Six Sigma Application to Minimize Castor 5 Inch Scrap Material in EOP Warehouse: A Case Study

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Abstract. Case study in this research at PT. Mega Andalan Kalasan, which one of the manufacturing companies engaged in manufacturing hospital equipment that often has problems regarding the quality of materials stored in warehouses. The problem is often found in the 5 Inch castor material that becomes scrap and incurs costs so that waste occurs. Based on data from April 2018 to September 2018, the percentage of scrap material is increasing every month from 1.44% to 1.77%. Due to these problems, the purpose of this research is to minimize the 5 Inch castor material which is a scrap to avoid waste costs in the Export Oriented Product Warehouse Unit of the company. The methodology in this study uses the Six Sigma method, namely by implementing the Define, Measure, Analyze, Improve, and Control (DMAIC) stages. The results obtained are the most dominant cause of scrap castor 5 Inch material is storage of material on a rack that is not organized with an RPN value of 240. Thus, it is necessary to make improvements to minimize the scrap castor 5 Inch material by conducting a routine briefing by the PIC Area Warehouse Unit Export Oriented Product before operational activities begin.

1. Introduction

Case study in this research at PT. Mega Andalan Kalasan (PT. MAK) Yogyakarta, where is a hospital manufacturing factory. One problem that is often encountered is the problem of material stored in the Warehouse Unit Export Oriented Product, which is often found in materials that are cast 5 Inch which experience scrap. Scrap material is material that is damaged in the production process [1]. Based on data from April 2018 to September 2018, the percentage of scrap material is increasing every month from 1.44% to 1.77%. The scrap material can come from returning the remaining material from the production department to the Export Oriented Product Warehouse Unit (remaining production), material handling errors, and discontinue products, and old designs.

Based on the explanation of the above problems, a study was conducted to minimize scrap 5-inch castor material in the Export Oriented Product Warehouse Unit of the company uses the Six Sigma method. Six Sigma is a structured methodology to improve processes that are focused on efforts to reduce process variances while reducing defects (products/services that are out of specification).

This research was only conducted in the Export Oriented Product Warehouse Unit section and the data used are scrap data of Castor 5 Inch material in April 2018 to September 2018 as a barrier and
assimilation used in this study is a blocking factor on grading on Severity (S), Occurrence (O), and Detection (D) does not exist. This study aims to minimize scrap 5 Inch castor material in the Export Oriented Product Warehouse Unit uses the Six Sigma method.

Six Sigma is also based on real data and facts which are used to perform a detailed analysis. It is based on continuous improvement of all aspects of functioning development in the organization as well as proactive management and cooperation without boundaries at every level in the enterprise. It should be underlined that it is not only an approach for solving the problems with manufacturing but also business processes [2].

Six Sigma is a well-structured, data-driven methodology for eliminating defects, waste or quality control problems of all kinds in manufacturing, service delivery, management, and other business activities [3]. According to [4], Six Sigma uses two major structured methods for improvement known as DMAIC (define-measure-analyse improve-control) and DMADV (define-measure-analyse design-verify). The highlight of the DMAIC method is the five-phased methodological framework that guides in conducting the improvement project [5].

The DMAIC methodology is used for improving production processes, successfully contributing to the reduction of the number of non-compliant products and reducing production costs [6]. Process improvements include reducing the occurrence of defects so that defects can be minimized as much as possible [7].

2. Methodology
This research method uses the stages in Six Sigma, namely DMAIC. According to [8], the DMAIC method is used to identify and eliminate waste that exists. Before identifying risk, researchers first recapitulate scrap data in the Warehouse section based on the SAP system then identified risks using the SIPOC diagram, the process of receiving residual production material. These data are then measured by risk using the Pareto diagram. According to [9], the Pareto diagram is a frequency distribution from the largest to the smallest data. So that the Pareto diagram is used to find out the most dominant causes of scrap to be resolved.

