INTEGRATED COST AND VALUE STREAM IN CRANKCASE PRODUCTION (CP)

Imam Rendi Pratama
Department of Technology Management, Institut Teknologi Sepuluh Nopember Surabaya, Indonesia
imamrendip@gmail.com

Moses Laksono Singgih
Department of Technology Management, Institut Teknologi Sepuluh Nopember Surabaya, Indonesia
moseslsinggih@ie.its.ac.id

ABSTRACT

Crankcase Production (CP) is a company engaged in manufacturing, one of which produces one component of the engine motor unit, namely the crankcase component. In the production process, there are still various indications of waste that cause a decrease in the efficiency and effectiveness of the production process. One of the biggest problems is defects, with a percentage of defects above 5%. Therefore, it is necessary to optimize the process of the crankcase to increase the effectiveness and efficiency of production. This study aims to eliminate waste in the production line of the crankcase by implementing the lean manufacturing concept. The lean manufacturing method used is the Waste Assessment Model (WAM) to distinguish waste in the manufacturing process. The integrated cost value stream introduces cost lines that can help facilitate decision-making. Based on the results of waste identification, the 3 largest wastes were found, namely defects, inventory, and transportation. There are 2 alternative improvements to overcome this waste, namely by changing the jig tool and changing the push-to-pull method. The results show that defect waste decreased to an average of 4.8%, the total value added cost decreased by 1%, total non-value added cost decreased by 55%.

CCS CONCEPTS

• **General and reference**; • **Document types**; • **General conference proceedings**;

KEYWORDS

Lean manufacturing, waste assessment model, activity-based costing, integrated cost value stream

ACM Reference Format:
Imam Rendi Pratama and Moses Laksono Singgih. 2022. INTEGRATED COST AND VALUE STREAM IN CRANKCASE PRODUCTION (CP). In *Proceedings of the International Conference on Engineering and Information Technology for Sustainable Industry (ICONETSI), September 21, 22, 2022, Alam Sutera, Tangerang, Indonesia.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3557738.3557843

ICONETSI, September 21, 22, 2022, Alam Sutera, Tangerang, Indonesia

ACM ISBN 978-1-4503-9718-6/22/09…$15.00
https://doi.org/10.1145/3557738.3557843

1 INTRODUCTION

Companies in manufacturing can be said to be highly developed and competitive. Companies are required to continue to make continuous improvements to the company's performance. Effective and efficient production has the potential to deliver products that are not only of high quality but also competitive. The Crankcase Production (CP) is a company engaged in manufacturing, one of which produces one component of the engine motor unit, namely the crankcase component. Crankcase products are the product with the highest demand at the moment, which is around 15.500 sets per month. The crankcase production process, which is continuous, is currently not running in a balanced manner following the assembly process. Meanwhile, to fulfill the current demand for crankcases, which is more than the average, which is 15,500 sets per month, this is done by working overtime.

Indication waste is found in the manufacturing process in Crankcase Production (CP), with a relatively large number of defective products. Based on these data, part of the crankcase looks quite high in its reject value, which exceeds the 5% limit of the company's stipulation. It can be said that the efficiency of the production process on parts crankcase has not been reached.

Lean manufacturing is a suitable method for optimizing process and performance production systems due to can measure, identify, analyze and provide improvement solutions and performance improvements in a comprehensive manner. Something the model is needed in the waste identification process. Some of the assessment tools to find out the waste problem is the used Waste Assessment Model (WAM).

To simplify decision-making, cost analysis use Activity Based Costing (ABC) is carried out on value streams. It is used in the identification of the various components of cost as well as perform an overall relative contribution analysis of those costs.

2 LITERATURE REVIEW

2.1 Lean Concept

In terms of language or terminology, the word "lean" means the arrangement of activities or solutions to reduce not only waste but also non-value added (NVA) operations and improve value-added operations (Wee, H. M and Simon Wu, 2009).According to Liker (2004) lean manufacturing is the optimal method for producing goods through the elimination of waste (waste), reducing costs, and increasing the ability of workers.

2.2 Seven Waste Concept

The concept of a lean approach in principle is the elimination of inefficiency (waste). This definition of waste can also mean all activities without added value to the company's output. There are seven types of waste (seven waste s) according to Hines & Taylor (2000), namely: overproduction, defect (reject), inventory, process, transportation, waiting/idle, motion.

