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Reducing Wall Shelf Product Defects Using the DMAIC Method in Furniture Industry Companies

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ABSTRACT

The object of research is a place of business that produces household needs and wood-based industries. One of the products it produces is a minimalist wall shelf. In the period January – December 2021 minimalist wall shelf products are the products with the most defects. Manufacturing companies in this study have a product defect tolerance limit of 5% of the total production, but minimalist wall shelf products have a defect of 5.64%. This study aims to determine the types of defects that occur in wall shelf products, identify the causes of defects minimalist wall shelves and provide suggestions for improvements to reduce the number of future defects. In this research the method used is DMAIC. In the minimalist wall shelf production process, 4 types of defects were found. Based on the Pareto diagram, it was determined that the type of lacquer defect was not suitable to be the most dominant type of defect, namely 80.1%, it was also found that the DPMO value and sigma value on minimalist wall shelves were 14,100 and 3.69. Based on the analysis of the fishbone diagram method and Failure Mode and Effect Analysis (FMEA), it is known that the main root cause of product defects is a dirty, dusty and windy environment with an RPN (Risk Priority Number) value of 448. Analysis was carried out using the 5W + 1H approach to find improvements to overcome the problems that occur, obtained suggestions for improvements for the company, namely making work area picket schedules, making closed work areas, daily and monthly check sheet forms for maintenance of work tools, making varnish process work instructions, making training schedules for operators and submitting additional goods forms.

Keywords: Check sheet, DMAIC, Quality control, Risk Priority Number.

1. INTRODUCTION

In the current era of globalization, business development is increasing rapidly, even though it is in an economy that tends to be unstable. This has an impact on business competition, both in the domestic and international markets, every company is required to be able to compete, in order to maintain the business it manages. One way to be competitive, or at least to be able to maintain the business he is in, is to pay full attention to the quality of the products produced by the company.

The purpose of quality control is to prevent product nonconformities from occurring. Each process tries to prevent product failure (defects), products that have been reprocessed, or product failures. To determine the level of product quality, the company applies the Six Sigma method. According to (kholil et al., 2021) Six Sigma is a structured methodology.

Quality control is related to the quality standards set by the company. According to (Haekal, 2023) quality aims to minimize the number of defective products, keep the finished product produced according to company quality standards and prevent defective products from passing into the hands of consumers. So to maintain product quality according to predetermined quality standards, companies need to carry out intensive and continuous control and supervision both on the quality of raw materials, production processes, and final products. In the product guarantee program, the company will always carry out activities.

The purpose of quality control is to prevent product discrepancies from occurring. Each process tries to prevent product failure (defects), products that have been reprocessed, or product failures. Preventive measures taken are expected to avoid high losses or production costs. To determine the level of product quality, the company applies the

Six Sigma method. According to (Prihanto, 2023) Six Sigma is a structured methodology for improving processes that are focused on efforts to reduce process variances while reducing defects in products or services.

Intensive Quality Control (QC) of its products starting from the components of the basic ingredients of the product, the production process. The purpose of quality control is to prevent product nonconformities from occurring. Each process tries to prevent product failure (defects), products that have been reprocessed, or product failures. To determine the level of product quality, the company applies the Six Sigma method. According to (Kholil et al., 2023) Six Sigma is a structured methodology.

Six Sigma can also be viewed as a customer-focused industrial process control by paying attention to production capabilities. In the application of Six Sigma, the target for defects and process failures is controlled within the target of 3.4 DPMO (Defects per Million Opportunities) meaning that in 1 million units of product produced there are only 3.4 units which are defective. This method is capable of gradually improving quality towards a failure rate of zero (zero defects). Six Sigma is a statistical-based quality improvement method that is carried out comprehensively using the DMAIC (Define, Measure, Analyze, Improve, Control) method. The DMAIC method aims to minimize defects and maximize the added value of a product. With the control process, quality, the company is expected to be able to prevent the occurrence of defective products which can ultimately increase productivity.

The object of this research is a company engaged in minimalist wall shelves and wood-based furniture. To carry out its daily production, the company applies a non-shift system. In its activities produce quality products to generate optimal profits. One of the products produced is a minimalist wall shelf. In every production there is always a defect in the production which is made from wood. The company itself targets a maximum number of defects of 5%. The following is an example of a company's product which can be seen in Figure 1

Figure 1 Example of a wall shelf product

Based on the results of the check sheet in the table and figure below, the results of the recapitulation of production data and wall shelf defects are obtained.

