Lean Six Sigma Analysis For The Effort To Minimize Defect In Production Process Of Pasted Kraft Bag In Pt. X

Anggia Kalista[a*], Ike Krisnawati[b]

Industrial Engineering, Faculty of Engineering, Universitas PGRI Ronggolaw,e Tuban Indonesia

e-mail address: anggiakalista@gmail.com

Abstract.

PT. X is a limited company that produces cements paper bags. In the process of the cement bags production PT. X often has a mistake that cause defect because of the failure process. The aims of this study is to describe how to decrease product defect in a company. Based on the analysis, PT. X is at the level of 3.38 sigma which means the process ability to make product according to specification is not bad, but the company has to upgrade the process ability because it is still far from the sixth level of sigma. Besides it, PT. X has non value-added activities with total 30.5% of the whole production time too. Lean six sigma method approach is a systemic and systematic approach to identify and reduce waste by continuous increasing radically to achieve the sixth level of sigma. Based on the research has done, the research is about calculation for the sigma level of the company and reduction of the activity which is from 51 activities become 47 activities, so it means that there are 4 activities that is reduced.

Keywords: Lean Six Sigma approach, Sigma level, Non Value Added Activity (NVA).

1. Introduction

In manufacturing industry to maintain company's existantion, the most important thing that can become asset of success in global competition is product quality. According to Kottler and Armstrong (2008:272) product quality is one of the main positioning means of marketers that has the direct impact to product/service's performance. Therefore, quality is closely allied with the value and customer satisfaction. A company have to make a good effort to produce products that have a certain quality because basically the main purpose of a business is to create many customers feel satisfied, Schnaars (1991) in Tjiptono (2008:24). In the effort to fulfill product specification, a company has to achieve it by having a good production system in order to not causing problems. One of the problems that is happen frequently is waste such as defect in production process. Reduction of defective product can be realized by quality controlling. One of the most appropriate methods to be applied is the Lean Six Sigma method. It is a systemic and systematic approach to identify and reduce waste or activities that do not have value added by continuously increasing radically to reach the sixth sigma level. The phase of six sigma implementation consist of 5 phases, it is DMAIC (Define, Measure, Analyze, Improve, and Control. (Vanany and Emila Sari 2017).

PT. X is a company in the field of cement bag production. The company has production capacity more than 300 million cement bags. But in the production process PT. X is frequently has a problem in defective product. The defect is categorized become 2 types, they are sticky bags and afval which is in big amount in the company. Based on the data from 2019 until march 2020, the production of pasted kraft bag are 292.398.345 bags with amount of defective product (afval) are 666.393 kg and cause financial loss up to Rp. 715.474.234. Besides it, in the process also has sticky bags problem with the amount of them are 2.933.932 bags and the repairing cost of them are Rp. 206.842.206. The defective products in the production process cause the company has loss and must bear the cost of quality, in this case is failure cost. So that, to reduce quality cost, it is necessary to reduce the defective products continuously in order to increase the company's profitability.

2. Research Methods

In this research is explained about the steps in conducting research in order to make the process of research can be structured and achieve the research's goal. The research is started from problem identification, field study and literature, making formulation of the problem and objective of the study, and also data collecting and processing. The data obtained in this research are primary data and secondary data. The primary data is such as the interview data about the activity of pasted kraft production process, time measurement data of production process activity, the interview data of the defective product's types and the cause of defect, the interview data in determining SOD (severity, occurance, detection) scale, and FMEA questionnaire. And then the secondary data is such as pasted kraft production data, the data of pasted kraft's afval, sticky bags data, and the data of sampling result of pasted kraft's defect. After the data is collected, then the data will be in the data processing phase. In this phase, the data will be processed through a lot of calculations and then will be analyzed.

Steps of the data processing of this research includes: Define, Measure, Analyze, and Improve. At the define phase is the phase that will be made an operation process mapping to know the whole activity of production process that potentially cause the defective product and beside that will also be made value stream mapping to know the whole activity and time of production from start to finish, identifying the defect such as torn bag, incompatible printing, the bag's size doesn't fit dimensions, oblique folds, and damaged tube, classifying activities such as value added activity (VA) and nonvalue added activity (NVA), and last is identifying Critical To Quality (CTQ) of the cement bag and the CTQ that is obtained are torn bag, oblique fold, and the bag's size doesn't fit dimension, the CTQ total are 3. So, the solution in reduction defective product in this research is focus on the defect of the CTQ. And then, next data processing is the measure phase, includes: making pareto diagram, P control chart, and calculating sigma value. The Analyze phase includes: analyzing VSM, pareto diagram, P control chart, sigma value, and making fishbone diagram to know the cause of the defects. At the Improve phase include making FMEA table to know the solution of the problem. The last are conclusion and suggestion. The following is a research flowchart that is used:

