



Quality Improvement to Reduce Paper Bags Defects Using DMAIC Method in Cement Industry

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ABSTRACT

Improving quality can affect increasing customer satisfaction, business profitability and business competitiveness to maintain industry sustainability in the future. This research focuses on the manufacturing process of paper bags in the cement industry, especially on high product defects. This research uses the Six Sigma method. DMAIC (Define, Measure, Analyze, Improve, and Control) methodology is supported by quality tools that have successfully analyzed and made recommendations for corrective actions. The method was used to propose several recommendations. After improvements were made using the Six Sigma method such as providing training to tubbing machine operators every three months and briefing the operators before work, there was an increase in the sigma value from 4.65 to 5.04 and there was a 14% decrease in the company's operational costs and rework costs. Based on the hypothesis test, there is a difference in the average number of defects between before and after the improvement. Improving quality can affect increasing customer satisfaction, increasing business profitability and increasing business competitiveness to maintain industry sustainability in the future.

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1. INTRODUCTION

The manufacturing industry is currently undergoing post-pandemic adjustments. Among them are industries engaged in the field of essential elements in development, namely the cement industry which is required to be able to meet the needs and demands of consumers. Products must be packed properly and neatly using cement bags (paper bags). Almost every day we can find defects in the manufacturing

process of cement bags. With a total of 36,897 pcs cement bags defect which could not be reworked, the company suffered a loss of IDR. 10,000/pcs or IDR. 36,897,000 of the total cement bag produced. Therefore it is necessary to take effective steps in controlling defects that occur in each process by using systematic control techniques. From the results of identifying defects, engine factors of tubing machines often cause defects during the

production of cement bags. Based on the company's historical data, manufacturing defects in cement bags because of the tubing machine is 0.67% meanwhile the company standard is 0.4%. Figure 1 shows the number of defects in the tubing machine process. Thus the need for quality control defect paper bag are 22.61% wide tube deviate, 20.50% length tube deviate, 19.47% longitudinal pasting thin and empty, 18.06% cross pasting thin and empty, 5.94% stamp incomplete, 5.81% spacing overlap, 4.70% pocket side fold and 2.91% perforation distance of the product paper bag to reduce the percentage of defective products by using the method of Six Sigma.

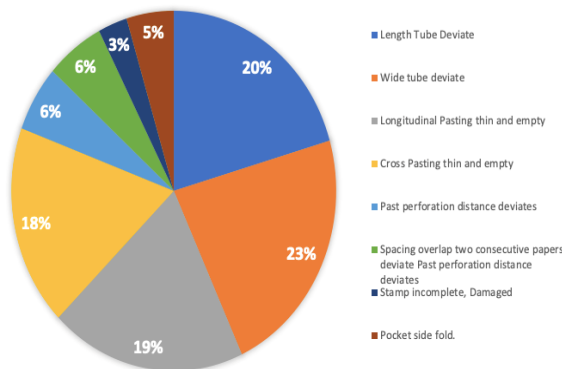


Fig.1. Number of defects in Tubing Machine (Source: data processing results, 2022)

Six Sigma is a continuous improvement process, that prioritizes the DMAIC stage (define, measure, analyze, improve, control). The DMAIC method (Define, Measure, Analyze, Improve, and Control) was supported by successfully analyzing and recommending corrective actions using quality tools to reduce express service execution time from 120.06 minutes to 64.00 minutes or a 53% improvement service cycle and successfully increased service process efficiency from 1.96 sigma to 3.80 (Fathurohman, Purba, & Trimarjoko, 2021). According to (Trimarjoko et al., 2019) in their research, the preliminary results indicate that the method proposed in this document could successfully improve the efficiency of the construction process (sigma level) from 4.48 to 5.02 sigma and reduce the cost. In another study, the results showed that for the defined level, a top priority for quality improvement using CTQ (Critical To Quality) was 92% color change. When measured, the

process capability value showed a final yield of 51.69%, which is below the Indonesian national standard of 69.2%. Similarly, modification has the effect of raising the sigma level from 3.7017 to 3.9614 by 7%. Improvement faults can also lower defects from 11.08% before improvement to 5.54% after improvement (Kurnia et al, 2021).

