Six Sigma Application on Cement Packing Quality Control and Analysis to Reduce Defect

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Abstract. Quality control is applied to achieve company’s vision to be a distinguished cement company in south east region. The objective of this article is to analyze the process quality control and assign six sigma methods to do so. It results 4.44 sigma with DPMO value of 1,638.6 which shows that the company is within USA average performance in similar industry. In addition, this article identify the CTO priority is the damaged sack. The causes of this damage are coming from factors such as methods, machine, human, environment and materials. Considering its urgency, failure mode that need to be prioritized are censors, cut belt conveyor, filling tube, saddle back. The remedial efforts for such failures are: (1) Consistently supervise workers; (2) routine check on packer machines; (3) develop standard operating procedures; (4) machines maintenance; (5) employee training.

Keyword. quality, Six Sigma, DPMO, cement

1. Introduction
Company X is established in 1950s determine to be a distinguish cement company in East Asia region. Therefore, the company apply quality control system in all its existing process. The quality control monitored in CCR (Central Control Room). It is starts in raw material selection, through the work in process, and ends in finished product. CCR can conduct the necessary action if a deviation is found. Packing department is also a subject of quality control because it has a significant role in providing quality product at the tip of the process. A flaw in packing will make a certain drop in finish product’s quality which showed by the deviation from its original specification such as its weight, damaged sack, loose glue or stiches. Those deviations are due to several imbalance processes in each packing process such as broken sensor, cement residue on weight sensor and lack of operator attention in stacking the cement sacks.

Regarding those condition, the objective of this paper is to analyze the process quality control. The six sigma methods is a preference in conducting such analysis. The Six Sigma method was chosen because it is a proven quality management method that can dramatically improve the quality to zero failure rates [1]

2. Literature Review

2.1 Quality control
Quality control is activities to ensure the operations and productions are aligned to its plan. If found any deviation, manager can correct it in such way so that the planned result still achieved [2]. Quality is factors imbedded in products intended to be perceived by consumer [3]. Quality control is actions to prevent any flaw that proceed at the very beginning or a process [4].

2.2 Six Sigma
Six Sigma is a method to develop and deliver products to its near perfection [5]. Six Sigma is a statistical concept to measure a defect related process. A six sigma companies are not necessarily free from any defect. Instead, those company manage to maintain their defect tolerance of 3.4 Defects per Million Opportunities (DPMO). Therefore, six sigma can be used to measure industrial performance [6].

2.3 DMAIC
There are five phases in Six Sigma, Define, Measure, Analyze, Improve, Control (DMAIC) [1].
• Define
At this stage, it is necessary to define some of the things related to the Six Sigma such as project selection criteria, the roles and responsibilities of those who will be involved in the Six Sigma project, key processes in the Six Sigma project and its customers, and the specific needs of customers and statements Six Sigma project objectives [1].
• Measure
There are three main things to do in this stage. Firstly, choosing or determining key quality characteristics (CTQ) that are directly related to the specific needs of customers. Secondly, developing a data collection plan through measurements that can be done at the process, output and outcome levels. Lastly, measure current performance at the process, output, and outcome levels to be defined as a performance baseline at the start of the Six Sigma project [1].

- **Analyze**  
  At this stage, it is necessary to determine the stability and capability of the process, establish the performance targets of CTQ to be upgraded in the Six Sigma project, identify the sources and root causes of disability or failure and convert many failures into the cost of quality failure [1].

- **Improve**  
  The development stage of the action plan is carried out using the 5W-1H method [1].

- **Control**  
  At this stage, the results of quality improvement are documented and disseminated. Successful best practices in improving the process are standardized and disseminated. Procedures documented and standardized work guidelines, and ownership or responsibility transferred from the Six Sigma Team to the owner or responsible person process. This means the Six Sigma project ends at this stage.

### 3. Methodology

The object of research is the packaging of cement bags used by the cement type bag cement. The data used in this research is the historical data of packer production and disability pouch in Company X’s in packer and port work unit. Besides that, interviews were conducted to analyze the cause of defect in cement bagging at factory. The data processed using Six Sigma method which then followed by five step approach of DMAIC as a tool in eliminating the source of main problem causing defect bag broken at packing process.

### 4. Result

Data collected is shown in Table 1.

| Date | Production qty (Sack) | Number of Flawed Pouch (Sack) | Date | Production qty (Sack) | Number of Flawed Pouch (Sack) |
|------|-----------------------|------------------------------|------|-----------------------|------------------------------|
| 1    | 83212                 | 113                          | 17   | 81145                 | 105                          |
| 2    | 68506                 | 98                           | 18   | 92724                 | 137                          |
| 3    | 86726                 | 187                          | 19   | 87779                 | 124                          |
| 4    | 81202                 | 143                          | 20   | 76645                 | 153                          |
| 5    | 76989                 | 130                          | 21   | 86147                 | 156                          |
| 6    | 84160                 | 110                          | 22   | 65561                 | 80                           |
| 7    | 89978                 | 100                          | 23   | 69758                 | 142                          |
| 8    | 81658                 | 108                          | 24   | 93824                 | 161                          |
| 9    | 64456                 | 70                           | 25   | 99566                 | 158                          |
| 10   | 104813                | 130                          | 26   | 91047                 | 199                          |
| 11   | 100957                | 168                          | 27   | 95140                 | 178                          |
| 12   | 96338                 | 117                          | 28   | 86917                 | 155                          |
| 13   | 83602                 | 134                          | 29   | 70635                 | 139                          |
| 14   | 84215                 | 237                          | 30   | 76785                 | 132                          |
| 15   | 71590                 | 135                          | 31   | 97749                 | 148                          |
| 16   | 76050                 | 123                          |      |                       |                              |