2.3 Waste Assessment Model (WAM)

The waste Assessment Model (WAM) is a model used to simplify the process of finding waste problems and identifying them to eliminate waste (Rawabdeh, 2005). This WAM provides an overview of the relationship between seven types of waste. In the waste assessment model method, data processing will be carried out in the form of seven waste relationships, Waste Relationship Matrix (WRM), and Waste Assessment Questionnaire (WAQ).

A waste Relationship is a tool used to reduce the amount of waste that affects each other between types to make the production process run optimally.

The waste Relationship Matrix (WRM) is a matrix used to analyze the measurement criteria. Columns in the matrix show the types of waste that are affected by other types of waste. The rows in the matrix indicate the impact of one type of waste on the other six types of waste. The diagonal side of the matrix has the highest relation value

Waste Assessment Questionnaire (WAQ) is used as a tool to identify and allocate waste types in a company's production line (Rawabdeh, 2005). This assessment is in the form of a questionnaire consisting of 68 different questions.

2.4 Value Stream Mapping (VSM)

The term value stream is translated as an activity that can be said to be special in the supply chain system, which will play a role in the design process, ordering process, and also in determining the specific value of the product (Hines and Taylor, 2000). Besides that, VSM is also used in the process of identifying which activities have value added and which activities are non-value added in the manufacturing industry.

2.5 Value Stream Mapping Tools

In VSM there are seven types of detailed mapping tools that are commonly used (Hines and). Rich, 1997), that is: Process Activity Mapping (PAM), Supply Chain Response Matrix (SCRM), Quality Filter Mapping (QFM), Production Variety Funnel (PVF), Decision Point Analysis (DPA), Demand Amplification Mapping (DAM), Physical Structure (PS).

2.6 Cost Integrated Value Stream Mapping

Cost Integrated Value Stream integrates VSM and cost aspects that function to produce a cost line to facilitate management in making decisions. The process of Redesigning VSM with this cost aspect is very helpful for management in refocusing on improvement areas.

Cost analysis is done by building an integration between the cost line in VSM and the timeline that already exists in VSM. Cost line helps simplify management when making decisions. The formulas below are what you need in cost analysis:

$$\text{Value added activity cost} = mi + CTi\left(\frac{Mi + Li}{3600}\right) \tag{1}$$

$$\text{mi} = 0 \ \text{(when no material is added to the activity)}$$

$$\text{Non value added activity cost} = \text{hi} \times \text{li} \tag{2}$$

$$\text{Total value added cost} = \sum_{\text{n}=1}^{\text{n}} \text{mi} + \text{CTi}\left(\frac{\text{Mi} + \text{Li}}{3600}\right) \tag{3}$$

$$\text{Total non} - \text{value added cost} = \sum_{i=1}^{n+1} hi \times li \tag{4}$$

Information :
CT = Cycle Time
M = Machine *rate* per hour
L = Operator *rate* per hour
m = material cost
I = Inventory (raw material, work in process (WIP), finished goods)
h = Holding cost inventory

3 METHODS

This research is descriptive research that contains a description and interpretation of a condition, development of opinion, an ongoing process, and a causal relationship. Data collection is the stage of collecting information on the total of the entire population in the study. This study uses secondary data sources.
To obtain data, the researchers used several techniques, namely:

- Interview

Data collected through the interview process must meet the following criteria:

- Holding a functional position in the company (managers, supervisors, and employees) in the production division
- Have worked in the company for at least 3 years.
- D3 education or above.
- Company documentation
- Company documentation is needed as research supporting data, where the data source comes from documents, records, or archives owned by the production division. The data needed in this study is a general description of the company, production process activities, material flow, cycle manufacturing processes, and production workforce needs.

