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ORIGINAL ARTICLE

Increasing Production Performance With The Use of Lean Six Sigma Methodology In a Filing Cabinet Company

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ABSTRACT – PT. Chubb Safes Indonesia, a safe cabinet manufacturer, intends to improve product quality while increasing the process speed. Based on preliminary research, several waste types occur, including waiting, inappropriate processing and defects. The percentage of defects that reached 2.67%, exceeding the 100% defects based on the company's target of 1% became the basis of the problems in the company in this study. This study aims to use the Lean Six Sigma method to improve company performance. The Define – Measure – Analysis – Improve and Control (DMAIC) approach is the basis for the completion stage in this research. The Define stage is carried out by identifying the type of defect, then making a SIPOC diagram, then the Measure stage is carried out by making a control chart to determine whether the production process is running stably and making a Pareto diagram to determine the dominant defect level, DPMO calculation, Sigma level and PCE. Furthermore, at the Analysis stage, an Ishikawa diagram is made to find out the causes of the defects that occur, input information about the types of failures that occur as well as analysis of causes, effects and recommendations for improvement based on the FMEA table. check to reduce defective products. At the Control stage, the implementation of the proposed improvements is then compared to the results of the calculation of DPMO, Sigma Level and PCE before and after implementation. Based on data processing, the PCE obtained is 38.42% which increases to 51.5% and the sigma level increases from 3.5 to 4.8. With the sustainable use of the Lean Six Sigma method at PT CSI, it will improve performance according to company targets.

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INTRODUCTION

PT Chubb Safes Indonesia (here in after referred to as PT CSI) is a supplier of security and protection systems used to safeguard goods, jewelries and important documents. The resulting product categories include various safe types employed in residences, offices, jewelry stores, banks, gas stations and several filing cabinets (storage drawers for valuable files), security doors and fire extinguishers. In addition, specifications resistant to fire and to bulking appear very necessary. Therefore, to achieve competitive advantage, critical attention on product quality has increasingly become mandatory. This effort demands continuous improvements to balance market realities. Filing cabinets are among the several security-based products in the form of drawers, where files or sensitive documents are stored and incorporate fireproof conditions as well as dismantling resistance.

Price, quality and delivery time are significant factors in production. Therefore, every organization is expected to constantly improve the quality of goods or services, in an effort to remain relevant in the global economy. Quality control is an engineering and management activity, where the value characteristics of existing products are measured, in comparison to specifications, with the need to implement appropriate strategies to balance any difference between actual and standard development. Furthermore, the quality control techniques are applied during raw material selection, in the production route and on the final product.

The LSS method is mostly applied in the production line to resolve various defect and waste problems, leading to an enhanced customer value. In addition, an increase in the sigma level was obtained at 1.5%, after the implementation [1]. Meanwhile, in the production of underwater rider R333B at PT XYZ, the finding process cycle efficiency extended from 28.55-31.87% [2]. Furthermore, the Lean approach focuses on reducing production waste, while Six Sigma involves a set of concepts and practices targeted at decreasing process variations as well as product failures or defects [3]. These joint applications are centered on problem solving methodologies, termed define, measure, analyze, improve and control (DMAIC).

Operational Excellence methodologies such as Lean Six Sigma have the potential to address and enhance understanding of processes and provide a methodology and toolset to aid effective root causing and corrective action implementation. Research using the LSS approach was done through the evaluation and analysis of Six Sigma for the performance of production processes in pharmaceutical companies. Utilization of the Lean Six Sigma methodology can determine the root causes for the implementation of corrective actions. The results obtained are problem solving that does not have a negative impact on production costs, production time or product quality [4].

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PT. CSI, carefully considers product quality and ensures consumers obtain excellent products, with warranty repairs. The company consistently strives to improve product quality aimed at increasing profit and achieving maximum sales targets. However, the current challenge involves the optimal means to adopt in eliminating deficiencies during production. The percentage of defective products from May-August extends to 2.67% per month, meanwhile the target was stipulated at 1%. Therefore, the need to conduct an evaluation on the production line appears very paramount. This study was aimed at determining the use of LSS methodology to increase production performance at PT CSI. The present research framework provides an overview of the LSS, followed by DMAIC methodology and conclusions.

Table 1. Product defect percentage (May-August,2017).

Month	Week	Product name	Number of product	Defects	Persentage of defects (%)
May	W-18	Filing Cabinets	90	2	2.23
	W-19		80	4	5
	W-20		109	4	3.67
	W-22		66	1	1.52
June	W-23	Filing Cabinets	78	2	2.57
	W-25		51	2	3.93
	W-14		94	4	4.26
July	W-28	Filing Cabinets	103	1	0.98
	W-29		92	2	2.18
	W-30		96	1	1.05
August	W-31	Filing Cabinets	93	3	3.23
	W-34		75	1	1.34
	Total		1027	27	2.67

RELATED WORK

Lean Six Sigma definition

This research adopted several definitions, including: Lean Six Sigma is a methodology known to maximize shareholder value by improving customer satisfaction, cost, quality, process speed and capital [2], [5] described LSS as a combination of Lean and Six Sigma and is defined as a business philosophy, systemic and systematic approach, used to identify as well as eliminate waste or non-value-added activities. These efforts involve radical continuous improvement to achieve an optimized performance level, by flowing product (material, work-in-process, output) and information using a pull system from customers to pursue excellence.

