out the SOP. SOP application consistently will improve the crimping process time on lathes. After the SOP is made and disseminated, the new operational map can be seen in Figure 5.

3.4 Step 4 Prototype

The results of this research stage are the results of measuring the operation process map carried out 10 times. The following results of the experimental data measurements that have been collected can be seen in Table 4.

STANDARD OPERATING PROCEDURE (SOP)

No. Document : CV BP_SOP_01
Manufacture Date : 02/06/2023
Activity : Production Process
Product name : Crimping
Page : 1 of 1

No	Activity Sequence	Work Area	Person Responsible
1	Thread Turning	Turning Area	Lathe Operator
2	Outer Diameter Turning	Turning Area	Lathe Operator
3	Thread Turning	Turning Area	Lathe Operator
4	Outer Diameter Turning	Turning Area	Lathe Operator
5	Long Turning	Turning Area	Lathe Operator
6	Inside Diameter Turning	Welding Area	Lathe Operator
7	Joining Bodies and Bottle Crimping HeadsTurning Area	Turning Area	Lathe Operator
8	External Turning (Finishing)	Milling Area	Milling Operator
9	Deep Scrolling	Welding Area	Lathe Operator
10	Hardening	Area Milling	Operator Milling
11	Manufacture of crimping body grooves	Turning Area	Lathe Operator
12	Combination of Bottle Crimping and Bottle Straightener	Milling Area	Milling Operator
13	Finished Product Storage	Warehouse Area	Supervisor

Implementation Procedure:

1. All production processes must be carried out carefully and carefully.
2. Workers are required to re-check all dimensions and the number of spare parts to be produced.
3. Workers should use earplugs, especially when milling and lathes are turned on.
4. Lighting in the production area must be turned on when the production process is running.

Figure 4. SOP for Making Crimping

Based on data processing from Table 5, the data uniformity test before improvement to determine the average standard of LCL and UCL can use formulas (1), (2), and (3).

Average Standard (AS) = $\frac{1}{10}\sum_{i-1}^{10}|4{,}489 - 897.81|$ = 1.79
UCL = 897.81 + 1.79 = 894.22
LCL = 897.81 – 1.79 = 901.40

Based on data processing from Table 6, the data uniformity test after improvement to determine the average standard of LCL and UCL can use formulas (1), (2), and (3).

Average Standard (AS) = $\frac{1}{10}\sum_{i-1}^{10}|4{,}368 - 873.67|$ = 1.69
UCL = 873.67 + 1.69 = 870.30
LCL = 873.67 – 1.69 = 877.04

