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Waste Analysis Of Pasted Woven Production Process Using Lean Six Sigma Method

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Abstrak

Penelitian ini dilakukan disebuah perusahaan yang bergerak dibidang produksi kantong semen yang meliputi pasted woven, pasted kraft, dan sewn woven. Dalam proses produksi *pasted woven* masih terdapat waste yang terjadi dilantai produksi. Adapun critical waste yang terjadi, yakni defect, waiting , dan *Environmental, Health and Safety* serta permasalahan lainnya yang menyebabkan *lead time* terlalu lama yakni 1430 menit. Penelitian ini bertujuan untuk mengetahui tingkat pemborosan yang terjadi dengan perhitungan Defect Per Million Opportunity dan tingkat sigma serta memberikan usulan perbaikan. Hasil penelitian menunjukkan bahwa reduksi *lead time* pada pemborosan kecacatan yang tidak bernilai tambah pada proses produksi pasted woven semula bernilai 1430 menit dapat direduksi menjadi 1365 menit melalui pengurangan aktivitas berupa delay sebesar 65 menit, sehingga mampu mengurangi cycle time dalam proses produksi pasted woven. Nilai rata-rata DPMO yang diperoleh sebesar 36898 dengan level sigma 3,284. Usulan perbaikan untuk mengurangi tingkat pemborosan melalui bantuan *Failure Mode and Effect Analysis* dan nilai *Risk Priority Number* diterapkan untuk menganalisis penyebab pemborosan yang terjadi. Rekomendasi bagi perusahaan memberikan pelatihan kepada operator agar tidak terjadi human error, melakukan inspeksi bahan baku sebelum memasuki proses produksi dan pengontrolan keadaan mesin secara berkala.

Kata Kunci : Mengurangi, Proses Produksi, pemborosan , Failure Mode Effect Analysis, Lean six sigma

Abstract

This research was conducted in a company engaged in the production of cement bags which include pasted woven, pasted kraft, and sewn woven. Waste is still generated on the production floor throughout the pasted weaved manufacturing process. The essential waste that happens, including faults, waiting, Environmental, Health, and Safety, as well as other problems that cause the lead time to be too lengthy, namely 1430 minutes. The goal of this study is to assess the degree of waste that happens by calculating Defects Per Million Opportunities and the sigma level, as well as to make recommendations for improvement. The research results show that the reduction in lead time for waste of non-value-added defects in the pasted woven production process, which was originally worth 1430 minutes, can be reduced to 1365 minutes by reducing activities in the form of a 65-minute delay, thereby reducing cycle time in the pasted woven production process. The average DPMO value was 36898 at a sigma level of 3.284. Proposed modifications to decrease waste are analyzed using Failure Mode and Effect Analysis and Risk Priority Number values to identify the sources of waste. Recommendations for companies provide training to operators to avoid human error, inspect raw materials before entering the production process and periodically control the condition of machines.

Key words *: Minimization, Production Process, Failure Mode Effect Analysis, Waste, Lean six sigma*

INTRODUCTION

The industrial world is currently experiencing a rapid increase. More and more companies are emerging, resulting in tighter competition between companies. This is also the case with cement bag manufacturing companies. Cement bags are one of the important components in the cement industry that functions as a cement wrapper. In the production process, there are 2 things that must be considered, namely productivity and quality. Productivity can be defined as the ratio of output and input. Increased productivity in the company occurs if the output produced can be greater than the input. This output is influenced by waste and defects in the production process. Every company should think of ways to increase productivity while still paying attention to good quality (Hairiyah et al., 2022). Meanwhile, quality is a product characteristic that meets consumer expectations and fulfills consumer demand (Joes et al., 2023).

The company produces various types of cement bags ranging from pasted woven, pasted kraft, and sewn woven, of the various bags produced pasted woven has a high level of sales but the quality produced has not met the standards of the company. Pasted woven is a type of cement packaging made from polypropylne. In the production process there is still waste that occurs on the production floor (Dhinar et al., 2023). As for the waste that occurs, namely defects, the company sets a defect standard of 9%, but in realization the defect reaches 11% or is still above the standard set by the company. The types of pasted woven defects include bad drawings, skewed covers and dead-end valves (Triagus Setiyawan et al., 2014). Then there is wasteful waiting, which is caused by the machine being broken down or not operating. This is because the machine is damaged, undergoing repairs and waiting for other damaged machines, causing the production process to stop. In addition, another indication of waste is the lack of fulfillment of the Environmental, Health and Safety (EHS) aspect, this is because many field workers still do not comply with regulations relating to occupational health and safety and sorting workers who work in uncomfortable conditions(Suseno & Taufik Alfin Ashari, 2022)

The presence of flaws, waiting times, and EHS issues suggests the presence of waste. Waste is defined as any action that does not contribute value during the transformation of inputs into outputs (Komariah, 2022). The lean six sigma method is one approach for reducing waste. The lean idea is a combination of tools and processes that aim to remove waste, shorten lead times, increase performance, and save costs. Lean is an ongoing endeavor to reduce waste and enhance value-added products (goods and/or services) in order to deliver value to consumers (Sarman & Soediantono, 2022). While sigma is a strategy for quality improvement towards the aim of 3, 4 failures per million chances (DPMO) (Lestari et al., 2022).