3. Results and Discussion

3.1 Defective product in Production process of Pasted kraft cement bag

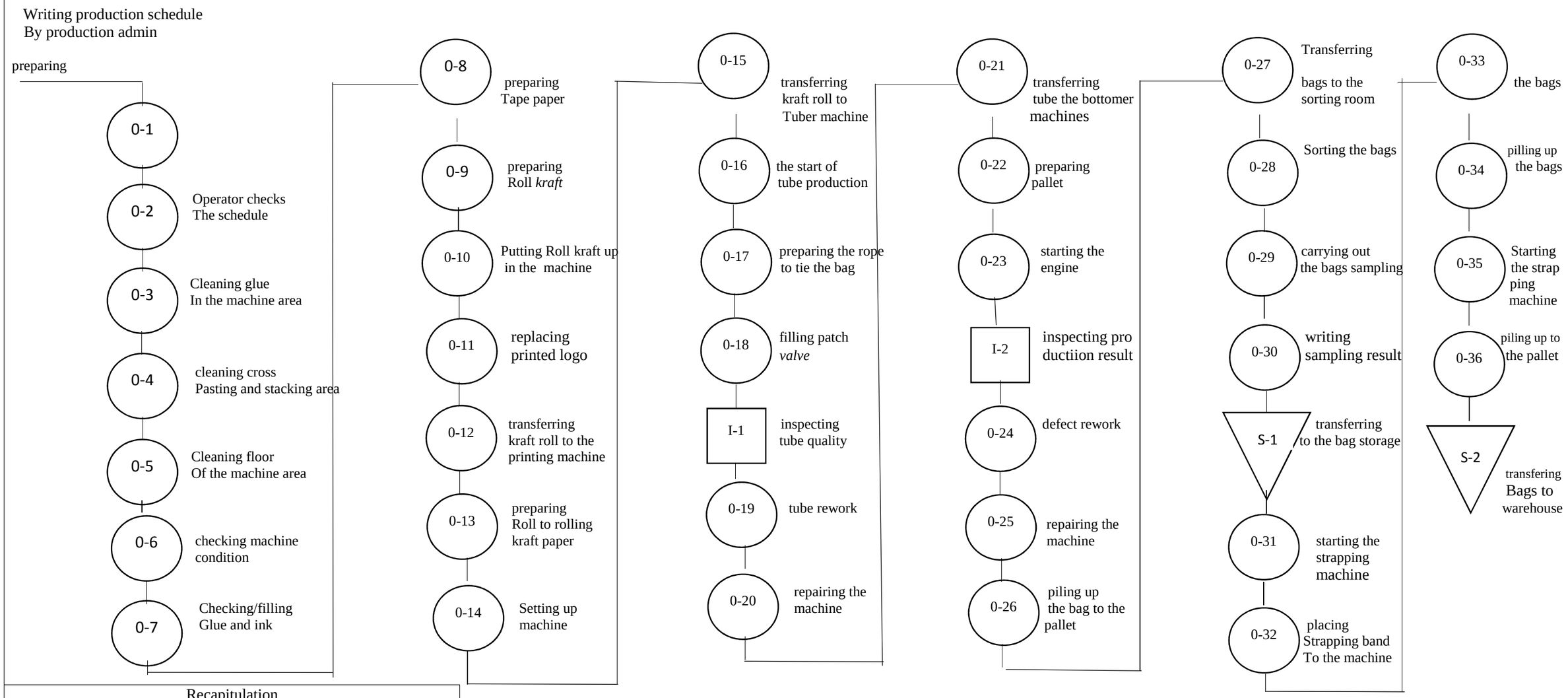
In production process of pasted kraft bag is frequently happen some problems that can cause loss for the company, one of the main cause is defective product. Defect in PT. X is categorized into two, they are: Afval (defect that can't be repaired and must be thrown away), and sticky bag (defect that can still be repaired). Based on the data is known that the amount of afval (defect that can't be repaired) is 667.998 kg with loss up to Rp 715.474.213. The amount of defective product that is quite large must be handled immediately so that it can be reduced. And the amount of sticky bag for one year from 2019 until March 2020 is quite large, there are 2.933.932 bags with repairing cost Rp 206.842.206. The problem of sticky bag must be repaired immediately so that the company loss can be reduced.