Sample size (Sack) : 2,605,874  
Number of Flawed Pouch (Sack) : 4,270

The type of defect that becomes a potential CTQ characteristic is a ruptured pouch. The defect is a type of potential defect that occurs in the production process and becomes a reference in finding DPMO and sigma level. In this study, the calculation of 31 periods showed the day in October and as
many as 2605874 items sack studied with the number of defects as much as 4270 items sak. Based on the calculations performed, the average value of the production amount per day is 84060.45 item sak with sigma value of 4.44. In addition, the value of DPMO obtained is 1638.6 indicates that if the process of packing as many as 1 million items then there are 1638 units of products that do not meet the standards or defect broken. With a sigma value of 4.44 with a DPMO value of 1638.6, it indicates that the packer process is already in the industry average of USA. This can be seen from Table 2 of the sigma level and DPMO values.

| Sigma | DPMO          |
|-------|---------------|
| 1-Sigma       | 691.462       |
| 2-Sigma       | 308.538 (Indonesia’s industry average) |
| 3-Sigma       | 66.807        |
| 4-Sigma       | 6.210 (USA industry average)    |
| 5-Sigma       | 233 (Japan industry average)    |
| 6-Sigma       | 3.4 (world class industry)      |

Based on the stability calculation using the control map p, the stability of the process on the cement with different pouch packaging for each period has been measured. The state of instability indicates that the packing process has not been done consistently high. However, the packing process has fallen into a very good category when looking at good DPMO and sigma values.

Based on the analysis of the cause of the ruptured sac then it can be seen the five causes of broken pouches are methods, machines, materials, environment, and humans. This can be seen in Figure 1 below.

Figure 1. Fishbone diagram of disabled pouch

The next step is to calculate the RPN to identify the failure mode that needs to be prioritized for analysis and follow up, because it is considered to be the main source of failure of the packer machine circuit. RPN calculation results can be seen in table 3 below:

| Priority   | Potential Failure Mode                     |
|------------|--------------------------------------------|
| Priority 1 | Heavy sensor is broken                     |
| Priority 2 | Belt conveyor wear                         |
| Priority 3 | The conveyor controller is damaged         |
| Priority 4 | Filling tube wear                          |
| Priority 5 | Worn saddle back                           |
| Priority 6 | Worn guide plate                           |
| Priority 7 | Less precision pincer position             |
| Priority 8 | Roto packer setting less precision         |
5W + 1H (What, Why, Where, When, Who, and How) conducted for continuous improvement of product quality. The following actions 5W + 1H could be done:

- **What** (what causes the occurrence of product defects)
  The cause of the occurrence of defective pouch burst in the packer process is the lack of accuracy and focus of the workers that will result in losses of companies that have to dispose of defective products.

- **Why** (why the improvement plan needs to be done)
  Improvement plans are undertaken to reduce the number of defective products and to achieve a company with zero defects so as to satisfy customers by producing products that are appropriate and precise to customer specifications.

- **Where** (where a corrective action plan would undertake)
  Improvement plan will be done in packer process by considering several aspects that can decrease the number of defects.

- **When** (when the corrective action plan is done)
  The corrective action is performed after an analysis of the sigma and DPMO values obtained by the company.

- **Who** (who is responsible for corrective action)
  Corrective action shall be taken by all parties directly related to the cement product type bag and related parties.

- **How** (how corrective steps are done)
  The settlement step is with intensive supervision and good coordination in the field in accordance with the causes of the problems that occur

5. **Conclusion**

The conclusions of this paper are:

- Priority critical quality (CTQ) characteristic is packed bag
- Factors causing the ruptured bag come from method factor, machine factor, human factor, environmental factor, and material factor.
- Priority failure modes that need to be prioritized for analysis and follow-up are heavily damaged, belt conveyor wear, damaged conveyor, filling tube wear, worn saddle back / back, worn guide plate, less precision pincer position, and Roto packer setting less precision.

Proposed improvements made based on results from the Fishbone Diagram:

- **Method**
  Conduct consistent supervision of workers and routine checks on packer machines as well as make work process procedures in the form of SOPs approved by the company.

- **Machine**
  Perform regular inspection and maintenance of equipment and schedules. In addition, the company also provides spare parts for preparation when there are components of equipment that must be replaced.

- **Man**
  Conduct training or training for workers to improve knowledge, motivation and safety awareness work.

- **Environment**
  Companies should design good air ventilation so that air circulation can run well to prevent moist packaging of cement bags in the rainy season. In addition it needs to do regular cleaning on the machine and room on the packer process so that no more cement dust attached to the weight sensor.

- **Material**
  The company must check the quality of existing materials to match the quality of the material that should be.
6. References

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