The steps in this research are as follows :

- Data Collection Stage
- At this stage is the collection of data needed during research where the data will then be processed to find out the best solution to the problem. The following data needs in research like Data regarding material flow, data related to production activities, data cycle time of each manufacturing process, data on labor requirements for each manufacturing process, machine hour rate, labor hour rate, material cost, amount of stockpile, Inventory holding cost, defect data in PPM
- Data Processing
- Data is processed after the data is collected at this stage, through literature studies and direct observations in the field. Data processing includes the following steps:
- Creation of Current State Value Stream Mapping
- It takes the data flow of the production process and leads time production activity to create a VSM.
- Identification of Current Cost Integrated State Map

Table 1: Machining Crank Case Process Inventory

No	Activity	Inventory	
1	Raw Material from Platform to OP1	400	pcs
2	WIP between OP1 and OP2	0	pcs
3	WIP between OP2 and OP3	0	pcs
4	WIP between OP3 and OP4	0	pcs
5	WIP between OP4 and check air micro and TC Cleaning	0	pcs
6	WIP between check air micro and TC Cleaning	0	pcs
7	WIP between Leak test and final appearance check	0	pcs
8	WIP between final appearance check and finish goods	200	pcs
	TOTAL INVENTORY	**600**	**pcs**

- Data that has been collected is used to design the current cost-integrated value stream map. There is data information flow, production, cost line, and timeline. The data are processed as follows: total value stream inventory, WIP calculation, total product cycle time, total value stream lead time, the total value added cost & non-value added cost
- Waste Identification and Measurement
- Waste Assessment model used for identification of *waste* using interviews and distribution of questionnaires with weighting to related sections
- Data Analysis
- At this stage, an analysis of the results is carried out on the collected data and process previously. Data analysis includes analysis of current and future VSM, as well as comparing the current and future cost integrated value streams. Data analysis produces interpretation and discussion to answer research problems
- Idea Recommendation Improvement
- This stage is an activity of analyzing the results of processing and drawing conclusions from the answers to the formulation of the problem

4 RESULTS

4.1 Identification of Current Cost Integrated State Map Lean

Table 1 follows the inventory of crankcase parts in the form of raw material, WIP, or finished goods from the finish of the casting process until delivery :

Table 2 is the result of calculating the cycle time for each machining crankcase manufacturing process:

Before calculating the total value added cost, we must first find out the machine data rate, operator rate, and material costs. The following Table 3 is the engine data rate in the manufacture of the crankcase

The labor hour rate at Crankcase Production Company (CPC) is Rp. 27,630. Data quantity and price of materials to make crankcase shown in Table 4 as follows

Table 2: Cycle Time for Machining Crank Case Process

No	Activity	Cycle Time (Second)
1	OP1	63
2	OP2	78
3	OP3	66
4	OP4	84
5	Check Air Micro & TC Cleaning	138
6	Leak Test	180
7	Appearance Check	54
	TOTAL PRODUCT CYCLE TIME	**663**

Table 3: Machining Crank Case Process Machine Rate

Machine name	Rate /hour	
OP1	Rp.	368,000
OP2	Rp.	468,000
OP3	Rp.	234,000
OP4	Rp.	682,000
Check Air Micro and TC Cleanning	Rp.	122,000
Leak Test	Rp.	110,000
Appearance Check	Rp.	12,000

Table 4: Raw Material Prices for Machining Crank Case Process

Material name	Unit	Price	
Raw parts crank case	1	Rp.	247,000
Raw Material Supplier	3	Rp.	62,000
Total		**Rp.**	**309,000**

Table 5: Raw Material Prices for Machining Crank Case Process

No	Proses	Value Added Cost	
1	OP1	Rp.	315,924
2	OP2	Rp.	10,739
3	OP3	Rp.	4,797
4	OP4	Rp.	11,827
5	Check Air Micro & TC Cleaning	Rp.	5,736
6	Leak Test	Rp.	6,882
7	Appearance Check	Rp.	594
	TOTAL VALUE ADDED COST	**Rp.**	**356,498**

So that the following table 5 is the value added cost data obtained Before calculating the total non-*value added cost*, we must first find out the holding cost data inventory, after that, we can calculate the non-value added cost like table 6 below.