Lean Six Sigma is a strategic approach aimed at pinpointing and eradicating inefficiencies or activities that don't add value in a business (Joes et al., 2023). It focuses on continuous enhancement to reach performance levels akin to six sigma standards. This involves streamlining the flow of both products and information using a pull system, ensuring alignment with the needs of both internal and external customers. The ultimate goal is to strive for excellence and perfection, aiming to produce just 3.4 defects per million opportunities (Munandar & Permana, 2020). The advantage of using the lean six sigma method is that it can identify a problem or waste in the production process and can reduce defects or failures that can burden in terms of time, money, consumers and opportunities. So this method can be used to minimize waste that occurs (Hesthi et al., 2023).

In its implementation, the waste reduction strategy in the lean six sigma method employs the DMAIC (Define-Measure-Analyze-Improve-Control) phases of issue solving. DMAIC is a systematic cycle with five improvement phases: define, measure, analyze, improve, and control, used to solve product or process problems using the lean six sigma technique. In each step of DMAIC, there are procedures that tend to alter depending on the variables that arise during the project (Somadi, 2020). The purpose of lean is to establish a smooth flow of products through the value stream process while eliminating all forms of waste. Six Sigma aims to increase process capabilities along the value stream in order to achieve zero faults and remove existing variances (Yoseph et al., 2023)

Failure Mode And Effect Analyze (FMEA) is a systematic technique for identifying and preventing as many hazards as possible that contribute to a failure using a top-down approach (Nurfitri Imro'ah, 2019). FMEA has a component in the form of a risk priority number consisting of Severity, identifying failures based on the severity experienced by the operator. The likelihood that the cause will occur and will result in a failure during use, and Detection The likelihood that the cause will occur and will result in a failure during use (Arum Bella Adelia, 2022). The outcome of FMEA is the formulation of steps to avoid or lessen the severity or likelihood of failure, starting with the most important. The risk priority number (RPN) is the product of the severity, occurrence rate, and detection rate. RPN determines the priority of the failure. RPN is used to examine the ranking based on the inability of a component to take steps to minimize criticality and improve the process (Bob Anthony, 2021).

At the company, there are 9 categories of waste factors abbreviated as (E-Downtime), including Environmental Health and Safety (EHS), which is a form of waste that happens due to neglect in paying attention to concerns relevant to the EHS principles. Defect The form of waste that results from the appearance of faulty items. Defects are usually encountered in the manufacturing industry since they are directly tied to business expenditures (Aziza & Afandi, 2018), *Overproduction is a type of waste caused by excessive production. This category is where the products produced exceed what was originally planned.* (Pattiapon et al., 2020), *Waiting The type of waste that occurs because a process is hampered so that the next process must wait for the previous process to complete its work, Non-Utilizing Employee The type of waste of human resources that occurs because employees as resources are not able to do their jobs optimally due to lack of competence, Transportation Excessive transportation activities will cause wasted costs, time, and energy, Inventory is the form of waste that results from an excess of production raw materials. The Just In Time idea is required to reduce current waste. Motion is a sort of waste that arises due to excessive movement by the operator and can slow down the operation, making the lead time longer* (Havi et al., 2018), Excess Processing is a sort of waste caused by the necessity for too many steps in the process. This category contains needless operations, such as reworking (Baharudin et al., 2021).

To address waste on the pasted woven factory floor, researchers apply the lean six sigma method to decrease waste and make improvement recommendations based on the Failure Mode Effect and Analysis (FMEA) methodology. The combination of these two approaches will enable the production of high-quality products while reducing existing waste.

RESEARCH METHOD

This study was carried out at company engaged in the production of cement bags in February 2024 till the needed data was obtained. The object of research studied is pasted woven bags. The data used in this study consists of two types :

a. Primary data
   Primary data is data that is measured during field research by researchers on the object of research. There are 3 methods used in data collection, namely observation, interviews, questionnaires.
b. Secondary data
   Secondary data is data obtained by researchers by collecting data that already exists in the company (company documents). The data collected in this study is the period January to December 2023 which consists of production process flow data, data on types of waste and defects, production time information data, and production quantity data.

This research employed the lean six sigma strategy with stages DMAIC (*Define, Measure, Analyze, Improve, Control)* (Romadhani et al., 2021).

1. *Define*
   This step involves observing and defining the company's current situation. Describing using a production process map that comprises both an information flow map and a physical flow map packed in the Big Picture Mapping software. Furthermore, after collecting the production process map and questionnaire data, the following stage is to detect waste in the manufacturing process.
2. *Measure*
   This stage conducts a detailed mapping of the production process. By measuring and processing the data that has been obtained which focuses on value adding and non-value adding processes. The point is to facilitate the process of identifying waste in each value stream, then making the right improvement proposals.
3. *Analyze*

This stage analyzes the mapping details that have been made. Identify data on defect types, defects, and the number of dominant defects in the production process. After that, identify the causes of waste and factors that affect the production process using Pareto diagrams and fishbone diagrams. In addition, at this stage, the determination of process capability is carried out to determine the ability of the process before further improvement is made.