Table 1. Production data and wall shelf defects on wooden knots

Production data and defects				
No	Month	Good Product	Defect	Percentage
1	January	1.345	84	6,25%
2	February	1.462	76	5,20%
3	March	1.248	64	5,13%
4	April	1.125	61	5,42%
5	May	1.350	74	5,48%
6	June	1.046	64	6,12%
7	July	1.250	74	5,92%
8	August	1.651	86	5,21%
9	September	1.523	84	5,52%

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Production data and defects				
No	Month	Good Product	Defect	Percentage
10	October	1.470	89	6,05%
11	November	1.685	90	5,34%
12	December	1.650	102	6,18%
	Total	16.805	948	5,64%

The table can be seen based on the graph, the company produces 16,805 minimalist wall shelves with an average of 1,400 wall shelves per month. During that period of the 16,805 pcs produced there were various defects, with the number of defects reaching 948 pcs.

Six Sigma, DMAIC in detail and the similarities of the Six Sigma methodology. The DMAIC method is a process that aims to make continuous improvements to the Six Sigma target. The five steps that must be taken when performing the DMAIC method are Define, Measure, Analyze, Improve, Control.

In order to produce good quality products, companies need to implement integrated quality control, one of which is the DMAIC (Define, Measure, Analyze, Improve, Control) method to raise the level of Six Sigma. The essence of the problem is to reduce the defects produced in the production process on wall shelves.

2. METHOD

In data processing, this study uses two methods for data processing, so that the objectives of this study can be achieved. The two methods used in this research are DMAIC (Define, Measure, Analyze, Improve, Control).

DMAIC in this study is used to determine the causative factors of defects that occur in products, calculate sigma values and DPMO (Defects Per Millions Opportunity), determine the Risk Priority Number (RPN), and provide suggestions for improvements to minimize the occurrence of defects.

1. Define

This stage is carried out to determine the description of Critical to Quality (CTQ) and the production flow that is being used by the company through the SIPOC (Supplier – Input – Process – Output – Customer) diagram.

2. Measures

At this stage, current performance is measured using several tools, namely Pareto Diagrams to determine which defects have the highest impact on product quality, DPMO to find out how many defects occur in one million opportunities, DPMO values are then entered into levels Six Sigma. The control chart is used to carry out product control to find out whether a product has crossed the control limit or not.

3. Analyze

After obtaining defects that most affect product quality, this stage is carried out to identify the causes of the occurrence of defects in a product and find the root causes of these causes by using a fishbone diagram. The factors on the fishbone diagram are obtained by conducting interviews with the quality department.

4. Improve

After getting the factors that cause product defects through the results of the fishbone diagram, the improve stage is the stage of increasing production performance using FMEA analysis to find out the Risk Priority Number (RPN) of the causes of defects and provide suggestions for improvements using 5W + 1H tools to reduce the occurrence of defects. In determining the RPN and proposed improvements, discussions are held with the quality department to determine which process has the most influence on the occurrence of product defects.

5.Control

After obtaining the results of 5W + 1H, at this stage a proposed improvement is made so that the problems that have been handled do not recur.

3. RESULTS AND DISCUSSION

Based on the collection and processing of data that has been carried out, then a discussion of the results of the research data processing is carried out. The analysis was carried out according to the method used, namely the DMAIC method on wall shelf products. There are 5 stages in this method including:

3.1 Results and Discussion of the Define Phase

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At the define stage, two tools are used to analyze, namely the CTQ (Critical to Quality) and the SIPOC Diagram. CTQ is used to find out what are the problems with the quality of wall shelf products. After knowing at this stage it is also necessary to know how the production process of wall shelves at CV. The 3 Bintang Brothers is executed using a SIPOC diagram. The following are the results of the analysis:

3.1.1 CTQ (Critical to Quality)

Determination of CTQ on wall shelf products is based on the type of defect that occurs in wall shelf products. In wall shelf products, it is known that there are 4 types of defects. These four types of defects are things that will affect the quality of wall shelf products. These types of defects are unsuitable varnish, knots, cracks, and wood fiber defects. Based on consumer requests that the product desired by consumers is a product that does not have these types of defects.