Table 6: Raw Material Prices for Machining Crank Case Process

No	*Inventory* Name	*Inventory Holding Cost*	
1	*Holding Cost Inventory* OP1	Rp.	14,000
2	Holding Cost Inventory OP2	Rp.	-
3	Holding Cost Inventory OP3	Rp.	-
4	Holding Cost Inventory OP4	Rp.	-
5	Holding Cost Inventory Check Air Micro & TC Cleaning	Rp.	-
6	Holding Cost Inventory Leak Test	Rp.	-
7	Holding Cost Inventory Appearance Check	Rp.	-
8	Holding Cost Inventory Finish Good	Rp.	10,000
	TOTAL NON-VALUE ADDED	Rp.	**24,000**

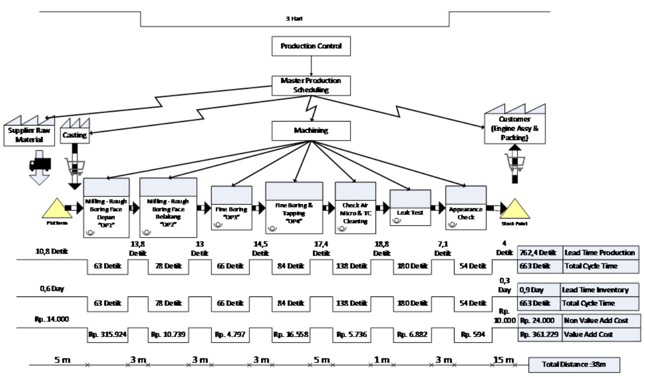

Figure 1: Current Cost Integrated State Map

Detail Value Stream Mapping Machining Crank Case can see in figure 1.

4.2 Identification Waste

Table 7 The following is the waste matrix value for the machining crankcase production process.
The waste value from WRM is used as the initial WAQ value according to there are 68 questions from the questionnaire. Question with "From", explains the type of waste as a trigger for other types of waste based on WRM. Questions with "To", explain each current waste as a result of influencing other types of waste. And the final result for the identification of waste can see in Table 8.
From the results of the questionnaire above, it was found that the 3 biggest wastes are defects, inventory, and transportation. Furthermore, VALSAT will be selected based on the results of weighting the waste.

4.3 Value Stream Analysis Tools (VALSAT)

4.3.1 Process Activity Mapping (PAM). The machining crankcase production process consists of 27 sequential work steps The details of the portion of each type of activity are shown in Table 9 below. From Table 9 above, there are 5 activities in the value-added category and 22 activities non-value added percentage that must be lowered. PAM machining crankcase results show the total time for the production of 1 product is 762 seconds with details for each activity type in table 10 follows.
From Table 10 Can be seen the time for activities value added of 429 seconds (56% total time), and non-value added of 44% need to be reduced so that it can be more provide added value for customers.

4.3.2 Supply Chain Response Matrix (SCRM). The tabulation of the results of calculating lead time and inventory is shown in table 11 below.
SCRM analysis found a total time of 4.17 days machining crankcase g un a reach product order. The total cumulative days of physical stock is 3.32 days (the average per day required for materials in the order fulfillment system). Days physical stock which is highly

Table 7: Waste Matrix Value Machining Crank Case

F/T	O	I	D	M	T	P	W	Score	%
O	10	10	4	6	8	0	4	42	15.56%
I	2	10	6	6	8	0	0	32	11.85%
D	4	10	10	10	8	0	8	50	18.52%
M	0	2	8	10	0	8	8	36	13.33%
T	6	6	6	8	10	0	6	42	15.56%
P	6	4	8	6	0	10	6	40	14.81%
W	2	10	6	0	0	0	10	28	10.37%
Score	30	52	48	46	34	18	42	270	100.0%
%	11.11%	19.26%	17.78%	17.04%	12.59%	6.67%	15.56%	100.0%	

Table 8: Calculation of Waste Ranking

	O	I	D	M	T	P	W
Final Result (Yj Final)	24.33	33.19	46.13	25.89	27.29	9.44	18.42
The final result (%)	13%	18%	25%	14%	15%	5%	10%
Ranking	5	2	1	4	3	7	6

Table 9: Summary of PAM Activities

Activity	Operation	Transport	Inspection	Storage	delay
Amount	5	13	2	1	6
Percentage	19%	48%	7%	4%	22%

Table 10: Summary of PAM Percentage

Activity	Operation	Transport	Inspection	Storage	delay
Amount	429	51,7	234	4	43,7
Percentage	56%	7%	31%	1%	6%

Table 11: Calculation of SCRM Machining Crank Case

No	Items	Days Physical Stock	Lead Times	Cumulative Days Physical Stock	Cumulative Lead Times
1	Raw Material Storage Area (F/G Casting)	1.54	0.56	1.54	0.56
2	Production Process Area (WIP Machining)	1	0.01	2.54	0.57
3	Finished Product Storage Area (F/G Machining)	0.78	0.28	3.32	0.85
				Total	**4.17**

correlated with the length of inventory accumulation in the order fulfillment system chain.

