

Analysis of the Application of Lean Maintenance to Optimize Transformer Maintenance Duration at MRO Company PT. Servo Indonesia Perkasa

Juma'in¹

¹Program Studi Magister Manajemen Fakultas Ekonomi dan Bisnis, Universitas Mercu Buana
Indonesia

Rosalendro Eddy Nugroho²

²Program Studi Magister Manajemen Fakultas Ekonomi dan Bisnis, Universitas Mercu Buana

Email : jumain.aqilla@gmail.com, rosalendro.eddy@mercubuana.ac.id

Abstract

This study was conducted with the aim of identifying the causes of waste that cause delays in the completion of Maintenance, Repair and Overhaul Transformer work carried out by PT SIP, to determine recommendations and proposals for appropriate improvements to overcome waste during the implementation of Maintenance, Repair and Overhaul Transformer activities carried out by PT SIP, and to evaluate the implementation of lean maintenance to overcome waste that causes delays in the completion of Maintenance, Repair and Overhaul Transformer work carried out by PT SIP. The method used in this research is the Quantitative Descriptive method. The results showed that CSM Analysis at eight stages of Pre Shutdown to Energize activities identified waste such as delays in HSE approval, material mismatches, lack of labor skills, slow delivery of samples, and unavailability of adequate personal protective equipment. Proposed improvements include parallel work, moving manpower to other activities, ensuring the availability of tools and parts, and modifying delivery schedules and locations for temporary placement of parts to optimize the duration of the Inspection & Overhaul stage. The implementation of Lean Maintenance at PT SIP reduced the overhaul duration to 297 hours, improved labor effectiveness, ensured spare parts readiness, increased productivity through ISO 45001, and kept SOPs and Work Instructions (IK) complete and up-to-date, all of which contributed to OHS risk management and operational efficiency.

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Keywords: Lean Maintenance; Duration Optimization; Transformer Maintenance; MRO Company; PT. Servo Indonesia Perkasa

INTRODUCTION

PT Servo Indonesia Perkasa as one of the companies engaged in Maintenance, Repair and overhaul contractors with specialization in the electrical field, the work done focuses on two things, namely the installation of new installations and maintenance of electrical installations. The coverage area worked on is in all regions of Indonesia both offshore and onshore, government buildings, power plants, private industry. In its existence in the Maintenance, repair and overhaul industry in the electrical field, the Company has received recognition from customers, this is evidenced by the amount of work carried out which every year experiences quite good growth and gets a very responsive market response.

Maintenance, Repair and overhaul work activities which are the main scope of the Company are transformers or more often we call them transformers, Transformers have a very important function in the distribution of electricity from the place where electrical energy is generated to the customer, The electrical energy generated must be converted using a transformer so that it can be used according to the needs of the user or customer To maintain a reliable and stable supply of electrical energy, of course, reliable and efficient transformer performance is needed to ensure that the supply of electrical energy can be fulfilled optimally (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2020). One of the crucial activities that are commonly carried out periodically to ensure that the performance of electrical equipment remains optimal is overhaul. According to Kiamah (2011), Overhaul is one of the planned maintenance activities carried out to ensure that every equipment used in the power plant is still functioning properly.

According to Nag (2002), one of the important targets in the implementation of overhaul is the achievement of the target completion time of overhaul work. This is because if there is a delay in the completion of overhaul activities, it can cause great losses to the company, customers in both the government sector, industrial sector and the wider community in general. The importance of the function of the transformer, of course, also requires regular and scheduled maintenance activities so that there is no breakdown in the middle of the journey. PT Servo Indonesia Perkasa is a company engaged in the field of contractors with the main business sector



is maintenance, Repair, Overhaul or we are familiar with the abbreviation MRO.

One of the main focuses of PT. SIP is to serve maintenance, repair and overhaul on transformers with all capacities, both large and small. The reliable and efficient performance of PT. SIP is certainly an unavoidable demand from the job giver or customer, so it is necessary to have good management steps in the internal company PT. SIP. One of the targets of maintenance, Repair and Overhaul work is the target of completing the work on time, this is certainly a concern because if there is a delay in the completion of MRO activities, then it is certain that there will be a large loss for both PT. SIP, Employers and the industrial sector and the wider community as users of electrical energy.