3.1.2 SIPOC Diagrams

Analysis using the SIPOC diagram is very useful to find out the entire production process of wall shelf products. Starting with knowing the suppliers of raw materials, the inputs needed to make wall shelf products, the process of making wall shelves, the output of the process and the customers who are users of these products. The following is the result of the SIPOC diagram in Fig.

1. Suppliers

Suppliers of raw materials used in wall shelf products in this company are local suppliers. The main raw material needed is Dutch teak wood. In addition, there are also other complementary raw materials that are imported from local Indonesian suppliers.

2. Inputs

The main component to proceed with the process of making wall shelves is the raw material. The main raw materials for making wall shelves are Dutch teak wood, wood glue, wood varnish paint, brackets and wall bolts. All raw materials are checked after being obtained from the raw material warehouse storage.

3. Process

At the stage of the wall shelf manufacturing process there are 10 processes, namely selecting wood, measuring and cutting wood, sanding/smoothing, joining, drilling for mounting brackets, varnishing, drying, product inspection and finally packaging. These processes are carried out by means of non-shift work.

4. Outputs

From this process a minimalist wall shelf product was produced

5. Customers

Customers at this company are customers from all over Indonesia.

3.2 Results and Discussion of the Measure Phase

At this stage, the sigma value of the wall shelf product is measured using SQL tools, the wall shelf production process is also measured using the P control chart to find out whether the production process is still within control limits or not, then the dominant defect type is determined using a diagram pareto. Here are the results of the analysis:

3.2.1 DPMO and Sigma Quality Level (SQL)

After collecting and processing the data, it was found that the number of wall shelf products produced was 16,805 units. From the results of the data processed using a check sheet, it can be identified that the number of defects that occurred in the wall shelf products produced was 948 units. There are also 4 types of defects found in wall shelf products.

Based on data collection regarding the amount of production and defects as well as the types of defects that occur in wall shelf products, calculations are carried out to find out and get the DPMO value and also the sigma level value of wall shelf products in which can be seen in table 2 below.

Table 2 DPMO Value and Sigma Level

Manufacture of Wall Shelf Products	DPMO value	Sigma Value	Defects percentage
	14.102	3,69	5,64%

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It is known from table 2 the DPMO value and sigma value of the wall shelf production process, where with these results the wall shelf production is included in the classification of the average value of the Indonesian industry. Even though the sigma value is at the level of 3.69, the percentage of product defects still exceeds the company's tolerance limit of 5%. There needs to be an effort by the company to be able to increase the sigma value and reduce the number of defects that occur in wall shelf products so that they can meet the tolerance standards set by the company.

3.2.2 P Control Map

The results of the analysis using the P control chart show that the wall shelf production process is still within the control limits, which can be seen in Figure 4.4. Even though all points are within the control limits, the CL value of 0.0564 is still below the limit set by the company, which is 5% or 0.05.

3.2.3 Pareto Charts

The Pareto diagram is used to determine the most dominant type of defect which will be continued for further analysis so that the cause of this type of defect can be identified. The dominant type of defect is varnish that does not match the value of 80.1% of the total defects that occur in wall shelf products produced by CV. 3 Star Brothers.

3.3 Results and Discussion of the Analyze Phase

At this stage an analysis is carried out using a fishbone diagram to be able to find out the cause of the most dominant type of defect. The most dominant type of defect in wall shelf products is varnish that does not match with a defect percentage of 80.1%. Where based on Pareto law already represents 80% of the defects that occur.

Based on the above analysis, it can be seen that there are 4 factors that are the cause of the occurrence of inappropriate lacquer defects. Each factor has the main cause and main root cause which will then be further analyzed using FMEA analysis to get improvement priorities based on the results of the highest RPN value. .

