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IMPLEMENTATION OF LEAN MANUFACTURING TO IDENTIFY AND MINIMIZE WASTE IN THE WELDING FRAMEBODY DEPARTMENT OF PT XYZ

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Abstract
PT XYZ is a transportation equipment manufacturing company that must always maintain that the products it produces can achieve sales targets. However, in carrying out the production process, PT XYZ often experiences shortages in the production process, one of which is due to problems in the welding frame body department. thus the objectives of this research are determine the flow of the production process in the welding frame body department, then analyze the waste that occurs in the body parts of the welding frame. This frame body welding department has a production process flow starting from St. Rear Frame 1 to St. Rear Frame 4, then St. Front Frame 1 to St. Front Frame 3, after that St. General Assy, Permanent Robot/Robot Handling, Fine Boring, Manual 1 and Manual 2, and ends in Tapping and Numbering. Based on the flow of the production process, it was found that St. Rear Frame 3 is the most problematic with a percentage of 21%. By using the DMAIC method, in the Define stage it was found that the most common problems occurred in St. Rear Frame 3 is a torn pipe lower jig B with a percentage of 6%. At the Define stage, it is also known that the root cause of the problem is the lack of accuracy from the operator who may be sleepy at work due to lack of rest, or even chatting which results in setting teaching too far because it is more dominant to the lower, not to the iron connection between the lower and the sub frame. Then at the Measure stage the target is to reduce 6% of the problems to 4%. Furthermore, at the Analyze stage, an analysis is carried out if the potential problem occurs then what next steps will be conducted which is useful for minimizing waste. At the Improve and Control stage, namely the steps taken to minimize the problem or waste (preventive actions) and what steps or ways to do if the problem or waste occurs again (contingent actions).

Keywords:
DMAIC; lean manufacturing; waste

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1. Introduction

Currently, many companies are competing to maintain the company in the development of the business world which is increasingly increasing rapidly. A manufacturing company is a company that must always increase its production results. This production must always be improved in terms of service to consumers and the quality of the product itself. Manufacturing companies must provide a guarantee of both service and quality to consumers so that companies can compete with other companies in taking the interest of their consumers. This can also prove that this company's product is in proper condition and of high quality.

Manufacturing is a series of production activities that transform a raw material into a new item with a higher value. Activities will be said to have added value if there are additions to several inputs to activities that will provide added value to the product according to consumer desires [1]. There are two types of flow in the manufacturing process, namely the flow of materials/semi-finished goods and the flow of information. The flow of materials/semi-finished goods occurs when moving materials from one work station another. As long as the

material flow takes place, of course, there are several factors that affect production results. One factor that is quite influential is waste or waste. Waste or waste is a work activity that does not add value in the process of making, or producing goods [2].

Indonesia has contributed 20.27% to the largest manufacturing industry in ASEAN on a national scale economy. Indonesia has been able to shift the role from commodity-based to manufacture-based. The manufacturing industry is considered more productive so that the value of raw materials can be increased, the workforce is expanded, and it contributes a lot to taxes and customs. Manufacturing value added places the top position for the manufacturing industry among ASEAN countries with an achievement of 4.5%.

Indonesia is ranked 9th out of all countries in the world when viewed globally. The automotive manufacturing industry has made a major contribution to the national economy (as shown by Figure 1). Based on UN data, the transportation equipment industry contributes as much as 1.35% to the national GDP in 2020. It has been more than 50 years that the automotive industry in Indonesia has developed, with the issuance of a Joint Decree between the ministers of industry and the minister of trade in 1969 regarding how to import vehicles. motor vehicles that are Completely Built Up (CBU) and Completely Knock Down (CKD) imported by the Brand Holder Sole Agent (ATPM) and also require ATPM to build a domestic motor vehicle assembly industry. With this policy, the local industry began to grow in the field of motorized equipment and components such as making jigs & fixtures, welding, trimming, and others. The growth of the transportation equipment industry in 2016 increased by 4.52% but fell again until 2019 by 3.43% due to the Covid-19 pandemic. The problem faced by the company is due to the Covid-19 pandemic, namely the depleting supply of raw materials and parts. Apart from that, the performance of the company is also needed for the automotive industry which is very useful for the Indonesian economy [3]. In full, the contribution of each industry can be seen in Fig. 1 below.

