Implementation of Lean Manufacturing to Minimize Waiting Waste and Defect Waste in Press Machine at PT XYZ

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Abstract

The purpose of this study is to minimize waiting waste and defect waste in an effort to reduce unproductive time and defects in the production of press machines at PT XYZ in accordance with the Lean Manufacturing concept. The problem with waiting waste is the high time of miss feed, inspection, DF fault, and product repair, while the problem with defect waste is a large number of lump defects. Resolving the defect waste problem certainly reduces the time for inspection and repair because the main problem is interconnected, namely ibutsu. The solution for the miss feed and DF faults is the redesign of the scrap drain, a stopper for fixing materials, and a vacuum protector with the Poka-Yoke concept. Meanwhile, the solution for defective waste is proposed to change the cleaning system to prevent ibutsu on dies with the PDCA concept (Plan, Do, Check, Act). The prediction for the total time that can be reduced after solving the waiting waste problem is 1,786.5 minutes, and the completion of the defect waste is predicted to reduce the percentage of defects from 2.48% to 0.5%.

Keywords
Lean Manufacturing, Waiting Waste, Defect Waste, Poka-Yoke, PDCA

1. Introduction
According to the Big Indonesian Dictionary (KBBI), a motorized vehicle is a vehicle that uses an engine (motor) to run it. The types of motorized vehicles in question range from passenger cars, buses, trucks and motorbikes. All types of motorized vehicles have always experienced growth in numbers in Indonesia. For passenger cars, the increase has reached an average of 8.98%, with a standard deviation of 3.34% since 1989. The growth of motorized vehicles in Indonesia continues to increase from year to year (Central Agency Statistics, 2014).

With the demand for passenger cars always increasing every year, PT XYZ as a car manufacturer in Indonesia, must be able to meet this demand. PT XYZ is a company that produces cars under the Suzuki brand name and is a car industry originating from Japan. Almost all car components are made independently by the company. The components made include the engine, transmission, body, to assembly. For the car body, there are 19 parts made by the pressing division at PT XYZ.

In making car bodies, metal plates and various metal specifications are used. The process of changing the slab into a car body is carried out using a press machine in an automation system because the process is done using more machines than human intervention. There are nine processes of forming the car body (outer and inner) in the press machine of PT XYZ. The process starts from moving the raw material in the storage to loading the material, the cleaning process in the washing machine, the waiting process at the destack feeder, the drawing process (forming the initial design of the metal plate raw material), the trimming process (cutting the remaining unused material), the bending process (re-shaping the car body curve in more detail), the reaming / piercing process (the process of forming a hole in the car body), the unloading/output process with the conveyor, and finally the inspection process. The concept of lean manufacturing states that waste is the main thing that must be done by the company continuously in order to meet the

demand with the best quality and without waste. There are seven types of waste that are observed, and the following results are obtained:

1. Overproduction

There is no excess production that occurs at PT. XYZ, this is because the process that has occurred is well structured according to the Just in Time concept so that the company can fulfil its production properly without excess production. This is also proven by the absence of material rust defects.

2. Transportation

The movement of goods which is currently running has also been going well because the new plant is built with a layout that has been arranged to minimize transportation waste in the previous factory. The position of the material warehouse is very close to the pressing machine, as well as the storage distance of the pressed material, which is stored right before the welding process. This is in accordance with the concept of cellular manufacturing.

3. Inventory

Inventory is also not the main waste in the pressing division, for the reasons mentioned in the previous section, overproduction waste.

4. Motion

The automatic movement that has been running on the pressing machine can be said to be very good because, with optimal movement, it will result in a fast production time, where the average SPM value of the pressing machine currently reaches 14.81 SPM and is approaching the maximum time of the pressing machine, namely 18 SPM. This is because the operator always focuses on increasing the SPM of the pressing machine.

5. Extra processing

Extra processing is also not the main waste in PT. XYZ, this is because the process is going well according to the value desired by the customer. For example, for ordering materials, the size and shape have been adjusted so that there is no excess processing carried out by the pressing machine and becoming waste. Another waste found in lean manufacturing is waiting and defects. The two wastes will be discussed in this study for reasons that will be explained in the next discussion (Figure 1).

