

CHAPTER 2 - LITERATURE REVIEW

2.1 Theoretical Perspectives

2.1.1 Root Cause Analysis (RCA)

Root cause analysis (RCA) is a structured approach method to find the root of the problem by identifying factors in an event (Ikayanti & Irianto, 2016). According (Sugiri, 2014) Root cause analysis (RCA) can be grouped into 4 groups: Security-based Root Cause Analysis (RCA), used to conduct analysis in the search for problems in accident investigations. The root cause of the problem is often viewed as a failure or loss of security protection, risk, or unknown danger.

1. Root Cause Analysis (RCA) Production-based, Root Cause Analysis (RCA) is used to control the quality of a production, by finding the root of the problem that causes incompatibility in a production process flow.
2. Root Cause Analysis (RCA) Process-based, Root Cause Analysis (RCA) is a continuation of production-based Root Cause Analysis (RCA), with an expanded range to include processes outside the production process. This Root Cause Analysis (RCA) group is commonly used for the development of a process.
3. Root Cause Analysis (RCA) system-based, this group is an amalgamation of the previous Root Cause Analysis (RCA).

2.1.2 Maintenance

Maintenance (Ernnie et al., 2017) is combination of engineering, administration, and supervision to ensure a system functions and runs in accordance with its functions.

The two types of maintenance are as follows:

1. Preventive maintenance is scheduled maintenance based on previously established intervals of time.
2. Corrective maintenance is scheduled maintenance based on problems that arise outside of the time frame that has already been established.

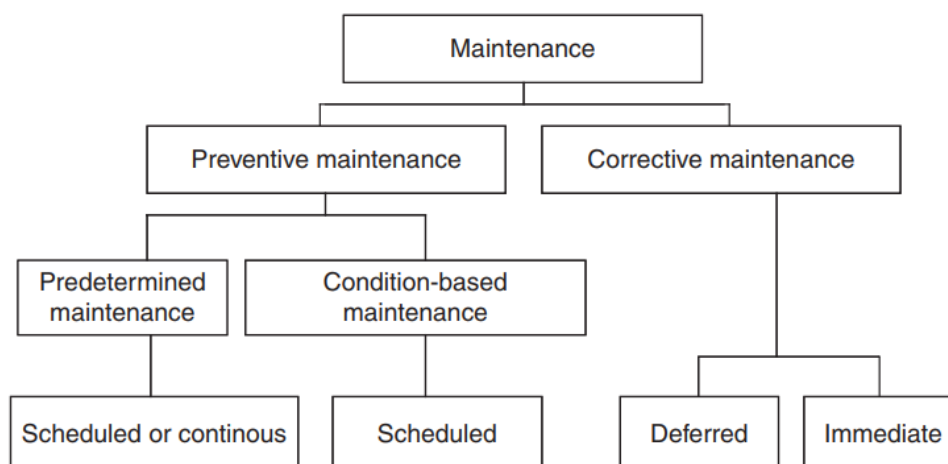


Figure 2.1 Maintenance Overview

2.1.3 Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) (Schiraldi & Varisco, 2020) is one more key performance indicator (KPI) for measuring the efficacy and productivity of each individual piece of equipment or material in the manufacturing sector. OEE was first introduced by Seiichi Nakajima at the end of the 1980s as a component of Total Productive Maintenance (TPM), a strategy for enhancing product quality and productivity by reducing kerugian due to failure, settings, low speed, and poor quality. OEE is measured by using three sub-indicators: availability, effectiveness of work, and quality threshold (quality).