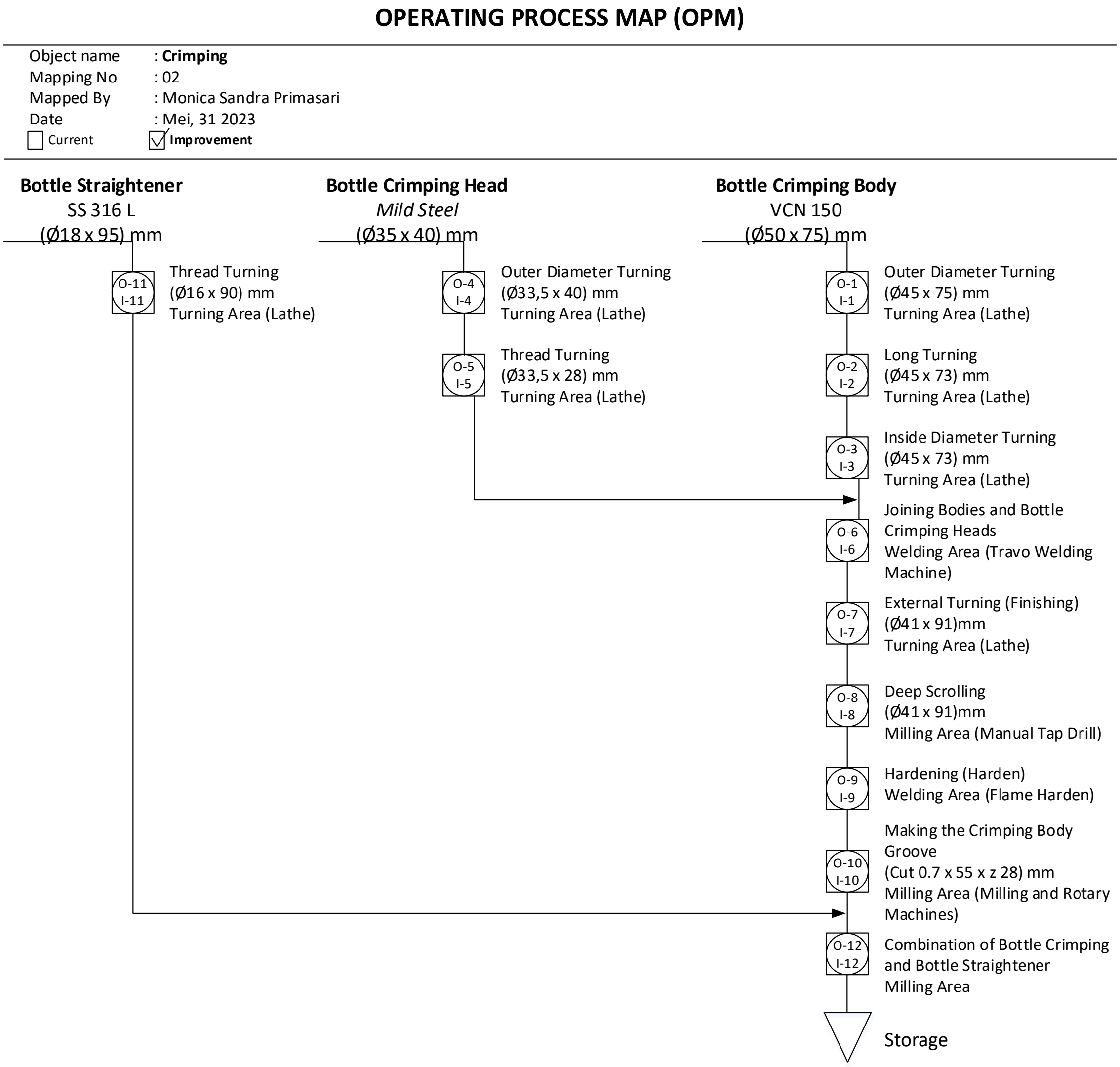

Figure 5. Operation Process Map After Improvement

Table 4. Process Time Measurement Results Before Improvement

Measurement (X)	Before Improvement			After Improvement		
	Xi (minutes)	Xi-XBar	|Xi-XBar|²	Xi (minutes)	Xi-XBar	|Xi-XBar|²
1	899.20	1.39	1.92	874,95	1,28	1,65
2	895.74	-2.07	4.30	873,54	-0,13	0,02
3	901.72	3.91	15.26	870,22	-3,45	11,87
4	897.55	-0.26	0.07	874,35	0,68	0,47
5	900.13	2.32	5.37	871,83	-1,84	3,37
6	893.65	-4.16	17.33	872,45	-1,22	1,48
7	895.30	-2.51	6.32	870,98	-2,69	7,21
8	898.87	1.06	1.12	877,67	4,00	16,03
9	896.22	-1.59	2.54	874,02	0,35	0,13
10	899.75	1.94	3.75	876,65	2,98	8,90
Amount	8,978.13		57.98	8,736.66		51.98
XBar	897.81			873.67		
Standard Deviasi (SD)	2.54			2.38		
Total Xi	8,978			8,736		
Total Xi²	80,606.81			76,329.22		
Total (Xi)²	8,060.73			7,632.97		

Table 5. Determination of Data Uniformity Test Before Improvement

Measurement (X)	Xi (minutes)		Average (minutes)	Remark
1 and 6	899.20	893.65	896.43	uniform
2 and 7	895.74	895.30	895.52	uniform
3 and 8	901.72	898.87	900.30	uniform
4 and 9	897.55	896.22	896.89	uniform
5 and 10	900.13	899.75	899.94	uniform
The average number of measurement			4,489.00	
Xbar			897.81	

Table 6. Determination of Data Uniformity Test After Improvement

Measurement (X)	Xi (minutes)		Average (minutes)	Remark
1 and 6	874.95	872.45	873.70	uniform
2 and 7	873.54	870.98	872.26	uniform
3 and 8	870.22	877.67	873.95	uniform
4 and 9	874.35	874.02	874.19	uniform
5 and 10	871.83	876.65	874.24	uniform
The average number of measurement			4,368.33	
Xbar			873.67	

After obtaining the LCL and UCL values, then make a graph of data uniformity before improvement which can be seen in Figure 6, and a graph of data uniformity after improvement can be seen in Figure 7.