Lean Six Sigma is a combination of Lean and Six Sigma, where Lean defines the measures of a smooth production process, by eliminating waste, while Six Sigma minimizes the variations in product defects. The successful application of the combined methodology has been proven by several researches, including [6], where DMAIC was utilized to reduce welding repair rate above 25% [7] employed the model to lower the production flaws in rotary switch. Furthermore, the major adopted tools in the DMAIC phase included project charter, value stream map (VSM), Ishikawa chart, and Taguchi factorial design. Therefore, the present study also requires LSS to eliminate waste, ensure smooth production line and minimize variations, in addition to generating products with virtually zero defects.

Lean and Six Sigma are two widely acknowledged business process improvement strategies available to organisations today for achieving dramatic results in cost, quality and time by focusing on process performance. Lean Six Sigma combines the variability reduction tools and techniques from Six Sigma with the waste and non-value-added elimination tools and techniques from Lean Manufacturing, to generate savings to the bottom-line of an organisation [8].

The sigma (σ) statistic is a parameter stating the average difference with the actual value. This does not mean Six Sigma relates six times the sigma, but is an accomplishment in the production process with continuous improvement. The approach is used to achieve 3,4 defects per-million opportunities (DPMO), equivalent to Six Sigma [8].

The accomplishment is a phasing process from one to six sigma, and is equivalent to 3.4. Furthermore, the ignition is depicted at 1.5 sigma shift in Figure 1.

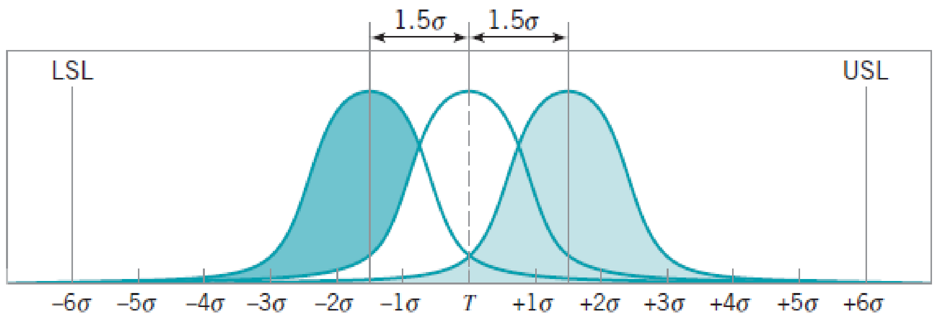

Figure 1. Six sigma achievement process [11].

DMAIC methodology in Lean Six Sigma

This study uses the DMAIC approach with the stages of Define, Measure, Analysis, Improve and Control. At the Define stage, identification of the types of defects that occur in the product, making a SIPOC diagram that is useful for identifying suppliers who are partners with the company, input in the form of raw materials used for the production process, product manufacturing process, output stating the product produced, and customer stating product users.

The Measure stage is applied to determine whether the production process is stable or not by using a control chart, measuring the level of Sigma and DPMO, making Pareto diagrams to determine the most dominant type of defect, measuring the level of efficiency of the production process using a Value Stream Map (VSM) using indicators. Process Cycle Efficiency (PCE).

The Analysis stage is the stage used to analyze the dominant causes of defects and waste that occur. The tools used at this stage are Ishikawa diagrams and the creation of a Failure Mode Effect Analysis (FMEA) table. Next, the Improve stage is the stage used for the proposed repair of defects and the elimination of waste that occurs in the production process, to reduce waste in this study the batch transfer technique is used, while for defect repair the proposed check sheet is used.

The Control stage is the stage to determine whether the production process improvement has gone well or not, by comparing the Six Sigma, DPMO and PCE indicators before and after implementation is carried out. Broadly speaking, the DMAIC stages in this study can be seen in Figure 2.

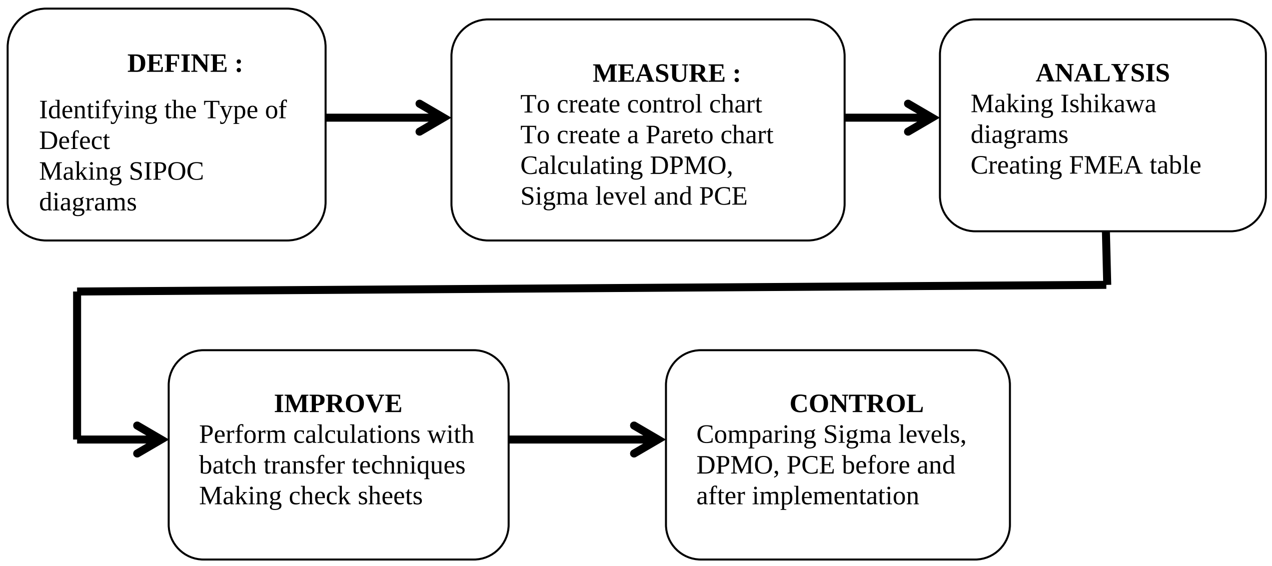

Figure 2. Flowchart of DMAIC.