The author's focus in this study is to analyze the waste that occurs during the implementation of Transformer overhaul by implementing the Lean Maintenance concept using Value Stream Mapping (VSM). The Lean Maintenance method using VSM has been commonly used in several previous studies to optimize maintenance activities in various sectors, including: railway transportation Croucamp & Telukdarie (2018), automotive (Ali, 2019; Kusumaningrum, 2018; Pombal et al., 2019; Wijayanto, 2018), production machinery Effendi (2019), and the steel industry (Lika, 2020). In contrast to these studies, in this study the authors will use the Lean Maintenance method for maintenance optimization in the electrical energy sector more specifically, namely transformers. In this case, the author will analyze the factors that cause waste in transformer maintenance, repair and overhaul. Based on the results of an extensive literature study conducted by the author, research related to maintenance optimization in the electrical energy sector (Transformers) is still relatively very little. Previous research that the author managed to find related to maintenance optimization in the power generation sector was research conducted by Muharram (2019) and research conducted by yoppy Setyo Duto (2023). The difference between this research and Muharram's research (2019) and yoppy setyo Duto's research (2023) is in terms of the object of maintenance and the location of maintenance.

Muharram analyzed the causes of waste in the maintenance of Combustor equipment (overhaul Combustor Inspection) in one of the power generation units in East Java, Yoppy setyo Duto analyzed Turbine equipment (overhaul Turbine Inspection) carried out in several power generation units in DKI Jakarta and Banten while the difference with the research conducted by the author is for the electricity sector, namely transformers carried out by PT. SIP as an MRO company in the generation sector, Distribution sector. In this study, some of the root causes that will be studied by the author are taken from waste found by previous studies in other sectors that



have the potential to become waste in the maintenance of power plants and electricity distribution. Yoppy (2023) identified the causes of waste in turbine inspection maintenance as Waiting, material or spare parts are not available, limited man power, long transportation of goods or material support, repetitive work.

METHOD

The method used in this research is the Quantitative Descriptive method. The descriptive analysis method in this study is used to analyze the process flow of overhaul activities and identify what are the wastes in each stage of the Maintenance, Repair and Overhoul process. In addition, quantitative methods are used to measure waste in the form of delays in completing Maintenance, repair & overhoul work carried out by PT. SIP using the Lean concept. The use of the Quantitative Descriptive method is expected to provide research output that can be used as managerial implications for the management of PT SIP.

RESULTS AND DISCUSSION

Waste Identification

Table 1. Waste sequence in OH Transformer activity

No	Category	1	2	3	4	5	Weight	Ranking
1	Defect	0	0	8	7	0	52	7
2	Overproduction	0	5	10	0	0	40	8
3	Waiting	0	0		5	10	70	1
4	Not utilizing employees	0	0	0	9	6	66	3
5	Transportation	0	0	0	10	5	65	4
6	Inventories	0	0	0	7	8	68	2
7	Motion	0	0	7	8	0	53	6
8	Excess Processing	0	0	5	10	0	55	5

Source: Processed Data of the Author 2024

The table above shows that the order of wastage in OH Transformer activities occurs mostly in the categories of Waiting, Inventories, Not Utilizing employees, Transportation, Excess Processing, Motion, Defect, Overproduction. The results of the weighting in the table above will



be used as a reference for the process of identifying the root cause of waste during the implementation of the Transformer overhaul. Therefore, this study will focus more on several waste categories that have a top 5 ranking that cause delays in the completion of Transformer overhaul.

Root Cause Analysis (RCA) Waste OH Transformer

Fish bone Diagram Analysis

Table 2. Types of Waste, Problems and Main Causes

Ranking	Category	Problems	Main Cause			
			Man	Machine	Method	Material
1	Waiting	Waiting for permission to enter the work of Infrared Connection, grounding System Pending HSE approval	√			
		Checking the work tool by the user is not on time	√		√	
		There is no special man power to handle the delivery of samples to the lab	√	√	√	
		Transformer up-down access that is not yet available		√	√	
		Rainy weather during Shutdown, inspection, Overhaul			√	
2	Inventories	Non-compliant Material Parts				√
		Bushing Crack		√	√	√
		Oil Engine Constraints			√	√
		Consumable parts not available			√	√
		Critical parts are out of stock (buffer)		√	√	√