Then determine the normality test of the data that has been obtained from data collection in Table 4. This study uses the Minitab 18 software to test the normality of the data using the Kolmogorov-Smirnov normality test method. The results of the data normality test before improvement can be seen in Figure 8 and the results of the data normality test after improvement can be seen in Figure 9.

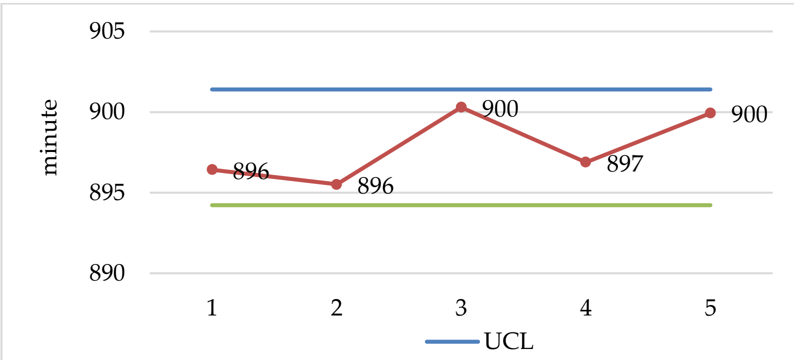

Figure 6. Data Uniformity Test Results Before Improvement

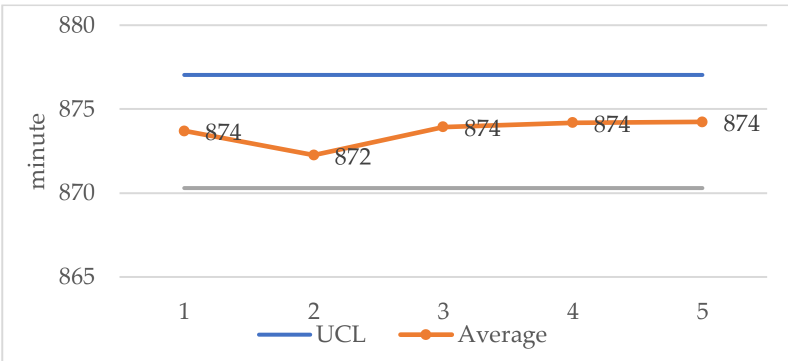

Figure 7. Data Uniformity Test Results After Improvement

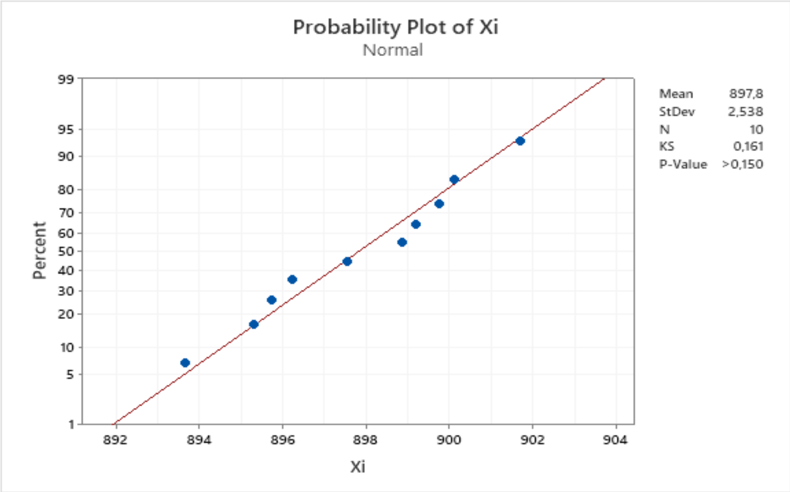

Figure 8. Data Normality Test Results Before Improvement

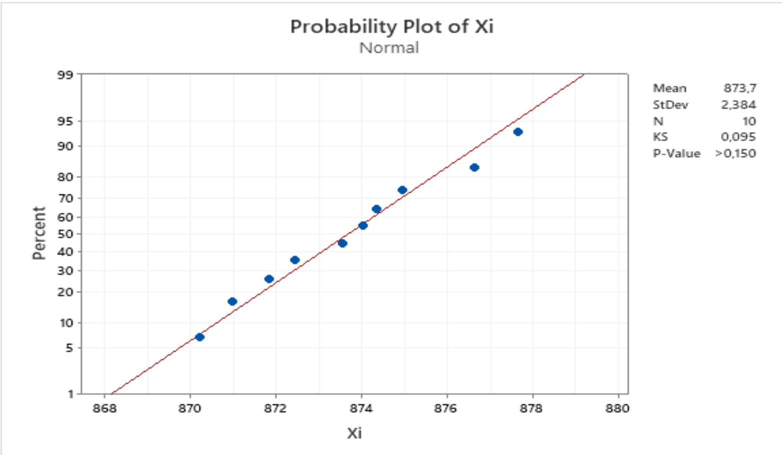

Figure 9. Data Normality Test Results After Improvement

Based on Figure 8 and Figure 9 the results of the data normality test before and after improvement, it can be concluded that the data is normally distributed because the p-value is > 0.150. The next stage determines the cycle time, normal time, standard time, and CSF value. A critical Success Factor (CSF) is a goal target for the cause of success (leading), which needs to be determined by the company before carrying out an improvement plan [40]. Before determining the cycle time, the results of the previous FGD determined the value of the slack factor both before and after the improvement can be seen in Table 6.

Table 6. Allowance Factor

Factor	Criteria	Before Improvement Mark (%)	After Improvement Mark (%)
Power released	Very light	6	6
Work attitude	Stand straight and rest on both feet	1.5	1.5
Work movement	Rather limited	2	2
Eyestrain	Almost continuous (meticulous) view	6	6
Workplace temperature conditions	Tall	5	5
Atmospheric state	There is a characteristic smell of engine and scrap dust	4	4
Good environmental conditions	Exceptional circumstances (cleanliness, noise, and repetitive work cycles)	10	5