4.3.3 Quality Filter Mapping (QFM). Quality Filter Mapping (QFM) is a tool for identifying quality problems (defects) along the supply chain. The following table 12 is the average reject part in the last 3 months (January 2020 to March 2020).

Table 12: Reject Data Machine Machining Crank Case

No	Process	Reject Rate
1	OP1	0.5%
2	OP2	0.2%
3	OP3	1.0%
4	OP4	5.0%
5	Check Air Micro & TC Cleaning	0.0%
6	Leak Test	0.0%
7	Appearance Check	0.0%
8	Delivery	0.0%

Based on the QFM machining crankcase above, it can be seen that the largest waste defect/reject is in the OP4 area with a reject rate of 5%.

4.4 Idea Improvement

4.4.1 Changing the Jig Tool. Improvements to the Jig Tool design on the OP4 engine can reduce defects (reject parts) which also have an impact on :

- The process flow is getting smoother, it can minimize waste in the form of waiting.
- Output production increases, so there is no need for inventory waste in the raw material area can be removed.

Modification of the OP4 machine tool jig is carried out in the Engineering department through technical studies and trials.

Before the repair, the tool design that is large enough does not make a perfect hole in the tool's taper-shaped material. It is necessary to improve the tool design so that the drilling power on the workpiece increases by changing the shape, position, and grip area. So that the new tool design applied in April 2021 has a grip area of 15 mm . position _ drilling from the inside of the workpiece as

Figure 2: Design Change of Jig Tool Machining Crank Case

well as the contact area in the form of a hole effective. Reject _ OP4 machine process parts machining production line has decreased as follows.

4.4.2 Changing Push Method to Pull. Sales forecasting is a management guideline to calculate the volume of material purchases and the level of inventory so stocking out is avoided. Just In Time production system developed by the company Japan is only to produce type requests consumer goods, the amount needed, when needed. Philosophy JIT emphasizes total management operations with the use of resources (raw materials, parts, personnel, and facilities) to the extent needed to increase productivity and minimize waste. JI T is supported by the principle of sustainable production flow d with condition cooperation of every part of the production process with components other.

A pull system is a production process to minimize inventory. If the JIT principle is applied to the production system, then the product is produced according to the number of requests at the time needed. The production control system earlier (push system) relies on the production schedule of the manufacturing process in each department. But by using the pull system method, the production schedule must be in sync starting from customer requests to the availability of raw materials. Table 14 The following is a comparison of stock inventory before repair and after repair.

Furthermore, changing the method from push to pull also has an impact on reducing transportation activities. Where previously each department had to send parts to customers (customers here are the next process, namely assembly parts) now from customers who take parts to each shop. So that in machining production there is only a transport process for taking the finished casting raw material. As for finishing good machining, it is enough to just prepare it at the stock point, where later the team from the assembly part will take the part.

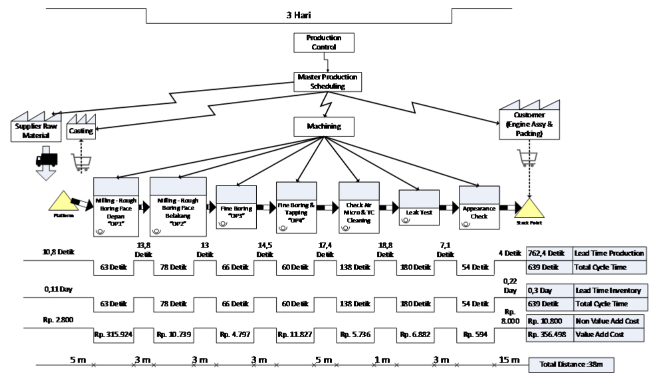

Figure 3: Proposed Integrated Value Stream Mapping

Based on the improvements above, it can be seen that the waste defect can be reduced to an average of 4.8% by replacing the jig tool on the OP4 machine. In addition, inventory waste and transportation waste can be reduced by changing the method from a push system to a pull system. In terms of inventory can be reduced to 360 pcs / day. And also in terms of transportation can reduce 1 manpower.