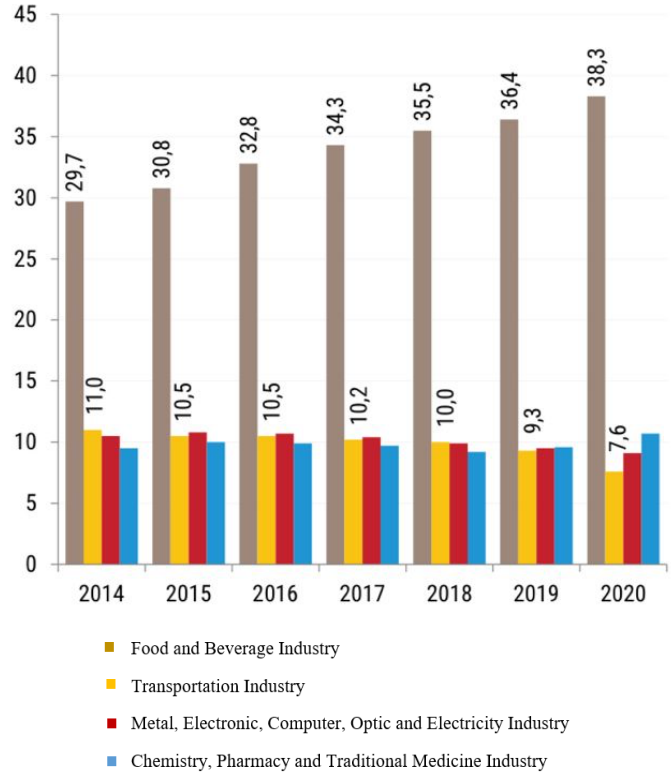

Figure 1. The biggest contribution of the industrial sector

PT XYZ is a transportation equipment manufacturing company that must always maintain that the products it produces can reach sales targets. However, in carrying out its production process, PT XYZ often experiences a shortage in the production process, one of which is due to a problem in the body frame welding. The production time continues and work station the assembly supply from the welding frame body department. This is a waste that if left unchecked will result in a product experiencing a shortage.

Good quality is very important so we need a method that can control problems and improve product quality in an effective and efficient manner. In the welding frame body, there is a logistics process namely moving parts from one work station to another work station. Therefore, by using Lean Manufacturing it is hoped that this will

minimize the waste that occurs in the welding frame body and make the logistics process flow in the welding frame body run smoothly [4], [5]. Lean Manufacturing is a useful approach in identifying and minimizing waste through improvement activities, thus the objectives of this research are determine the flow of the production process in the welding frame body department, then analyze the waste that occurs in the body parts of the welding frame.

2. Experimental Method

A. Literature Study

A literature study is a series of research activities carried out to collect information from books, scientific journals, previous research, magazines, etc. in the future will assist researchers in compiling research reports. Therefore, this literature study is useful for researchers in solving problems in this practical work research. The problem will be solved because there are references from several sources related to the problem that the author raises.

B. Field Observations

Field observations are a series of research activities held directly at the location where the research takes place. This field observation is useful to make it easier for writers to retrieve actual data by looking at real conditions. The author made field observations at the welding frame body department in line 3.

C. Interviews

Interviews are a series of research activities conducted by researchers by asking questions to informants. Questions in the form of topics related to the research that the author raised. By asking questions to the informants, information will be obtained which will later be useful for the smooth running of research that has not been obtained from previous methods.

D. Processing Data

Processing Data is carried out using the DMAIC method (Define, Measure, Analyze, Improve, Control) [6]. The Define stage is the initial stage used to find the source of problems that exist at PT XYZ by using the SIPOC Diagram tools [7], the production process flow in the welding frame body department, Pie Charts, Pareto Diagrams, Fishbone Diagrams [8]. Furthermore, the Measure stage is the second stage which is carried out to measure the level of waste from the production process and the targets made to reduce this waste can be reduced. Then the third stage is *a*nalyze which is the stage in finding a solution that will be applied later and seeing whether the solution is valid or invalid so that improvement can be held. The next step is Improve and Control, this step is the implementation stage of the solutions conducted to deal with existing problems and make improvements if the impact of these problems cannot be overcome and how to prevent these problems from recurring, this stage can use KTPPA tools (Kepner Tregoe Potential Problem Analysis). In detail, the measurement methods in this study are presented in Fig. 2 below.