3.2 Define Phase

In define phase will be explained about operation process mapping, the kind of defect identification and CTQ, Value Stream Mapping (VSM), and activity classification. The first discussion is explanation about operation process mapping. Operation process mapping is identification of sequence of activities in a process. The purpose of making a process map is to give description about steps that is needed to identify the source of error or defect, and also unwanted variations, **(**Evans dan Lindsay (2007). The following is operation process mapping of pasted kraft bag production based on the research in PT X. (Fig 1, Fig 2)

OPERATION PROCESS MAPPING

OBJECT NAME : PASTED KRAFT BAG
NUMBER OF MAP : 01
MAPPED BY : IKE KRISNAWATI
DATE OF MAPPING : 02 SEPTEMBER 2020



Recapitulation		
Activity	Amount of Activity	Duration
operation	36	37.391
inspection	2	64
storage	2	1020
Total	40	38.385

Fig 1. Operation process mapping of pasted kraft cement bag

After making operation process mapping, the next is making Value Stream Mapping (VSM). The following is Value Stream Mapping of pasted kraft bag production

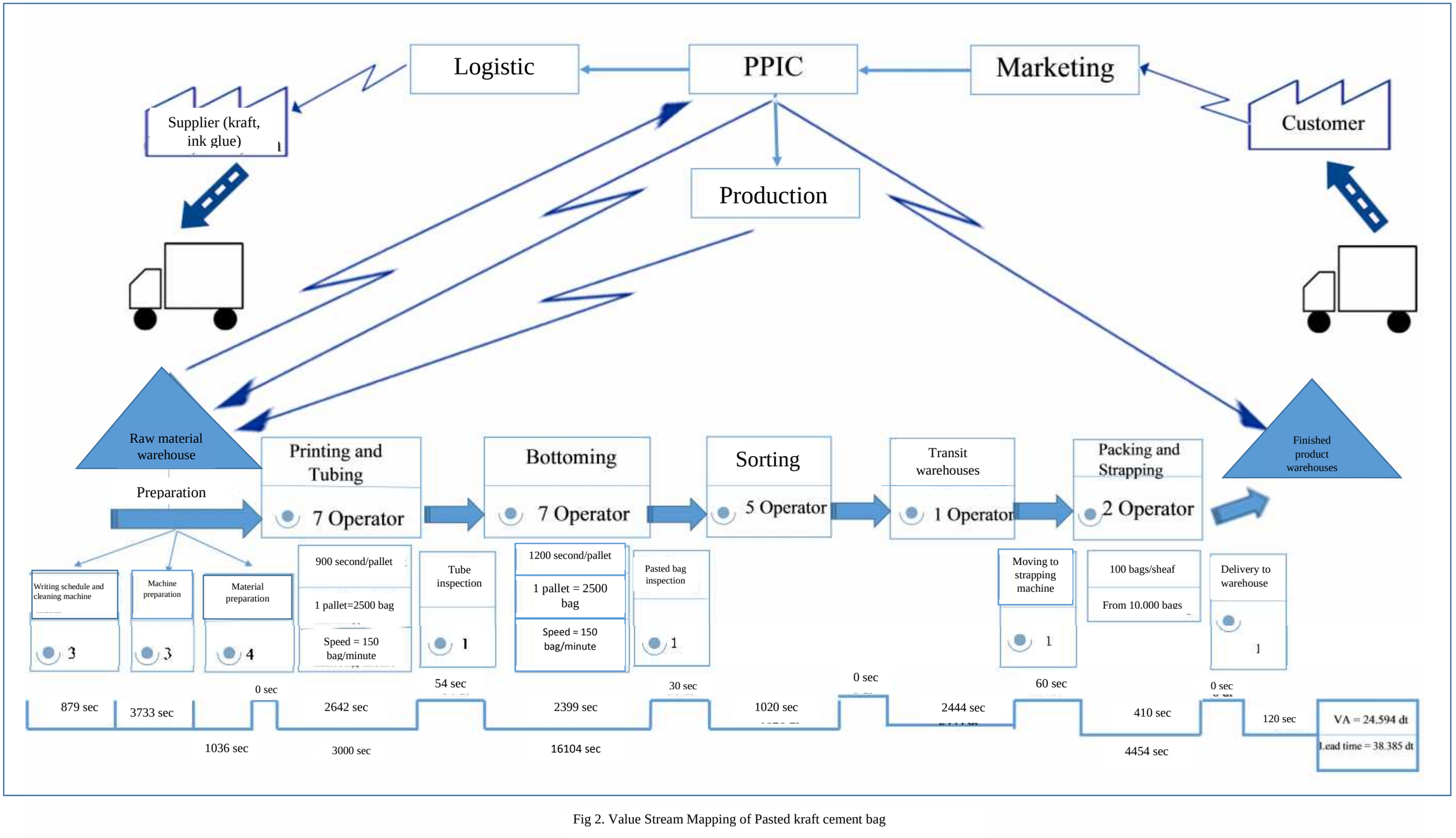


Fig 2. Value Stream Mapping of Pasted kraft cement bag

In the Value Stream Mapping, the process production phases are categorized into 7 process, they are: 1) preparing phase, includes: activity of schedule writing, machine cleaning, preparing machine, and activity of material preparing with total time of preparing phase are 5.648 sec includes 1.036 sec for VA (Value Added) time and 4.612 for NVA (Non Value Added). 2) Printing and tubing phase with total times are 5.642 sec includes 3.000 sec for VA time and 2.642 sec for NVA time. 3) phase of bottoming process with total time 18.503 sec includes 16.104 sec for VA time and 2.399 sec for NVA time. 4) phase of sorting process with total time 1.020 sec, the total time of sorting process is Non Value Added (NVA) Activity. 5) phase of process in transit warehouse with total time 2.444 sec where the total of the time is time for Non Value Added Activity. 6) phase of strapping and packing process with total time 4.854 sec includes 4.454 sec for VA time and 410 sec for NVA time. 7) the last process phase is delivery to finished product warehouse with total time 120 sec and the total of the time is categorized as Non Value Added activity. The total time in production process that has mapped in VSM is 38.385 sec with the total time of VA 24.594 sec, so the production process is still categorized less efficient because the amount of value added activity is less than the the total time of whole process. Non value added activity is necessary to be reduced in production process and the whole time of production process have to maximized for activity in tubing and bottoming phase.