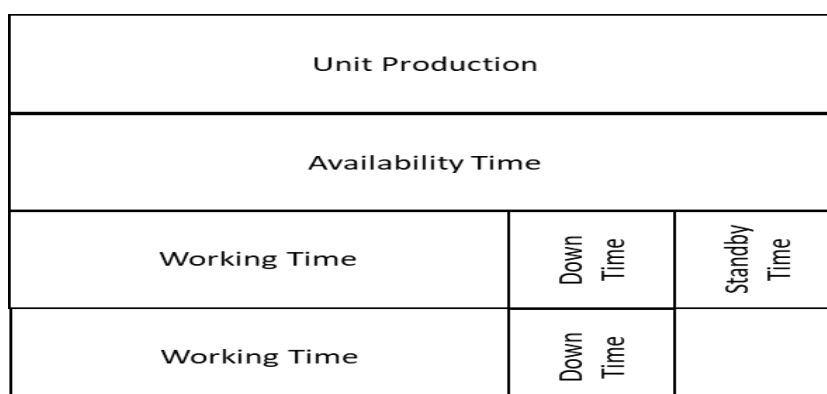


Figure 2.2 OEE Time Model

Purpose of OEE (Hossen, 2016) is a set of tools that can be used to detect problems with a machine or system, as well as to measure production effectiveness and product quality.

$$OEE (\%) = Availability (\%) \times Performance Efficiency (\%) \times Rate of Quality Product (\%) \quad (2.1)$$

Description:

2.1.3.1 Availability

Availability is actual production time, compared to planned production time. If the availability value is 100%, it means that the process always runs at a time that matches the planned production time (there is never any downtime). Availability, which is divided into setup/adjustments and breakdowns.

$$Availability = \frac{Required\ availability - Downtime}{Required\ availability} \times 100 \quad (2.2)$$

Or

$$Availability = \frac{Actual\ operating\ time}{Planned\ Operating\ time} \times 100 \quad (2.3)$$

In this study availability uses the following formulation:

2.1.3.1.1 Physical Availability (PA)

Physical Availability (PA) is the percentage of time availability of a unit of heavy equipment operating without due to unplanned damage or planned repairs (Schedule) based on (Silalahi Rajandi, Zaenal & Dono Guntoro, 2018). The equation used to calculate Physical Availability (PA) is:

$$PA = \frac{W + S}{W + R + S} \times 100\% \quad (2.4)$$

Description:

PA = Physical Availability (%)

W = Number of Tool Working Hours (Hours)

S = Number of Hours Tool Unused/*Standby* (Hours)

R = Number of hours for repair (hours)

2.1.3.2 Performance

Performance rate is the ability to maximize the acceleration of production. If the Performance value is 100%, then the process has run at maximum speed (theoretically, based on Ideal Cycle Time and Total Pieces).

$$\text{Performance rate} = \frac{\text{Total number produced}}{\text{Expected production}} \times 100 \quad (2.5)$$

Or

$$\text{Performance rate} = \frac{\text{Theoretical cycle time} \times \text{units output}}{\text{Actual cycle time}} \times 100 \quad (2.6)$$

Description:

Total number produced : Units produced over the course of the shift.

Expected production : Expected number of units to be manufactured

In this study availability uses the following formulation:

2.1.3.2.1 Mechanical Availability (MA)

Base on (Husean et al., 2019), Mechanical Availability (MA) is the percentage of the calculation used to assess the unit's operating condition, while accounting for the breakdown time factor is used to evaluate the unit's dependability and efficiency in performing its duties. The equation used to calculate Mechanical Availability (MA) is:

$$MA = \frac{W}{W + R} \times 100\% \quad (2.7)$$

Description:

MA = Mechanical Availability (%)

W = Number of Tool Working Hours (Hours)

R = Number of hours for repair (hours)

2.1.3.3 Quality

Quality is the production of no defective products at all.

A formula for the quality rate is as follows:

$$\text{Quality rate} = \frac{\text{Production output} - \text{Quality defects}}{\text{Production output}} \times 100 \quad (2.8)$$

In this study availability uses the following formulation:

2.1.3.3.1 Achievement of Production

Achievement of production (AP) is a formula that shows achievement to calculating performance from production. The equation used to calculate Used of Achievement of production (AP) is:

$$AP = \frac{P}{TP} \times 100\% \quad (2.9)$$

Description:

AP = Achievement Of Production (%)

P = Number of Production (Ton)

TP = Number of Target Production (Ton)

2.1.4 Define Measure Analysis Improve Control (DMAIC) Method

DMAIC (Define, Measure, Analyze, Improve, Control) is one of the methods used in Lean Six Sigma to perform process improvement and troubleshooting based on (Kumar & Sharma, 2012). Here are the steps in the DMAIC Method:

1. Define

Define is the first step to determine the problem that occurs base on (Kumar & Sharma, 2012). To determine which problem occurs with multiple queries:

- a. What problems occurred and became the focus of discussion?
- b. What are the goals of a project?
- c. Who are the customers in this project and the effect on those customers?
- d. What processes will be lifted?