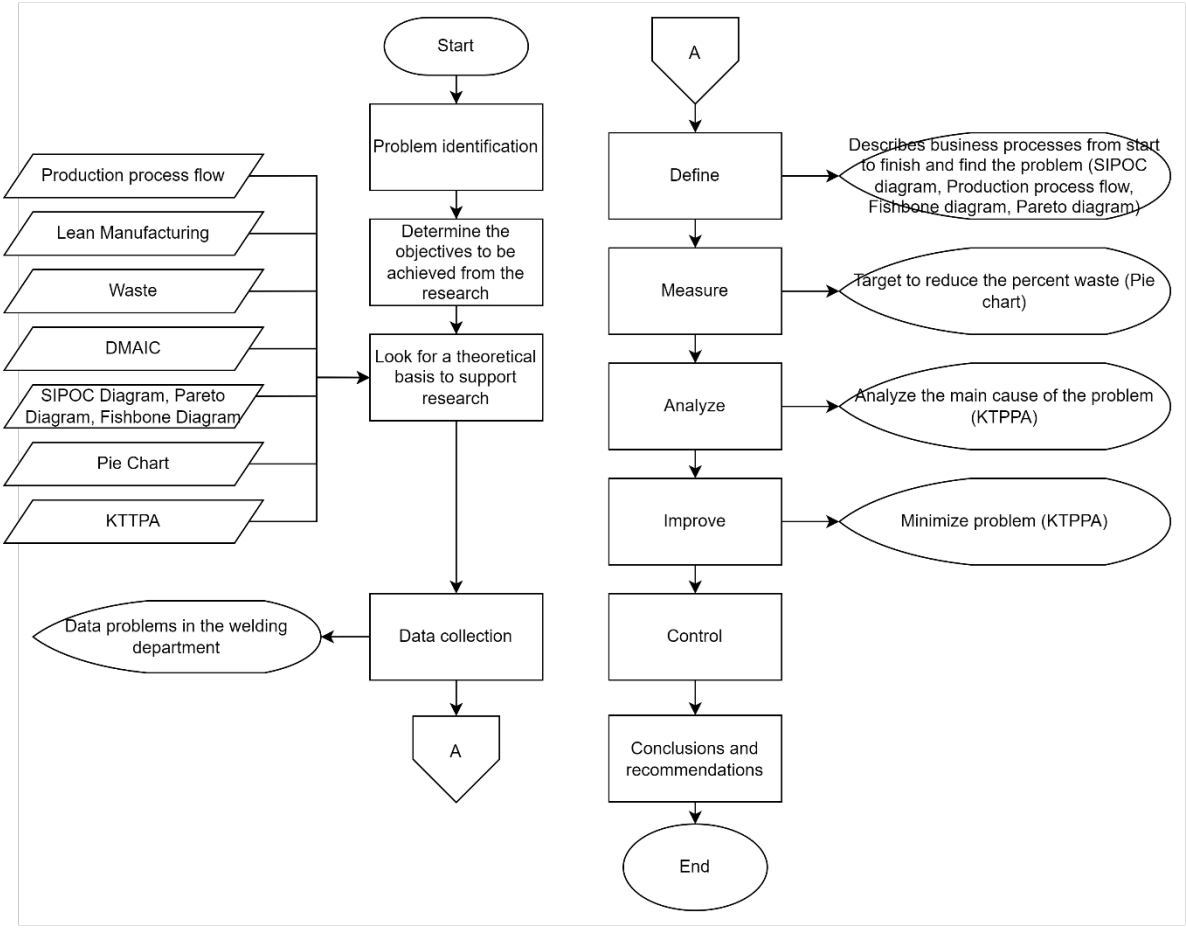

Figure 2. Research method flowchart

3. Result and Discussion

Results

Processing Data is conducted using the DMAIC method to overcome and solve problems that exist in the welding frame body department. The stages in DMAIC are started with the Define (Problem Identification) stage, Measure (Measurement), Analyze (Problem Analysis), Improve (Improvement) and the last is Control (Control).

A. Define

The Define is held to determine several factors that cause problems in the welding department starting from the goods coming from the supplier until the goods are sent to the assembly unit. By using the SIPOC diagram, you can see the business process from start to finish in the welding department. Fig. 3 is a SIPOC diagram in the welding department.

Supplier	*Input*	*Process*	*Output*	*Customer*
- WAHO 1	*- Front dan Rear Frame*	*- Welding*	*- Welding Frame Body*	*- Painting Steel*
- LC	*- Pipe R & L*			
- Press	*- Sub Frame*			
	- Plate Pivot Unit			
	- Engine Hanger R & L			
	- Stay Upper Cover			

Figure 3. Welding frame body SIPOC diagram

The process of automation in welding using a welding robot is used to make work more productive, effective, and efficient. Apart from that, this is an innovation made by the company in its production process. A welding section is a place for welding motor parts, one of which is the frame body.

The process that occurs is the process of welding or welding which is carried out at the Rear Frame, Front Frame, General Assy, Permanent Robot, Fine Boring, Manual, Tapping, and Numbering stations. For welding from the Rear Frame station to Fine Boring using a robot, but for Manual, Tapping, and Numbering still use manpower to complete the welding deficiencies caused by the previous robot. Fig. 4 is the flow of the production process from the welding frame body.