4. *Improve*

   This stage provides alternative improvements to the factors that cause waste. After that, the Future Big Picture Mapping proposal is made which has been adjusted to changes from the handling of waste that has an effect on waste management..

5. *Control*

   The control stage serves to monitor the improvement of the waste of the pasted woven production process that takes place continuously and for a long time. In this research, the control stage cannot be implemented because the decision to propose this research is left to the company, so that no control efforts can be made.

Process capability shows the process is able to produce according to specifications (Rimantho & Athiyah, 2018), by measuring the level of CTQ (Critical to quality). CTQ are attributes that are present during the process, because they are directly related to consumer demand and satisfaction (Utomo et al., 2022). While DPMO is the number of errors that appear to occur if the activity is repeated one million times.

To get the sigma value calculation, the value of DPMO (*Defects per Million Opportunities*), with formula :

Formula *Defects per Opportunities* (DPO)

$$\text{DPO} = \frac{\text{amount of defective produced}}{\text{amount of } \mathit{unit} \text{ production } x\ CTQ} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Rumus *Defect per Million Opportunities* (DPMO) :

$$\text{DPMO} = \frac{\text{amount of defective produced}}{\text{amount of } \mathit{unit} \text{ production } x\ CTQ} \text{ x } 1.000.000\ldots\ldots (2)$$

The improvement method used is Failure Mode and Effect Analysis (FMEA). FMEA is a method used to determine, identify, and eliminate known failures from a process. Formula *Failure Mode Effect Analysis* (FMEA) (Wicaksono et al., 2023)

RPN = *Severity* x *Occurrence* x *Detection*............................(3)

RESULT AND DISCUSSION

Define

This stage identifies problems in pasted woven production process. Moreover, the researcher examined the identification process by elaborating on the main process map, which was segmented into information flow maps and physical flow maps through the utilization of big-picture mapping.

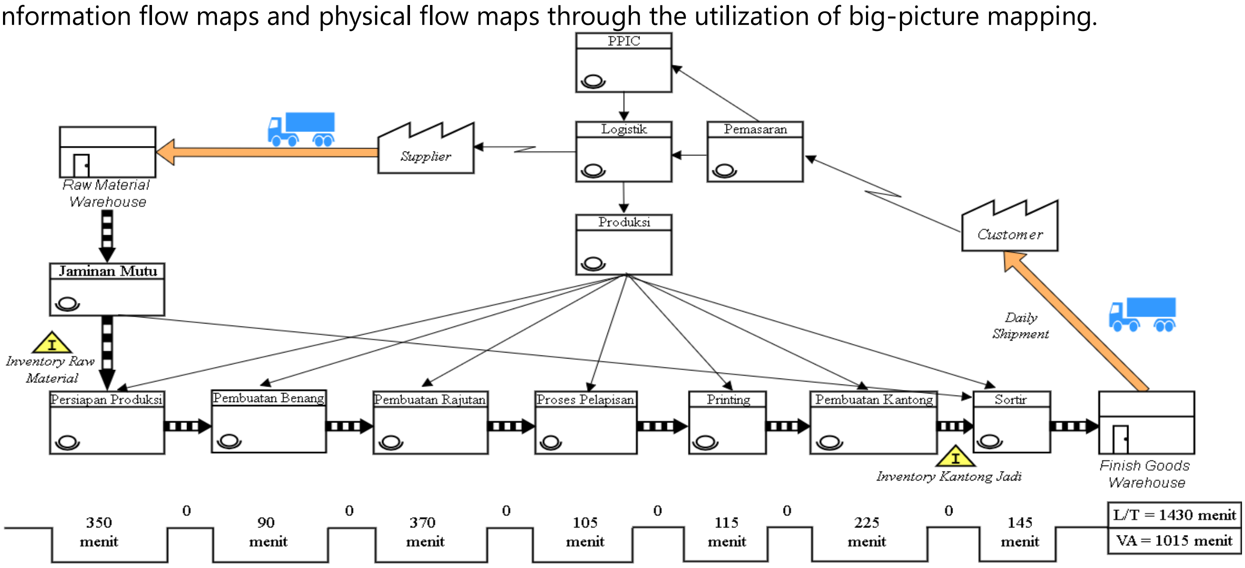

Figure 1. Initial Big Picture Mapping

According to the Big Picture Mapping picture, the overall lead time for pasted woven manufacturing is 1430 minutes, which includes a total value-added time of 1015 minutes, a total necessary non-value-added time of 180 minutes, and a total non-value-added time of 235 minutes. Thus, the difficulty in the pasted weaved production process is that the whole lead time is 1430 minutes long. Thus, the computation of the Process Cycle Efficiency (PCE) number is as follows:

$$\text{PCE} = \frac{Value\ added}{lead\ time}\ x\ 100\% = \frac{1015}{1430}\ x\ 100 = 70{,}97\%$$

Based on the original Process Cycle Efficiency (PCE) value, the result was 70.97%, indicating that the pasted weaved manufacturing process is still inefficient, requiring improvements. To determine the waste that happens, the researcher need the assistance of a questionnaire that includes the idea of E-Downtime. This questionnaire will be given to six responders who are specialists in pasted weave manufacture. The contents of the questionnaire describe each sort of trash, and weights will be assigned based on the actual conditions in the industrial region. The answer options are organized using a weighting system, with the highest scores being 5 (always happens), 4 (often happens), 3 (very often happens), 2 (rare), and 1 (extremely uncommon).