Based on the activity classification that has been made, it can be known obviously about activity that is categorized value added and non value added. Besides that, it also can be known the description about time which is spent for value added activity and non value added activity. The following is recapitulation result of activity VA, NNVA, and NVA.

Tabel 1. The activity classification

	Kind of activity	**duration (sec)**	**Percentage**
1	VA	24.594	69.50%
2	NNVA	10.307	26.85%
3	NVA	3.484	3.65%
	Total	38.385	100%

Based on the result of activity classification can be understood that the value added activity is 69.50% and also non value added is 30.5%, so it is necessary to make improvement in order to make production time can be allocated more for activity which is value added. After analyzing production activity, the next is identifying defective product in PT. X. there are 2 types of defective product, they are afval and sticky bag. Afval is defective product that can't be repaired and must be thrown away, and sticky bag is defective product that can still be repaired by sorting the cement bag. The cause of sticky bag is high splashing of glue. The following is types of defective product in PT. X that is shown by the Tabel 2:

Table 2. Types of defective product in PT. X

	Category	**Defect types**
1	Afval	Torn bag
2	Afval	Unmatch printing
3	Afval	Bag size Doesn't fit with the dimension
4	Afval	Oblique folds
5	Afval	Cement tube is damaged
6	Sticky bag	Sticky in bottom of the cement bag (top and down)
7	Sticky bag	sticky valve
8	Sticky bag	Sticky with another paper bag

Based on some of defect types, so it is necessary to determine Critical To Quality (CTQ) in order to make the solution of improvement can be focused more in the problem that is become priority of improvement. *Critical To Quality* is critical quality that is necessary to be maintained its quality by the company because the types of this quality is really important for the customers. *Critical To Quality* for pasted kraft cement bag is cement bag that is in accordance with the quality requirements of the customer. In this case the CTQ are torn bag, size bag doesn't fit the dimension, and oblique folds. The following is the table of defect types that become the CTQ.

Table 3. defect types that become the CTQ.

	Category	Defect types of the CTQ
1	Afval	Torn bag
2	Afval	Size doesn't fit the dimension
3	Afval	Oblique folds
	Total CTQ	**3**

But, beside that PT. X also have problem with sticky bags. Some of sticky bags are sticky in top bottom and down bottom of the cement bag, and also sticky valve where the 3 part of the cement bag is also include important quality that have to be maintained in order to make sticky bag to be reduced. Therefore, object of this research is only focused in defect types such as torn bag, the bag size doesn't fit with its dimension, oblique folds, and sticky bags and then all of the defect types will be calculated, and analyzed to obtained improvement recommendation of the defect types.

