Product quality control based on lean manufacturing and root cause analysis methods

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Abstract. Product quality is one of the most critical things in a product offered. Flat glass is one of the many products produced because of high consumer demand. This requires the company to run the production process well to create products that meet consumer expectations. The purpose of this study was to determine the type and amount of waste in the glass-making production process and analyze the root causes of the glass-making process. The method used in this study is a mixed method, namely quantitative and qualitative approaches, which are directly measured using the Lean Manufacture concept approach. Lean manufacturing is a production activity that focuses on reducing waste in all aspects of the company's production activities. From the results of the study, it can be concluded that the cause of reject is influenced by two factors, namely humans and machines, human factors due to not running the standard operational procedure (SOP) properly, the factors of the machine due to not doing the appropriate machine settings at a particular station.

1. Introduction

A competitive and dynamic manufacturing industry raises a lot of competition with the same product. XYZ Company is a company that manufactures flat glass. High demand from consumers, so that requires the company to run the production process by procedures and standards and produce quality products by consumer expectations. In the production process of this flat glass, there are several products that experience defects during the production process. By company standards contained in the control department, there are 4 (four) types of defect products, namely: un-standard primary, un-standard secondary, standard primary, and standard secondary defect. Quality Control is part of the production process that is very influential in improving product quality [1]. The cause of the defect is that during the cutting process there is a rupture of the glass on the mainline installation and the process of removing the glass from the table for packing scratches on the glass. The number of defects in this company is 15% so that it exceeds the standard defect set by the company, which is 10%. So far, the company has made efforts to reduce defects including improvements in processes and human resources. Improvement efforts aim to improve product quality. Quality is the suitability of the product expected with the product received by the consumer. In other words, quality is the suitability of products with specifications desired by consumers. By providing quality products through the quality of the company's services to consumers, which will reduce complaints and costs incurred due to defect products. Quality of service is an important thing that should be improved by the company [2]. So, in this study using lean
manufacturing methods and root causes will get the type of waste that affects the quality of flat glass products and looks for root causes of problems, so that the highest waste occurs.

Lean Manufacturing a systematic approach to identifying and reducing waste through continuous improvement by flowing the product to the customer in pursuit of perfection [3]. Lean manufacturing is about eliminating waste and non-value added tasks [4]. Lean Manufacturing is the most powerful manufacturing systems in the world [5]. Lean Manufacturing is defined as "A philosophy, based on the Toyota Production System, and other Japanese management practices that stand to shorten the timeline between the customer order and the final product and elimination of waste [6]. Root Cause Analysis is identified from problem [7]. So that by implementing lean manufacturing methods and root cause analysis, we can find out the types of waste that often arise and cause defects and know the root causes of waste in the production process of glass sheets. Knowing the waste that causes a defect in the production process of flat glass, the right strategies and actions can be taken to improve quality and reduce defects in the production process of flat glass.

2. Experiment method
The method of this research is a quantitative method with lean manufacturing and root cause analysis concept approaches. Lean Manufacturing as a comprehensive set of practices and techniques for benefit by eliminating the waste, cost and improving quality [8]. Lean manufacturing is about eliminating waste (the non-value-added components in any process) and satisfy customers [9]. The lean practice is used by the manufacturers around the world to enhance their competitiveness because that lean practices will reduce waste and control the essential process related to production [10]. Root Cause Analysis (RCA) is a process for identifying causal factors using a structured approach with techniques designed to provide a focus for identifying and resolving problems [11]. Furthermore, the root cause is the fundamental breakdown or failure of a process which, when resolved, prevents a recurrence of the problem [12]. RCA is a problem-solving process for conducting an investigation into the identified incident, problem, concern or non-conformity [12]. This study has several steps, namely: (1). Data collection; (2). Depiction of Big Picture Mapping; (3). Compilation of Value Stream Map; (4). Activity Identification; (5). Identification of Waste; (6). Calculation of Waste; (7). Data analysis.