Methodology in Lean Six Sigma

In define stage, the initial step involved identifying the prevalent defect types. Based on careful observations, 10 error categories were detected between September 4th to October 30th, 2017. These deficiencies include:

1. Uneven powder paint (striped stain on the product surface from the powder coating)
2. Gap defect in the form of black lines on two or more painting boards
3. A faulty lock error, in the form of a key with poor functionality
4. The drawer does not lock properly
5. Blobor defect, including the form of painting with external drying interval
6. Cracked putty, for example defects in the form of broken putty on the painting surface
7. Sport is not neat, meaning untidy welding defects

8. Drawer dent failure
9. Welding does not stick to the product surface
10. Cracked handle flaws

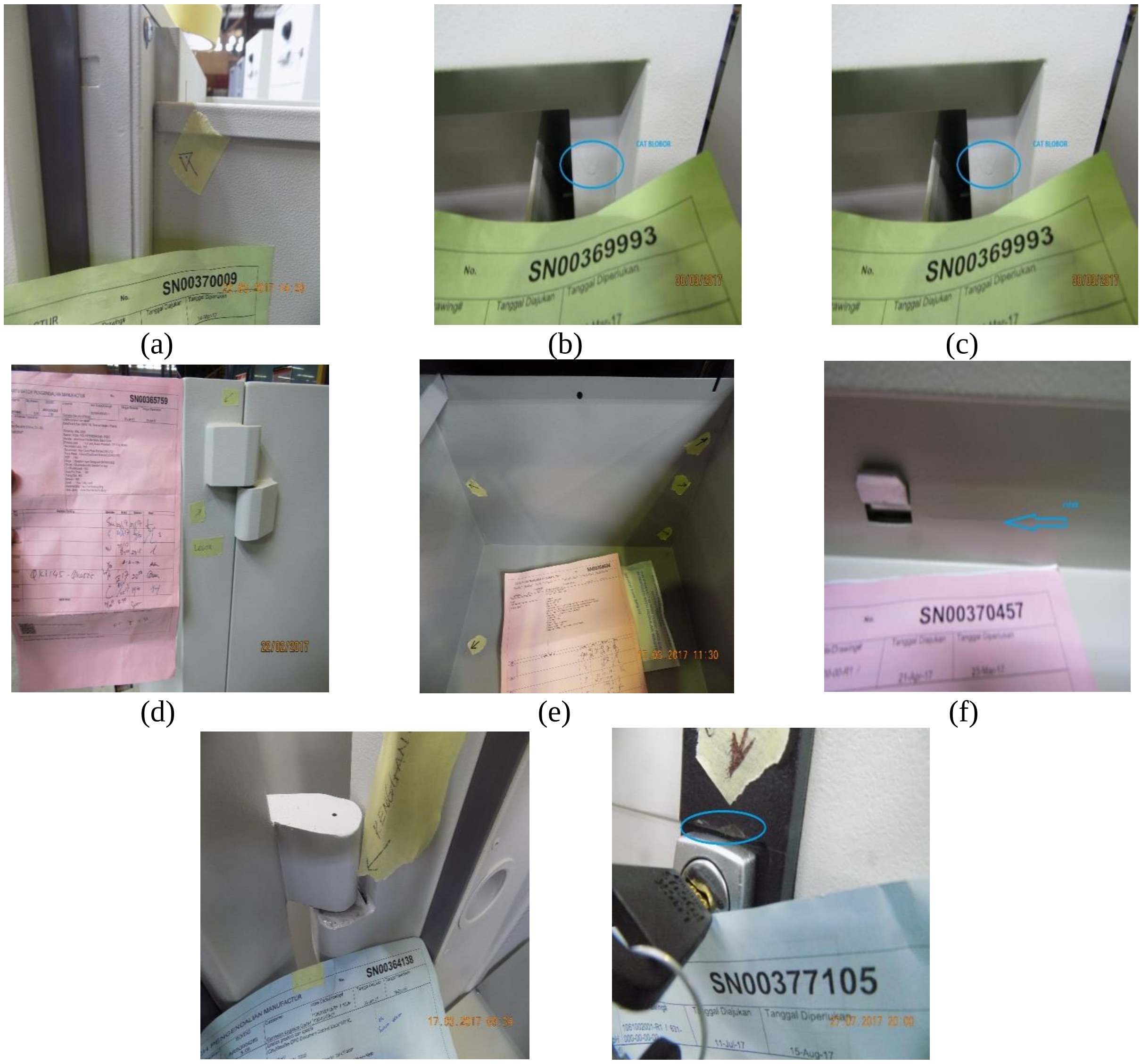

Figure 3. Types of defects, (a) Striped (b) Gap defects (c) Blobor defect (d) Cracked putty (e) Sport is not neat (f) Drawer dent (g) Welding does stick (h) Cracked handle.

Customer supply input process output (SIPOC) diagram is generated for the subsequent define stage. This figure aims to determine the supplier, input, production process order, output and the customer [9]. The SIPOC diagram at the define stage is as in Figure 4.