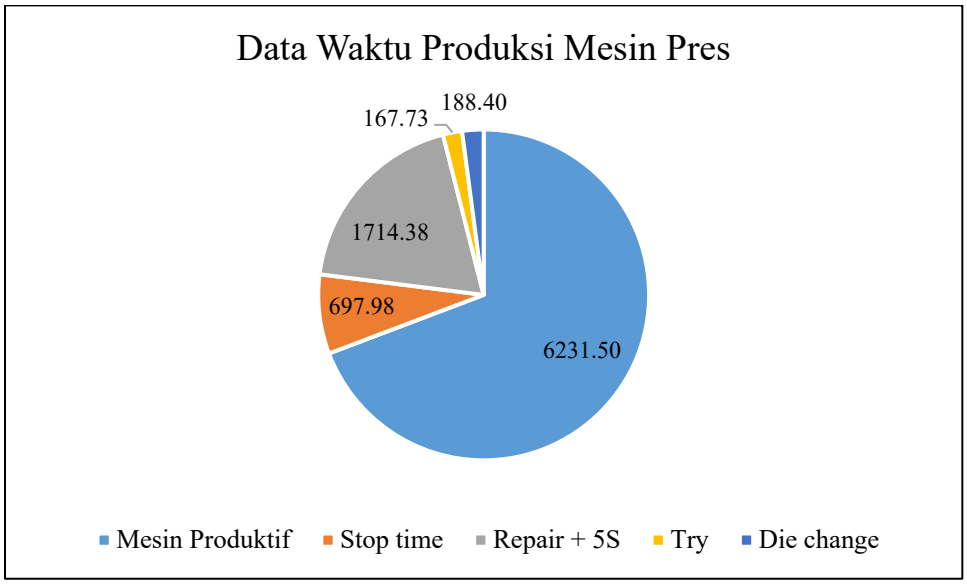


Figure 1. Press machine production time data

The problem with the production process in the pressing machine is the high time the machine is not productive (not producing a product due to various things) which causes a reduction in the amount of production produced by the pressing machine. Total unproductive machine time that occurred in April 2017 reached 2,678.5 minutes from the available 9,000 minutes. The time of the unproductive press machine is divided into several types, namely stop time, product quality that must be repaired, 5S, try process, and die change process. Stop time and repairs that occur can be said to be waste that must be minimized in accordance with the concept of lean manufacturing (Sundar et al., 2014).

Repair time itself is the biggest cause of unproductive machines, which reached 1,714.38 minutes in the pressing division. This is due to the large number of defective products that need repair.

The number of defects in April 2017 reached 1,961 pieces out of 79,016 pieces, or the equivalent of 2.48%. The actual percentage obtained also did not reach the company's target percentage of defects, which was 2%. Of these various processes, unproductive machine processes and product defects are the main waste to be eliminated in this research. There are two types of waste from this, namely waiting waste and defect waste(Kostic et al. 2013, Hassan 2013, Kornfeld and Kara 2013, Pusporini and Andesta 2012, Panat et al. 2014). Waiting waste contained in the press machine production process is when the operator has to wait until the machine can return to production because previously, there were obstacles that caused the machine to be unproductive. At the same time, the definition of defect waste is a defective product caused by the production process of a pressing machine that does not run smoothly. Therefore, improvement proposals are needed in order to minimize waste.

2. Research Methodology

This research methodology begins with field observations made at PT. XYZ Cikarang pressing division located in GIIC Industrial Estate Blok AC No.1 Cikarang Pusat Bekasi, West Java. Furthermore, identifying the known problem is a large amount of defect waste and waiting waste. The causes of these two problems were then found. The cause of defect waste is ibutsu (foreign objects) that stick to the material, causing a defective product, while the cause of waiting waste is the stop time on the machine caused by ineffective scrap disposal channels, poor vacuum storage, and difficulty installing the material accordingly, with mounting standards. With the causes of these problems, this study focuses on reducing the number of stop times on pressing machines and reducing the number of defects by reducing the number of ibutsu.

Problems include identifying the type of stop time that is the dominant cause and the focus of research using the Pareto diagram. Identify the root causes of this type of stop time with a cause-and-effect diagram. Poka-Yoke repair application on the scrap sewer system, application of stopper, and manufacture of vacuum protector. Application of P-chart to find out the cause of defects. Replacement of the material cleaning system using the PDCA (Plan, do, check, act) method (Evans and Lindsay, 2010).

3. Results and Discussion

In exploring the problem of waiting waste and defect waste at PT XYZ, the collection of production time data and company defect data was carried out. From the production time data, it was found that stop time and repair were the main problems with the high waiting waste. Then the data classification is carried out to get the cause of the biggest stop time in Figure 2.