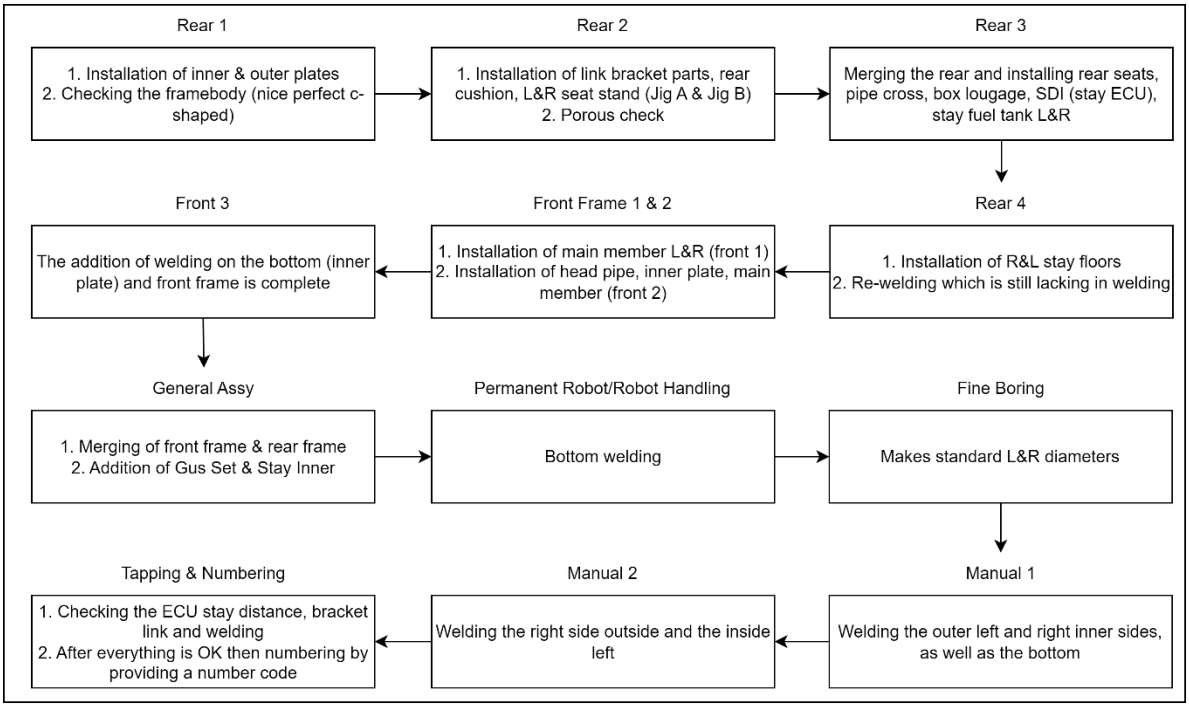

Figure 4. Production process flow of welding frame body

St. Rear Frame 3 is the work station that has the most frequent problems with a percentage of 21%. At this station the parts in separate conditions between L and R are then combined at the rear. In this process, Seat Rear, Pipe Cross, Box Laugage, Stay ECU, Stay Fuel Tank (L&R) are installed.