Personal needs	Drink, take a break, and restroom	5	5

Factor	Criteria	Before Improvement Mark (%)	After Improvement Mark (%)
(men)			
	Total	39.5	34.5

Based on Table 6, the value of the allowance factor before improvement (α) is 39.5% or 0.395. Furthermore, to determine the adjustment factor (p) before and after improvement according to the results of the previous FGD, the results can be seen in Table 7.

Table 7. Adjustment Factor (Westinghouse)

Factor	Rating		Value Before Improvement	Value After Improvement
Skill	Excellent	B1	+0.11	+0,11
Effort	Good	C1	+0.05	+0,05
Conditions	Fair	E	-0.03	0,00
Consistency	Good	C	+0.01	+0,01
	Total		+0.14	+0,17

Based on Table 7, the value of Westinghouse data before improvement or p = 1 + total adjustment factor = 1 + 0.14 = 1.14. These two values, both the allowance factor value and the Westinghouse factor value, can be used to determine the normal time and standard time. Calculation of cycle time can use formula equations (5), (6), and (7).

$$CT = \frac{8.978}{10} = 897.81$$
$$NT = 897.81 \times 1.14 = 1{,}023.51$$
$$ST = 1023.51 \times (1 + 0.395) = 1{,}427.79$$

The results of data processing related to the standard time before improvement can be concluded that the ST value of 1,427.79 is the CSF time.

Based on Table 6, the value of the allowance factor after the improvement of (α) is 34.5% or 0.345. Based on Table 7, the Westinghouse data value after improvement or p = 1 + total adjustment factor = 1 + 0.17 = 1.17. These two values, both the allowance factor value and the Westinghouse factor value, can be used to determine the normal time and standard time. Calculation of cycle time can use formula equations (5), (6), and (7).

$$CT = \frac{8.736}{10} = 873.66$$
$$NT = 873.66 \times 1.17 = 1{,}022.19$$
$$ST = 1022.19 \times (1 + 0.345) = 1{,}374.84$$

The results of data processing related to the standard time before improvement can be concluded that the ST value of 1,374.84 is the CSF time.