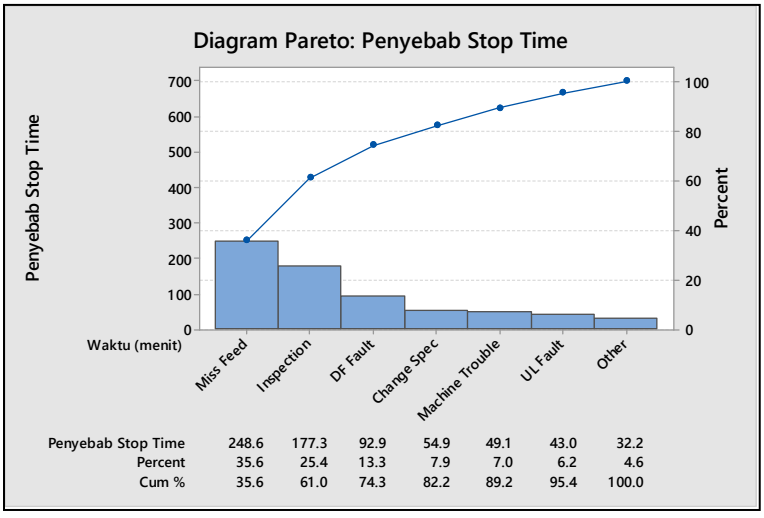


Figure 2. Pareto diagram cause stop time

The results of the Pareto diagram above show that miss feed, inspection, and destack feeder faults are the main problems that cause stop time, where the three problems are the cause of high waiting waste, apart from the high repair time. Apart from these causes, there is a fairly big defect problem in the company, where the percentage of defects reaches 2.48% and cannot meet the company's target of 2%. This high defect is also the cause of the high time of inspection and repair because it has the same root cause. So that by decreasing the number of defects, it will also reduce the time for inspection and repair.

To make it easier to find solutions to existing problems, it is necessary to make a cause and effect diagram in order to get the root of the problem from these causes. It can be seen in Figure 3 is the cause and effect diagram for the miss feed problem and Figure 4 for the DF Fault problem.

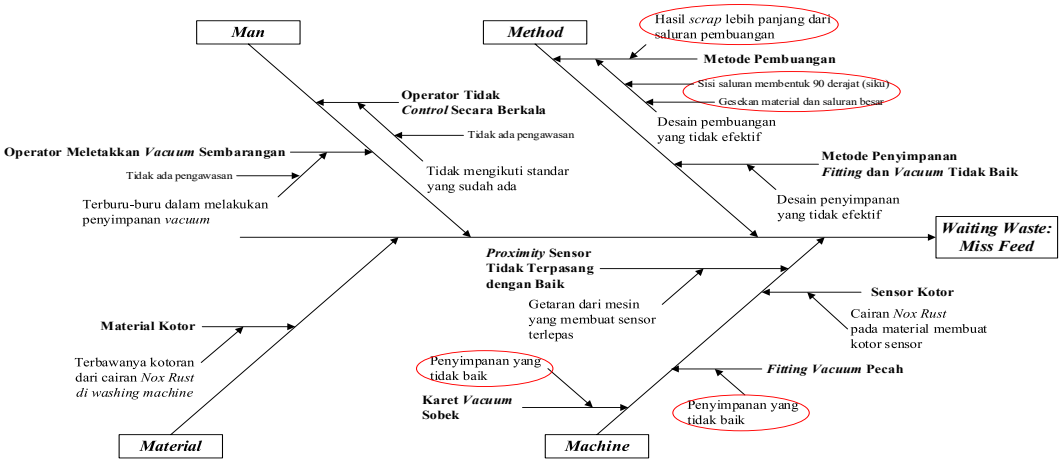


Figure 3. Cause and effect diagram miss feed

From the cause and effect diagram that has been made, improvements are made using the concept of Poka-Yoke, which is to prevent mistakes from happening to eliminate waste (Kurhade 2015). For miss feed, it is known that the root of the problem from the causes that occurred, namely the problems in the scrap material disposal method, as well as vacuum storage and fittings. After knowing the root of the problem that occurred, then suggestions for improvements can be made to solve the existing problem.

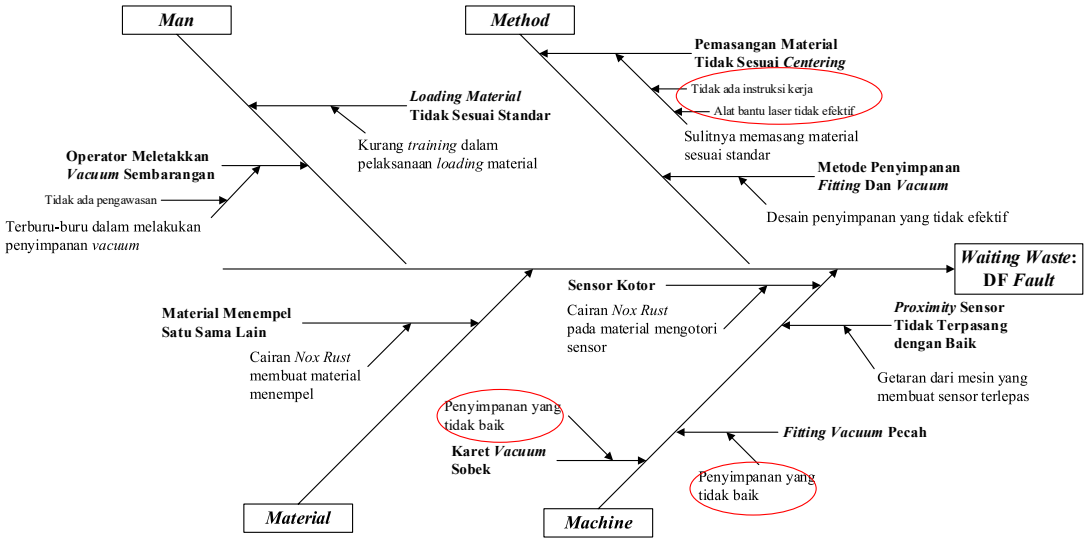


Figure 4. Cause and effect diagram DF fault

To reduce the stop time due to miss feeds, a better design is proposed to minimize the accumulation of scrap in the sewer because a well-designed product can help in terms of economy and manufacturing. A good design product can reduce scrap and reduce production costs (Sharma 2008). The design proposal is in Figure 5.