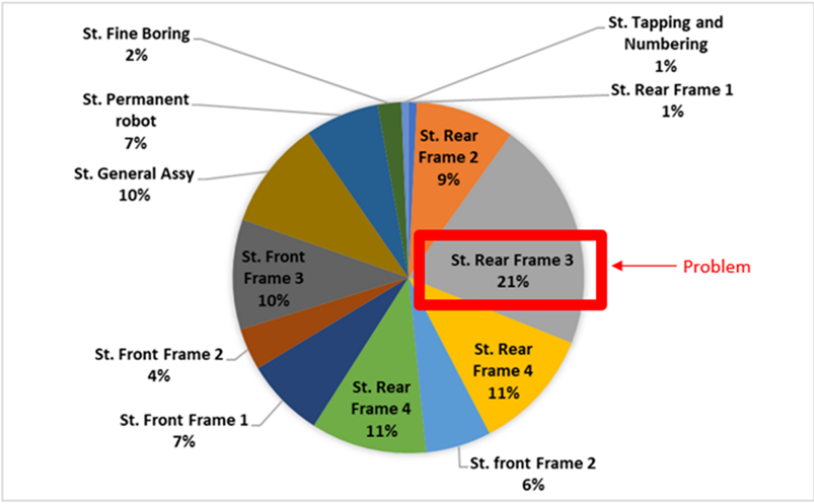

Figure 5. Problem diagram at each work station

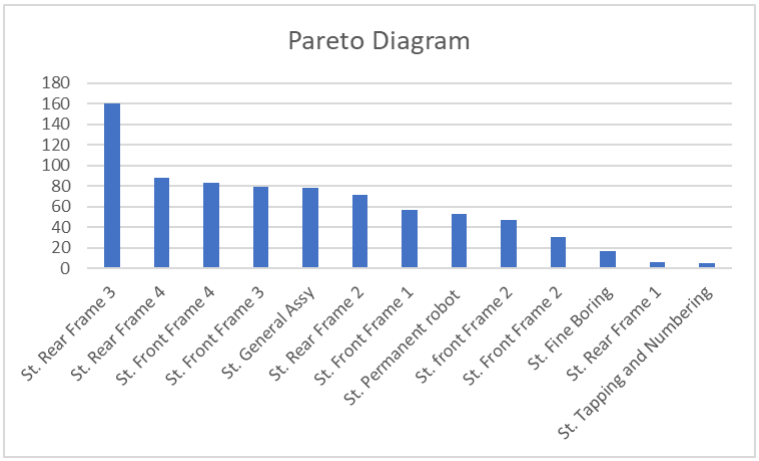

Figure 6. Pareto Diagram

After it became known that St. Rear Frame 3 is the work station that contributes the most problems as can be seen in Fig. 5 and Fig. 6. Rear Frame 3. The most common problem is the welding of the pipe lower jig B with the number of incidents being 10 times in the period January 2021- May 2022 and can be seen in Fig. 7.

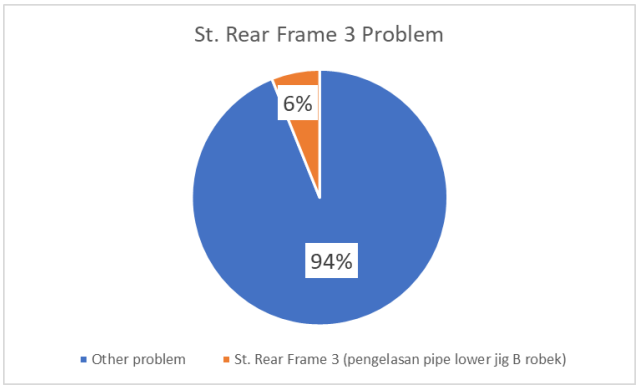

Figure 7. Percentage of Broken Pipe Lower Jig B Problems

Pipe lower jig B problems accounted for as much as 6% of the total problems that exist in St. Rear Frame 3 as shown in Fig. 8. This is a fairly big problem, and the root cause must be sought why this torn pipe lower jig B can occur.

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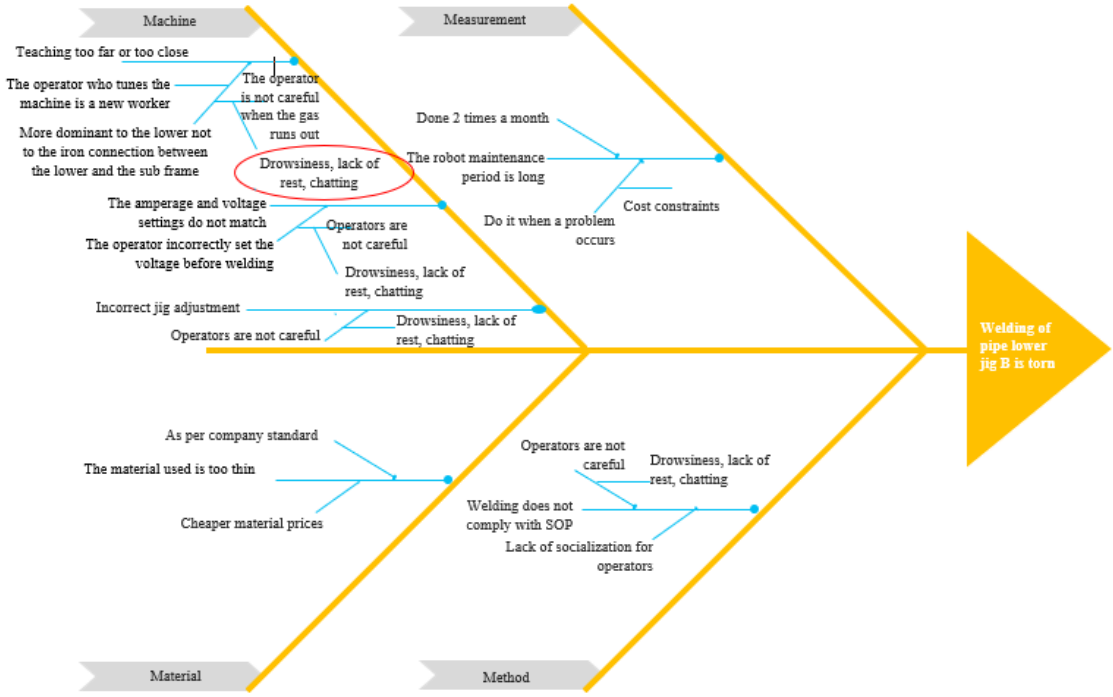