MEASURE STAGE

The measure phase in this study was aimed at evaluating the production process stability, in accordance with the nature of the observed defect data and the modified quality control. Under this circumstance, each product unit was examined to identify flaws and proffer possible solutions. Therefore, the U map control chart was applied [10]. Furthermore, observations were conducted at 30 intervals between September 4th-October 31st, 2017, where sampling were affected randomly with a total sample and disability unit of 668 and 46, respectively.

$$\bar{u} = \frac{46}{668} = 0.068$$

Figure 5 and 6, shows the use of Minitab version 17 software to complete the control chart.

Defects per million opportunities (DPMO) calculation

According to [11], the derivation of DPMO formula is as follows:

$$\boldsymbol{DPU} = \frac{Defects}{Total - Unit} \tag{1}$$

$$\boldsymbol{DPO} = \frac{DPU}{OP} \tag{2}$$

$$\boldsymbol{DPMO} = DPO \times 1.000.000 \tag{3}$$

Meanwhile DPU = 0.068, DPO =0.0068, DPMO =6.800 or equal to 3,5σ.

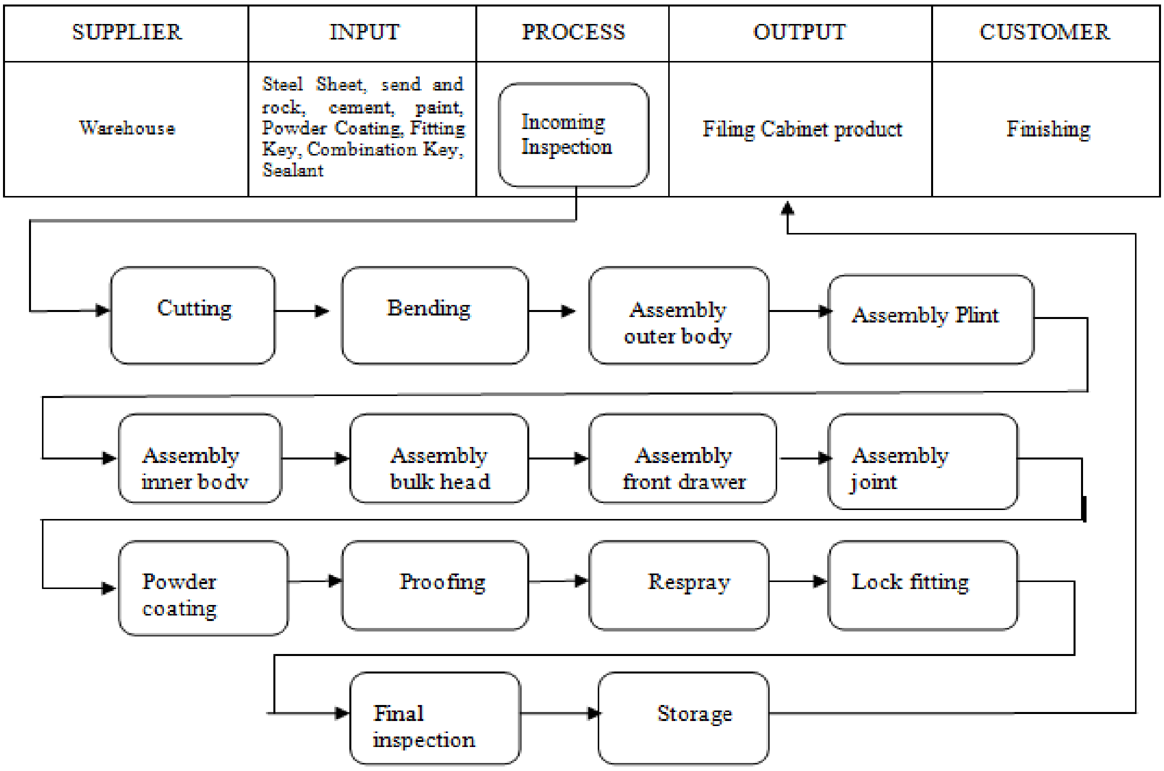

Figure 4. SIPOC diagram.

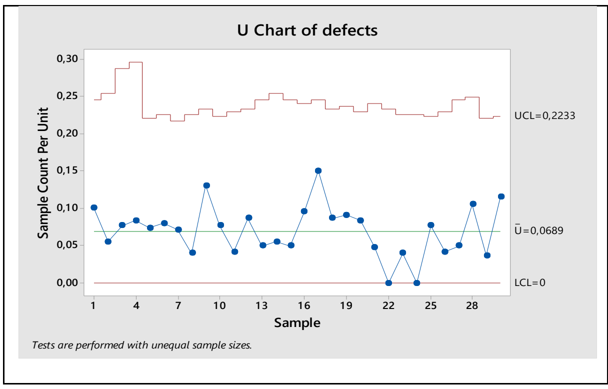

Figure 5. P Control Chart of defects.

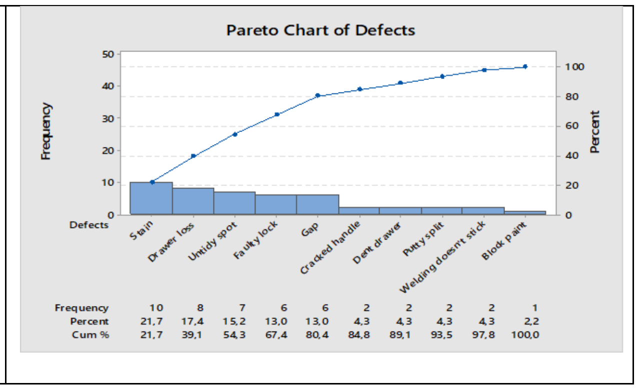

Figure 6. Pareto Chart of defects.