Quality improvement for cement bags has been studied in some research. The study done by (Shesarina & Fitriana, 2022), used Lean Six Sigma to improve quality in the cement bagging process. In the measure stage, they use Process Activity Mapping and Value Stream Mapping to observe the production process. In the analysis stage, they use a cause-and-effect diagram to analyze the problem's root cause. There is an improvement in sigma level value from 3.573 to 3.757. The improvement efforts based on the failure priority are consistently supervised workers; routine checks on packer machines; development of standard operating procedures; machine maintenance; and employee training. Another study used Lean Six Sigma to identify the quality problem in a new cement bag production line and used a cause and effect diagram and FMEA method to identify the root cause of the problem (Putri et al, 2018). Meanwhile, Sutrisno et al (2019) study is to reduce defects in cement packing using a Six Sigma method. They use Risk Priority Number to list the main source of failure in packer machine circuits that need to be prioritized. After the improvement the sigma value is 4.44 and within the USA average performance in similar industries.

This study aims to identify the quality of cement bags in the cement factory by finding solutions and strategies to improve the quality and identify what are the factors that cause these defects based on the type of the defect. The difference with the previous study is that they did not classify the defect of the cement bag, we used a Pareto chart to classify defect priority in the analyzed phase in the Six Sigma method and we stated a hypothesis whether there will be a difference on the average number of defects before-after improvement. We use 5W+1H to develop continuous improvement recommendations and a paired T Test method to test the hypothesis.

2. LITERATURE REVIEW

Quality is an attribute of goods and services decided by the consumer or user and attained through measurement and continual improvement processes. As a result, each business must monitor the quality of the goods and services it provides to customers (Amrina et al, 2020). The business environment is becoming more competitive, which drives companies to continually develop and enhance the quality of their output, pushing the number of defective products in the manufacturing process and maintaining control over product quality as the success factor in their production system. A product that doesn't meet its specifications and adheres to the previously established quality standard is considered poor (Mustaniroh et al, 2021). Six Sigma is a business improvement methodology that, for the service sector, aims to increase customer satisfaction, cost, quality, processing speed, and investment capital at the fastest rate possible to maximize shareholder value (Haviana, 2019). Even in a complicated industry like healthcare, DMAIC may be used as a road map to implement the Lean Six Sigma mindset and enhance a process. Its relevance and durability depend heavily on incorporating process control into long-term strategies and including the appropriate stakeholders (Monday, 2022). For product-based industries, where fulfilling the needs of the consumer is of the highest priority and when those needs can appear unpredictable, Six Sigma is a version, philosophy, strategy, and collection of tools to enhance process and service quality (Keykavoussi & Ebrahimi, 2018). Six-Sigma DMAIC methodology was beneficial for improving sigma levels, decreasing standard deviation values, and lowering predicted parts per million outside of specification limitations. Six Sigma using The DMAIC approach is well-known and capable of serving an important function in the manufacturing business by minimizing variability in the bearing component process (Bhargava & Gaur, 2021).

3. RESEARCH METHOD

This research was carried out by following the steps of implementing the Six Sigma method, namely Define, Measure, Analyze, Improve and Control which shows in Fig. 2.

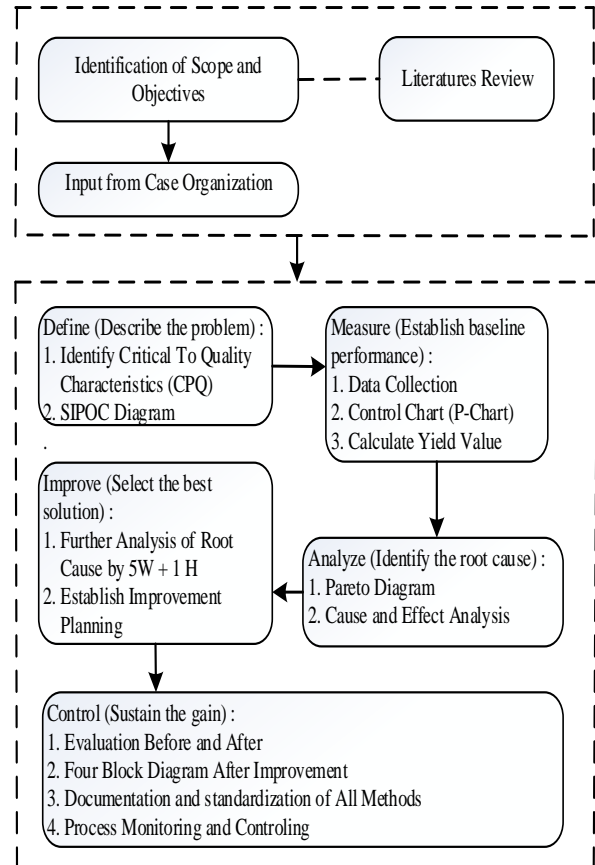


Fig. 2. Study framework
(Source: data processing result, 2022)