Figure 8. Fishbone Diagram

Once it is known that welding pipe lower jig B is a problem that often occurs, using the Fishbone Diagram it can be identified the root of the problem that occurs and can be seen in Fig. 9. Torn welding on the pipe lower is a waste type of defect because the frame body is torn due to teaching which is too far and is more dominant to the lower not to the iron connection between the lower and the sub-frame because the operator is not careful when the gas runs out due to drowsiness, lack of rest, chatting. This causes motion waste and has implications for time waste. Motion waste and time waste are some of the causes of waste referring to lean manufacturing [5], [9], [10].

B. Measure

From the known problems, the target is to minimize the problem in welding pipe lower jig B from 6% to 4%, which means minimizing the frequency of occurrence of 10 times to 6 times the maximum can occur as can be seen in Fig. 10.

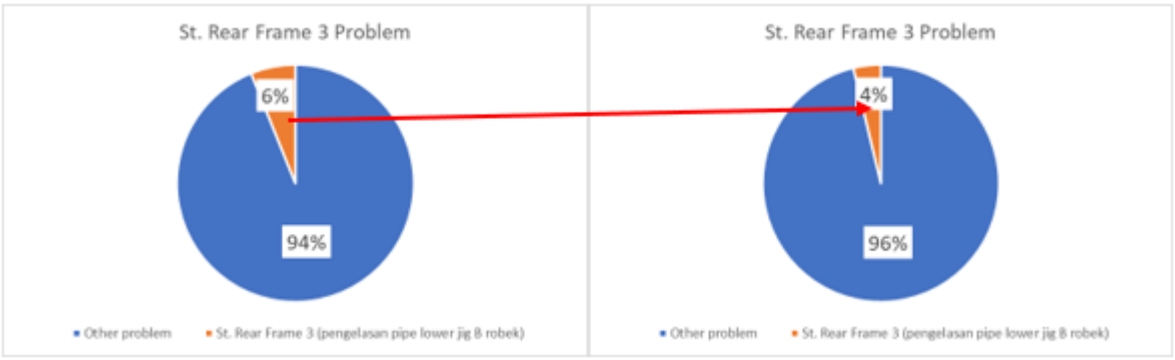

Figure 7. Improvement Targets

C. Analyze

Table 1. KTPPA table

Factor	Potential Problem	Possible Causes	Preventive Actions	Contingent Actions	Pros and Lack	Judge-ment
Machine	Teaching too far or too close	More dominant to the lower not to the iron connection between the lower and the sub frame	Re-teaching the robot in the lower section	Check the jig or repair the weld manually by inserting the used nozzle into the lower pipe hole	Pros: Welding will be perfect Lack: -	Valid
		The operator who tunes the machine is a new worker	Conduct training for the operator	Reprimand the operator for implementing and carrying out the SOP that has been set by the company	Pros: Operators will understand more about the SOPs set by the company Lack: -	Invalid
		The operator is not careful in checking the gas indicator because he is sleepy, lacks rest or talks	Reprimand the operator for implementing and carrying out the SOP that has been provided by the company and routinely checking the gas indicator and immediately filling the gas until it is full again if the gas runs out	The company provides SP for operators	Pros: Operators become more serious and concentrate on doing work Lack: -	Valid
	The amperage and voltage settings do not match	The operator incorrectly set the voltage before welding	Check the voltage and voltage before welding whether it is correct or not	Change the voltage and voltage until it is suitable	Pros: Welding will be perfect Lack: takes a little time to change the voltage to normal	Invalid

Factor	Potential Problem	Possible Causes	Preventive Actions	Contingent Actions	Pros and Lack	Judge-ment
Machine	The amperage and voltage settings do not match	Operators are not careful because they are sleepy, lack of rest or chatting	Reprimand operators for implementing and carrying out SOPs that have been provided by the company	The company provides SP for the operator and changes the voltage back to normal	Pros: Operators become more serious and concentrate on doing work Lack: wasting time to change the voltage to normal again	Invalid
	Incorrect jig adjustment	Operators are not careful because they are sleepy, lack of rest or chatting	Reprimand the operator for implementing and carrying out the SOP that has been provided by the company and always checking the jig on the machine before using the machine	Do a reset and the company can provide SP for the operator if it happens repeatedly	Pros: Operators become more serious and concentrate on doing work Lack: time consuming to do jig reset	Invalid
Measure-ment	The robot maintenance period is long	Done twice a month	Perform maintenance three times a month	Carry out maintenance as soon as possible for the robot so that the robot can return to its prime and the robot is not constrained by anything	Pros: Robots rarely experience errors Lack: Requires a higher cost	Invalid