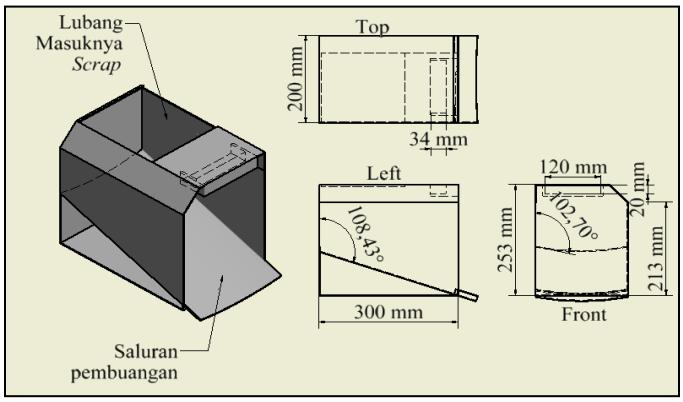


Figure 5. Proposed material drain design on dies

With the proposed design that has been given, the differences in the scrap disposal design before and after the repair are as follows in Table 1.

Table 1. Difference of initial design and proposed scrap sewer

Initial Design	Proposed Design	Information
The channel line has 90^0 angled sides	Curved channel path is curved like an arc shape	To avoid scrap getting stuck on the side of the channel
The side of the 90^0 elbow is flawed due to sloppy construction	The line side of the channel is mandatory there must be no blemishes	To avoid scrap getting stuck on the side of the channel
Channel derivation angle $101,31^0$	Channel derivative angle $108,43^0$	So that the channel line is steeper and makes it easier for scrap to fall
It can't be removed	Can be removed from dies	To facilitate maintenance
The channels are not wavy	Corrugated channel	To create less friction between the material and the channel

For the problem of torn vacuum rubber and damaged fittings as the cause of a miss feed, the repair is to provide a proper storage area in the form of a vacuum protector. Currently, storage is very messy, as can be seen in Figure 6. The proposed new storage area prevents the fittings and vacuum rubber from friction between the dies and the operator on duty.

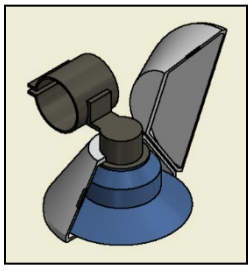


Figure 6. Vacuum protector proposed design

The proposed design for vacuum storage and fitting in the form of a vacuum protector in Figure 6 has several advantages, namely that the vacuum head and fitting are protected from collisions and dust due to the condition of the vacuum, and the fittings are closed. The vacuum protector is made of plastic which is easy to make, and the price is also relatively low.

From the cause and effect diagram for the DF fault, it is known that the root causes of the causes that occur are the installation of the material not according to the centering and storage of vacuum and fittings. The problem of the difficulty of placing the material is helped by the presence of a stopper, as shown in Figure 7. The stopper consists of two parts, namely the main stopper, which is used as operator assistance when installing the material and iron bars to support the main stopper, which is attached to the base loading material. This stopper is useful for indicating where the material is placed to match the placement standard in Figure 7.

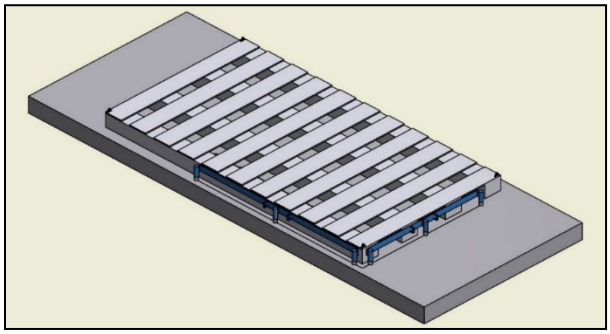


Figure 7. Illustration of material palette installation result with base loading material

The following are the basic differences in the arrangement of the installation work process before and after using the stopper in Table 2:

Table 2. Difference of Initial Process and Proposed Centering Process after Redesign

No	Initial Process	Proposed Process	Information
1	Prepare the laser according to the procedure	Prepare iron tube and stopper according to work instructions.	The new proposal will be added with new work instructions so that the installation of the stopper is in accordance with the centering of each component part
2	Mount the palette according to the laser position	Install the pallet according to the stopper position	The Poka-Yoke concept is to avoid mistakes that previously existed in the incorrect centering position with only a laser benchmark.