Table 1. Recapitulation of Waste Questionnaire Results

No	Waste	Respondent						Weight	Ranking
		1	2	3	4	5	6		
1	*Defect*	3	4	3	3	3	4	3,3	1
2	*Environmental, Health, and Safety*	3	3	3	3	4	3	3,1	2
3	*Waiting*	3	3	3	3	3	3	3	3
4	*Motion*	3	3	2	2	2	3	2,6	4
5	*Non-Utilizing Employee*	3	2	2	3	3	2	2,5	5
6	*Overproduction*	3	3	3	2	2	3	2,3	6
7	*Excess Processing*	3	2	1	3	3	2	2,1	7
8	*Transportation*	2	2	2	2	2	2	2	8
9	*Inventory*	1	2	2	2	2	2	1,8	9

Based on Table 1, the highest weighting results obtained in ranking order 1 to 3 are defects with a weight of 3.3; Environmental, Health, and Safety with a weight of 3.1; and waiting with a weight of 3,0.

Measure

After determining the ranking of each sort of waste, the next step is mapping the value stream with the help of value stream analysis tools (VALSAT). The researcher multiplied the average waste by the weighting value contained in the VALSAT table with a multiplier factor of High (H) = 9, Medium (M) = 3, and Low (L) = 1 to determine the results.

Table 2. VALSAT Score Calculation

Waste	Weight	VALSAT						
		PAM	SCRM	PVF	QFM	DAM	DPA	PS
Overproduction	2,3	2,3	6,9	0	2,3	6,9	6,9	0
Waiting	3	27	27	3	0	9	9	0
Transportation	2	18	0	0	0	0	0	2
Excess Processing	2,1	18,9	0	6,3	2,1	0	2,1	0
Inventory	1,8	5,4	16,2	5,4	0	16,2	5,4	1,8
Motion	2,6	23,4	2,6	0	0	0	0	0
Defect	3,3	3,3	0	0	29,7	0	0	0
Environmental	3,1	27,9	0	0	3,1	9,3	0	0
Not utilizing	2,5	7,5	0	0	22,5	0	0	0
Totally	133,7	52,7	14,7	59,7	41,4	23,4	3,8	

Based on the table, the most significant ranking is obtained for the Process Activity Mapping (PAM) tool, so the tool used in the calculation is Process Activity Mapping (PAM). Next, the researcher carried out an analysis of defects in the pasted woven production process.

Table 3. Number and type of Pasted Woven Production Defects

Month	Production Data	Cacat gambar jelek	Cacat *cover* miring	Cacat *valve* buntu	Number of defects	Percentage of defects month
January	58.919	3.027	2.697	1.796	7.520	13%
February	180.986	6.267	7.487	5.875	19.629	11%
March	229.428	8.575	7.547	6.724	22.846	10%
April	181.699	7.668	7.457	6.704	21.829	12%
May	146.743	7.259	5.172	6.453	18.884	13%
June	238.335	9.187	9.169	7.348	25.704	11%
July	251.910	8.617	9.587	8.262	26.466	11%
August	219.055	7.746	8.567	6.892	23.205	11%
September	257.766	8.782	9.734	7.933	26.449	10%
October	86.341	3.390	2.292	4.532	10.214	12%
November	194.171	6.928	7.516	5.887	20.331	10%
December	180.312	6.371	6.166	5.383	17.920	10%
Total	2.225.665	83.817	83.391	73.789	240.997	11%

After determining the type and percentage of defects in pasted woven production, the next step is to determine the process capability value of the pasted woven production process by reviewing the value of the pasted woven output produced in the sigma value measure.

- The calculation of DPO and DPMO in January 2023

  DPO = $\frac{\text{amount of defective pasted woven}}{\text{amount of pasted woven production} x\ CTQ} = \frac{7520}{58919 \text{ x } 3} =$ 0,042544

  DPMO = DPO x 1000000 = 0,042544 x 1000000 = 42544

  The calculation above indicates that in January 2023, there were defects of 7520 kg of pasted woven with a total production of 58919 kg. Meanwhile, the quality characteristics (CTQ) are three types of defects, so the chance of failure occurring in one million products is 42,544 kg of pasted woven.