		Accessoris parts are not available when Tools Oil Change, Calibration, Bushing are damaged		√	√	√
3	Not Utilizing employees	Man Power is not able to operate the equipment properly BDV Onsite Oil Test, DGA Oil Test on Lab	√	√	√	
		Man power not all understand SOPs Removing and installing HV, LV Connections	√	√	√	
		User owner Installation lacks understanding of the system	√	√	√	
		Specialist workforce [can read drawings] connections	√			
		Advisor & Man power lacks knowledge of the type of components installed in the transfromtor	√	√		
		Man Power Less Quantity for SFRA Test, Tan Delta Winding Test, Turn Test, Ratio Test, Excitation Current Test, Group Vector Test, Insultance Resistance Test, Polarization Index Test, Dishutter Test	√		√	
		Man Power certified for work at level 2	√	√		
4	Transporta tion	The process of sending the DGA Oil Test sample from site to lab.	√	√		
		No machine for Winding Transformer	√	√	√	

5	Excess Processing	Sample breaks during the delivery process from site to lab because packing is not up to safety standards.	√		√	
		The unavailability of PPE according to the number of people working, the work area has not been inspected by the User	√		√	
		Cable without label when removing protection connections			√	

Source: Processed Data of the Author 2024

The data in the table above will then be used as a reference for making improvement steps combined with using the Why Analysis tool which will be discussed in more depth in the next sub-chapter.

Why Analysis

Tabel 3. Why Analysis Identifikasi Waste

Object	Cause	Why - 1	Why - 2	Why - 3	Why - 4	Why - 5
Man	Man Power certified less	Budget is still lacking	There is no OJT program yet			
	Man Power is not certified less	Personnel in STO are still lacking	MRO Job Orders that are done simultaneously are still lacking			
	Advisor doesn't exist yet	Advisor procurement budget is still	Job Analysis for Advisor has not been created			



		insufficient				
	Compliance Representative does not exist yet	Compliance Representative Budget is still lacking	Job Analysis Compliance Representative has not been created			
	Internal Auditor does not exist yet	Internal Auditor's procurement budget is still insufficient	Job Analysis for Internal Auditors has not been created			
Machine	Transportation Tools less	The budget for additional transportation tools is still insufficient	No Cost Analysis of Operating Lease Transportation Tools has been made			
	Repair Tools less	The budget for the addition of Repair tools is still lacking	No Cost Analysis of Operating Lease Repair Tools has been made			
	Special Tools less	The budget for the addition of Special tools is still insufficient	No Special Tools Operating Lease Cost Analysis has been made			

	Laboratory Tools does not exist	The budget for the addition of laboratory tools is still insufficient	No Operating Lease Cost Analysis of Laboratory Tools has been made			
	Accessories Tools less	The budget for the addition of Accessories tools is still insufficient	No Cost Analysis of Operating Lease Accessories Tools has been made			
Method	SOPs are not complete	There is no routine SOP review	There is no target KPI for SOP review			
	IK is not complete	There is no routine IK review yet	There is no target KPI for IK review			
	Compliance Work Sheet does not exist yet	There is no strategic management policy to prepare Compliance Documents	<i>No Business Feasibility Study Analysis has been made for the preparation of a Compliance Work Sheet</i>			
	Internal Audit Method does not exist	There is no strategic management policy to prepare	<i>No Business Feasibility Study Analysis has been made for the</i>			



		Internal Audit Methods	<i>preparation of a Compliance Work Sheet</i>			
	ISO does not exist yet	There is no strategic management policy to prepare for ISO Implementation	<i>No Business Feasibility Study Analysis has been made for the preparation of a Compliance Work Sheet</i>			
Material	Consumable Parts less	There is no monitoring of the readiness of Consumable parts for OH needs	No warehouse available to store Consumable Parts	Vendors still have Consumable Parts in stock		
	Accessories Parts less	There is no monitoring of the readiness of Accessories parts for OH needs	No warehouse to store Accessories Parts	Vendors still have Accessories Parts in stock		
	Tool Spare Parts Less	There is no monitoring of the readiness of spare parts for OH needs	No warehouse available to store Spare Parts	Vendors still have Spare Parts in stock		
	Critical Parts (Buffer) less	There is no monitoring of the readiness of critical parts	No warehouse available to store Critical Parts	Vendors still have Critical Parts in		



		needed for OH		stock		
	1st Brand Parts less	There is no monitoring of the readiness of 1st Brand parts for OH needs	2nd Brand Parts Available in the Market	Users have a limited MRO Budget		