Value Stream Map (VSM)

According to [12], the value stream map relates to water flow from upstream to downstream. In a smooth transition, less obstacles are observed, including an absolute distribution. Meanwhile, in a condition where the raw materials received from the supplier are then processed at each work station without experiencing obstacles or with added value, then the production line is completely conducted. Furthermore, the following indicators are used to determine an efficient functional process.

$$\boldsymbol{Process-Cycle-Efficiency} = \frac{Value-Added-Time}{Manufacturing-Lead-Time}$$

The production line commencing from raw material processing to finished products, comprises 40 activities, termed: initial administration, raw material inspection, cutting area carriage, cutting process, anticipating the bending process, bending area transfer, bending process, awaiting the assembly stage, movement to assembly unit, removing outer body parts, processing outer body assembly, detach part plinth, process assembly plinth, separate inner body segment, process inner body, process bulk head assembly, remove front drawer, process front drawer, detach body drawer, process assembly body drawer, process assembly joint, transportation to powder coating conveyer, awaiting powder coating process, loading body & drawer unit, powder coating process, unloading of drawer unit, expecting the proofing process, movement to proofing area, disconnecting drawer components, proofing process, anticipating the flock fitting process, lock fitting transport, re-spray process prior to lock fitting, process lock fitting, process response after lock fitting, transportation to the finishing area, awaiting the finishing/final inspection, finishing, packing, and transportation of end products to the warehouse. Furthermore, the total value-added activity and manufacturing lead time were 781.42 and 2033.77 minutes, respectively.

$$\boldsymbol{Process-Cycle-Efficiency} = \frac{781{,}42}{2033{,}77} \times 100\% = 38{,}42\%$$

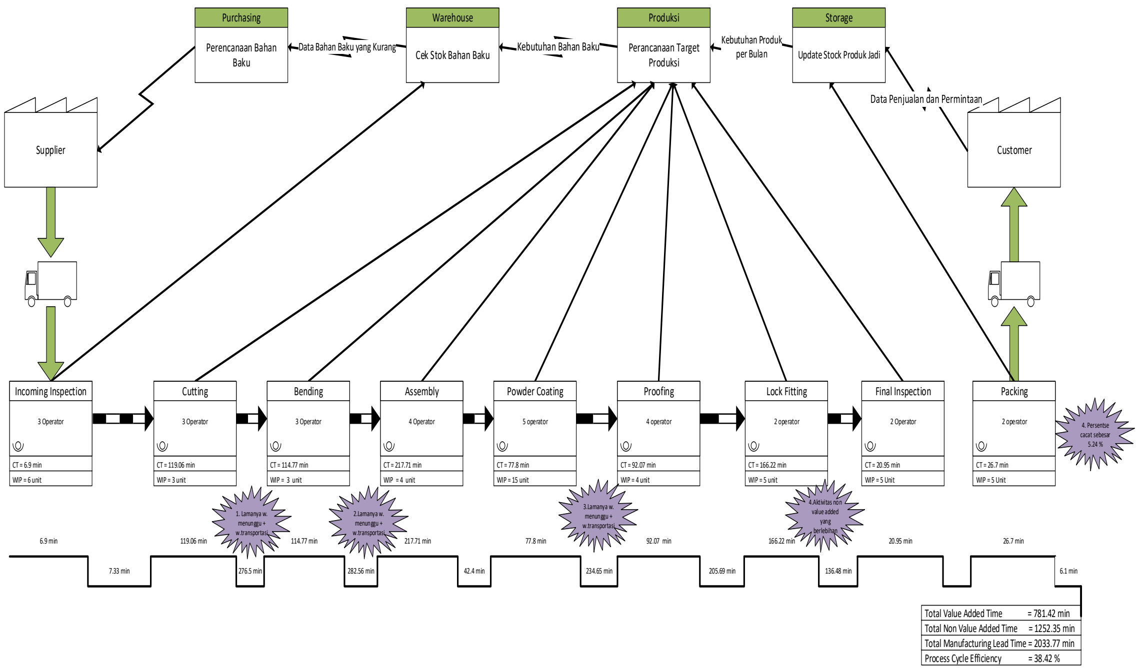

Figure 7. Current Value Stream Map.

ANALYSIS STAGE

Waste analysis

Based on the value stream mapping and metric calculations, the production process cycle efficiency and the total manufacturing lead time were obtained at 38.42% and 2033.77 minutes, respectively. The resulting production inefficiency was due to the waiting time between processes, estimated at 45.73%. These activities include waiting time from the cutting to ending (276.5 minutes), bending to assembly (282.56 minutes), powder coating to proofing (234.65 minutes), as well as lock fitting to final inspection (136.48 minutes), and therefore, resulting to a total of 930.19 minutes.

However, the reason for this long waiting time was probably attributed to the use of a batch system, where a single job needs to be completed before another commences. Meanwhile, the causes of the interaction between components in accomplishing a work is illustrated in the following Ishikawa diagram (Figure 8). Based on the figure, the sources of waste in the production process and workers, in addition to waiting time, was attributed to human error. This is due to the negligence of operators in the welding process, and downtime on certain machines. Furthermore, the barriers are not possible to predict, as a result of insufficient records.

Defect analysis

Pareto chart in Figure 6 shows the priority order of defects, including striped (21.7%), drawer loss (17.4%), untidy spot (15.2%), faulty lock (13%) and gap (13%), with a total number of disabilities at 80.4%. This means the 80.4% error is possibly adjusted, as the remaining defects in the production aggregates to 19.6%. However, the disability causes include, the striped defect in powder coating, resulting from a shift in the painting surface support. This situation does not enable the flowing paint to dry on time. Furthermore, drawer loss defects were due to mechanical failure, where the product does not lock appropriately. This is caused by operator error in the lock fitting settings. Also, the untidy spot influenced by the blunt welding needle, where the welding does not focus on a particular point, but spreads from a predetermined position, leading to untidy appearance. The faulty lock defect occurs due to dysfunctional locking system from incorrect key setting.