After the most dominant cause of risk, then a risk analysis was carried out by calculating the value of the Risk Priority Number (RPN) for the scrap material using the FMEA method based on the results of the brainstorming with the PIC Area Warehouse and PPIC. Through the FMEA method, the dominant causes of product defects will be known following the value of the RPN [10]. According to [11] the formula used to calculate RPN is:

$$RPN = Severity \times Occurrence \times Detection$$  \hspace{1cm} (1)

Then the risk evaluation of the highest RPN value is carried out by determining the proposed improvement using the Five Why Analysis method so that scrap material can be minimized. Each source of the problem will be determined what causes up to five stages of the question why so that the root causes can be found and solutions are sought [12]. The last step is to control the proposed improvements that have been given to minimize scrap material. Following is the flow of the research methodology used.

1. Determine (D)
   It is the first stage to discuss the problem, the process of determining internal and external objectives and requirements. Determining customer needs, determining goals and problems, forming teams, and determining sources are parts of the define phase. The tools used in define are SIPOC diagrams (Suppliers, Inputs, Processes, Outputs, and Customers), affinity diagrams, and relationship diagrams.

2. Measuring (M)
The purpose of improving the basics of repairs is basic. Measure is a step in collecting data, what is agreed to is to set performance standards. Important tools in this phase usually include trend charts, Pareto charts, process flow diagrams, and measurement of process capability (sigma level, or it can also be called a sigma process).

3. Analysis (A)
   It is a device that is carried out when doing root problems with data in the analysis. The results of the analysis can be used to create solutions in developing and improving the supporting processes. The tool used is FMEA (Failure Mode Effect and Analyze) causal diagram, Pareto diagram, flow chart, and control diagram. According to [13] Priority number RPN is the product rating severity, occurrence, and detection that shows the ranking of corrective action needs.

4. Improve (I)
   The step enhances the full understanding of the main causes that analyze in phase, with the intention of either controlling or overcoming these problems to achieve maximum results. Six Sigma tools commonly used in this phase include regression analysis, hypothesis testing, experimental design (DOE), and variance analysis (ANOVA).

5. Control (C)
   The stage of control on adopting DMAIC is about maintaining changes made in the improvement phase. The aim is to maintain acquisition, restore repairs to ensure success, plan repairs, and win approval documents, business processes, and required training records.

3. Result and Discussion
   3.1 Define
   Based on the results of the scrap data recapitulation in the Warehouse section of the company, it can be seen that the amount of scrap material in the section has increased from 1.44% to 1.77%. More details are explained in table 1.

| Month  | Warehouse Stock (Unit) | Total Scrap (Unit) | Presentation |
|--------|------------------------|--------------------|--------------|
| April  | 7423                   | 107                | 1.44%        |
| May    | 7246                   | 108                | 1.49%        |
| June   | 7321                   | 105                | 1.43%        |
| July   | 7159                   | 112                | 1.56%        |
| August | 7367                   | 117                | 1.59%        |
| September | 7228              | 128                | 1.77%        |
| Total  | 43744                  | 677                |              |
| Average| 7291                   | 113                | 1.55%        |

In facilitating the depiction of the stages of the material acceptance process in the Warehouse Unit Export Oriented Product section until the material is stored in a Warehouse that can lead to the occurrence of scrap material, a SIPOC (Supplier-Input-Process-Output-Customer) diagram is used. Parts that can cause scrap material are found in the Warehouse operator section. More details are explained in figure 2.
Supplier (Produksi) | Input | Process | Output | Customer  
|------------------|-------|---------|--------|-----------
| Component / part hospital equipment Export Oriented Product unit (Castor 5 Inch) | Component / part hospital equipment Export Oriented Product unit (Castor 5 Inch) | Start | Component / part hospital equipment Export Oriented Product unit (Castor 5 Inch) | Scrap Material  

**Figure 1.** SIPOC Diagram of Acceptance of Production Remaining Materials in the Warehouse Section

### 3.2 Measure

Based on the recapitulation of data on the causes of the scrap material, a Pareto Diagram was made to determine the causes of scrap material that must be prioritized to be completed. Pareto diagram is a graph to map problems in decreasing frequency sequence [14]. Events are arranged according to their size, from the largest on the left to the smallest on the [15]. Figure 2 is a Pareto diagram of the data on the causes of the scrap material.