The table above shows what are the causes of the problems of each object related to waste identification. In addition, most of the possible problems found in the results of Why Analysis are related to budget, human resources and procedures. Furthermore, the results of the use of Why Analysis in the table above will be used as a reference for the next analysis process. Experts and authors will conduct further analysis to determine the improvement steps that must be taken to overcome the existing problems. Several improvement steps have been prepared more carefully to be more effective when used as explained in the Table below:

Table 4. Transformer Overhaul Repair Steps

Ranking	Category	Problems	Repair Steps
1	Waiting	Waiting for permission to enter the work of Infrared Connection, grounding System Pending HSE approval	(1) Coordination with users regarding the need for supporting data early. (2) Man power departs when the entry permit is available. (3) Actively coordinate with users.
		Checking the work tool by the user is not on time	(1) Preparation of completeness / supporting documents for applying for a work permit in accordance with the needs of the site, (2) Sending tool data / calibration early to the user for early checking
		There is no special man power to handle the	Send samples from site direct to external labs selected by the company

		delivery of samples to the lab	
		Transformer up-down access that is not yet available	Coordination with the support team { usually a separate vendor)
		Rainy weather during Shutdown, inspection, Overhaul	(1) Making a tent (2) Coordination with heavy equipment [crane] (3) Addition of supporting work tools
2	Inventories	Non-compliant Material Parts	(1) Gasket / seal / Parts inventory of several sizes based on standard minimum available 3 sets, (2) Increase the number of special tools [minimum 2 sets], (3) Internal training man power
		Bushing Crack	(1) Increase the number of special tools [minimum 2 sets], (2) Internal training man power
		Oil Engine Constraints	(1) Check the readiness of the machine, (2) Detailed inspection of job support needs, Using Own Power Supply [Generator]
		Consumable parts not available	(1) Check the readiness of the machine, (2) Detailed inspection of work support needs, using their own power supply [generator]
		Critical parts are out of stock (buffer)	(1). Provide additional critical parts for Transformer overhaul. (2) Coordination with other generating units for other additional

			options
		Accessoris parts are not available when Tools Oil Change, Calibration, Bushing are damaged	(1). Provide additional critical parts for Transformer overhaul.
3	Not Utilizing employees	Man Power is not able to operate the equipment properly BDV Onsite Oil Test, DGA Oil Test on Lab	(2) Coordination with other generating units for other additional options
		Man power not all understand SOPs Removing and installing HV, LV Connections	Providing regular Training SOP Removing and installing HV, LV Connections
		User owner Installation lacks understanding of the system	(1) Active Coordination with Users (2) Providing education
		Specialist workforce [can read drawings] connections	(1) Provides regular training in reading connection drawings (2) Adding Man power has competence [can read single line or drawing protection system.
		Advisor & Man power lacks knowledge of the type of components installed in the transfromtor	(1) Provide regular training of the type of components installed in the transformer (2) Provide experienced Advisors (3) Creating a Job Analysis Advisor
		Man Power Less Quantity for SFRA Test, Tan Delta Winding Test, Turn Test, Ratio Test, Excitation Current Test, Group Vector Test, Insultance	(1) Addition of man power expert (2) Training man power from external team [manufacturer] (3) Establish cooperation with other companies that have equipment