In the assessment stage, a failure mode effect analysis (FMEA) was also generated. [13], described FMEA as an engineering technique used to define, identify, and eliminate known and/or potential failure, problems, errors, and so on from the system, design, process, and/or service, prior to customer engagement. Table 2 provides a detailed representation of FMEA in the present study.

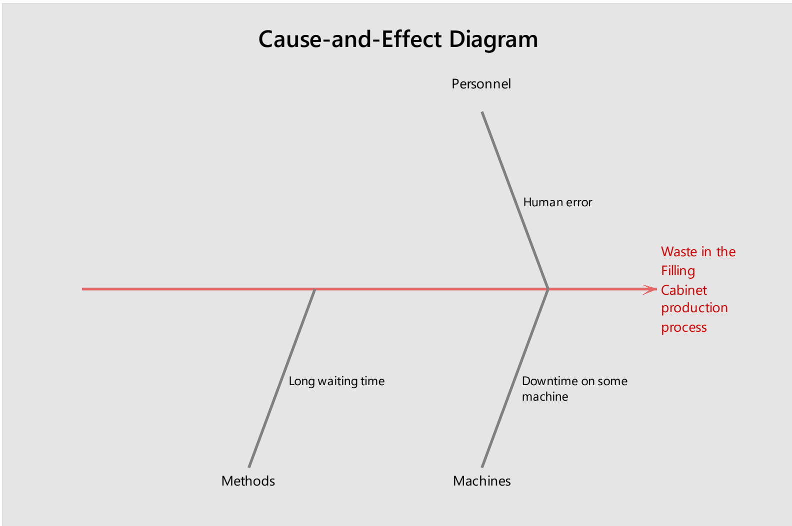

Figure 8. Ishikawa diagram for waste cause.

Table 2. Failure mode effects analysis.

No	Process function	Potential failure mode	Potential effects of failure	S	Potential causes of failur	O	Current control	D	RPN	Recommended actions
1	Powder coating	Striped	Rework	5	shifting hunger on the painting surface, to ensure the flowing paint does not dry on time	9	Visual	8	360	Create a check sheet for machine maintenance
2	Lock Fitting	Drawer loss	Reset	5	Operator error in key setting	8	When locking is done, manually	6	240	Create a check sheet for checking lock fitting
	Lock Fitting	Faulty lock	Reset	3	Operator error in key setting	7	When locking is done, manually	6	126	Create a check sheet for checking lock fitting
	Welding	Untidy spot	Rework to increase processing time	3	blunt welding needle on the welding machine	7	Visual	7	313	The addition of a digital counter to the welding machine

IMPROVE STAGE

Improvement to decrease wasting time

The proposed improvement to minimize lead time involves reducing the waiting period from one station to another. Production processes are performed in batches, where a single set comprises 5 units of the product. For instance, the cutting work station has to conduct an operation process of 5 new units. The result is transferred to the subsequent work station, including the bending process section. Therefore, batch transfer techniques are employed to minimize waiting time.

Batch transfer calculations are performed in the transportation process from several work stations, including the shift from cutting to bending, bending to assembly, powder coating to proofing and proofing to lock fitting work stations. The following provides a calculation to determine the batch size for the first (Q1) and second (Q2) jobs. Furthermore, the data on the number of units per batch and the cycle time of the filing cabinet manufacturing process are represented below.

1. Calculation of transfer back from cutting work stations to bending work stations
   Total batch size (Q) = 6 units
   Cutting station time (PA) = 118.52 minutes
   Bending station time (PB) = 114.27 minutes
   Set up time at the Bending station (SB) = 0 seconds
   The determination of the batch size for the first (Q1) and second jobs (Q2) are as follows:

$$Q_1 \geq \frac{QP_A - S_B}{P_R + P_A} = \frac{(6x119.06) - 0}{119.06 + 114.17} = 3.06 \approx 3 - unit$$
$$Q_2 = Q - Q_1 = 6 - 3 = 3 - unit$$

2. Calculation of the transfer back from the bending workstation to the assembly work station
   Total batch size (Q) = 6 units
   Bending station time (PA) = 114.17 minutes
   Assembly station time (PB) = 217.74 minutes
   Set up time at the Bending station (SB) = 0 seconds
   The determination of the batch size for the first (Q1) and second jobs (Q2) are as follows:

$$Q_1 \geq \frac{QP_A - S_B}{P_R + P_A} = \frac{(6x114.17) - 0}{119.06 + 217.74} = 2.06 \approx 2 - unit$$
$$Q_2 = Q - Q_1 = 6 - 2 = 4 - unit$$

3. Calculation of the transfer from powder coating to proofing work station
   Total batch size (Q) = 6 units
   Powder coating (PA) station time = 77.8 minutes
   Proofing station time (PB) = 92.07 minutes
   Set up time at bending station (SB) = 0 seconds
   The determination of the batch size for the first (Q1) and second jobs (Q2) are as follows:

$$Q_1 \geq \frac{QP_A - S_B}{P_R + P_A} = \frac{(6x77.8) - 0}{77.8 + 92.07} = 2.75 \approx 3 - unit$$
$$Q_2 = Q - Q_1 = 6 - 3 = 3 - unit$$