4. RESULT AND DISCUSSION

Define

The results of data collection on total production and total product defects paper bag caused by machines tubing by the total number of product defects paper bag of 394,002 pcs of the total production paper bag 59,097,363 pcs, with a defect percentage of 0.67% with a target percentage of defects caused by machines that are 0.4%. There are 8 CTQs for quality paper bags, i.e. Length Tube Deviate, Wide tube deviate, Longitudinal Pasting thin and empty, Cross Pasting thin and empty, Stamp incomplete, damaged, Spacing overlaps two consecutive papers deviate, Past perforation distance deviates, and Pocket side fold.

Table 1. Critical quality

Defect Type	Amount Defect (pcs)
Length Tube Deviate	80,784
Wide tube deviate	89,092
Longitudinal pasting thin and empty	76,725
Cross pasting thin and empty	71,138
Past perforation distance deviates	23,386
Spacing overlap two consecutive papers deviate past perforation distance deviates	22,878
Stamp incomplete, Damaged	11,471
Pocket side fold	18,528

(Source : Production Dept, 2022)

Company SIPOC diagram and production process SIPOC diagram paper bags can be seen in Fig. 3.

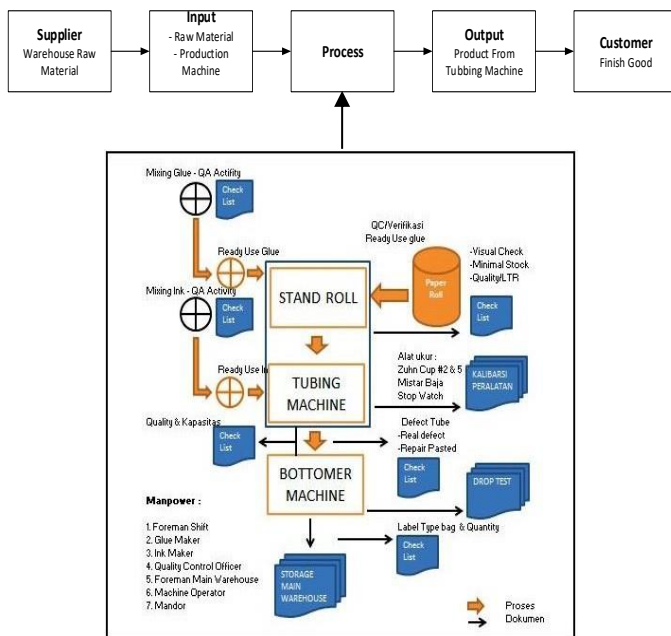


Fig. 3. SIPOC Diagram
(Source: production dept, 2022)

Based on Figure 3, the SIPOC diagram for paper bag production has problems with product defects caused by tubing machines. Next, determine the Project Six Sigma needs to identify some things related to the Project Six Sigma. Roles and responsibilities of the people who will be involved in the project Six Sigma. Project Six Sigma is made to find out the problem of defects in the product paper bag to improve the level of product defect paper bags produced by a tubing machine.

Measure

The measurement stage is carried out through 2

stages, namely the stage of diagram analysis control (P-Chart) and level measurement stages sigma, Defect per Million Opportunities as well as value yield. Data is taken from paper bag production using the P-Chart. From this data, a P-Chart control chart can be made. This means that the actual percentage is still higher than the company's target percentage, which is 0.67% actual from the company's 0.4% target. Thus, on the department paper bag PT. Indocement Tunggul Prakarsa, Tbk. requires improvement to reduce the level of defects by the target standard machine tubing set by the company is 4.14 or 0,4% which means that the process capability to produce products is still far from the company's target. To measure the level of Six Sigma from the results of the paper bag production process did the following steps: Calculating DPMO (*Defect Per Million Opportunities*).