		Resistance Test, Polarization Index Test, Dishutter Test	
		Man Power certified for work at level 2	(1) Addition of man power expert (2) Training man power from external team [manufacturer] (3) Purchasing Height Achievement Equipment (1 unit)
4	Transportation	Length of delivery process for DGA Oil Test samples from site to lab.	(1) Send 2 samples from the site directly to the laboratory (2) Cooperation with several laboratories
		No machine for Winding Transformer	(1) Procurement of heavy equipment with Operating Lease
5	Excess Processing	Sample breaks during the delivery process from site to lab due to non-safety packing.	(1) Send 2 samples from the site directly to the laboratory (2) Cooperation with several laboratories (3) Use lab-standard Protection
		The unavailability of PPE according to the number of people working, the work area has not been inspected by the User,	(1) Coordination with the support team { usually a separate vendor) (2) Preparation of tools in accordance with the standards to be worked on (3) Complete PPE according to the number of people who will work in the area (4) Coordination is immediately carried out Inspection by the user, (5) Training all teams [Company Internal Training]
		Cable without label when removing protection	(1) Make sure the User is at the location



		connections	(2) Drawing preparation is already in place (3) Man power has the competence [can read single line or drawing protection system.
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The table above shows what are the repair steps that must be taken to overcome all causes of waste during the Transformer overhaul. All information regarding the improvement steps that need to be taken will be used as a reference for the next step, namely taking corrective actions using the 5W+1H tool to determine who are the PICs needed for the implementation process of all the improvement steps that have been prepared.

5W+1H Analysis

Table 5. Determination of Corrective Action with 5W 1H

5W 1H ACTION DETERMINATION	
OBJECT 5W 1H	ACTION
1. Man	
What: Problem	Transformer Overhaul work progress that exceeds the manufacturer's standard time.
Why: The Main Cause	Lack of training and expert leaders in supervising all transformer overhaul activities
Where	Laboratory, Area Transformer and Transformer
When	Subsequent transformer overhaul.
Who: Who is the PIC	Maintenance Manager, Engineering Manager, Human Resource (HR) Manager, Administration Manager
How: Corrective Action	- Recruiting new employees with experience - Conducting On Job Training (OJT) - Adding knowledge sharing items to the Key Performance Indicator (KPI) target to increase employee motivation and enthusiasm to continue learning. - Borrowing experienced executors from other areas as QC for the implementation of Transformer Overhaul



Remarks: Corrective actions have been approved by the management and have begun to be implemented	
2. Machine	
What: Problem	The progress of the Transformer Overhaul work is hampered due to poor specifications of existing parts.
Why: The Main Cause	Specification of exiting parts that do not use the upgrade type
Where	Area Transformers and Transformers
When	ipgrade target and implementation on net Overhaul Transformer
Who: Who is the PIC	Maintenance Manager, Engineering Manager, Human Resource (HR) Manager, Administration Manager
How: Corrective Action	• Submission of Operational and Investment Budget for upgrading the specifications of parts needed for Overhaul Transformer • Use of parts specifications with upgrade type gradually
Remarks: Corrective actions have been approved by the management and have begun to be implemented	
3. Method	
What: Problem	Ineffective and organized Transformer Overhaul activity flow sequence
Why: The Main Cause	SOPs and IK related to transformer overhaul activities are still incomplete
Where	Laboratory, Area Transformer and Transformer
When	Next Overhaul Transformer
Who: Who is the PIC	Maintenance Manager, Engineering Manager, Human Resource (HR) Manager, Administration Manager
How: Corrective Action	• Conduct regular and scheduled SOP and IK reviews • Adding items for review or making new SOPs and IK to employee KPI targets
Remarks: Corrective actions have been approved by the management and have begun to be implemented	
4. Material	



What: Problem	The progress of the Transformer Overhaul work is hampered due to unavailable parts and tools (special tools and repair tools)
Why: The Main Cause	Monitoring the readiness of OH parts that are still not optimal
Where	Warehouse, Laboratory, Area Transformer and Transformer
When	Next Overhaul Transformer
Who: Who is the PIC	Maintenance Manager, Engineering Manager, Human Resource (HR) Manager, Administration Manager
How: Corrective Action	• Addition of monitoring the readiness of parts needed for Overhaul Transformer at each preparatory meeting. • Submission of Investment and Operational Budget for the addition of tools and parts needed for OH. • Coordination with other generating units as a backup plan
Remarks: Corrective actions have been approved by the management and have begun to be implemented.	

The table of use of the 5W+1H tools above is explained to all stakeholders such as the PT. SIP during the Inspection Management Meeting.