4. Calculation of the transfer from proofing to lock fitting work station.
   Total batch size (Q) = 6 units
   Proofing station time (PA) = 92.07 minutes
   Time of lock fitting (PB) station = 166.05 minutes
   Set up time at Bending station (SB) = 0 seconds
   The determination of the batch size for the first (Q1) and second jobs (Q2) are as follows:

$$Q_1 \geq \frac{QP_A - S_B}{P_R + P_A} = \frac{(6x92.07) - 0}{92.07 + 166.05} = 2.14 \approx 2 - unit$$
$$Q_2 = Q - Q_1 = 6 - 2 = 4 - unit$$

Improvement to decrease defect variance

Based on the FMEA table, the proposal for the process of repairing the striped defect involves developing a machine maintenance check sheet. During the production process, operators encounter certain challenges in effecting the machine maintenance. This is due to the absence of defects, and therefore, are unable to ascertain the right conditions for mechanical checks. Moreover, to reduce the variation of striped errors, a machine maintenance check sheet appears necessary, as illustrated in Figure 9.

To reduce the variation of defets in drawer loss and faulty lock at the lock fitting process,it is necessary to check all the part elements in the drawer loss and faulty locks, so that they run according to their function so does not occur.The proposed examination sheet is as in Figure 10. Possible improvement to minimize the occurrence of spot untidy defects caused by blunt welding needles is to propose a periodic replacement of the needles.

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Checklist :Powder coating machine daily maintenance program

No :..

Date :..

No	Checklist	Condition		Action	Descrption
		good	not good		
1	Bearing blower			Lubrication	
2	Boomer lighter			Clean and setting	
3	Pneumatic parts			Clean	
4	Nozzle and their direction			Clean	
5	Rinsing tub			Clean	
6	Phosphating tub			Clean	
7	Powder boat filter			Clean	
8	Rel conveyor			Clean	
9	Pretreatment tub			Clean and setting	

Figure 9. Check list for daily powder coating machine maintenance.

CONTROL STAGE

Implementation of machine maintenance daily checklist form

Powder coating machine operators are mandated to fill in the daily maintenance checklist form for 10 days during the implementation. The device operates for 15-16 hours per day. Daily checks and maintenance are performed every morning at 07.30, prior to production. Moreover, routine assessment of machine components and maintenance tends to prevent unnecessary downtimes. During the 10 days of implementation phase, no damage or downtime occurred. Previously, the company checked and performed routine maintenance once in a week by the maintenance operators.

Implementation of check sheet use for lock fitting process

Function checks currently conducted below 5 intervals, are considered insufficient. This condition is to enable defective products to pass the inspection. The proposed improvement involves the provision of a more specific check sheet design proposal for only the inspection of lock fitting results. This is different from the previous check sheet design not particularly devoted to the cabinet filing, but combined with a final check or inspection. However, the implementation results of standardization using check sheets succeeded in reducing the types of faulty lock defects or stuck locks and drawer loss.

During the 10 days implementation, no faulty locks and drawer losses were recorded. Moreover, the creation of check sheets and the application in the lock fitting process is focused on assessing the functionality. This process involves the installation of a lock and drawer in a cabinet filing manufacture. Therefore, ensuring the functional state of the both objects is very significant. However, defective products from the lock fitting process are on average a malfunction, where the key or drawer does not work properly. As a consequence, the use of a check sheet requires the operator or supervisor to examine the function at least five times. Subsequently, without any functional problem observed, the machine is, therefore, declared to have successfully passed the inspection.

Implementation of transfer batch technique

The implementation of the batch transfer technique, conducted by dividing the process into 2 job orders, succeeded in reducing waiting and production lead times at several workstations. This batch process results in transfer delay from station A to B, because A requires product unit completion, based on the specific number of batch units. Subsequently, the samples were conveyed to station B, after completion. Therefore, the waiting time for the transfer from cutting to bending was estimated at 150.96 minutes, reducing waiting time of transfer from bending to assembly by 152.21 minutes, reducing waiting time from powder coating to proofing station by 28.66 minutes, and reducing processing waiting time from the proofing to the lock fitting stations at 106.55 minutes.

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Checkseet design for Lock Fitting Inspection

Date :......................................

No	Point inspection	Standard	Inspection Result		Signature
			good	Not good	
1	Hole kl housing clean from PCDE,BCL	Clean			
2	Function telescope slide is fine	Smooth			
3	Function KL is fine	Smooth			
4	Function KCL/EL is fine	Smooth			
5	Locking catch and stopper are in correct position	According to spec			
6	Smooth locking bar movement	Smooth			
7	Gap body and drawer according to standard	<3mm			
8	Gap drawer and drawe according to standard	2-3 mm			
9	Tilt drawer according to standard	Max 0.5 mm			
10	Flatness drawer and body	+/- 1mm			
11	Gap drawer and inner body	No friction			
12	KCL locked position and KL open edge	Kl can't esc			
13	KL lock position	Drawer >5mm			
14	Combination modifier key according to standard	As a function			
15	Function push/pull handle according to standard	As a function			
16	AVA lock according to standard	Work instruction			
17	Dry catch bolt goes into the bulk head hole	Min 6 mm			
18	Handle's appearance	No Scratch			
19	Label calor	Specifiction			
20	Label chubb safes	There is			
21	Label certificate	There is			
22	Series number	appropriate			
23	The palette used is appropriate	appropriate			

Figure 10. Checking form for lock fitting.