- Sigma Level Calculation

  Since there is no conversion table for DPMO to sigma values with a value of 42544, the researcher uses interpolation:

  DPMO = 42716 (X2), sigma conversion value = 3,22 (Y2)

  DPMO = 43633 (X1), sigma conversion value = 3,21 (Y1)

  DPMO = 42544 (X), sigma conversion value (Y) is

  $$\frac{X - X_1}{X_2 - X_1} = \frac{Y - Y_1}{Y_2 - Y_1}$$

  So :

  $$\frac{42544 - 43633}{42716 - 43633} = \frac{Y - 3{,}21}{3{,}22 - 3{,}21} \leftrightarrow \frac{-1086}{-917} = \frac{Y - 3{,}21}{0{,}01}$$

  $-917Y + 2943{,}57 = -10{,}86$

  Y = $\frac{-2954{,}43}{-917}$ = 3,221

Table 4. Recapitulation of DPO, DPMO, and Sigma Level Values for the Period of 2023

Month	Production quantity (kg)	Number of Defects (kg)	CTQ	DPO	DPMO	Level sigma
January	58.919	7.520	3	0,042544	42544	3,221
February	180.986	19.629	3	0,036152	36152	3,297
March	229.428	22.846	3	0,033192	33192	3,335
April	181.699	21.829	3	0,040046	40046	3,250
May	146.743	18.884	3	0,042895	42895	3,201
June	238.335	25.704	3	0,035949	35949	3,280
Month	Production quantity (kg)	Number of Defects (kg)	CTQ	DPO	DPMO	Level sigma
July	251.910	26.466	3	0,035020	35020	3,311
August	219.055	23.205	3	0,035310	35310	3,307
September	257.766	26.449	3	0,034202	34202	3,323
October	86.341	10.214	3	0,039432	39432	3,257

November	194.171	20.331	3	0,034902	34902	3,313
December	180.312	17.920	3	0,033127	33127	3,316
Average				0,036898	36898	3,284

Based on the table above, the average DPMO value and average sigma value for January December 2023 can be seen as follows:

Average DPMO value = $\frac{\text{Total DPMO January}-\text{December}}{12} = \frac{442771}{12} = 36898$

Average *sigma* value = $\frac{\text{Total } Sigma \text{ for January}-\text{December}}{12} = \frac{3941}{12} = 3{,}284$

Analyze

At the analysis stage, the researcher determines an analysis based on the amount of waste that occurs and its negative impact on the company so that effective and efficient improvement proposals can be determined to eliminate waste

1. *Defect*
   Defects occur because the pasted woven production results do not meet the quality criteria established by the firm. Usually, defects come from processes that do not comply with work standards, poor raw materials, and errors.
2. *Environmental, health and safety*
   Environmental, health, and safety issues occur since workers are less aware of occupational safety and health. The proofs are revealed from the continued occurrence of minor work accidents.
3. *Waiting*
   Waiting occurs because it occurs when the production process stops. The production process stopped due to damage to the machine used.
4. *Motion*
   Motion occurs because workers make unnecessary movements when carrying out activities, namely picking up avalanches that fall during the sorting process.
5. *Non-Utilizing Employee*
   In the Production Process: This type of waste does not occur because all operators and employees are well-utilized with parts that suit their knowledge and abilities.
6. *Overproduction*
   This form of waste does not exist in the production process, because the product is made using a make-to-order system or according to customer orders.
7. *Excess Processing*
   The production process does not occur due to this type of waste occurs because the instructions and tools used during the production process have been considered and planned well by the company.
8. *Transportation*
   In the production process does not cause this type of waste because the number of means of transportation and the distance traveled have been properly considered
9. *Inventory*
   There is no proof of waste of this type of inventory in production since the inventory control system is properly implemented, ensuring that resources and completed goods are controlled to satisfy requirements.

Based on the Activity Mapping approach, the overall production time for weaved paste is 1430 minutes, with a total of 32 activities given in the table below:

Table 5. Calculation of the initial amount of time

No	Activity	Total Time (minutes)	Percentage (%)
1	*Operation*	1015	70,97%
2	*Transportation*	70	4,90%
3	*Inspection*	90	6,30%

4	*Storage*	20	1,40%
5	*Delay*	235	16,43%

Table 6. VA, NNVA, dan NVA

No	Category	Total Activity	Total Time (minutes)	Percentage (%)
1	*Value Added*	15	1015	70,97%
2	*Necessary Non Value Aded*	8	180	12,60%
3	*Non Value Added*	9	235	16,43%

Based on the calculated CTQ, an analysis is carried out to uncover the cause of the highest defects using the Pareto diagram.

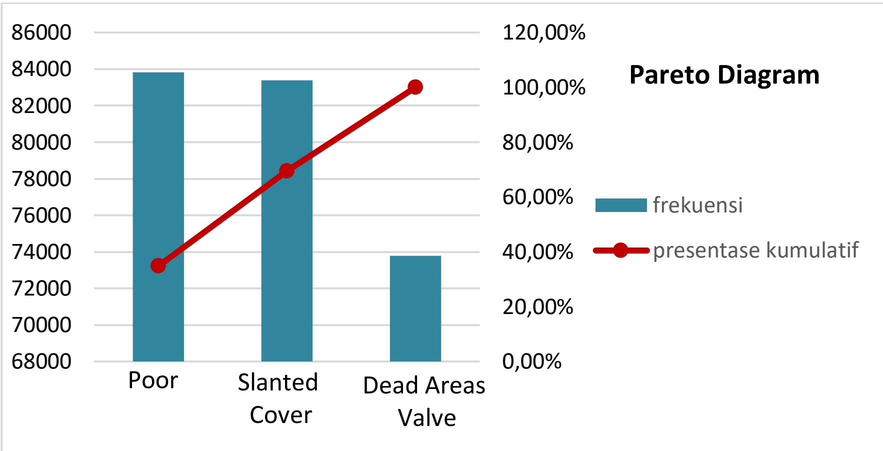

Figure 2. Pareto Diagram

According to the Pareto diagram, the most common defect categories are poor image defects (34.8%), slanted cover defects (34.6%), and dead areas valve defects (30.6%).