Analysis of the Implementation of the Next Transformer OH FSM

Table 6. Schedule Future State Mapping Action Overhaul Realization Table

[illegible]

In Table 6 of the Schedule Realization Table of Future State Mapping Action Overhaul Transformer, the duration of the Before FSM activity is 400 hours (16.67 days) and the After FSM activity is 297 hours (12.38 days). With the FSM action carried out by PT SIP, the Activity Duration is 103 Hours (4.29 days) faster. All information regarding the realization of the Future State Mapping Realization Analysis of the Transformer Overhaul Activity used can be seen in the following Table 7:

Tabel 7. Analysis Table of Future State Mapping Realization of Overhaul Activities

Code	Activity	Before FSM (Hours)	After FSM (Hours)	Improvement (Hours)
X1	Pre Shutdown	193	135	58
X2	Shutdown	14	14	0
X3	Testing Before MRO	18	11	7
X4	Inspection & Overhaul	131	113	18
X5	Kalibrasi Unit Proteksi	12	4	8
X6	Testing After MRO	18	6	12
X7	Re Connection & Final Inspection	11	11	0
X8	Energizing Trasnformator	3	3	0
Total Duration		400	297	103

In Table 7 Analysis of the Realization of Future State Mapping Action Overhaul Transformer and Figure 4.30 Chart of Future State Mapping of Transformer Overhaul Activity shows the Duration of Improvements in Pre Shutdown Activity (X1) 58 hours, Testing Before MRO (X3) 7 hours, Inspection & Overhaul (X4) 18 hours, Protection Unit Calibration 8 hours & Testing After MRO 12 hours provides significant Improvement Duration Hours with a total faster duration of 103 hours. FSM Actions carried out by PT SIP include Work Effectiveness, Man Power Allocation Management, Proper Tool Procurement Organization and Parts that are available on time have a positive impact on the Duration of Activities to be Faster. The results of the implementation of the Transformer Overhaul repair can be seen the impact of waste elimination which is the main goal of Value Stream Mapping, namely waste).



Managerial Implications

Table 8. Table of Managerial Implications of Research Results

Component	Before	After	Impact
Total Overhaul Duration	400 hours (16.67 days)	297 hours (12.38 days)	Improvement 103 hours (3.29 days)
Man Power	Quite a lot of manpower is idle	The use of man power is more effective	Better effectiveness of using man power
Spare Parts	Monitoring the readiness of spare parts is not optimal	Regular monitoring of spare parts readiness	Better spare parts readiness
ISO Compliance	Doesn't have ISO 45001 yet	On Process Auction Consultant ISO 45001	Providing employee peace of mind and a robust framework to manage risks and opportunities arising from OSH, a healthy and safe workplace, and protecting our most important asset, human resources from mental and physical illness.
Standard Operational Procedure (SOP)	There has been no routine review of SOPs	SOP reviews are carried out regularly	SOPs are more complete and always updated
Work Instructions (IK)	IK review has not been added to employee KPI targets	IK review has been added to employee KPI targets	IK is more complete and always updated

Table 8 shows how the impact is compared before and after the study. In addition, several components have experienced significant improvements, especially for the components of overhaul duration, ISO Compliance, SOP and Work Instructions. These four components are one of the important components and are always the main focus for the management of PT SIP during



the implementation of the Transformer overhaul. Therefore, the results of this study are highly appreciated by management and deserve to be used as a reference by other companies. The concept generated by this study can also be used as a reference for the implementation of Transformer overhaul activities. Therefore, the Managerial Implications generated by this research can be of maximum benefit to more companies.