During the interval between 15-30 December, 2017, after implementation, based on the earlier proposed improvements, the average defect unit is equal to

$$\bar{u} = \frac{6}{237} = 0.0253$$

The production process is believed to operate effectively, as observed in the control chart of Figure 13. Calculation of Defect Per Million Opportunities (DPMO):

$$DPU = \frac{6}{232} = 0.0253$$

$$DPO = \frac{0.0253}{10} = 0.00253$$

$$DPMO = (0.00253)x(1.000.000) = 2.530$$

$$Equal - to = 4.8\sigma$$

The results of the PCE calculation obtained the following outcomes:

$$\boldsymbol{PCE = Process - Cycle - Efficiency} = \frac{787{,}29}{1532{,}25} \times 100\% = 51{,}38\%$$

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Checklist :Powder coating machine daily maintenance program

No :.Monday...............................
Date :.18th Des 2017.................

No	Checklist	Condition		Action	Descrption
		good	not good		
1	Bearing blower	√		Lubrication	
2	Boomer lighter		√	Clean and setting	Clean up
3	Pneumatic parts	√		Clean	
4	Nozzle and their direction		√	Clean	Clean up
5	Rinsing tub	√		Clean	
6	Phosphating tub	√		Clean	
7	Powder boat filter	√		Clean	
8	Rel conveyor	√		Clean	
9	Pretreatment tub	√		Clean and setting	

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JAKARTA

Figure 11. Checking form at implementation phase.

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Checkseet design for Lock Fitting Inspection

Serial Number :SN00372462
Date :18th Dec 2017.

No	Point inspection	Standard	Inspection Result: good	Inspection Result: Not good	Signature
1	Hole kl housing clean from PCDE,BCL	Clean	√		
2	Function telescope slide is fine	Smooth	√		
3	Function KL is fine	Smooth	√		
4	Function KCL/EL is fine	Smooth	√		
5	Locking catch and stopper are in correct position	According to spec	√		
6	Smooth locking bar movement	Smooth	√		
7	Gap body and drawer according to standard	<3mm	√		
8	Gap drawer and drawe according to standard	2-3 mm	√		
9	Tilt drawer according to standard	Max 0.5 mm	√		
10	Flatness drawer and body	+/- 1mm	√		
11	Gap drawer and inner body	No friction	√		
12	KCL locked position and KL open edge	Kl can't esc	√		
13	KL lock position	Drawer >5mm	√		
14	Combination modifier key according to standard	As a function	√		
15	Function push/pull handle according to standard	As a function	√		
16	AVA lock according to standard	Work instruction	√		
17	Dry catch bolt goes into the bulk head hole	Min 6 mm	√		
18	Handle's appearance	No Scratch	√		
19	Label calor	Specifiction	√		
20	Label chubb safes	There is	√		
21	Label certificate	There is	√		
22	Series number	appropriate	√		
23	The palette used is appropriate	appropriate	√		

CHUBB SAFES INDONESIA
JAKARTA

Figure 12. Checking form for lock fitting at implementation phase.

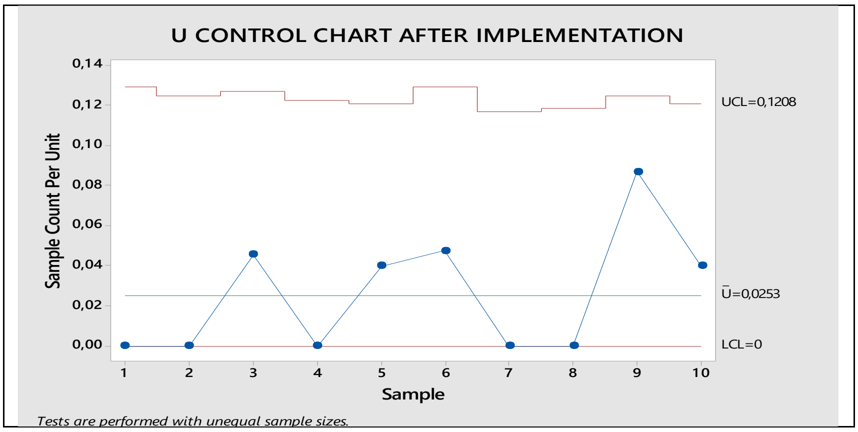

Figure 13. Control chart-u after implementation.

DISCUSSION

Utilization of the Lean Six Sigma method to improve the performance of the production process at PT CSI using the DMAIC approach showed an increase in six sigma of 37.14% and Process Cycle Efficiency of 12.88%. The lean approach requires the implementation of a lean culture with the motto of continuous improvement for the effective use of the Lean Six Sigma method in the company.

The research that has been carried out also needs to be equipped with an analysis based on the cost aspect in accordance with the studies that have been carried out by researchers [14] and researchers [15]. Regarding the company's readiness to excel in global competition towards industry 4.0, the research that has been done is something that other companies need to follow, namely to find out the PCE value and the level of sigma that has been obtained by the company at this time. For the sustainability of the company, each company is expected to be able to continue to make continuous improvement and find out the company's position compared to other companies in order to excel in business competition.

CONCLUSION

Subsequent deductions were generated, after carefully considering the processes of define, measure, analysis, improve and control stages in this study. Defect types in the filing cabinet products comprise 10 errors termed, 21.7% striped, 17.4% drawer loss, 15.2% untidy spot, 13% faulty lock, 13 % gap, defect of crack handle, putty split, dent drawer, welding does not stick respectively by 4.3% and block paint defect by 2.2%.

The result of dpmo calculation prior to implemention showed 6,800, with the sigma level of 3.5. Meanwhile, after implementation was estimated at 2,530 and the sigma level showed 4.8 or dpmo decreases by 62.79%, as the sigma level increased by 37.14% Process cycle efficiency (PCE) prior to implementation was evaluated at 38.42%, and after implementation, the value 51.5% or a 12.88% increase. In the future, it is necessary to collaborate with other researchers, regarding lean culture and costs, so that this research is more optimal.

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