3.3 Measure phase

Measure phase is a phase that contains data calculation where the data has been obtained before, the data is data time of production process activity from preparing phase until process in finished product warehouse, and data of defective product in PT. X. In this phase is about calculation of cycle time production process and calculating defect data by using pareto diagram, P control chart, and sigma value. The data of defect types that is used in calculation are torn bag, oblique folds, and bag size doesn't fit with its dimension because the 3 types are critical quality of the company that is necessary to be maintained, beside that sticky bags data will also be calculated. But in pareto diagram calculation the data of all defect types will be used. (not only torn bag, oblique folds, and bag size doesn't fit with its dimension) because it is used to give description about all of defect types that is frequently happen during production process. The following is pareto diagram of cement bag defective product in PT.X:

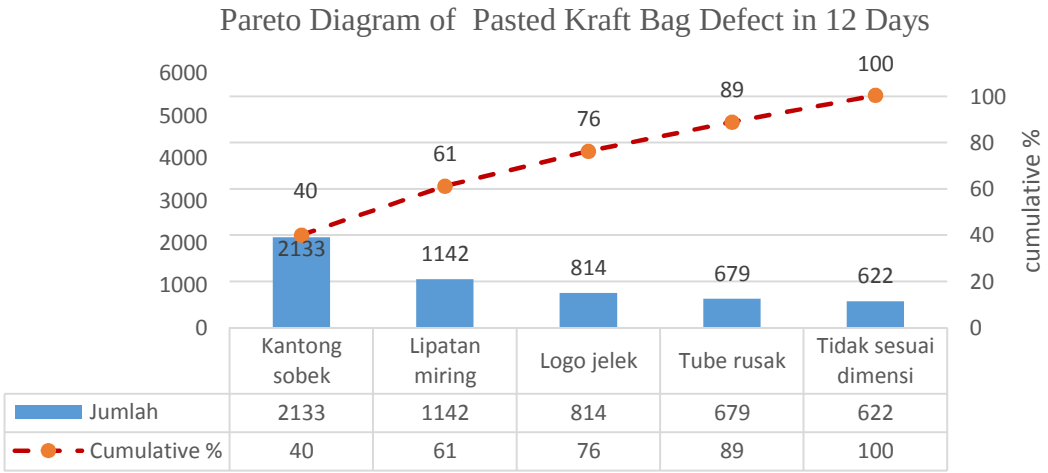


Fig 3. Pareto diagram of cement bag defective product in PT.X:

Based on pareto diagram can be understood that the defect types that is the most dominant is torn bag, the amount of torn bag is up to 40% from total of defect 5.390 bags for 222.000 product sample in 12 days, then oblique folds 21%, unmatch printing 15%, damaged tube 13%, and bag size doesn't fit with its dimension 11%. Pareto diagram is a diagram that can be used to describe sequence of events that is the most frequently happen, so it can be used as problem priority selection that will be finished, so the defect that are necessary become priority based on pareto diagram are torn bag and oblique folds due to the amount of them are large enough and beside that, the 2 types of defect are includes CTQ so they must be reduced but, because type of defect bag size doesn't fit with its dimension also includes CTQ, so it also must be become priority because CTQ is customer's qualification that must be fulfilled by the company to increase customer's satisfaction, so the defect level of cement bag that become CTQ have to be reduced.

After knowing the priority overview of defective product that is necessary improved based on pareto diagram, the next is doing calculation with P control chart to know the control of quality in production process is being in control or out of control. P control chart is a control chart to know ratio between defective product and total production. The next is calculation using P chart control for the data of torn bag, oblique folds, bag size doesn't fit with the dimension, and sticky bags from all of production line using defective product data that is collected in 12 days.

