Design of Flat Shoes Quality Control System using PDCA (Case Study at PT DAT)

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Abstract. The D’Arcadia Treasure (DAT) is a Small and Medium Enterprises (SME) that made shoes from traditional Indonesian fabrics. The research objective is to design a structured and documented quality control system to make companies easier to control the production process according to the quality standards desired by consumers. The initial stage is to identify of DAT’s Critical to Quality that will be the basis for compiling a Quality Plan, then using Statistical Process Control method for the control process and Cost of Quality identification. The results of the initial condition analysis are known there are 5 stages of the main process of making flat shoes as the object of research, namely spraying, pattern making, sewing, assembly, and finishing. Furthermore, the quality control system is designed to be divided into 3, namely raw material receipts, production processes, and finished goods equipped with quality control tools checksheet tables and instructions for use. The results of the implementation and analysis of Failure Mode Effect Analysis obtained the highest RPN value of 224 in the assembly process. The entire series of control processes are carried out with the Plan Do Check Action procedure which is a continuous cycle to be implemented in the company.

Keywords: Quality control system, Statistical Process Control, Failure Mode and Effect Analysis, Plan Do Check Action

1. Introduction

Quality has become an important component of every modern organization throughout the world and will remain an important part in efforts to improve performance [1]. Good quality according to the consumer's point of view if the product purchased is in accordance with the wishes, has benefits that are in accordance with the needs and equal to the sacrifices incurred by consumers. If the quality of the product cannot meet the desires and needs of consumers, then they will regard it as a poor quality product [2]. Quality control is engineering and management activities, by measuring the characteristics of product quality, comparing it with specifications or requirements, and taking appropriate corrective actions if there is a difference between the actual appearance and the standard [2]. Factors that influence quality control are process capability, specified specifications, acceptable levels of non-conformity and quality costs. Statistical Quality Control (SQC) is used to quality control process, while the quality cost calculation is intended to find out what costs must be incurred by the company in the process of controlling the quality of its products [2]. Quality control can be achieved with three approaches, namely the raw material approach, the quality of the production process, and the final product approach [3]. The application of Failure Mode and Effect Analysis (FMEA) aims to prevent
problems occurring in processes and products. If used in design and manufacturing processes, FMEA can reduce failure or reduce costs by identifying and improving products and processes quickly during the development process [4]. Overall, quality control must be carried out through a continuous process. The continuous quality control process can be carried out by implementing the PDCA (plan-do-check-action) introduced by Dr. W. Edwards Deming [5]. This PDCA approach has been applied to analyze hospital services that recommend quality improvements in the X-ray service unit based on minimum standards of hospital services [6].

D'Arcadia Treasure (DAT) is an SME that produces handmade shoes for the DAT brand, most of which use traditional Indonesian fabrics such as batik, weaving, lurik, which are made by combining other materials such as canvas, denim, leather, suede, jute, and so on. Other materials used are also synthetic or genuine leather for rubber insole and antislip for outsole. This business is also responsible for several other client brands made by DAT using their materials as needed. Some types of shoes produced are sandals, flat shoes, wedges, heels, clogs, sneakers, and boots, but the special output produced by DAT is flat shoes.

![Figure 1. Flat shoes, the products observed](image)

A touch of innovation that follows current trends or fashions, makes shoes unique and beautiful. Along with the development of its business, DAT products that have been marketed are often imitated by similar SMEs with the same selling price and even higher but lower quality. Design innovations continue to be developed so that almost every month DAT produces 24 Stock keeping Units (SKUs) or product numbers. The production target of 200 pairs of shoes per day by setting working hours is not limited and workers are paid per unit of product produced, as a result often over stock due to a marketing process that has not been maximized and the quality control and guarantee process cannot be carried out properly. The company has not implemented a quality control process with the right concept, so that when there are products that are not in accordance with the quality standards received by the customer, the company will replace the product with a new product but with a different model and not in accordance with the customer's wishes. Likewise with products that are not sold because defects can be returned and then sold at production prices.

This study aims to design a structured and documented quality control system, identify and monitor the process behavior to achieve the desired product quality using Statistical Quality Control (SQC) tools. The results are then implemented and analyzed by the Failure Mode Effect Analysis (FMEA) method. The implementation of the quality control process is then carried out with the Plan Do Check Action (PDCA) cycle.