As already explained, defect waste has a large enough effect on high waiting waste because product defects cause high inspection and repair. Therefore, product defects must be reduced and Plan, Do, Check, and Act (PDCA) is used to solve them.

a. Plan

The PDCA plan is responsible for planning improvements. For that, the source of the problem must be known. In accordance with what has been explained in Sub-chapter 4.3.2, there are two things that cause an inspection, one of which is the presence of defective products from the press. This indicates that the inspection problem is closely related to the problem of product defects that occur in the pressing division, especially lump defects, because these two problems have the same root cause, namely ibutsu or dirt.

Ibutsu contained in dies can cause defective products to swell from the results of the press, so that when the operator checks the pressed car body components and finds that the product has a lump defect, the operator stops

the process and checks into the machine to find the ibutsu causing the bump. This stopping process is called an inspection and will reduce the production time of the press machine. Due to its relationship with defective products, Figure 8 calculates the P-Chart control chart for lump defects to determine the stability of the production quality of the pressing division car body components.

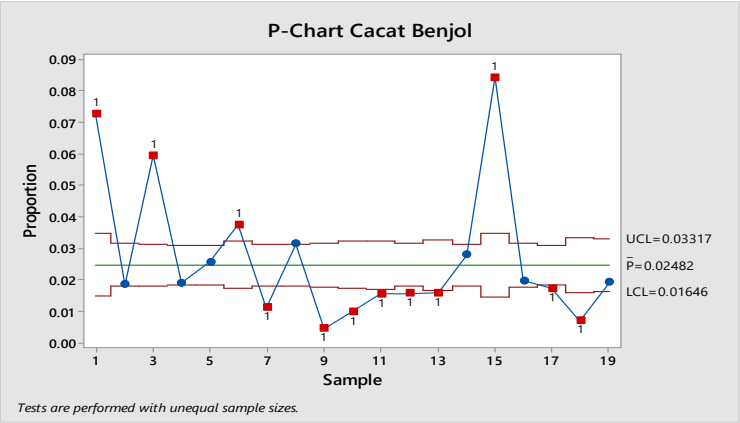


Figure 8. P-Chart of Benjol disabilities for the period of April 2017

From Figure 8, it can be seen that there are many defects that are out of control or indicate that the process is currently very out of control. Many periods are out of control, namely periods 1, 6, 7, 9, 10, 11, 12, 13, 17, and 18. Uncontrolled processes, one of which is because there are many types of parts that are produced, and not all types of parts have a large number of defects. Types of car body components that have a higher defect rate are usually found in the outer part due to a higher level of inspection. This is because the outer part is the appearance of the car body, so it must have high quality because it can be felt directly by consumers.

The cause of inspection that occurs in the press machine production process is caused by dirt attached to the material or dies when the press is running. There are various types of dirt that cause lumps, ranging from conveyor rubber, plastic and paper wrapping materials, glove stitches, and grams of scraps of material due to burry. After knowing that the main problem of defects, inspection, and repair that occurs is caused by ibutsu, it is necessary to investigate how to solve this problem by finding the root causes of the presence of ibutsu or foreign objects in the production process. In Figure 9, you can see the cause and effect diagram of the causes of the presence of ibutsu in the production process. This cause and effect diagram is obtained from the results of interviews with quality employees in the pressing division at PT XYZ. The branch of the problem is broadly divided into 4, namely in terms of Man, Method, Material, and Machine.