Future State Value Stream Mapping

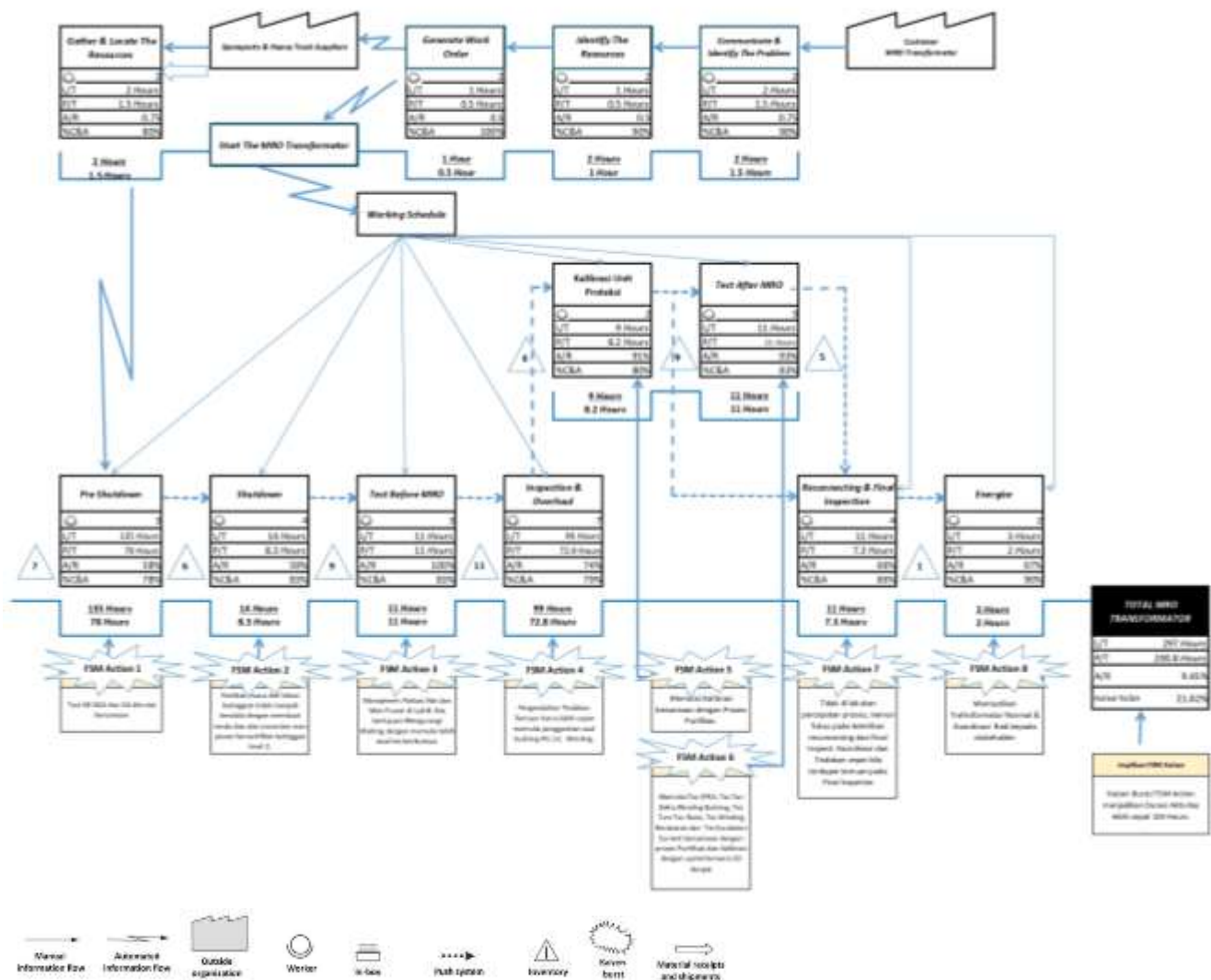


Figure 1. Future State Value Stream Mapping (VSM) Transformer Overhaul

Figure 1 The Future State Value Stream Mapping (VSM) Chart of Transformer Overhaul, Kaizen Burst in each activity provides improvement implications on the Lead Time (L/T) Duration of 103 Hours. Before Kaizen Burst, the Lead Time (L/T) in Current State Value Stream Mapping (VSM) was 400 Hours. And after Kaizen Burst, the Lead Time (L/T) in Future State Value Stream Mapping (VSM) is 297 Hours. Kaizen Burst also provides an improvement in Activity effectiveness at an Activity Ratio (A/R) of 7.95%. Before Kaizen Burst, the Activity Ratio (A/R) in Current State Value Stream Mapping (VSM) was 1.50%. And after the Kaizen Burst, the Activity Ratio (A/R) in Future State Value Stream Mapping (VSM) is 9.45% and is already close to the Rolled %C&A success rate of 21.82%. Kaizen Burst is a Future State Mapping (FSM) Action that must be carried out by PT SIP which is suggested by the Author to provide the effectiveness of Transformer Overhaul activities.