**Figure 2.** Pareto Diagram Causes of 5 Inch Castor Material in Warehouse Unit Export Oriented Product

Based on these results, the cause of the 5 inch castor material that becomes scrap which needs to be prioritized to be resolved in an effort to minimize the 5 inch castor material that becomes scrap in the Export Oriented Product Warehouse Unit section is the remaining production. This is because the
amount of castor 5 inch material which becomes scrap in section Export Oriented Unit Product Warehouse caused by residual production of 485 units (71.6%).

3.3 Analyze
Based on these results, the cause of the 5-inch castor material that became a priority to be completed to minimize scrap material in the Warehouse Unit Export Oriented Product section is the remaining production. Then a risk analysis is carried out through 2 stages, namely risk assessment using the Failure Mode and Effect Analysis (FMEA) method and the probability determination of the causes of the 5-inch castor material that becomes scrap.

The following is a risk analysis table and calculation of the Risk Priority Number (RPN) that causes scrap 5-inch castor material for the period April 2018 to September 2018.

Table 2. Risk Analysis and Calculation of Risk Priority Number (RPN) Causes of 5 Inch Castor Material Scrap in Warehouse Unit Export Oriented Product Section

| Process Description                                      | Potential Failure Mode | Potential consequences of failure | S  | Causes of potential failure | O  | Detection Method                                      | D  | RPN |
|----------------------------------------------------------|------------------------|----------------------------------|----|-----------------------------|----|-------------------------------------------------------|----|-----|
| Storage of materials in the Warehouse Export Oriented Product | FIFO doesn't work well | Material storage on a shelf disorganized Lazy operators place material following the provisions (oldest batch) | 6  | Material storage on a shelf disorganized Lazy operators place material following the provisions (oldest batch) | 8  | Improve material arrangement Conducting routine briefings and checkers must ensure the placement of returned items | 5  | 240 |
|                                                          |                        | The operator is lazy to update the stock card | 7  | The operator is lazy to update the stock card | 5  | Doing routine briefings and checkers always checks every item that enters and exits from the shelf | 4  | 210 |
|                                                          |                        | Conditions in the field do not match the Product Status Data (DSP) | 4  | Conditions in the field do not match the Product Status Data (DSP) | 5  | Foreman is more regularly doing DSP updates | 4  | 96  |
| Material is broken on the shelf                         | 3                      | Material falls from the shelf     | 2  | Material falls from the shelf | 2  | Routinely do pallet replacements that are not suitable for use | 4  | 24  |
|                                                          |                        | The material was wet because the gutters leaked | 2  | The material was wet because the gutters leaked | 2  | Move material to dry place | 2  | 12  |
|                                                          |                        | The material on the inside was hit by the material to be inserted into the rack | 4  | The material on the inside was hit by the material to be inserted into the rack | 4  | Operators are more careful and in no hurry to put material into a rack | 4  | 48  |

According to [16], severity is the quantification of how serious the conditions are caused if a failure occurs which is consequently mentioned in the failure effect, this severity is made on 10 scales (1-10) which show the consequences that are not serious (1) to very serious (10). Occurrence is the level of probability of failure, the occurrence is made in 10 scales (1-10) which shows that very rare consequences (1) until it is very possible (10). While detection is the level of possibility of the failure of the control that has been given, this detection is made in 10 scales (1-10) which indicates the possibility of escaping from a small control (1) to the possibility of escaping large control (10). Based
on the results of the risk analysis, the value of the largest RPN is the potential failure of the lazy operator to place the material following the provisions (the oldest batch). According to [17], RPN confirms the priority level of a failure. The RPN value is used to rank potential process failures [18].