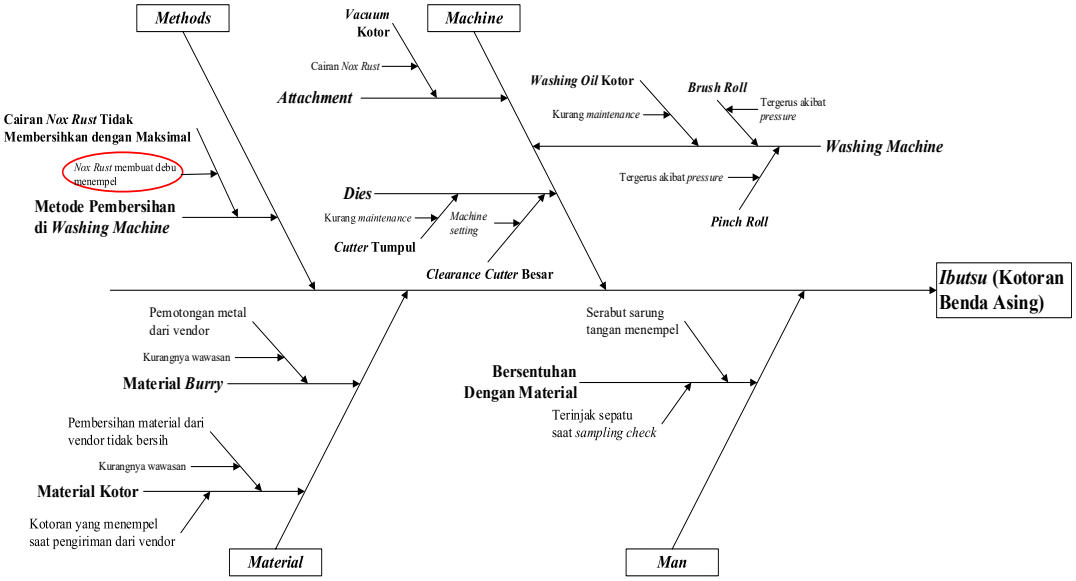


Figure 9. Cause and effect diagram the cause of Ibutsu

From the above causes, it can be concluded that lump defects occur when there is Nox Rust making dirt on the dies. Ibutsu can be in dies because the material does not go through the washing process with 100% cleaning or the tools from the press need maintenance. The previous discussion has stated that maintenance has been carried out, so the discussion that will be carried out now is cleaning in the washing machine, which is not 100% due to a poor cleaning system. Because of this, the root cause of the washing process is not good enough. The current washing process can be seen in Figure 10.

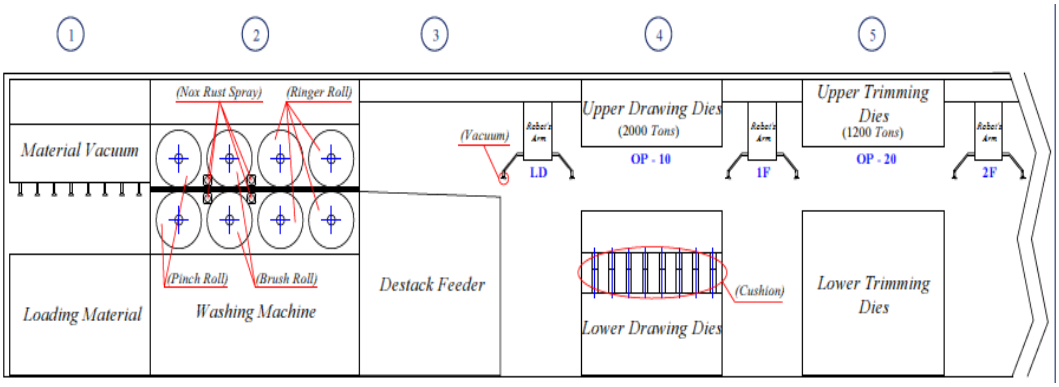


Figure 10. Initial washing material process

Currently, an automatic cleaning system is implemented by the company to remove bottlenecks, so there is no overall control over the washing results. The stress on the ringer role that is given to drying each material can be different because it depends on the needs. For the inner part, because it has a deeper indentation than the outer part, the pressure is given less so that the material remains wet due to the Nox Rust liquid, in order to increase the material's tension when pressed by the press so that it does not break easily. After the three processes have been completed, the material has been cleaned and then moved to the destack feeder to be lifted by the robot's arm, and the pressing process can be carried out.

b. Do

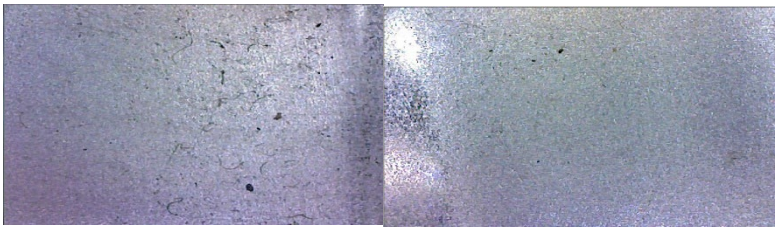
Do in PDCA is making/finding solutions to these problems. From the washing process, the next step is to identify whether the currently running washing process has achieved good results. Then the comparison before and after washing is carried out to determine the changes that occur after the washing process. Materials before and after

the washing process will be viewed using a microscope and carried out at the Manufacturing Process Laboratory, Industrial Engineering, Bina Nusantara University. After seeing the microscopic results of the material before and after washing, if it is proven that the washing process does not clean the material properly, then proceed with an experiment using other liquids as cleaning agents.

Through the literature study, it was found that metal cleaning, which is usually also used in the industrial world, is using cold cleaning. Cold cleaning is used to remove various compounds from metal surfaces using solvent-based compounds to clean. Cold cleaning techniques include wiping with a cloth filled with solvent, cleaning with spray, or soaking with solvent. Most of these cold cleaning is relatively inexpensive and relatively easy methods. Solvent fluids used include butanol, acetone, chloroform, methyl ethyl ketone, hexane, naphthas, mineral spirits, toluene, xylenes, Benzene, ethers, fluorocarbons, and other solvent-containing liquids. Some of these substances can be used for the decomposition process or only for the cold cleaning method (Morrison and Murphy 2015).

c. Check

The check process is reviewing and analyzing the results of previous experiments. The microscopic results of the material before and after the washing process can be seen in Figure 11.