2.1. Data collection
At this stage data collection is carried out by field observation and defect data usage for 3 (three) months at PT. "XYZ." Data was taken in December 2017 - February 2018. Table 1 shows data on the defect of flat glass products at PT. XYZ.

| No | Month          | Total Production (CONV.C/S) | Non Standard Frequency (CONV.C/S) |
|----|----------------|-----------------------------|-----------------------------------|
| 1  | December 2017  | 101382,4                    | 5786,069                          |
| 2  | January 2018   | 243875,9                    | 8769,844                          |
| 3  | February 2018  | 154839,2                    | 2735,285                          |
|    | Total          | 500079,5                    | 17291,198                         |

Based on the data in table 1, it can be seen that flat glass products with the most defects in January 2018 reached 51% as many as 8769,844 out of the total 3 (three) months data collection. Whereas in February 2018 there were 16% or as many as 2735,285 or there was a decrease in the number of defects.

2.2. Depiction of big picture mapping
Big Picture Mapping (BPM) is an overall picture in a process. In this description of BPM, it describes all the activities in the production of flat glass at XYZ Company. So, by drawing BPM, we can know the production process from beginning to end and reach the consumers. In describing BPM, it can also identify waste. Figure 1 is a picture of the BPM of flat glass production processes at PT. XYZ.
Figure 1. Big picture mapping sheet glass production process at XYZ company.

Based on BPM, we can know the information flow of the glass manufacturing process. The following is the information flow of the glass making process, namely:

- The flow of information starts from customers who order the factory of XYZ Company, according to the size and demand needed by consumers.
- XYZ Company orders suppliers of primary raw materials and cullet raw materials. According to customer request type and type.
- After the raw material comes to XYZ Company is put into a storage warehouse all for quality inspection determined by the factory.
- The primary raw material warehouse input order data.
- The order is continued to go down to the factory, and an order schedule is made according to the customer's desires.
- After sending the order schedule data, the production process will be prepared.
- Before going into the process of mixing raw materials, the production department orders to send the main raw material. After thinking about the process of mixing raw materials for 5 minutes.
- Next, a metal detector will be carried out so that it is not mixed with the iron group; this process takes 5 seconds to length.
- Then the main raw material will be mixed with cullet raw material for 5 minutes
- After that, the glass mixture is melted for 10 minutes with a temperature of ± 1600oC.
- Next is the stirring and refining process is the process of mixing molten glass to mix all the previous ingredients
• In the refining process is the process of refining glass, and releasing bubbles from inside the glass by providing nitrogen gas to bind oxygen.
• Furthermore, forming process is the process of creating the desired size of glass, this process has a lot of reject bottom defects because the roll settings are not precise and pass molten glass into a metal blast which means passing and floating tin. This process has many reject bottom defects.
• After that, the annealing process is to cool the glass slowly using a blower.
• Glass washing is done to clean the glass from the remnants of production.
• Dark booth is an inspection process carried out by a machine called inomes.
• The chemical coating is done to spray chemical liquid to superimpose glass so that it is not easily overgrown with fungi.
• Cutting is the process of cutting glass according to the size ordered.
• Next is checking the QC to take sampling for research.
• After packing is done.
• And sent to the warehouse waiting for delivery.
• Next will be sent to consumers.

2.3. Identification of waste
Indirect observation of the factory there is a high waste in the glass manufacturing process at the define stage or data collection, waste can be identified in the process of glass mixing, namely:

2.3.1. Overproduction. Excessive production processes that are not needed by consumers. The method of making glass at XYZ Company which is classified as overproduction is:
• Exceeding product capacity in production from the target is usually to anticipate the occurrence of a lot of demand with a short period with consumers.
• Anticipating if in the production process a sudden problem occurs while with the demands of consumers with a short period.

2.3.2. Defects. Defects that occur in FL 5 products of XYZ Company which covers the quality problems of glass products, which include defects are:
• Number of consumer complaints
• The occurrence of Bottom Defect
• Chipping defects
• The occurrence of the Tin Defect
• Swing defects
• Disability of Distortion

2.3.3. Inventory. This waste occurs an excessive inventory. Inventory can also be information, work orders. In the glass making process which includes a waste on inventory is;
• Overproduction so that inventory piles up
• More production than demand for safety stock

2.3.4. Conveyance. In waste (waste) this occurs a disruption of the excessive use of vehicles is:
• Transporting glass, for example, can carry three packs but only transport one pack.
• Do not think about the closest distance that harms the company.

2.3.5. Processing waste. In this processing waste, there is a handling of product quality that is not by the procedure: the following are classified as processing waste:

• Lack of understanding or training on product quality so that it is not careful about rejecting products and passing them, after a final check, there are many who reject and have to do quality control twice to ensure there is no poor quality glass to the consumers.