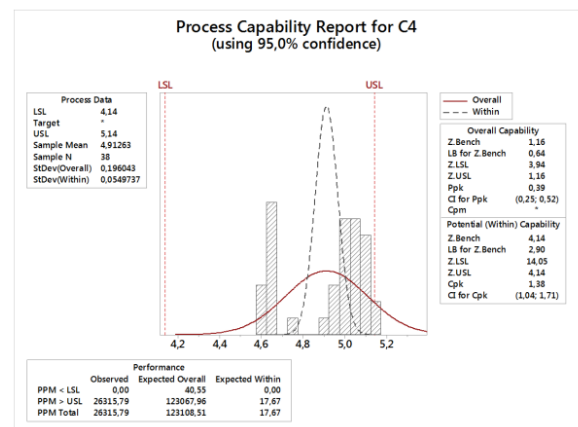


Fig. 4. The capability process of Z bench before improvement (Source: data processing results, 2022)

From the calculation above, it can be seen that the sigma value is 2.98, so it can be said that the production produced by the machine does not reach the set target, so it needs improvement. The DPMO value of the paper bag production process produced by the machine tubing from April to March, the average DPMO was 848 pcs, which means that out of one million opportunities, there were 848 pcs with the possibility of defects. If the DPMO value is converted into a sigma value, then the average sigma value is 4.64 meaning that the production process paper bag produced by the machine tubing is already in the industrial class average, which is between 4 and 5 sigmas, but the company's capabilities are still far from the

6 select-free production process is 0.67%, this is certainly not expected by the company because the target, namely the defect rate is 3.4 out of one million opportunities. The average value yield has an average of 99.33%, which means the process's ability to produce a tolerance limit for the level of defects set by the company is 0.4%.

Analyze

Analyze is the third stage in the Six Sigma process. The purpose of this stage is to analyze the main causes which cause problems in the process. In this study, the main causes of these problems were analyzed using: the Pareto diagram. The calculation results can be described in the Pareto diagram shown in the following Figure 5. A Pareto analysis was conducted to explain that 80% of the largest defect from tubing machine was on wide tube deviate amount 89,092 pcs or 22.6%.

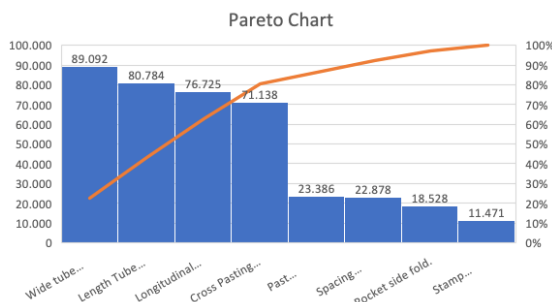


Fig. 5. Pareto diagram of defect
(Source: data processing results, 2022)

The result of the Pareto diagram is used to make the Cause-effect diagram. The problems of processes were analyzed to get what was the dominant cause of the defect. The Cause and Effect Diagram of the problem is shown in Figure 6 below. After we know the cause of the defect, we will minimize it and hope that the improvement can reduce the number of defects. Therefore the hypothesis are :

H0 : There is no difference between the average number of defect before and after improvement

H1 : There are differences between the average number of defect before and after improvement

Improve

The activities in this phase are to identify the proposed improvement from the root cause that was achieved in the analysis phase by

conducting brainstorming using 5W+1H and the product improvement matrix plan error became a problem in this study. The proposed improvement plans using the 5W – 1H method are as follows: Concept of Improvement for Defects in Wide Tube Deviate. the results of the proposed improvements for defects in the width and length of the tube deviate, namely: (1). Human Factors, namely Human Resource Development provides training to machine operators tubing every three months and Foreman does briefing before carrying out the production process so that the operators. understand about machine tuning tubing and reduce errors in work. (2). Machine factor, that is before the operator sets the machine the Foreman gives instructions for machine operators in the form of briefing about machine setup tuning. (3). Material Factors, namely quality control check the mixture of water and glue before carrying out the production process. (4). Method Factor, namely installing display machine SOP tubing of area machine. (5). Environmental factors, namely the foreman suggesting to the company that it is necessary to add fans and provide earplugs to operators.