Factor	Potential Problem	Possible Causes	Preventive Actions	Contingent Actions	Pros and Lack	Judge-ment
Measure-ment	The robot maintenance period is long	Done only when a problem occurs due to cost constraints	Doing robot maintenance not only when there is a problem but also doing regular checks on the robot	Carry out maintenance as soon as possible for the robot so that the robot can return to its prime and the robot is not constrained by anything	Pros: Robots rarely experience errors Lack: Requires a higher cost	Invalid
Material	The material used is too thin	Follow company standards	Operators must be careful in welding because the material is too thin	Doing repairs to cover the torn welding results due to thin material	Pros: Welding is not torn Lack: -	Invalid
		Cheaper material prices	Replace it with a material that is thicker than the previous material at the same price	Make changes to new standards to change materials	Pros: The material used is stronger Lack: higher price	Invalid
Method	Welding is not in accordance with the SOP	Operators are not careful because they are sleepy, lack of rest or chatting	Reprimand the operator for implementing and carrying out the SOP that has been provided by the company and always checking the jig on the machine before using the machine	The company can provide SP for operators if it occurs repeatedly	Pros: Operators become more serious and concentrate on doing work Lack: -	Invalid

Factor	Potential Problem	Possible Causes	Preventive Actions	Contingent Actions	Pros and Lack	Judge-ment
Method	Welding is not in accordance with the SOP	Lack of socialization for operators	Conduct training for the operator	Re-socialize the SOP that the company has made for operators	Pros: Operators have been equipped with new SOPs so that welding work will be in accordance with SOPs Lack: The company will spend money, time and energy to re-socialize.	Invalid

Table 1 above is the analyze stage where this stage is the stage in finding a solution that will be applied later and seeing whether the solution is valid or invalid so that improvement can be conducted. Based on Table 1. above, the broken pipe lower jig B problem is caused because the teaching is too far or too close. Teaching that is too far or too close can be caused because it is more dominant to the lower not to the iron connection between the lower and the sub-frame. The operator who tunes the machine is a new worker and also the operator is not careful in checking the gas indicator due to sleepiness, lack of rest or chatting. With the handling that can be done, it is hoped that waste can be reduced and the company can apply the handling suggestions listed in Table 1.

D. Improve and Control

Improve and control stage the improve and control stage is the implementation stage of the solution held to deal with existing problems and make improvements if the impact of these problems cannot be resolved and how to prevent these problems from recurring, at this stage you can use KTPPA (Kepner Tregoe Potential Problem Analysis) tools.

Seeing that the operator's lack of accuracy in checking the gas indicator causes the teaching to change (too far or too close) is the root of the problem. Even though other potential problems that occur are not the main problem, they can also cause these problems to occur. With actions like Table 2. it can reduce waste from 6% to 4%. This is a very good thing because it can improve performance and maximize existing processes in the production process in the welding frame body department, especially at St. Rear Frame 3. The following is Table 2 which can be seen as follows.

Table 2. Improve and control KTPPA table

Factor	Potential Problem	Possible Causes	Preventive Actions	Contingent Actions	Pros and Lack
Machine	Teaching too far or too close	More dominant to the lower not to the iron connection between the lower and the sub frame	Re-teaching the robot in the lower section	Check the jig or repair the weld manually by inserting the used nozzle into the lower pipe hole	Pros: Welding will be perfect Lack: -
		The operator who tunes the machine is a new worker	Conduct training for the operator	Reprimand the operator for implementing and carrying out the SOP that has been set by the company	Pros: Operators will understand more about the SOPs set by the company Lack: -
		The operator is not careful in checking the gas indicator because he is sleepy, lacks rest or talks	Reprimand the operator for implementing and carrying out the SOP that has been provided by the company and routinely checking the gas indicator and immediately filling the gas until it is full again if the gas runs out	The company provides SP for operators	Pros: Operators become more serious and concentrate on doing work Lack: -
	The amperage and voltage settings do not match	The operator incorrectly set the voltage before welding	Check the voltage and voltage before welding whether it is correct or not	Change the voltage and voltage until it is suitable	Pros: Welding will be perfect Lack: takes a little time to change the voltage to normal