CONCLUSION

1. In the Current State Mapping (CSM) analysis carried out on 8 (eight) stages of activities Pre Shutdown, Shutdown, Test Before MRO, Inspection & Overhaul, Protection Unit Calibration, Test After MRO, Reconnecting & Final Inspection, Energize found several Waste as follows:
 - a. Waiting
 - 1) Waiting for permission to enter Infrared Connection work, grounding system pending HSE approval.
 - 2) Checking the work tool by the user is not on time
 - 3) There is no special man power that handles the delivery of samples to the lab. Send samples from site direct to external labs selected by the company
 - 4) Transformer up-down access that is not yet available.
 - 5) Rainy weather during Shutdown, inspection, Overhaul.
 - b. Inventories
 - 1) Non-compliant Material Parts
 - 2) Bushing Crack
 - 3) Oil Engine Constraints
 - 4) Consumable parts not available
 - 5) Critical parts are out of stock (buffer)



- 6) Accessoris parts are not available when Tools Oil Change, Calibration, Bushing are damaged.
- c. Not Utilizing employees
 - 1) Man Power is not able to operate the equipment properly BDV Onsite Oil Test, DGA Oil Test on Lab.
 - 2) Man power not all understand SOPs Removing and installing HV, LV Connections.
 - 3) User owner Installation does not understand the system
 - 4) Specialist workforce [can't read drawings] connections
 - 5) Advisor & Man power lacks knowledge of the type of components installed in the transfromtor
 - 6) Man Power Less Quantity for SFRA Test, Tan Delta Winding Test, Turn Test, Ratio Test, Excitation Current Test, Group Vector Test, Insultance Resistance Test, Polarization Index Test, Dishutter Test.
 - 7) Operational downtime for employees who are not confident in K3.
 - 8) Lack of Man Power certified work at level 2 altitude
- d. Transportation
 - 1) Length of delivery process for DGA Oil Test samples from site to lab.
 - 2) No machine for Winding Transformer
- e. Excess Processing
 - 1) Sample breaks during the delivery process site to lab due to non-safety packing.
 - 2) The unavailability of PPE according to the number of people working, the work area has not been inspected by the User,
 - 3) Cable without label when removing protection connections
2. The recommendations produced and the improvement plan to overcome waste during the implementation of Maintenance, Repair and Overhoul transformer activities carried out in the design of Future State Mapping are as follows:
 - a. Doing work in parallel.
 - b. Move manpower to another activity for a pending activity.
 - c. Ensure the availability of tools (special tools & repair tools))
 - d. Ensure the availability of sufficient consumable and critical parts in the warehouse.
 - e. Modification of delivery schedule and temporary placement location of roll in parts to optimize duration during the Inspection & Overhaul stage.



3. The implementation of repairs with the Lean Maintenance approach to overcome Waste which causes delays in the completion of Maintenance, Repair and Overhaul transformers carried out by PT. SIP gives the following Managerial Implications:
 - a. Total Overhaul Duration, Implementation to 297 hours (12.38 days). The implication for waste is that it provides an Improvement of 103 hours (3.29 days).
 - b. Man Power, the implementation of the use of man power becomes more effective. Implications for waste, namely Effectiveness in providing better use of man power.
 - c. Spare Parts, the implementation of monitoring the readiness of spare parts on a regular basis. Implications for waste are better spare parts readiness.
 - d. ISO Compliance, implementation of Management On Process of ISO 45001 consultant auction. The implication on waste is that Job Productivity increases because it provides employee peace of mind and a solid framework to manage risks and opportunities arising from OSH, a healthy and safe workplace, and protects the most important asset, human resources from mental and physical illness.
 - e. Standard Operational Procedure (SOP), the implementation of SOP Review is carried out regularly. The implication on waste is that the SOP is more complete and always updated
 - f. Work Instructions (IK), the implementation of IK Review has been added to the employee KPI target. The implication on waste is that the IK is more complete and always updated

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