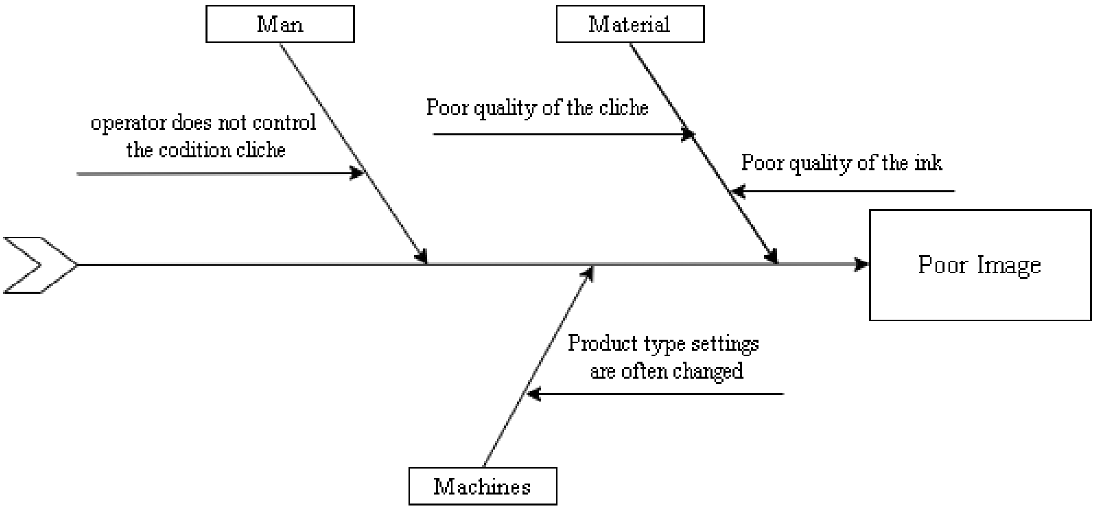

Figure 3. Poor Image defect

Based on the findings of the investigation of the cause and effect diagram for poor image defects, the cause in terms of material is the poor quality of the ink and cliche, which causes the resulting image to be less good, the cause from a human perspective is that the operator does not control the condition of the cliche, causing the resulting image to be imperfect, and causing from a machine perspective, the product type settings are often changed, causing the machine not to work optimally

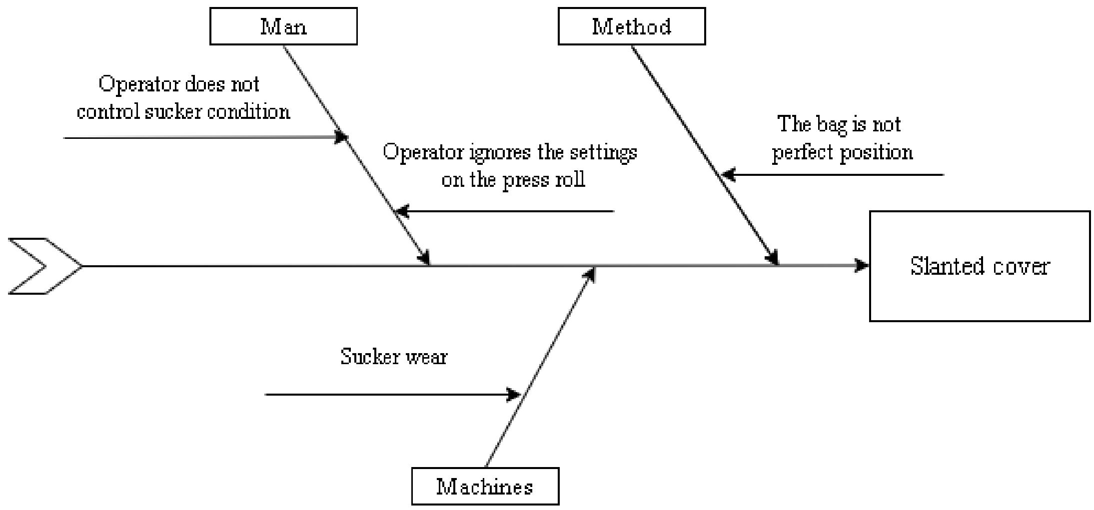

Figure 4. Slanted cover defect

Based on the analysis of the cause and effect diagram for the slanted cover defect, the cause of the method is that the bag is not in the perfect position, so the resulting slanted cover is not precise. The cause from a human perspective is that the operator ignores the settings on the press roll and does not control the suction cup's condition, resulting in the cover's failure. The cause in terms of the machine is a worn suction cup, which causes opening failure.