Control

At this stage a control concept will be given so that it is hoped that if a problem occurs it can be immediately resolved and the existing problem will not recur. The control concept given is basically in the form of work instructions for the beginning of production, during the process, and at the end of the process. The results of the implementation are five points in the check sheet tube length and width defects deviated. The first is training for operators by Human Resource Development so that operators can understand their work. Second, he gave instructions from the work briefing by Foreman to the operator before the production process began so that the operator understood how to operate the machine tubing. The third, namely ha she installed the SOP. Display on the machine tubing the aim is to reduce operator errors in work and to operators to be more careful to reduce the rate of defects in cement bag products produced when the production process begins. The fourth, namely checking the raw material for the mixture of water and glue by quality control.

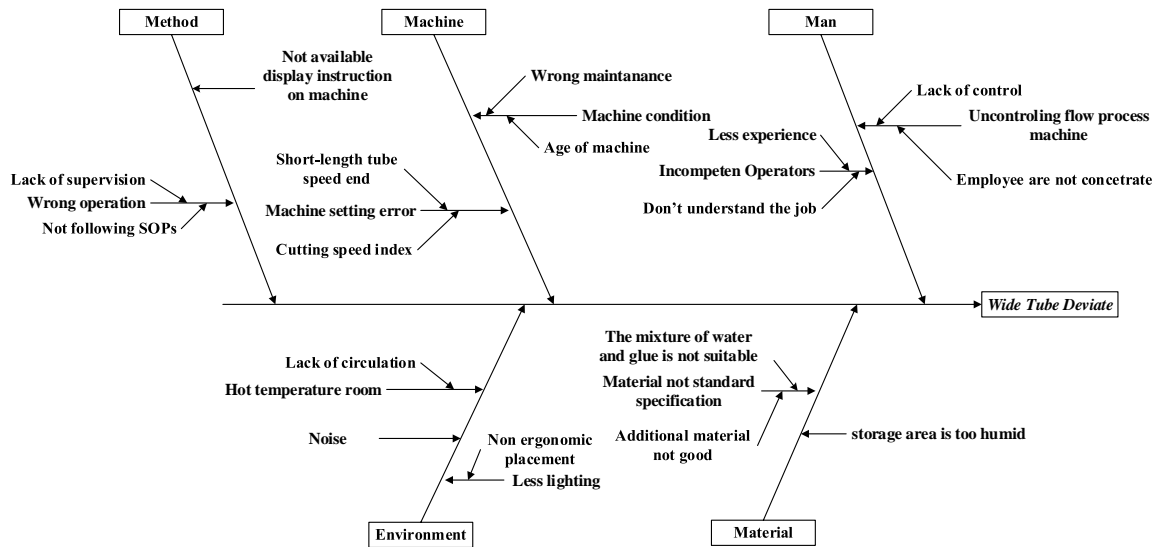


Fig. 6. Fishbone diagram
(Source: data processing results, 2022)

Fifth, the addition of fans is still in the process of being submitted to the company and earplugs have been provided to operators security and operator comfort at work. The control stage was the last in the Six Sigma method, where in this stage the process capability sigma level calculation was conducted again after the improvement. The results of the next implementation are four points in check sheet longitudinal defects and cross pasting thin and empty. The first, namely has he checked engine components by maintenance every 60 minutes. The goal is that the production process is not hampered so that the quantity produced is to company specifications. The second is that the raw material for the mixture of water and glue has been checked by Quality Control. The goal is to minimize errors in mixing water and glue according to company standards.

The third, namely installed machine Standard Operational Procedure display tubing of the area, the machine aims to reduce operator errors in work and operators are more careful to reduce the product defect rate paper bag produced when the production process starts. Fourthly, the addition of fans is still in the process of submitting a request to the company, and ear plugs have been provided to operators for security and operator comfort at work.