Factor	Potential Problem	Possible Causes	Preventive Actions	Contingent Actions	Pros and Lack
Measure-ment	The robot maintenance period is long	Done only when a problem occurs due to cost constraints	Doing robot maintenance not only when there is a problem but also doing regular checks on the robot	Carry out maintenance as soon as possible for the robot so that the robot can return to its prime and the robot is not constrained by anything	Pros: Robots rarely experience errors Lack: Requires a higher cost
Material	The material used is too thin	Follow company standards	Operators must be careful in welding because the material is too thin	Doing repairs to cover the torn welding results due to thin material	Pros: Welding is not torn Lack: -
		Cheaper material prices	Replace it with a material that is thicker than the previous material at the same price	Make changes to new standards to change materials	Pros: The material used is stronger Lack: higher price
Method	Welding is not in accordance with the SOP	Operators are not careful because they are sleepy, lack of rest or chatting	Reprimand the operator for implementing and carrying out the SOP that has been provided by the company and always checking the jig on the machine before using the machine	The company can provide SP for operators if it occurs repeatedly	Pros: Operators become more serious and concentrate on doing work Lack: -
		Lack of socialization for operators	Conduct training for the operator	Re-socialize the SOP that the company has made for operators	Pros: Operators have been equipped with new SOPs so that welding work will be in accordance with SOPs Lack: The company will spend money, time and energy to re-socialize.

Discussion

Based on the Fishbone Diagram it can be seen the root of the problem that occurs. Torn welding on the lower pipe is a type of defective waste because the frame body is torn due to teaching that is too far and is more dominant downward not to the steel joint between the lower and sub-frame because the operator was not careful when the gasoline ran out due to drowsiness, lack of rest, chatting, etc. The resulting waste can be in the form of off line production because part of the frame body is damaged so it cannot be sent to the production line and must be repaired again in the welding section which adds time. Lean manufacturing which is applied as an approach in this study is in accordance with lean principles, namely by applying lean philosophy and concepts through a series of steps, beginning with planning the change, defining the success elements, and concluding with implementation and progress monitoring [11]. The creation of a setting that makes the other process aspects possible is necessary for the adoption of lean manufacturing. This setting will guarantee that staff members feel empowered and have access to the resources they need to take responsibility for products and processes, work in focused teams, and have autonomy in developing solutions and process improvements [9].

The main focus of Lean is eliminating waste (waste) or anything that does not have added value in the process [12]–[14]. Not only is material wasted, but also a wide range of other resources, including time and energy. There are 7 types of waste in Lean, namely transportation, inventory, motion, waiting, overproduction, processing and defects [10]. In this study, the waste that occurs is waiting time and motion. Waiting is the term for lost time caused by sluggish or stopped production in one stage of the production chain while a stage before it is finished. For instance, in the manufacturing line, if one activity takes longer than another, whatever time the worker in charge of the subsequent task must wait is wasted. In order to make up for this lost time, the task that requires more time must be made more efficient, additional staff must be hired, or the workflow must be better organized or scheduled [4], [5], [15]. Whereas related to motion, all motion that could be decreased, whether it comes from a person or a machine, is considered wasteful motion. A margin of motion is squandered if it is used to add value that might have been added with less motion [10]. Motion can relate to anything from a worker stooping to pick up something on the production floor to more wear and tear on machines that necessitates replacement due to capital depreciation [11], [15].

4. Conclusion

Based on observations made in the welding frame body and the results of the analysis that the author has done in identifying waste in the production process flow in the welding frame body department, it can be concluded that the Welding Frame body has 12 work stations that are useful for converting several parts into frame bodies. Each work station has its own functions and duties. The production process flow in the frame body welding starts from St. Rear 1 to Rear 4, then St. Front 1 to St. Front 3, after that St. General Assy, Permanent Robot/Robot Handling, Fine Boring, Manual 1 and Manual 2, and ends in Tapping and Numbering. The tear in the welding on the lower pipe jig B is a waste type of defect because the frame body is torn due to the teaching being too far away and more dominant to the lower not to the iron connection between the lower and the sub-frame because the operator is not careful due to drowsiness, lack of rest, chatting.

By checking and resetting the jig or doing used manual weld repairs by inserting a nozzle into the pipe lower and reprimanding the operator for implementing and carrying out the SOP that has been provided by the company are the methods used to minimize waste. In minimizing waste, there are advantages, namely welding will be perfect and will not create minus in production. So the advice that the author can give is from the problem of welding the pipe lower jig B torn, so that the operator in the welding frame body always checks the machine first before using it so that the teaching is not far away and if this happens again because the operator is not thorough, the operator can be reprimanded and given SP so that they always focus on work and always apply the SOP that the company has set. In addition, the operator must also frequently check the gas indicator so that the gas does not run out and cause the teaching change.

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