2. Measure

Measure is a stage to explore information on a problem that occurs clearly, so that accurate data is obtained to analyze in accordance with (Jamil, 2017)

3. Analysis

Analysis is a stage to conduct analysis using several tools / methods such as Root cause analysis (RCA), 5 Why, Focus Group Discussion (FGD), or Overall Equipment Effectiveness (OEE), so as to bring up steps to solve problems (Jamil, 2017).

4. Improve

Improve is an advanced stage of analysis that has been done by combining existing knowledge and data.

5. Control

Control is the last stage in the DMAIC method because at this stage it is a further step to the improvements that have been made and a verification of whether the improvements made can solve the problems that occur.

Sesuai dengan (Jamil, 2017), aktifitas dari control adalah:

- a. Determine the dependent and independent variables based on the project.
- b. Operational Definitions conclusion
- c. Establish implementation parameters
- d. Information gathering and investigation of the issue or project being looked into

- e. Verify the projections
- f. Considering Measurement Frameworks
- g. Select the Process Capability and the Reference Point.

2.1.5 Focus Group Discussion (FGD)

Focus Group Discussion (FGD) is a data collection method used to justify a problem by focusing on data collection through interviews with a group of people. Focus Group Discussion is useful for identifying group knowledge, ideas, values, beliefs, and attitudes (Basnet, 2018) . Focus group discussion (FGD) based (Paramita & Kristiana, 2013) is a qualitative method used for decision-making or to explore data on opinions, perceptions, and attitudes towards a product, concept, or service. This method tends to be faster than other qualitative methods. The weakness of this method is that it cannot be used for quantitative purposes or discussion of very sensitive topics, and results are strongly influenced from the point of view of participants, so competent participants are needed in their fields. In this study, the Focus Group Discussion (FGD) method was used as a tool to evaluate or assess mechanical capabilities.

Advantage Focus Group Discussion:

1. Help to reach agree or disagree in the discussion of an issue.
2. With Focus Group Discussion, you can make cost efficiency in data collection.
3. Free and open discussion among respondents generates new ideas that can be very useful for decision making.
4. FGDs are not static. Moderators can bring in any changes to better facilitate discussion during group discussions.
5. Expressions other than verbal ones such as stimulated movements and activities, can provide useful insights for organizers.
6. Individuals in groups feel safer, freer, and free to express their feelings and thoughts than individually.

7. Individuals in groups are more likely to express opinions or attitudes spontaneously in response to questions.

Disadvantages Focus Group Discussion:

1. Inexperienced moderators may face problems controlling some participants who are trying to dominate the group.
2. Respondents may be reluctant to share some sensitive ideas and issues publicly.
3. Due to the small sample size and heterogeneity of individuals, results may be inadequate to make projections or a combined picture of the situation.
4. Focus Group Discussion (FGD) can be highly artificial arrangements, influencing respondents to express and act unreasonably and the findings may be far from the truth.
5. Focus Group Discussion (FGD) are limited to being able to obtain more in-depth information from an individual that may be needed.

2.1.6 Matrix Diagram

The matrix diagram is one of the few tools used by PT. ABC to compare customer needs and issues with existing programs that have High Impact.