3.4 Results and Discussion of the Improve Stage.

At this stage an analysis is carried out to find out suggestions for improvements that will be given to the company. The use of FMEA and 5W + 1H tools at this stage aims to be able to find out the priority levels of repairs and proposed steps for improvements to types of varnish defects that are not suitable for minimalist wall shelf products. Following are the results and discussion:

3.4.1 Failure Mode and Effect Analysis (FMEA)

Table 3 Highest RPN Results

Main Root Causes	RPN VALUE	RPN RANK
Unenclosed Room	448	1
No Maintenance	294	2
Operators Less Training	150	3
No SOPs	125	4
Lack of Lighting	50	5

Based on table 3 above, it can be concluded that the main root cause of incomplete mold availability is a top priority in repairs with an RPN value of 448. The failure type category is included in the moderate or medium category. Following are the results of the analysis of the main root causes with the highest RPN values:

The room is not closed

The main root cause that has the highest RPN value is the room in the lacquer process that is not closed which causes many dust particles to enter making the room dirty and also the wind that enters from outside causes defects in the lacquer to be inappropriate. This defect itself can be seen from the presence of lumps of varnish or the presence of product parts that are not coated by the varnish itself

3.4.2 5W+1H

From the results of the calculation of the RPN value, the order that becomes the priority for repair is the cause with the highest RPN value because the highest RPN value is obtained by calculating the value of how big the potential failure impact is, the frequency of potential failure occurrences, and the ability of the detection tool used to detect potential failure occurrences. .

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To clarify, proposed improvements are prepared according to the 5W+1H principle, which aims to clarify what needs to be done, why it needs to be done, where the problem occurs, when the failure occurs, who made the failure and how to make improvements to each potential cause of failure of the varnish not conforming to the product wall shelf. From this analysis, the results of proposed improvements to the problem of unsuitable varnish on wall shelf products are making a picket schedule for cleaning the work area, making a special varnish work area, daily machine checklist forms and monthly machine maintenance, varnish process work instruction forms, training schedules and forms procurement of goods.

3.5 Results and Discussion of the Control Stage.

At this stage, the proposed form of improvement is based on the results of the 5W + 1H that was previously given at the improve stage. Each proposed improvement is based on a potential cause that occurs in the type of lacquer defect that is not suitable for a minimalist wall shelf product. The results and discussion are as follows:

1. For dirty, dusty and windy potential causes

The proposal to make a picket schedule and special room for the lacquer process aims to minimize the occurrence of inappropriate types of lacquer defects caused by adhering dirt due to a dirty work area and also uneven varnish results due to too strong winds outside the work area.

2. For the potential cause of a dirty sprayer machine

The proposal to make a daily checklist and monthly maintenance on the sprayer machine is to be able to find out whether the sprayer machine is in good condition or not and also maintain the condition of the machine so that it does not cause lumps on wall shelf products as a result of the sprayer machine not working according to its function due to lack of maintenance on the machine .

3. For potential cause of incomplete spraying

The absence of standard work instructions causes a potential for failure in the varnish spraying process, therefore to minimize this it is proposed to make work instructions for the varnish process in making minimalist wall shelves.

4. For potential cause, the operator is less thorough

The uneven ability of operators in the process of making wall shelves causes failure, therefore it is proposed to provide training on work instructions and machine maintenance training by making a proposed training schedule for production operators.

5. For potential cause of dim light

The condition of the work area that has less lighting causes the potential for this failure to occur. It is proposed to add lights to work areas that require good lighting. The creation of a goods procurement form is a proposed improvement to this potential failure.

4. CONCLUSION

Based on the results of research conducted on the production of wall shelves, the following conclusions are obtained:

1. In the minimalist wall shelf product produced by CV. 3 Bintang Bersaudara there were 4 types of defects found including inappropriate varnish, wood knots, cracks and defects in wood grain

2. Based on the results of identification using the Pareto diagram, it was found that the most dominant type of defect was non-conforming lacquer at 80.1%, and the factors that led to the occurrence of these defects included: (1) environmental factors caused by uncovered rooms and lack of lighting in space, (2) human factors caused by production operators who were not careful during the production process, (3) machine factors where machine performance decreased due to dirty sprayers and (4) work method factors caused by the absence of soup in the varnish process.

3. After an analysis using the DMAIC method with proposed improvements prepared according to the 5W+1H rule, the proposed improvements are as follows: a picket schedule form and it is also proposed to make a special room for the varnish process to reduce dirt on potential causes, dirty, dusty and windy. For the potential cause of a dirty sprayer machine, a daily check list for the condition of the machine is made to find out the condition of the machine and a form is also made to carry out monthly maintenance so that the condition of the machine is maintained. For potential causes of imperfect spraying, work instructions are proposed for the varnish process. For potential cause operators are less well-versed due to lack of training, a training schedule is made for operators. Finally, for a potential cause of lack of lighting, a goods procurement application form is made to add lighting to the work area.

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