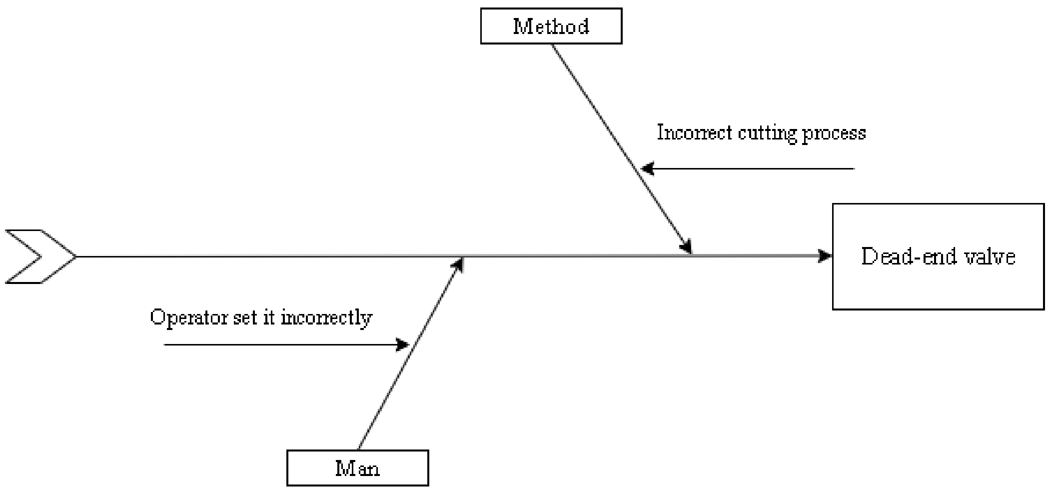

Figure 5. dead-end valve defect

Based on the analysis of the cause and effect diagram of the dead-end valve defect, the cause in terms of the method is an incorrect cutting process, which causes the valve to retreat from its proper position. From a human perspective, the cause is that the operator set it incorrectly, causing the vacuum suction point to not be at the standard.

Improvement

Steps are taken to reduce defects in the pasted woven production process at this stage. These steps involve establishing a plan to improve the pasted woven production process and identifying priorities for the improvement plan.

Table 6. RPN Value Calculation

Potential Failure Mode	***Potential Effect of Failure***	**S**	***Potential Cause***	**O**	***Current Control***	**D**	**RPN**
Poor image	The design of the pasted woven bag is not perfect, so the bag looks unattractive	8	Inappropriate selection of ink supplier	6	Criteria for ink raw materials are tightened by providing report cards for suppliers	7	336
			inaccurate selection of cliche supplier	5	Criteria for cliche raw materials are further tightened by providing report cards for suppliers	6	240
			No control of cliche conditions	8	Checking cliche conditions with checklists every day	8	512
			frequently changing product type settings	6	Specialization of 1 machine for a maximum of 3 types of products	6	288
Slanted Cover	The pasted woven bag is not precise, so when the cement is filled, the bag is not of perfect dimensions.	7	The bag is not in the perfect position	5	Controlling the position of the bag before the machine is started	6	210
			there is no control of the condition of the sucker	7	checking the condition of the sucker with a checklist every day	8	392
			operator ignores the settings on the press roll	6	Supervisor in charge of supervising the performance of workers in the factory	5	210
			Sucker wear	8	carrying out routine maintenance on the machine so that it is always in a stable condition	6	336
Dead Areas Valve	The cement entry hole is plugged so that the bag cannot be filled with cement	6	Setting error	7	Supervision from the team head during the production process	6	252
			incorrect cutting process	6	Supervision from the team head during the production process	6	216

Table 7. Proposed Improvement of Waste in the Pasted Woven Process

No	**Types of waste**	***Rank Priority***	***Root Cause***
1	*Defect*	1	• Carry out measures to standardize the pasted woven production process • Train operators to avoid human error.
2	*Environmental, Health, and Safety*	2	• Procurement of field supervisors • Provision of more appropriate chairs for sorting workers
3	*Waiting*	3	• Controlling the condition of the machine periodically
4	*Motion*	4	• Reducing non-value-added activities
5	*Non-Utilizing Employee*	5	• Supervision from the team head during the production process

No	Types of waste	*Rank Priority*	*Root Cause*
6	*Overproduction*	6	• There is no waste of this type because the amount of production is made according to demand
7	*Excess Processing*	7	• There is no waste of this type because there is planning and monitoring regarding the tools used
8	*Transportation*	8	• There is no waste of this type because the machine layout is well-arranged
9	*Inventory*	9	• There is no waste of this type because the inventory control system is implemented well so that control of materials and finished products meets standards.