2. Research methodology

The initial stage is to identify the DAT Critical to Quality (CTQ) for customers who will be the basis for compiling the quality plan (Quality Plan), then using the Statistical Process Control (SPC) method for the control process as well as cost of quality identification. The next stage is to design a quality control system that is in accordance with the conditions of the company and the production process carried out. Data retrieval is carried out by direct observation at the factory location and involving company owners and workers to fill in data forms in the form of production data, sales data, inventory data and defect and disability data. The results of data processing and analysis produce a system that can be used by D.A.T to control and guarantee quality by applying the use of check sheets as well as the instructional sheets made specifically for DAT with flat shoes products as objects in this study. The results of the design are then implemented and analyzed using the Failure Mode Effect Analysis (FMEA) method, in addition to the Cost of Quality calculated from the implementation. All stages of
the research were then identified as a cycle of Plan Do Check Action (PDCA) which became a reference for companies to carry out the process of quality control continuously.

3. Results and Discussion

3.1. Production capacity
DAT makes products continuously with a total monthly production capacity of 2800 pairs with a maximum capacity of 8000. All production processes are done manually, which is why companies rely on human resources to reduce or increase volume. For standard shoe models 1 tailor can produce approximately 20 pairs of shoes per day, as well as 1 person assembler can produce approximately 20 pairs of shoes per day. DAT has 6 tailors and 6 fabricators who work for 6 working days, so that the minimum number of shoes that can be produced in a week is 720 pairs.

3.2. Type of Machine and Number of Machines
Making shoes that are done manually still requires several machines to facilitate the production process. Some of the machines owned by DAT are 6 sewing machines for horizontal sewing process, 1 leather set-up machine for leather which is useful for thinning the ends of the material, 1 cangklong machine for sewing upper curved parts, 1 compressor with spraygun for gluing the material, and 1 grinding machine to flatten sole shoes.

3.3. Analysis of Current Quality Control Conditions
A good quality control system is a quality control system that exists when receiving raw materials, production processes and finished products. In identifying the current quality control conditions will be discussed regarding the quality control of raw materials, production processes and finished goods that are applied in DAT at this time.

The quality control of raw materials in DAT has not been implemented. Based on the results of the interview with DAT Production, it was explained that the raw material received from the supplier had not been inspected by the company. Raw materials received directly are stored in the raw material warehouse. There are several raw materials that are inspected in the process. Inspection of the main raw materials, namely batik cloth, weaving and lurik is done during the pattern making process. The inspection is only done visually and there is no recording. Supporting raw materials are also inspected for outsole and insole materials. Outsole and Insole are inspected before the assembly process takes place. Both inspections are done visually and there is no recording. Batik fabrics, weaving and striated, require a quality control system with a 100% inspection process because the material is the main object and characteristic of DAT shoes. Outsole and Insole also require a quality control system with a 100% inspection process because these materials affect the comfort quality of DAT shoes.

The quality control of the production process applied by DAT is currently divided into two, namely the initial and final inspections. Initial inspection is carried out after the sewing process, while the final inspection is carried out during the finishing process. In the production process itself is divided into 5 main stages namely the process of spraying, pattern making, sewing, assembly and finishing. Based on the results of company information, during the spraying process, pattern making and assembly were not carried out.

The spraying process is a vulnerable process because it depends on weather conditions, if the weather does not support it will greatly affect the results of gluing and risk of causing material defects. The results of the spraying are not inspected so that good or bad quality material is continued to the next process. The pattern-making process is a fairly difficult process because it requires high accuracy in equating the pattern motifs right and left. The results of the pattern making continue to the sewing stage without prior inspection.

The initial inspection process is only done when entering the sewing process, where the parts examined are upper. On inspection the sewing results are carried out by checking the tidiness, the quality of the material and the similarity of the motif. The initial inspection phase is not recorded for
products that are received or rejected, so the company cannot measure the stability of the process. The product received is continued to the assembly process and the rework process or scrap will not be continued. The next process is assembly, where the results are not inspected first but proceed to the finishing stage and inspected simultaneously. This stage is the final inspection which is a unit of quality control of the finished product.