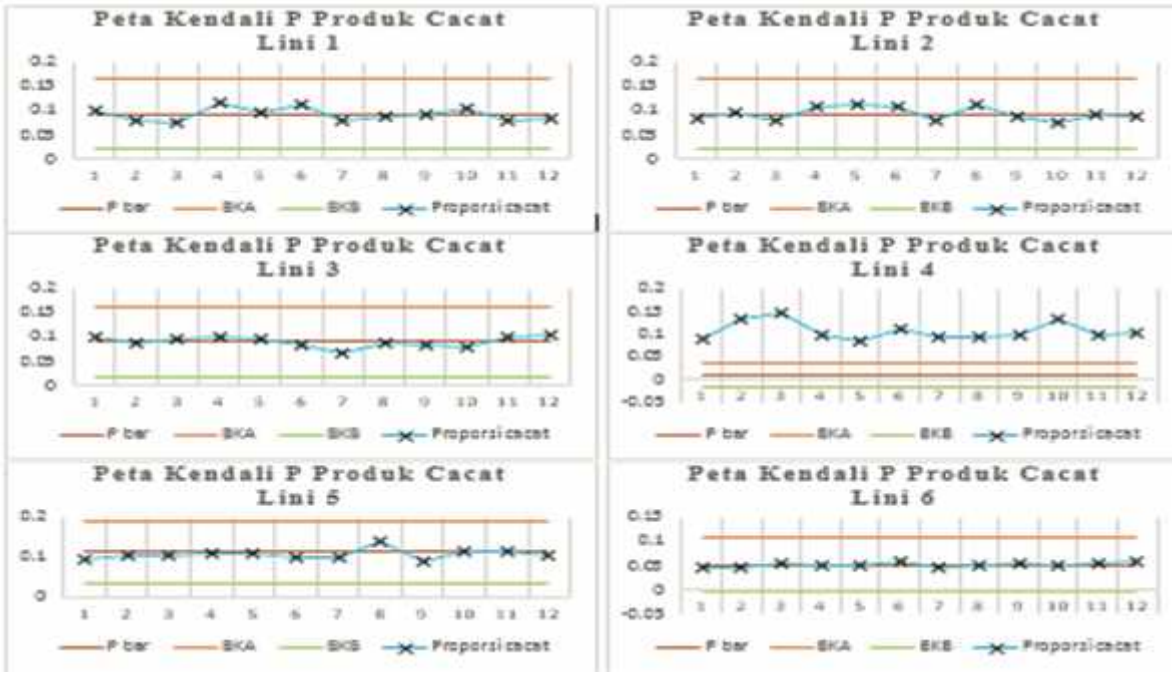


Fig 4. P chart control from all of production line using defective product data that is collected in 12 days

Based on P control chart can be understood that there is one production line which is out of control, it is line 4. For another production line is in control, so line 4 is necessary become priority of improvement in order to make it become in control. The following is recapitulation result of P control chart calculation of defective product in each production line.

The next of measure phase is doing calculation of sigma value. Sigma value is a value that is used to rate process that has been going on by using indicator of defective product's amount and using sigma value guidelines as a reference for process assessment. Component that is used in determining sigma value is the amount of defect, amount of production, and the possibility of a defect. The following is recapitulation result of sigma value from all of production line in producing pasted kraft cement bag:

Tabel 4. Result of sigma value

	Line	Sigma value
1	1	3.37
2	2	3.36
3	3	3.38
4	4	3.30
5	5	3.28
6	6	3.62

Based on calculation of sigma value can be understood that PT. X in production process of pasted kraft cement bag for each line is in 3 level of sigma. So it has to improve quality from side of production process in order to increase sigma value. Next calculation is calculation in reducing activity that is non value added to achieve process that is lean. .Based on calculation of VSM tools selection, tools that is selected is Process Activity Mapping (PAM). Reduction of non value added activity in PAM is by changing activity's cycle time, so time for non value added activity will be reduced. Change of cycle time is applied to delay activity because there is no problem with another activity such as transportation, inspection, and inventory. Based on the reduction of activities in PAM there is a reduction activity that is before 51 activities become 47 activities. Reduction of delay activity is happened for activity of cement bag repairing in tuber and bottomer machine, and also activity of machine repair in tuber and bottomer. The activity reduction is recommended by improving machine scheduling that is high potential cause defective product.

3.4 Analyze phase

In analyze phase is about analyzing process failure that can cause defective product such as torn bag, oblique folds, bag size doesn't fit with the dimension, and sticky bags. The following is recapitulation result of defect types with each their cause that have been analyzed using fishbone diagram

Tabel 5. Analyzing process failure that can cause defective product

Effect	Factor	Cause
Torn bag	Man	Incorrectly in adjusting machine
		Inaccurate in checking machine condition
	Method	The knit perforation hasn't been replaced
		The worn out sucker hasn't been replaced
	Machine	The knit perforation is less sharp
		The cutter is damp
		The kraft paper stuck in machine (feeder)
		The kraft paper stuck in machine (alignment)
		Sucker is worn out
	Material	The Kraft paper is damp
		The Kraft paper is too thin
Doesn't fit the dimensions of the size	Man	*Incorrectly in adjusting machine*
		Operator make a wide space to longitudinal glue
	Method	The bag measurement is not according to the established quality standard
Oblique fold	Machine	*The Forming unit* is adjusted frequently
Sticky bags (STB, SDB, SV)	Man	Maintenance of stacking equipment is less than optimal
	Method	The Stacking is not neat Inclined tube position
	Machine	The machine is worn out
Every operator is different in pasting	Man	Adjusting pasting glue is not standard
	Method	Rubber sheet setting is not measured proper