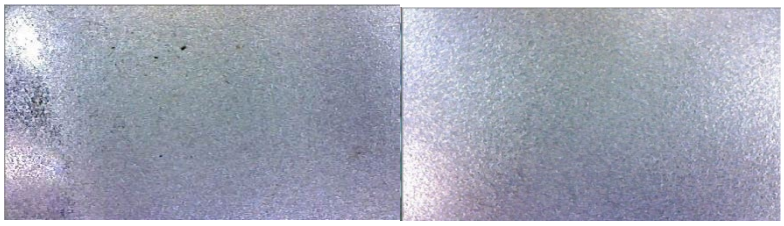


(a) (b)

Figure 11. Results of material microscopy (a) Before washing and (b) After washing

In Figure 11, it can be seen that the material before washing has a lot of dirt, and after washing, it looks like the material is cleaner but still leaves some dirt. This can be said to be a problem for the company because the cleaning is not perfect, which causes blemishes. This imperfect cleaning is known because the process and fluids used are not precise.

Furthermore, the experiment was carried out at the Manufacturing Process Laboratory, Industrial Engineering, Bina Nusantara University using a different liquid, namely Wash Benzene. From the experimental results with the same drying treatment, the difference is shown in Figure 12.



(a) (b)

Figure 12. Microscope results using liquid (a) Nox Rust - Alco 108 and (b) Wash benzene

In Figure 12 above, it can be seen that by using different fluids, the results obtained are also different. Benzene Wash Liquid can be said to be better at cleaning dirt contained in the material than Nox Rust liquid. From the above analysis, it is known that the cause that can cause a stop time in the form of an inspection and bump defects is the dirt on the dies due to a poor washing process. In addition to a bad washing process, it can also be caused by poor maintenance for the washing section, poor maintenance clearance of the cutting, and cut burry material from the vendor. The suggestion that can be given is that PT XYZ must have an inspection schedule with the company to ensure that the cut material received is a good result, then maintenance must also be properly scheduled, and periodic checks of

cutting material, cutter clearance, cleaning fluid filters, pinch roll, brush roll, and ringer roll are done well. Meanwhile, for the main problem, namely the washing process that is not running perfectly, the solution is to change the process that is currently running. Figure 13 shows the process of proposals given to the company.

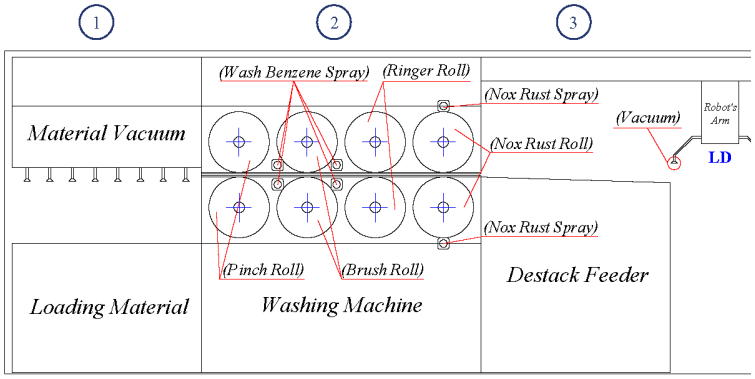


Figure 13. Washing material proposed process

The proposed process was to change the liquid from Nox Rust - Alco 108 to Wash Benzene because it has been proven to better clean the dirt in the material. After going through the brush roll process and spraying with Benzene Wash liquid, the next step is drying using a ringer roll. In this process, a large amount of pressure will be used to dry the material so that it can sweep away the dirt thoroughly. After the process is complete, then the material is given Nox Rust liquid which functions as an anti-rust liquid and increases the material's stretch so that it doesn't break easily when pressed. This Nox Rust liquid is absorbed by the Nox Rust roll so that when the material passes through the Nox Rust roll, the material will be coated with the Nox Rust liquid.

d. Act

The PDCA act is to select and implement the processes used. The process chosen was the proposed process because the number of ibutsu was less when viewed under a microscope. A smaller number of ibutsu means a smaller number of defects. Therefore, the goals or objectives of reducing the number of defects in this new process design are achieved.

The sub-chapter Check, as shown in Figure 12, shows the difference in washing results with Nox Rust Alco 108 and Wash Benzene liquid. The picture shows that Benzene Wash liquid is able to clean better. However, this Nox Rust liquid is still needed to prevent rust and stretching of the material. Therefore, Nox Rust liquid is still used in the washing process. Table 3 is a structure of the process before the change and after the change as previously described.