Table 8. Proposed time calculation

No	Activity	Total Activity	Total time (minutes)	Presentage (%)
1	*Operation*	15	1015	74,36%
2	*Transportation*	2	70	5,13%
3	*Inspection*	4	90	6,59%
4	*Storage*	2	20	1,47%
5	*Delay*	5	170	12,45%

Based on the table 8, after determining improvements to the pasted woven production process, the total proposed activities became 28 activities with a lead time of 1365 minutes.

$$\% \text{ efficiency improvement} = \frac{Initial\ Lead\ Time - Proposed\ Lead\ Time}{Initial\ Lead\ Time} \text{ x } 100\%$$

$$\% \text{ efficiency improvement} = \frac{1430-1365}{1430}\ x\ 100\% = 4{,}5\%$$

By calculating the percentage of improvement in efficiency, which amounts to 4.5%, the value of the proposed Process Cycle Efficiency (PCE) can be determined using the formula below:

$$\text{PCE} = \frac{Value\ added}{lead\ time}\ x\ 100\% = \frac{1015}{1365}\ x\ 100 = 74{,}35\%$$

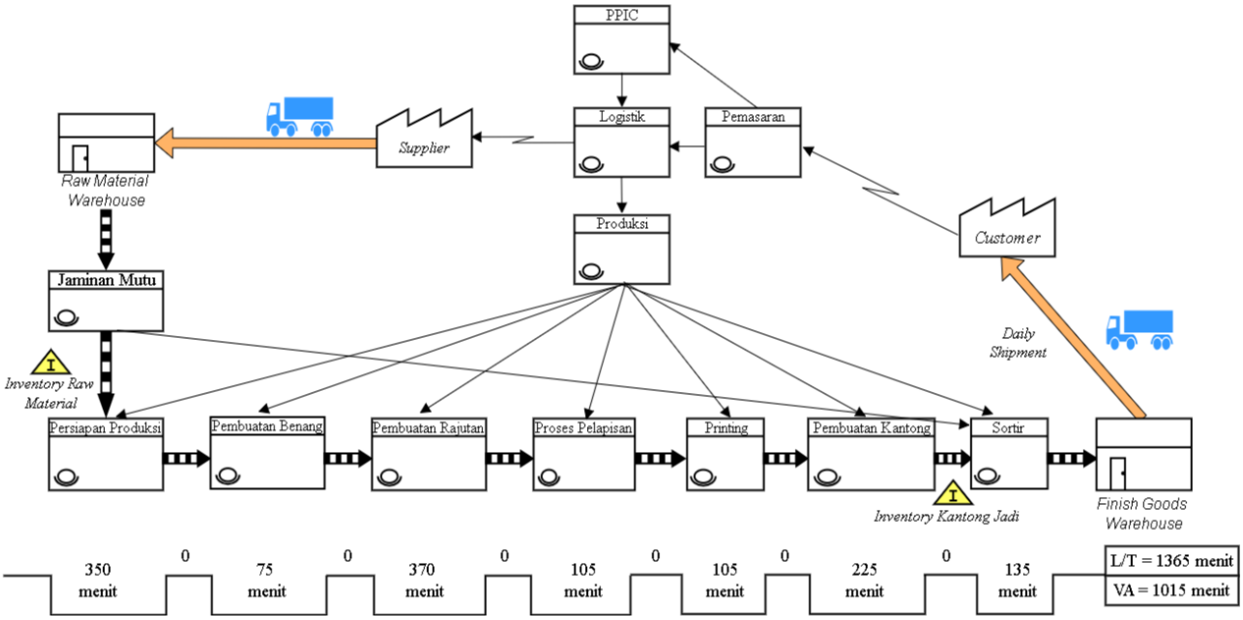

Figure 8. Proposed *Big Picture Mapping*

The difference between this research and previous research is that the research location is carried out at a company engaged in the production of cement bags with the object of pasted woven. The results showed that there is waste that must be reduced where the total production lead time reaches 1430 minutes with a process cycle efficiency of 70.97%, which means that the pasted woven production process is still not running efficiently, therefore improvements are needed by reducing non-value added activities by reducing delay activities by 65 minutes, an increase in efficiency of 4.5% is obtained, resulting in a process cycle efficiency value of 74.35% or 1365 minutes, which means that the pasted woven production process is running efficiently.

CONCLUSION

The findings indicate that the lead time reduction for non-value-added defects in the pasted woven production process, initially at 1430 minutes, can be decreased to 1365 minutes by mitigating activities, specifically a 65-minute delay. Consequently, this leads to a reduction in the cycle time within the pasted woven production process. The average DPMO value acquired was 36898, corresponding to a sigma level of 3.284. Proposed improvements to reduce waste using Failure Mode and Effect Analysis (FMEA) resulted in the highest Risk Priority Number (RPN) value of 512, with the cause being a lack of control over cliche conditions; recommended improvements include checking cliche conditions with a checklist every day. Aside from that, the second highest Risk Priority Number (RPN) rating is 392 because the sucker's condition is beyond control. The advice is to examine the sucker's condition on a daily basis using a checklist. On the other hand, for the third highest Risk Priority Number (RPN) value of 336, because the selection of ink suppliers was not appropriate, recommendations for improving the criteria for ink raw materials are more stringent by providing report cards for suppliers

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