2.3.6. Idle time. At the idle time there is a waiting time between human or machine processes. The following are classified as idle time:

• Termination of the production process due to resetting the machine to change the size and type of glass.
• Wait for raw materials that are still in the warehouse so that the process stops.

2.3.7. Unnecessary motion. In this waste, there is an unnecessary motion, which is an unproductive movement of staff or employees (for example: moving to find files/files, and running). The service disruption process is classified as a waste of unnecessary motion, namely:

• Staff/employees leave work during working hours without an urgent purpose.
• Staff/staff rest before time.

In the stage of identifying waste, the biggest waste will be integrated into the form of lean methods. For the waste value, it will be broken down into seven types of waste, namely: overproduction.

2.4. Measurement of waste

Questionnaires were distributed to 9 respondents who understood and understood the process of making glass. Respondents consist of Asc. Drawing; Unit Head; Section Cold; Q.A Manager; Section Chief QA; Unit Head; Assistant Section Melting; Section Cold; Assistant Section QC. The following is the data on the distribution of the waste identification questionnaire found in the process of making flat glass:

| Waste Type           | Weight (W) | Frequency (F) | WxF | Priority of Correction |
|----------------------|------------|---------------|-----|------------------------|
| Defect               | 4.4        | 3.7           | 16.3| 1                      |
| Overproduction       | 3.8        | 3.1           | 11.75| 2                      |
| Processing Waste     | 3.4        | 2.1           | 7.3 | 3                      |
| Inventory            | 3          | 2.2           | 6.7 | 4                      |
| Unnecessary Motion   | 3          | 2.1           | 6.3 | 5                      |
| Conveyance           | 3.1        | 2             | 6.2 | 6                      |
| Idle Time            | 3.2        | 1.9           | 6.1 | 7                      |

Based on table 2, shown that defect has the highest value with value is 16.3, and overproduction which value 11.75. Figure 1 is the value of the type of waste.
3. Result and discussion

To find out the cause of the waste defect in the production of flat glass glasses in the Company with the analysis phase using the system of 5 why (cause), found in Figure 3. Based on figure 3, the causes of the waste defect are caused by several factors, namely human, machine, material, and method. From the above figure is the results of discussions with employees of the QA section are known to be the factors that cause defects due to several factors, and the causes are as follows: 1. Human Factors: Operators at XYZ Company does not understand the importance of SOPs, so that rejects do not occur that exceed the tolerance limit of the company. And there needs to be further evaluated. 2. Machine Factors: The machine used is not by the appropriate settings so that there is still a defect or the presence of a station contaminated with hard objects that make a defect. 3. Material Factors: The quality of raw materials is not maintained so that it is still mixed with raw materials that are not needed for production. 4. Method Factors: SOPs made by factories that are not run properly. By not working well, there needs to be an improvement in implementing the SOP, so that all workers understand well and run the SOP because it is one of the standards at work. The purpose of an SOP is to reach out of the operations correctly and always in the same manner [13]. By looking at these objectives, it requires stages in implementing SOP, one of the methods is socialization and involves several elements of production, quality in compiling SOPs. The importance of having SOPs is, also, to help in explaining job description of each employee, SOP also improves the effectiveness of production because employees already know how to work in each stage of the production process, and also what kind of product is considered as having good quality [14].

Technical advice for XYZ Company is a workshop and product knowledge training and how to implement standard operating procedures and implement monitoring and evaluation systems. If the factors and root causes of the problems that have the most influence on product quality are caused by humans, then there must be a program to increase labor capacity, and if it is caused by machinery, a maintenance schedule can be applied and how to arrange work instructions in caring for the engine. Also, for further research it can be continued to measure the frequency level and how to detect defective products using the Failure Mode Effect and Analysis method and Process Control Statistics in controlling and knowing the increase and decrease in defective products. The results of this study are by the journal Meri and Wijaya [15], that human factors also have a large influence on the company because it influences to maintain quality to understand quality so it must understand the company’s Standard Operating Procedure (SOP). Machine factors are considered very important because they can avoid interference or defects in the product.
4. Conclusion
It can be concluded that the type of waste with the highest value is a defect of 16.3. Whereas the root cause of the problem so that the amount of high waste defect is due to human and machine factors because it does not understand the production process of flat glass adjusted to the standard operating procedure (SOP) at the company.

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