Table 3. Initial process and proposed washing machine

No	Initial Process	Proposed Process
1	Pinch roll, push the material to the next process.	Pinch roll, push the material to the next process.
2	Brush roll, clean dirt and spray Nox Rust - Alco 108 liquid.	Brush roll, clean dirt and spray Benzene Wash liquid.
3	Ringer roll provides pressure as needed to dry the material, the inner part is usually given a greater pressure than the outer part.	Ringer roll, apply great pressure until the material becomes dry or there is no cleaning fluid.
4	Go to destack feeder.	Nox Rust - Alco 108 spray, gives fluid back with the help of the Nox Rust roll. This fluid functions as an anti-rust fluid and increases the stretching of the material.
5	-	Go to destack feeder

The proposed improvement that has been discussed in the previous sub-chapter has the objective of obtaining an estimated result of the waiting waste and defect waste that can be minimized. The calculation is obtained by comparing

the amount of waiting waste time and the number of production pieces before and after the proposed improvement. From the estimation results, it can be seen whether the proposed improvements will get the maximum benefit. From the above calculations, the total additional time that can be had for the press division is 1,786.5 minutes or 29,775 hours during the April 2017 period, the result of eliminating waiting waste. This additional amount of time can be used to manufacture other body parts. The amount of additional production obtained with an average SPM of 14.81 was 26,458 pieces. Meanwhile, from defect waste, the decrease in the number of defects is predicted to reach 1,568 pieces, and the percentage of defects decreased from 2.48% to 0.5%.

4. Conclusion and Suggestion

After conducting the discussion and analysis that has been done, the following are the conclusions that have been produced:

1. There are two types of causes of waiting waste, namely stop time (miss feed, inspection, DF fault) and repair in the press machine production process. The problem with the miss feed is caused by the presence of scrap that has accumulated in the drain, and there is no proper storage for vacuum and fittings. For the DF fault, the fault is caused by improper installation of the material so that the centering position is not according to the procedure, and the storage arm is incorrect. For inspection and repair problems, the main cause of the ibutsu is found on the dies when the press machine is running. This is the same as the main cause of defect waste, namely ibutsu, which causes production results to become lumpy defects.
2. The solution to minimizing waiting waste (miss feed and DF faults) is the application of the Poka-Yoke concept to the design innovation for scrap sewer, stopper (for material installation), and vacuum protector (to prevent damage to vacuum and fittings). Meanwhile, the solution to minimize defect waste, inspection, and repair is the application of the PDCA concept in an effort to change the cleaning system in order to minimize ibutsu on dies and improve the quality of cleaning results. In addition, the estimated total waiting time that is minimized from the proposed improvements is 1,786.5 minutes and can increase the production rate by 26,458 pieces in one month. Meanwhile, from defect waste, the decrease in the number of defects that occurred reached 1,568 pieces and the percentage of defects decreased from 2.48% to 0.5%.

Suggestions from this study are as follows:

1. The proposed design that has been approved should be implemented immediately considering the amount of waste that can be minimized and the benefits that can be obtained after implementing the proposed design.
2. After the application of the proposal, a new work instruction is also needed so that operators can easily use the new design. In addition, training is also needed to run the production process smoothly on the press machine with the newly proposed design and system.
3. We recommend that the staff from the pressing division not only focus on increasing the SPM of each type of car body component, but start to be reminded of the importance of minimizing existing waste due to inappropriate processes.
4. Maintenance of the washing machine must be carried out regularly to prevent ibutsu that appears as a result of the washing process and inspection to the vendor must also be carried out to reduce the dirt on the product.

References

Central Agency Statistics. Available: http://www.bps.go.id/linkTabelStatis/view/id/1413, 2014.

Evans, J. R., and Lindsay, W. M. Managing for Quality and Performance Excellence, 8th ed., Mason, Cengage Learning, 2010.

Hassan, M. K., Applying lean six sigma for waste reduction in a manufacturing environment. American Journal of Industrial Engineering, 1(2), 28-35., 2013.

Kostic, N. S., and Nikolic, I. Lean Six Sigma in Food Industry. Serbia: International Journal of Basic and Applied Sciences, 13, 2227-5053, 2013.

Kornfeld, B., and Kara, S., Selection of Lean and Six Sigma projects in industry. International Journal of Lean Six Sigma, 4(1), 4-16, 2013.

Kurhade, A. J., Review On "Poka-Yoke: Technique to Prevent Defects". *International Journal Of Engineering Sciences and Research*, pp. 652-659, 2015.

Morrison, R. D., and Murphy, B. L., *Chlorinated Solvents: A Forensic Evaluation,* Royal Society of Chemistry, California, 2015.

Pusporini, P., and Andesta, D., Integrasi Model Lean Sigma Untuk Peningkatan Kualitas Produk. Jurnal Teknik Industri, 10(2), 91-97, 2012.

Panat, R., Dimitrova, V., Selvy Selvamuniandy, T., Ishiko, K., and Sun, D., The application of Lean Six Sigma to the configuration control in Intel's manufacturing RandD environment. International Journal of Lean Six Sigma, 5(4), 444-459, 2014.

Sharma, P. C., *Textbook of Production Engineering.* S. Chand and Company Ltd, New Delhi, 2008.

Sundar, R.., Balaji, A. N., and Satheesh Kumar, R. M., A Review on Lean Manufacturing Implementation Techniques. *12th Global Congress on Manufacturing and Management*, Vellore: Elsevier, pp. 1875-1885, 2014.