Table 2.1 Matrix Diagram for CSM Formulation

CUSTOMER NEED		SPECIFIC PROBLEM (After Condition Audit)	PROGRAM						Ket.
			1st Program	2nd Program	3rd Program	4th Program	5th Program	6th Program	
Heavy Equipment Performance (Physical Availability)	1st Customer Needed	A Spesifik Problem 1	3	2				1	3 = High Impact 2 = Medium impact 1 = Low Impact
		B Spesifik Problem 2						2	
	2nd Customer Problem	C Spesifik Problem 3	3	2				1	
		D Spesifik Problem 4	2	2		2	3	2	
Productivity	1st Customer Problem	E Spesifik Problem 5	1			2			
	2nd Customer Problem	F Spesifik Problem 6	3	3				2	
Cost efficiency	1st Customer Problem	G Spesifik Problem 7	2	2	2	2	3	1	
		H Spesifik Problem 8	3	2			3	1	
	2nd Customer Problem	I Spesifik Problem 9				1		2	
		J Spesifik Problem 10			1				

2.1.7 Customer Solution Management (CSM)

Customer Solution Management (CSM) is one of the programs of PT. ABC. Customer Solution Management (CSM) is a strategy to build long-lasting relationships through serious efforts to help customers succeed by focusing on customer needs and appropriate innovation and improvement. It can be concluded that CSM is a mutual business where both should benefit equally and strive together so that there is no inequality between the two. The goal is to achieve long-term business success through the strengthening of sustainable cooperation, and this makes the two grow together.



Figure 2.3 Long-lasting Relationship CSM Program

Here are the benefits of Customer Solution Management (CSM):

Benefits for Customer:

1. Improve business performance through long-term partnerships
2. Get the right solution according to the customer's business needs
3. Increased manpower competence with comprehensive assistance.
4. Organizational growth.

Benefits for PT. ABC:

1. Delivering PT. ABC Value
2. Increase share of wallet (revenue)
3. Maintain market share PT. ABC product
4. Improve PT. ABC brand image and presence
5. Building competencies in internal PT. ABC

In Customer Solution Management (CSM) exist Customer Relation Chart (CRC) & Customer Relationship Level (CRL).

2.1.8 Customer Relation Chart (CRC)

The customer relationship chart (CRC) is a definition of the elaboration of vision and mission to the main goal of the customer, who can be filled with the assets and capability value of PT. ABC Group. This is key to ensuring mutualism between PT. ABC and its customers.

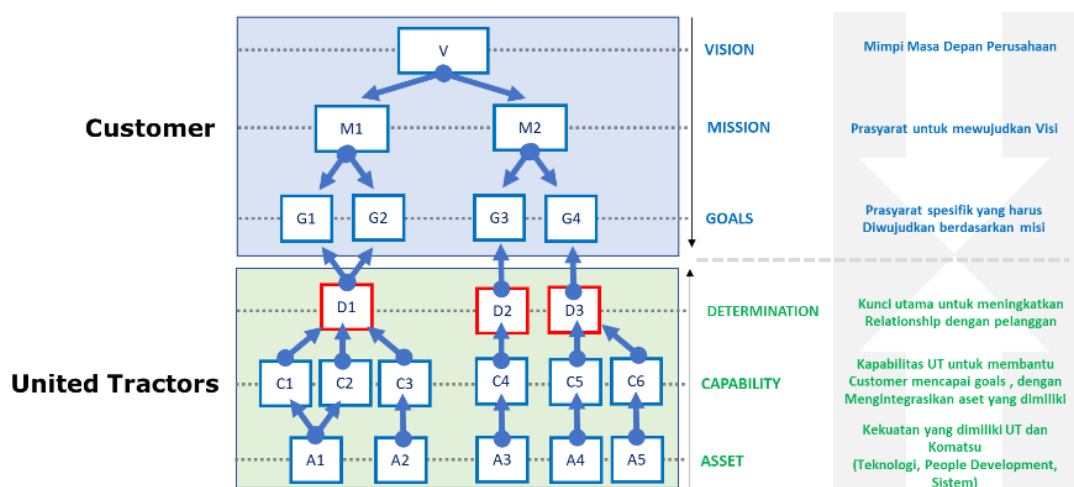


Figure 2.4 Customer Relation Chart (CRC)

2.1.9 Customer Relationship Level (CRL)

Customer Relationship Level (CRL) is the level of attachment between PT. ABC and the customer. This leveling is assessed by the customer based on the internal personal assessment of PT. ABC. This needs to be known from the beginning so that we know the Customer Solution Management (CSM) project in order to know the limit of the assessment level from the customer.