3.4 Improve
After the root cause of the problem causing the scrap material, the next step is to find a solution to the problem. The steps in making improvements for minimizing scrap material use the Five Why Analysis method. The following is the Five Why Analysis of the 5-inch castor material that becomes scrap.

| Question | Information |
|----------|-------------|
| Why is the storage of material on the shelf unorganized? | Because the operator is lazy to place the material following the provisions (the oldest batch) and the checker does not routinely check the suitability of the stock card with Product Status Data (DSP) and the placement of returns on the remaining production material. |
| Why do lazy operators place materials following the provisions (oldest batch) and checkers do not routinely check the suitability of stock cards with Product Status Data (DSP) and the placement of returns on the remaining production material? | Because this has become a habit for a long time, both from the operator and the checker in the Warehouse Unit Export Oriented Product section. |
| Why is the placement of material not following the provisions (oldest batch) and checking the suitability of the stock card with non-routine Product Status Data (DSP) has become a habit long ago? | Because of the lack of briefings every day before operational activities began long ago. |
| Why are there minimal briefings every day before operational activities begin? | Because the PIC Area Warehouse has not routinely conducted briefings before operational activities have begun and so far the briefing has only been carried out only if the audit will be held in the Warehouse section. |
| Why hasn't the PIC Area Warehouse routinely conducted a briefing before the operational activities began? | Because the PIC Area feels reluctant to direct workers to the Warehouse section because most workers in the Warehouse section are older / senior to themselves and there is a lack of supervision from the section head Warehouse regarding the habituation of the briefing. |

Based on the description of the Five Why's analysis, the solution that can be recommended to minimize the cause of the 5-inch castor material that becomes scrap in the Warehouse Unit Export Oriented Product section is as follows:

a. The operator began to get used to placing the material following the provisions (the oldest batch).

b. The checker is more routine in checking the suitability of the stock card with Product Status Data (DSP) as well as the placement of returns for the remaining production material every time they make a shift.

c. Briefings are not only limited to the holding of an audit in the Warehouse section.

d. The PIC area Warehouse Unit Export Oriented Product is more routine in conducting briefings to workers in the Warehouse Unit Export Oriented Product section before operational activities begin.
e. The Head Warehouse Section is more routine in supervising the briefing by the PIC Area Warehouse Unit Export Oriented Product before operational activities begin.

3.5 Control
After making a corrective action in the form of a proposed improvement to the results of the Five Why 'analysis, the cause of scrap 5-inch castor material in the Warehouse Unit Export Oriented Product section, the next step is to control the results of improvements using the Six Sigma method. Without control of the results of these improvements, the repair process will not achieve the expected results. In addition, the control starts from the PIC Area Warehouse Unit Export Oriented Product and the Section Head Warehouse is very much needed in the effort to repair it.

4. Conclusion
Based on the results of each stage of Six Sigma, at the stage of defining the parts that can lead to the occurrence of scrap material are found in the Warehouse Unit Export Oriented Product operator. At the measuring stage, the cause of scrap material that must be prioritized for completion is the remaining production. In the analyse stage, the largest RPN value is the potential cause of material storage failure on an unorganized shelf. At the improve stage, the proposal given is addressed to the operator, checker, PIC Area Warehouse Unit Export Oriented Product, and Section Head Warehouse to make the proposal that has been given. While at the control stage, control efforts must be made to the results of improvements using the Six Sigma method that has been given.

The limitation of this study is that the researcher assumes that the blocking factor for giving values to Severity (S), Occurrence (O), and Detection (D) does not exist. So that the next study is expected to consider the disrupting factors (block) on the value of Severity (S), Occurrence (O), and Detection (D) so that the results of the assessment of the three factors obtained are more valid.

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