Current quality control of finished goods is included in the final inspection carried out during the finishing process. Observations were made on material quality, gluing, stitching, assembly, and similarity in shoe size. At this stage only manual recording is done for the number of products that are feasible and not feasible to sell, but there are no known types of defects. Even records are not done routinely, companies have not implemented binding regulations to document inspection. This stage aims to find out the number of products that are successfully produced by the assembly operator and tailor, so that it can be known the work wages per day for the operator.

3.4. Designing a Quality Control System

Based on the results of the analysis of the quality control conditions applied by DAT, a more structured quality control system was designed. The overall design of the quality control system is divided into three sub-systems, namely the quality control system for raw materials, the production process and finished products. In the part of the quality control system, there are basic elements which consist of main and supporting raw materials. For the basic elements of the quality control system the production process is divided based on the stages of production, namely the results of spraying, pattern making, sewing and assembly processes. The last system is controlling the quality of finished products that have basic elements in the form of the results of the finishing process of production. The general quality control system design in DAT can be seen in Figure 2.

![Figure 2. Designing a Quality Control System for DAT](image)

3.5. Designing Check Sheet and Inspection Instructions

The quality control process is carried out using quality characteristics guidelines that have been established as Quality Plans and followed by the creation of inspection sheets and inspection instructions. Furthermore, each quality control operator is required to complete a check sheet in accordance with the inspection instructions. The quality characteristics that have been made are
followed by making a check sheet for each material. Example for the process for material quality control, the sheet contains the raw material code, the name of the raw material, the date of arrival and inspection, the name of the inspected material, the various characteristics of the quality, and the status of the recipient. This check sheet has two signs, namely "−" there is no defect, while the sign "✓" means that there is a disability. Figure 3 is an example of a check sheet that is used to examine the main raw material, namely batik cloth.

![Check Sheet Example](image)

**Figure 3.** An example of a check sheet

The designed check sheet is followed by making inspection instructions. This inspection instruction aims to make it easier for the operator to inspect each fabric. Figure 4 is an example of inspection instructions for filling out a sheet checking the main raw material for batik cloth.

3.6. Failure Mode and Effect Analysis (FMEA)

Based on the results of system implementation, several types of failures in making flat shoes are obtained in the sewing and assembly process. Both processes obtained data from the implementation for 14 days from November 24th until December 7th, 2017. This process is a critical process in making flat shoes. In this study, FMEA is used to describe failures that occur in the type of failure in the sewing and assembly process and its causes. The results of FMEA on Table 1 are carried out to determine the priority of improvement on failures that occur by calculating the Risk Priority Number (RPN) value obtained from the multiplication of the three variables of severity, occurrence, and detectability to improve product quality. Data collection and ranking ranking of each FMEA criterion is obtained from the results of interviews with the DAT Production Head and obtained the highest RPN value of 234 in the assembly process because the assembly is less neat.
Figure 4. An example of inspection instructions

Table 1. FMEA Implementation Results on Flat Shoes

| No. | Process Function | Potential Failure Mode | Potential Effect(s) of Failure | S | Potential Cause(s) | O | Current Process Control | D | RPN |
|-----|------------------|------------------------|-------------------------------|---|-------------------|---|------------------------|---|-----|
| 1   | Stitching        | Thread pulled          | Wrinkled Upper                | 3 | Thread pieces are too short | 7 | Visual inspection     | 8 | 168 |
|     |                  | Stitches not neat      | Stitches are not straight     | 3 | Operator performance decreases | 7 | Periodically supervision | 8 | 168 |
|     |                  | Shrinking material     | Material cannot be used       | 3 | Bad material quality       | 6 | Identify the ingredients that are easy to stretch | 8 | 144 |
|     |                  | Different left-hand motives | Different motive of a pair of shoes | 4 | The pattern is less precise | 5 | Periodically supervision | 8 | 160 |
|     |                  | Material defects       | Visual defects                | 4 | Bad material quality       | 5 | Identify types of ingredients that are easily fragile | 8 | 160 |
| 2   | Assembly         | Uncluttered assemblies | Discomfort when used          | 4 | Uncompressed sole mounting | 7 | Periodically supervision | 8 | 224 |
|     |                  | The stitches are open  | Upper cannot be used          | 4 | Careless Tailor operators | 6 | Periodically supervision | 8 | 192 |
|     |                  | Material defects       | Visual defects                | 4 | Bad material quality       | 5 | Identify types of ingredients that are easily fragile | 8 | 160 |
|     |                  | Unsuitable upper back composition | Discomfort when used | 5 | The operator did not use the standard | 5 | Measurement of before and after assembly | 6 | 150 |
|     |                  | Gluing is not neat     | Decreases aesthetic value     | 3 | Gluing time is not long enough | 5 | Set the standard of drying time | 8 | 120 |
3.7. Costs of Quality
The collection of data on the quality control system that has been implemented, followed by the calculation of the quality costs. The quality costs calculated in this case are the cost of valuation and the cost of internal failure. The assessment costs calculated are raw material inspection costs, spraying, sewing, assembly, finishing and inspection equipment production processes.