adjustment	Material	Glue viscosity is too low

Tabel 6. FMEA of bag size doesn't fit with the dimension

No	Potential Failure Mode	Potential effect	Severity	Potential Causes	Occurance	Control	Detection	RPN	Recommended Action
1	The torn bag	The machine is not running properly so it can cause the kraft paper become paper	4	Incorrect in adjusting machine	5	Monitoring and warning from the production supervisor	2	40	A field supervisor is needed, running a reward and punishment system, should have SOP of machine adjustment that is easily understand, should have a training program regularly
		The possibility of broken machine is unpredictable so it can cause the defect	5	The operator is careless in checking machine condition	7	Monitoring from machine operator	4	140	Should have a field supervisor
		The process of making bags is not maximal because cutter is not working, and sucker is not balance	5	The machine is not running properly because the kneet perforation is less sharp and sucker is worn out	6	Monitoring from machine operator	6	180	Regularly control activity is needed by making machine form control and making maintenance schedule that is clear and easily understand
		Poor machine performance can cause the defect	4	Life cycle of the machine tools is over but it hasn't been replaced	2	Monitoring from machine operator	5	40	A field supervisor is needed, should have form control, and making the better maintenance schedule
		The kraft paper is thin and tear easily	5	The kraft paper is not according to the established standard	4	Checking material quality	3	60	Making standard measurement that is easily to understand
2	The bag size doesn't fit to the dimension standard	The machine is not running properly so it can cause the size of bag isn't fit with standard	5	Incorrectly in adjusting machine	5	Monitoring and warning from the production supervisor	2	50	A field supervisor is needed , running a reward and punishment system , should have SOP of machine adjustment that is easily understand, should have a training program regularly
		The size of the bag is not wide enough	5	The operator is careless in giving space for longitudinal glue	5	Monitoring and warning from the production supervisor	4	100	Should have a field supervisor
		Can cause bag size doesn't fit the dimension	6	The bag measurement is not according to quality standard that is established	4	Monitoring and warning from the production supervisor	3	72	Making standard measurement that is clear
		The machine is not running properly, so it can cause thet bag size doesn't fit	5	Machine adjustment is not according to standard that is established	5	Monitoring and warning from the production supervisor	2	50	A field supervisor is needed , running a reward and punishment system , should have SOP that is easily understand, should have a training program regularly
		The forming unit performance is not working optimally so it causes the defect	5	Incorrectly in adjusting machine	5	Monitoring from machine operator	6	150	Making control form and checking machine regularly, and also making better maintenance schedule that is easy to understand
3	Sticky bags (STB, SDB, SV)	The glue is too thick and it causes sticky bags	4	The operator is careless in adjusting the pasting glue	7	Monitoring and warning from the production supervisor	3	84	Should have a field supervisor

No	Potential Failure Mode	Potential effect	Severity	Potential Causes	Occurance	Control	Detection	RPN	Recommended Action
		The glue has a poor quality and it causes the defect	5	The glue making is not made according to quality standard	6	Checking material quality	3	90	A field supervisor is needed, Making standard measurement that is easily to understand
		Rubber shet is not proper and it can causes sticky bags	3	The operator is incorrectly in setting rubber shet	6	Monitoring and warning from the production supervisor	3	54	A field supervisor is needed , running a reward and punishment system , should have SOP of machine adjustment that is easily understand, should have a training program regularly
		Pasting adjustment is not proper and causes the defect	3	Every operator is different in adjusting pasting	7	Monitoring and warning from the production supervisor	3	63	A field supervisor is needed, and should have SOP that is easily understand,
		The long size causes the glue too much and causes the sticky bags	3	The size of rubber shet is too wide	6	Monitoring and warning from the production supervisor	4	72	Making SOP of machine adjustment
		The watery glue causes high splashing and make the bag is sticky	4	The glue viscosity is too low	7	Checking material quality	4	112	Making form control of glue checking
4	Oblique folds	The tube position is running incline and causes bottom pad is not in the proper position	3	The stacking is not neat	4	Monitoring and warning from the production supervisor	3	36	A field supervisor is needed, and should have SOP that is easily understand,
		The stacking equipment is not working properly	4	The maintenance of stacking equipment is not optimal	3	Monitoring from machine operator	4	48	Making control form and checking machine regularly, and also making better maintenance schedule that is easy to understand