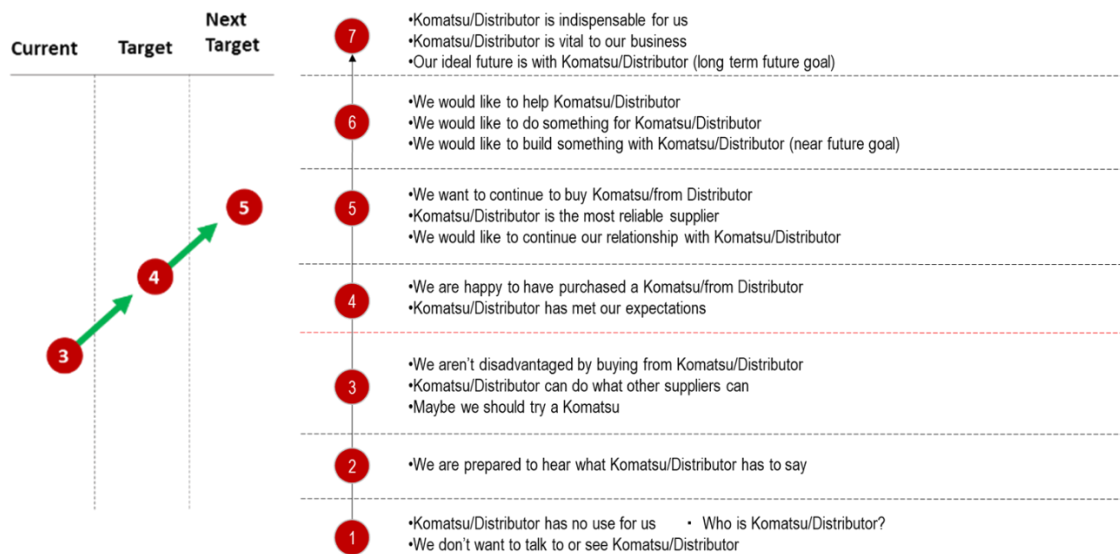


Figure 2.5 Customer Relationship Level (CRL)

2.2 Previous Studies

In accordance with the research (Patel & Deshpande, 2016), Overall Equipment Effectiveness (OEE) is crucial as a tool for evaluating labor performance in the manufacturing sector. OEE is recommended in order to reduce stress, increase productivity and quality standards, and by doing so, increase the effectiveness of a machine or system. Overall Equipment Effectiveness (OEE) of the manufacturing system is best maximized by taking into account metrics for material availability, labor productivity, and product quality. And in another study (Daman & Nusraningrum, 2020), Overall Equipment Effectiveness (OEE) was used to evaluate the cause of the low OEE value on Hitachi EX2500-6 excavator EX157 and EX158 units and determine how to improve equipment performance using the fish bone diagram and 5W1H method. While in this study Overall Equipment Effectiveness (OEE) yang digabungkan dengan metode Root Cause Analysis (RCA), 5 Why dan

Focus Group Discussion (FGD) was used to evaluate a SCANIA P360 / P410 dump truck on performance that was still below the target of PT. XYZ.