The results showed that production lead time could decrease by 0.6 days or decrease by 60%, cycle time could decrease by 24 seconds or 4%, the total value added cost decreased by Rp. 4.7311 or 1%, and the total non-value added cost decreased by Rp. 13,200 or 55%.

5 CONCLUSION

The conclusions obtained from this study include the following:

The Waste Assessment Model (WAM) method produces 3 (three) categories of waste The main production line of machining crankcases is defect/ reject parts (25%), unnecessary inventory (18%), and transportation (15%).

Waste arises as a result of several problems. Process OP4 (fine boring and tapping) causes it, right? reject parts highest in machining crank production line case, reject rate of 0.5%. Furthermore, waste unnecessary inventory, in the area of raw materials for the machining production line, obtained days of physical stock of 1.54 days. Stock raw materials excess and their absorption are not optimal due to limited machining production capacity. And the last is transportation waste. This transportation waste is due to the layout of the casting and machining processes in different buildings

Table 13: Reject Data Conditions Before and After Repair

Condition	Period	Production Quantity (pcs)	Number of Rejects (pcs)	Reject Rate (pcs)
Before Repair	Jan	15,700	894.9	5.7%
	Feb	16,200	1101.6	6.80%
	Mar	15,950	972.95	6.10%
After Repair	April	16,100	772.8	4.80%
	May	16,200	793.8	4.90%
	Jun	15,500	744	4.80%

Table 14: Inventory Conditions Before and After Repair

No	Activity	Inventory			
		Before		After	
1	Finished good casting and OP1	400	pcs	80	pcs
2	WIP between OP1 and OP2	0	pcs	0	pcs
3	WIP between OP2 and OP3	0	pcs	0	pcs
4	WIP between OP3 and OP4	0	pcs	0	pcs
5	WIP between OP4 and check air micro and TC Cleaning	0	pcs	0	pcs
6	WIP between TC Cleaning and Leak Test	0	pcs	0	pcs
7	WIP between Leak test and final appearance check	0	pcs	0	pcs
8	WIP between final appearance check and delivery	200	pcs	160	pcs
	TOTAL INVENTORY	**600**	**pcs**	**240**	**pcs**

Recommendations for overcoming waste are to modify the jig tool and change the push method to pull

Improvements made can reduce total value added cost from Rp. 361,229 to Rp. 356,498. Reduction of total non-value added cost from Rp. 24,000 to Rp.10,800Display Computer codes can be inserted using “ComputerCode” style.

REFERENCES

[1] Goriwondo, William M., Samson Mhlanga, and Alphonce Marecha. (2011), “*Use of The Value Stream Mapping Tool for Waste Reduction in Manufacturing (Case Study for Bread Manufacturing in Zimbabwe)*”, Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management.

[2] Hines, P., and D. Taylor. (2000) Going Lean, Lean Enterprise Research Center, Cardiff Business School.

[3] Hines, P. and Rich, N. (1997), “The seven value stream mapping tools”, International Journal of Operations & Production Management, Vol. 17 No. 1, pp. 46-64.

[4] Liker, J. K. (2004). The Toyota Way. United States: Mc Graw hill.

[5] Mc. Williams, Douglas L and Edem G. Tetteh. (2008), *“Value-Stream Mapping to Improve Productivity in Transmission Case Machining”*, Proceedings of the 2008 Industrial Engineering Research Conference J. Fowler and S. Mason. Eds.

[6] Rawabdeh, I. (2005), *“A Model for the assessment of waste in job shop environments“*, International Journal of Operations & Production Management, Vol. 25 No. 8, pp. 800-822.

[7] SdRother, M., & Shook, J. (2003). *Learning to See, Value Stream Mapping to Create Value and Eliminate Muda.* Cambridge: The Lean Enterprise Institute, Inc.

[8] Wee, H.M and Simon Wu. (2009), *“Lean supply chain and its effect on product cost and quality: a case study on Ford Motor Company”*, Supply Chain Management: An International Journal 14/5 (2009) 335–341.