3.5 Step 5 Test

At this stage, namely the test stage which serves to compare research results in terms of determining CSF taken from the results of calculating the standard time before and after improvement. The results of the comparison can be seen in Table 8.

Table 8. Comparison of Test Results Before and After Improvement

Parameter	Unit	Before Improvement	After Improvement	Remarks (ratio)
Cycle Time (CT)	minutes	897.81	873.67	
Normal Time (NT)	minutes	1,023.51	1,022.19	
Standard Time (ST)	minutes	1,427.79	1,374.84	52.95
Makes 1 product	o'clock	23.80	22.91	
	days	0.99	0.95	
	working days	3.40	3.27	1.26

3.6 Impact After Improvement

The theoretical implications of this research can add references to other researchers in terms of implementing the process design thinking method in improving the crimping process time on lathes. While in practice, this research has implications for the manufacturing industry in the turning sector where the standard time for making the crimping process can be improved by re-mapping the crimping production process on lathes.

Based on the research results, the crimping process time has decreased by 52.95 minutes, which means that production can increase the amount of production per month. This will affect the company's ability to fulfill orders from customers and increase delivery times to customers. The contribution of this research as a body of knowledge includes the design of an engineering system, where there is a new mapping process on the operation map of the process of making crimping products on lathes in the manufacturing industry.

4. DISCUSSION

The gap analysis of this research is related to the implementation of process leveling design which can also be applied to various manufacturing and community service industries. One implementation of this method is in the mapping of business flows, how to eliminate waste of time in the process of procuring medical equipment in satisfying health services [41]. In addition to that, poor workstation design is a risk factor for operators in assembly production lines, therefore it is necessary to relay out anthropometric workstations to facilitate the development of sustainable workplaces. to improve the human factor performance as well as productivity index in manufacturing companies by eliminating the performance of operators performing manual and mechanical tasks on the production line in the box assembly department [42]. Other research examines user interface/user experience (UI/UX) design which is very important because with good design and meeting user needs, it can make users feel comfortable when using a product, so this design needs to be made using Design Thinking method combined with Usability Testing [23], [24].

The implementation of the DTP method is necessary to solve problems by focusing on the customer's perspective to better determine the needs of user implementations. So that the main complaints from customers can be resolved by applying these methods and increasing customer satisfaction [31]. DTP is a thinking process in which one seeks to understand the user, challenges assumptions, and redefines the problem to identify alternative strategies and solutions that may not be immediately apparent at the understanding level [41]. This research applies DTP to create a new process operation map using the FGD, and IRD methods and measuring the production process called talk time with several trials so that the effectiveness of the product manufacturing process can be outlined in the SOP. This research covers knowledge about industrial engineering including design and manufacturing techniques, where in the crimping production process several parts are removed because they do not have added value so that the measurement results of the production process are more effective and efficient.

5. CONCLUSION

This research concluded that several problems were found that disrupted crimping production on lathe machines. Identification of problems starts from the absence of SOPs, the machine being old, production support tools limited and not meeting specifications, careless workers, and the work environment is not good. The solution in this research is to create an SOP according to the results of the production process mapping trial, implementation for engine renewal, inventory of equipment that does not meet specifications, re-inspection and supervision during the measurement process, providing training to workers regarding safety SOPs, and noise workers are required to use earplugs. This research resulted in a reduction in the standard time for the crimping process, previously the processing time for 1 product was 1.428 minutes, while the standard repair time was 1.375 minutes. So this research succeeded in reducing the standard time in the crimping production process or reducing CSF by 3.71%.

In theory, the implications of this research can be used as a reference by other researchers in terms of using or developing knowledge regarding the DTP method in almost the same industry. The practical implication is that this research has applied the DTP method in terms of reducing non-value-added process time into value-added activities or reducing waste. So this research is expected to provide continuity of orders by customers because each product delivery is according to a predetermined schedule. The author has recommendations for further research, namely taking the theme of Lean Six Sigma (LSS) combined with the digitalization of Industry 4.0, whereby the implementation of lean manufacturing uses the VSM method and the implementation of Six Sigma uses other approaches such as Define-Measure-Analyze-Improve-Control (DMAIC) which is supported digitalized machine tools. It is hoped that productivity on this lathe can be sustainable and increase customer satisfaction.

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