Table 2.2 Thesis Research in the Most Related Research

NO	YEARS	AUTHOR	TITLE	METHODE	RESEARCH FINDING
1	2016	PATEL & DESHPANDE	A REVIEW ON IMPROVEMENT IN OVERALL EQUIPMENT EFFECTIVENESS	OVERALL EQUIPMENT EFFECTIVENESS (OEE)	Overall Equipment Effectiveness (OEE) is crucial as a tool for evaluating labor performance in the manufacturing sector. OEE is recommended in order to reduce stress, increase productivity and quality standards, and by doing so, increase the effectiveness of a machine or system
2	2020	DAMAN & NUSRANINGRUM	ANALYSIS OF OVERALL EQUIPMENT EFFECTIVENESS (OEE) ON EXCAVATOR HITACHI EX2500-6	OVERALL EQUIPMENT EFFECTIVENESS (OEE)	Overall Equipment Effectiveness (OEE) is used to evaluate the cause of low OEE values on Hitachi EX2500-6 excavators EX157 and EX158 units and determine how to improve equipment performance using the fish bone diagram and 5W1H method.
3	2017	MOHAMMADI ET AL	PERFORMANCE EVALUATION OF BUCKET BASED EXCAVATING, LOADING AND TRANSPORT (BELT) EQUIPMENT – AN OEE APPROACH	OEE, PERFORMANCE MEASUREMENT, AVAILABILITY, UTILIZATION, SPEED FACTOR, BUCKET CAPACITY, MINING EQUIPMEN	The performance of BELT equipment is low, mine productivity decreases. The method uses OEE. Dominant factors: downtime, production speed and product quality. The improvements were Improved machine maintenance, operator training, and management systems resulting in an increase in OEE of BELT equipment from 60% to 75%. Mine productivity increased. Improvement of BELT equipment performance is possible by analyzing factors and repairs appropriately.

NO	YEARS	AUTHOR	TITLE	METHODE	RESEARCH FINDING
4	2020	FEBRI PRABOWO	ANALYSIS OF "HARD CHROME" PERFORMANCE IMPROVEMENT IN MAINTENANCE ENGINE SERVICES INDUSTRY	OEE, DMAIC, HARD CHROME, 5W1H	The performance of hard chrome machines is low, customer complaints are increasing, production speed is decreasing. By using DMAIC (Define, Measure, Analyze, Improve, Control). Dominant factors: quality of results of improvement & speed of production. Improvements made: Improved welding process quality & machine maintenance resulted in OEE hard chrome machines increased from 60% to 70%. Quality improvement & increased production speed. The conclusion of this study is that the improvement of hard chrome machine performance is possible by analyzing the factors and improvements appropriately.
5	2023	CERNA ET AL	EVALUATION OF THE OVERALL EFFECTIVENESS (OEE) OF AUTONOMOUS TRANSPORTATION SYSTEM (ARS) EQUIPMENT AND ITS IMPACT ON MINE DESIGN: OPEN PIT MINE CASE STUDY	OEE, AHS, EVALUATION, AUTONOMOUS, MINE	This journal discusses the use of autonomous transportation systems (ARS) in open-pit mines in Chile, increasing the Overall Equipment Effectiveness (OEE) of mining equipment by 15%. ARS provides benefits through non-stop operation, more accurate control, and reduced accident risk. In addition, these technologies influence mine design by enabling tight area operations and faster material transport, impacting overall mine efficiency and performance.

NO	YEARS	AUTHOR	TITLE	METHODE	RESEARCH FINDING
6	2013	AHN & LEE	IMPORTANCE OF OPERATIONAL EFFICIENCY TO ACHIEVE ENERGY EFFICIENCY AND EXHAUST EMISSION REDUCTION OF CONSTRUCTION OPERATIONS	OVERALL EQUIPMENT EFFECTIVENESS (OEE)	This research discusses operational efficiency which is the key to energy efficiency and reducing exhaust emissions of construction projects. With good planning and scheduling, efficient equipment use, and optimal operation and maintenance, energy savings of up to 20% and emissions reductions of up to 30% can be achieved. The construction industry needs to raise awareness, implement standards, and provide training to realize the economic and environmental benefits of operational efficiency.
7	2022	HIA ET AL	PERFORMANCE METRIC DEVELOPMENT TO MEASURE OVERALL VEHICLE EFFECTIVENESS IN MINING TRANSPORTATION	OVERALL EQUIPMENT EFFECTIVENESS (OEE), MINING TRANSPORTATION OVERALL VEHICLE EFFECTIVENESS (MTOVE)	This study discusses mining transportation overall vehicle effectiveness (MTOVE), a new metric to measure the effectiveness of mining vehicles. MTOVE combines vehicle availability, performance, and quality, and has proven to be effective in assisting management in decision-making and inter-company comparisons.
8	2021	(Munandar, 2021)	ANALYSIS AND SUGGESTIONS FOR IMPROVEMENT OF MARUBENI ENGINE PERFORMANCE AT PT. INDONESIA NUCLEAR INDUSTRY (PERSERO) WITH OVERALL EQUIPMENT EFFECTIVENESS (OEE) APPROACH	TOTAL PRODUCTIVE MAINTENANCE (TPM), OVERALL EQUIPMENT EFFECTIVENESS (OEE)	Research on Marubeni machines PT. Indonesia's Nuclear Industry found that its performance was subpar (OEE 64.65% vs. JIPM 85%). Analysis using the TPM method found maintenance downtime, defective products, and specification non-conformance as major factors. For repairs, it is recommended to increase the frequency and quality of maintenance, repair of production processes, and periodic calibration of machines. This increase is expected to bring OEE closer to the JIPM target