3.5 Improve phase

In Improve phase is will be made improvement recommendation using *Failure Mode and Effect Analysis* (FMEA). FMEA method is a method that is used to identify and analyze a failure and the cause and effect to avoid the failure. FMEA table of torn bag After knowing some improvement recommendation of the problem, so it is necessary to choose the recommendation based on the 4 highest value of RPN, the number are 180, 150, 140, and 112 with selected recommendation are recruiting field supervisor, making machine form control specially in forming unit, sucker, and cutting unit, making machine maintenance regularly for part of machine that is potentially cause defective product, and making viscosity form control.

4. Conclusion

PT X in its production process, there is activity that is value added and non value added. The percentage of value added activity is 69.50% and non value added activity is 30.50% with production lead time is 38.385 seconds. Based on diagram pareto analysis every production line has defective product and the most dominant is defect types of torn bag with average percentage is 40%, so it is necessary to make improvement in order to reduce the defective product. Based on P control chart analysis and sigma value it can be understood that sigma level of production process from each of production line (line 1-6) are 3.36, 3.37, 3.38, 3.30, 3.28, 3.6. Improvement

recommendation in reducing pasted kraft bag's defective product is selected based on 4 highest score of RPN, they are 180, 150, 140, and 112 and the recommendation that is selected are recruiting field supervisor, making machine form control specially in forming unit, sucker, and cutting unit, making machine maintenance regularly for part of machine that is potentially cause defective product, and making viscosity form control.

References

Afferdhy Ariffien, et al., 2021. Lean Six Sigma Analyst in Packing House Lembang Agriculture Incubation Center (LAIC), Journal of Physics: Conference Series,.

Ambar, Pertiwi, dkk. 2014. Pendekatan Lean Six Sigma Guna Mengurangi Waste Pada Proses Produksi Genteng dan Paving. Jurnal Teknik Industri: Fakultas Teknik. Universitas Brawijaya. Hal 313-324.

Aulia Ishak, et al., 2020. Reducing Waste to Improve Product Quality in the Wooden Pallet Production Process by Using Six Sigma Approach in PT. XYZ", IOP Conference Series: Materials Science and Engineering.

Bambang Suhardi, Maudiena Hermas Putri K.S, Wakhid Ahmad Jauhari. 2020. Implementation of Value Stream Mapping to Reduce Waste in a Textile Products Industry", Cogent Engineering

Khawarita Siregar, Elvira. "Quality Control Analysis to Reduce Defect Product and Increase Production Speed using Lean Six Sigma Method', IOP Conference Series: Materials Science and Engineering, 2020

Fakhrus, Ari Sanny, dkk. 2015. Implementasi Metode Lean six Sigma Sebagai Upaya Meminimalkan Cacat Produk Kemasan Cup Air Mineral 240 ml (Studi Kasus Perusahaan Air Minum). Jurnal Gaussian: Vol 04, No 02, Hal 227-236

Gasperz, Vincent.2011. Lean Six Sigma for Manufacturing abd Service Industries. Vinchristo Publication, Bogor.

Gaspersz, Vincent. 2017. The Executive Guide To Implementing Lean Six Sigma. Jakarta: PT. Gramedia Pustaka Utama

M Fadiana, S M Amin, A Lukito, Warli. "How Concrete Operational Student Generalize the Pattern?: use Semiotic Perspective", Journal of Physics Conference Series, 2019

Purnawan, Adi Wicaksono, dkk. 2017. Peningkatan Pengendalian Kualitas Melalui Metode Lean Six Sigma. Jurnal Teknik Industri: Fakultas Teknik. Universitas Diponegoro. Vol 12, No 03

Sugiono, dkk. 2014. Pendekatan Lean Six Sigma Untuk Mengurangi Waste Proses Produksi Brown Paper Jurnal Teknik Industri: Fakultas Teknik. Universitas Brawijaya. Hal 406-417

Wiganda. 2018. Kajian Pengurangan Pemborosan Proses Produksi Kemasan Karton Bergelombang Dengan Lean Six Sigma di PT DAYACIPTA KEMASINDO PLANT KARAWANG. Skripsi: Program Sarjana Alih Jenis Manajemen Departemen Manajemen. Fakultas Ekonomi Dan Manajemen. Institut Pertanian Bogor.