Inspection data for the production process carried out from November 24 to December 2, 2017, namely as many as 24 sheets of material on spraying, 445 pairs of flat shoes on sewing, 404 pairs of flat shoes on the assembly and 158 pairs of flat shoes in finishing, while for raw materials carried out since December 12 to 20, 2017 as many as 34 fabrics, 120 insoles, and 220 outsoles. Based on the data, the total assessment fee is Rp. 438,158.83. For internal failure costs, the calculation is done based on the condition of the defective product. Reject costs are issued for 3 pieces of the finishing process, while the rework costs are charged to the sewing process as many as 39 pieces and the assembly process is 36 pieces. There is no rejected material for raw materials. The total cost of internal failure from November 4 to November 8, 2017 is Rp. 849,220.63. Based on these calculations, obtained the total cost of quality from the results of implementation for 2 weeks for the production process and 1 week for raw material inspection that is equal to Rp. 1,287,379.46. Based on these calculations, obtained the total cost of quality from the results of implementation for 2 weeks for the production process and 1 week for raw material inspection that is equal to Rp. 1,287,379.46. The results of this quality cost calculation can be used as one of the quality control parameters for the company.

3.8. Quality Control Process with PDCA
Based on the results of the design and preparation of the check sheet, and the implementation phase that has been carried out, a quality control cycle is designed with the PDCA approach. This approach can be used as a guideline for companies to carry out the process of quality control continuously. Table 2 describes the PDCA approach to controlling the quality of flat shoes products.

| Control Process | Plan |
|-----------------|------|
| **Acceptance of Raw Materials** | Preparation of Quality Characteristics Guidelines (Quality Plan), making check sheets for the main raw materials and supporting raw materials, and making inspection instructions. |
| **Production Process** | Preparation Quality Plan, making check sheets for spraying, pattern making, sewing and assembly processes as well as making inspection instructions. |
| **Finished Products** | Preparation Quality Plan, making check sheets for finishing products in the production process and making inspection instructions. |

| Control Process | Plan |
|-----------------|------|
| **Plan** | Completing check sheet according to inspection instructions |
| **Check** | Check the filled check sheet and analyze the results |
| **Action** | Perform separation of raw materials that are not in accordance with the quality characteristics to be further carried out the process of returning or repurchasing to suppliers. |

Source: primary data processed and verified by the owner of DAT, 2018

4. Conclusion
The results of data processing and preliminary analysis of the condition of the company can describe the process carried out by the company so far uncontrolled and not well documented so that the company is in desperate need of a plan for its production system and structured quality control planning. After planning and handling this quality control system can be implemented can facilitate the creation of a quality management system that can help companies document every activity in the
production process and quality control. In addition, the company can also make improvements to production process errors and quality control that have not been well documented. At the stage of this research the following processes have been carried out:

• The results of the analysis of the initial conditions are known to have 5 stages of the main process of making flat shoes namely spraying, pattern making, sewing, assembly, and finishing. There are 2 stages of inspection, namely the results of sewing and finishing.

• The design of a divided quality control system 3, namely for the receipt of raw materials, production processes, and finished goods based on a quality plan that has been previously determined.

• The results of the quality control system design are then followed by the manufacture of quality control aids in the form of a checksheet table and instructions for use for each control process that has been planned so that it can be implemented.

• The implementation process is then continued with the analysis process using the Failure Mode Effect Analysis (FMEA) method which generate the highest RPN value of 224, namely in the assembly process where the assembly process is not neat.

• In the implementation process, the total cost of quality is obtained for 2 weeks for the production process and 1 week for raw material inspection, which is Rp. 1,287,379.46.

• The results of this control process will then be carried out by the Plan Do Check Action (PDCA) procedure.

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