NO	YEARS	AUTHOR	TITLE	METHODE	RESEARCH FINDING
9	2020	CHOUDHARY	OPTIMIZATION OF LOAD–HAUL–DUMP MINING SYSTEM BY OEE AND MATCH FACTOR FOR SURFACE MINING	TRUCK DISPATCH SYSTEM, OPTIMIZATION, PRODUCTIVITY, OEE, MATCHING FACTOR	This journal discusses the optimization of the load-haul-dump system with the OEE approach and matching factors can boost productivity by up to 10-15% in surface mining. This is done through improved availability, performance, and quality of load-hauling equipment, as evidenced by Indonesian coal mining data which experienced an increase in OEE from 75% to 80% and matching factors from 0.8 to 0.9 post optimization. In other words, this strategy is effective in boosting the productivity and efficiency of surface mining.
10	2020	LAKHO ET AL., N.D.	IMPLEMENTATION OF OVERALL EQUIPMENT EFFECTIVENESS (OEE) IN MAINTENANCE MANAGEMENT	OVERALL EQUIPMENT EFFECTIVENESS (OEE); LEAN MANUFACTURING; MAINTENANCE MANAGEMENT; TOTAL PRODUCTIVE MAINTENANCE (TPM); LEAN TOOLS	This journal concludes that OEE, a measuring tool and equipment effectiveness enhancer, can provide great benefits to companies in terms of productivity, efficiency, and product/service quality. With commitment, training, realistic targets, and regular monitoring, proper implementation of OEE can be key to business success.
11	2021	SIBARANI ET AL	IMPROVING THE OVERALL EQUIPMENT EFFECTIVENESS (OEE) OF DRUM TESTING MACHINE IN LABORATORY OF TIRE MANUFACTURING USING FMEA AND PFMEA	OVERALL EQUIPMENT EFFECTIVENESS (OEE), FAILURE MODE EFFECT ANALYSIS (FMEA), PROCESS FAILURE MODE EFFECT ANALYSIS (PFMEA), DRUM TESTING MACHINE, RISK PRIORITY NUMBER (RPN).	A study aimed to boost the OEE (Overall Equipment Effectiveness) of tire manufacturing drum testing machines. Using FMEA/PFMEA techniques, they identified key failure modes impacting OEE, often related to belts, bearings, and motors. Implementing corrective actions like preventive maintenance and process optimization significantly improved OEE from 53.6% to 67.2%, saving over \$100,000 annually. The study concludes that FMEA/PFMEA and regular preventive maintenance are effective tools for enhancing drum testing machine OEE.

NO	YEARS	AUTHOR	TITLE	METHODE	RESEARCH FINDING
12	2024	KIEKI WINTARTO (PROPOSE STUDY)	IMPROVEMENT OF OVERALL EQUIPMENT EFFECTIVENESS (OEE) OF DUMP TRUCK SCANIA P360/P410 IN CUSTOMER PT. XYZ	ANALYSIS (RCA), 5 WHY DAN FOCUS GROUP DISCUSSION (FGD), OVERALL EQUIPMENT EFFECTIVENESS (OEE)	In this study Overall Equipment Effectiveness (OEE) yang digabungkan dengan metode Root Cause Analysis (RCA), 5 Why dan Focus Group Discussion (FGD) was used to evaluate a SCANIA P360 / P410 dump truck on performance that was still below the target of PT. XYZ.