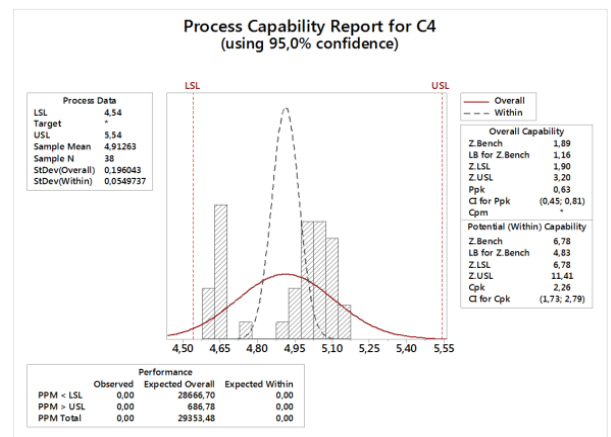


Fig. 7. The capability process of Z bench after improvement (Source: data processing results, 2022)

The calculation of the Z-bench capability shows a result of 6.78 meaning that after implementing the Six Sigma method, the process capability of producing products can meet company targets. Fig. 7 shows the results of improvement in this study. It has better results than the conditions before the improvement. The results of the implementation of the Six Sigma method state that there is a decrease in defects in paper bag products after the method is applied six sigma that there is an increase in the sigma value from 4.65 to 5.04, which means there is decline for costs incurred by the company due to defects in paper bag products of 14% of sales. Based on the improvements that have been made for three months in the tubing machine process, it

can be seen by looking at the position of the tread as measured using the Four Block Diagram method. The aim is to determine the improvements that have occurred in the tubing machine process after repairs have been carried out and the position of the control and technology side is known. Furthermore, after implementation is shown in the Fig. 8.

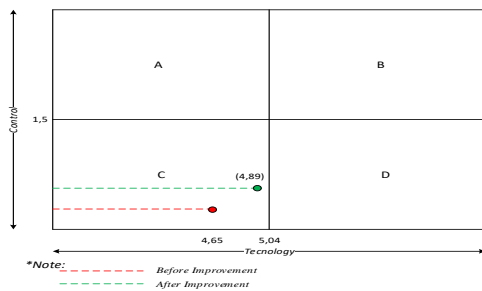


Fig. 8. Four block diagram after improvement (Source: data processing results, 2022)

It can be seen Fig. 8 that the quadrant value is in quadrant C, which means that after making improvements with six sigma method the company was able to improve a good control system but was still lacking in terms of technology utilization. Thus, companies must improve their technological systems to reach quadrant D. To statistically test whether there is a change in the number of defects between before and after the improvement, a paired t-test was conducted. Before conducting a paired t test, it is necessary to test the normality of the data. Fig. 9 shows the results of the normality test. The Sig. value of Shapiro-Wilk is greater than 0.05, so the data is normally distributed. After that, the paired t test was conducted. Fig. 10 shows the results of the paired t test, with Sig. obtained is 0.001. Sig. < 0.05 then H0 is rejected, which means there is a difference in the average number of defects between before and after the improvement.

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Data Rject Sebelum Perbaikan	.101	26	.200 [*]	.960	26	.393
Data Rject Setelah Perbaikan	.131	26	.200 [*]	.958	26	.348

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Fig. 9. Normality test (Source: data processing results, 2022)

Pair 1	Data Rject Sebelum Perbaikan - Data Rject Setelah Perbaikan	Paired Samples Test							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
		58.731	75.121	14.732	28.389	89.073	3.986	25	.001

Fig. 10. Paired T test (Source: data processing results, 2022)

With a total paper bag defect before the method was applied six sigma of 36,897 pcs which could not be reworked, the company suffered a loss of IDR 10.000/pcs or IDR 36.897.000 of the total paper bags produced. After the implementation of the Six Sigma method, the number of defective paper bags was 5,205 pcs which could not be reworked, so the company suffered a loss of IDR. 5.205.000 which means after applying the method Six Sigma there is a decrease in costs that are not incurred when reworking the product paper bag which is IDR 31.692.000 per month.

5. CONCLUSION

From the results of the research that has been done, it can be concluded that the main cause of defects that occur in the paper bag production process is caused by machines. Tubing is the operator doesn't understand his job, the machine setting is short tube step end, the mixture of glue and water is not according to standard, there is no SOP display on the machine tubing, Damage to engine components, No fans and Not wearing earplugs. The results of the implementation of the Six Sigma method on paper bag product defects are a decrease in product defects caused by tubing machines. The average defect before improvement was 6,732 pcs per month for tube length deviation, after improvement the defect was 5,205 pcs. Therefore, the sigma value is increased from 4.65 to 5.04, which means there is decline for costs incurred by the company due to defects in cement bag products.

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