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Analysis of the Effect of Six Big Losseson the Performance of Gas Metal Arc Welding Machine in the Training Institutes in Serang Banten Using the SEM-PLS Method.

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Abstract

One of the important elements in the world of the manufacturing industry is to maintain optimal machine performance to increase company productivity. Measuring machine performance can be done by implementing Total Productive Maintenance by evaluating Overall Equipment Effectiveness and identifying all losses that occur so that improvements can be made to eliminate them. The main components of the OEE evaluation are all six big loss indicators that have an impact on machine performance and productivity. A training institute located in the city of Serang Banten Indonesia conducts competency-based training in several vocational fields. One of the training areas carried out is the welding engineering department. Training in welding techniques must be supported by machine performance which is always in optimal condition. The occurrence of damage to the welding machine will cause decreased productivity and delays in training... *This research was conducted to analyze all six big loss indicators that affect performance on Gas Metal* Arc Welding machines using the SEM-PLS method. The results showed that there were 5 (five) six big loss indicators that affected the low performance of the welding machine, namely breakdown losses (x11) Setup and Adjustment Losses (x12, Idling and Minor Stoppages Losses (x21), and defect losses (x31) Reduced yield losses (X32).Five indicators are priority improvements that must be made to improve machine performance so that the performance of the welding machine can be optimal.

Keywords: GMAW welding machine, TPM, OEE, Six Big Losses, SEMPLS.

1. INTRODUCTION.

Indonesia is a developing country with the fourth most populous population in the world, with 275.36 million people in the first half of June 2022. There are 208.54 million people of working age with an unemployment rate of 8.40 million. (Central Bureau of Statistics, 2022). This high unemployment rate will have an impact on poverty which can lead to increased social unrest and crime in society. The government improves the skills and competencies of job seekers through training so that they can get jobs or open independent businesses.

A training institute located in the city of Serang, Banten Indonesia, is actively conducting training with competency-based training programs in several vocational fields. One of the leading professions at the training institute is welding technique training. Certification examination conducted by a professional Certification Institute at the end of training.

In increasing the productivity and effectiveness of training, it is necessary to support the performance of the welding machine which is always in optimal condition. This research was conducted to evaluate all six big loss indicators on machines with Gas Metal Arc Welding (GMAW) welding machines which affect the low performance of the welding machine.

The steps taken are to measure the performance of the welding machine by implementing TPMand evaluating Overall Equipment Effectivenessby identifying all the losses that occur and making improvements to eliminate these losses. The main component of the OEE evaluation is the improvement of all six big loss indicators making continuous improvements to increase machine performance and productivity.

Research conducted by (Mardono et al., 2019) evaluated all of the Six Big Losses indicators with SEM-PLS steelrolling mill which affects the low value of OEE. The results of the study show that the availability and performance variables have a significant effect on OEE to increase productivity and reduce production costs. The improvement that must be done is to eliminate all losses that affect low OEE.

Research conducted by (Wijaya et al., 2021) used a statistical test using the Smart PLS on the conveyor belt of a Coal-fired Power Plant for the OEE value. The results show that reducing the level of damage to the belt will increase the OEE value which will significantly increase the value of productivity.

2. LITERATURE REVIEW

TPMis a maintenance approach that helps to achieve flawless production with no breakdowns, no stalls or slowdowns, no defects, and no accidents. (Chandra Kiran Kestwal, 2017).

The main target of implementing TPM according to (Agustiady&Cudney, 2016):

a. Production: The Overall Production Effectiveness of at least 80% and the Overall Equipment Effectiveness of at least 90%.
b. Quality: Operate in such a way that there are no customer complaints.
c. Cost: Reduce production costs by up to 30%.
d. Delivery: Delivery of goods to consumers is up to 100% successful.
e. Safety: Accident free
f. Multi-skill Labor: Employee morale and thinking activities increase up to three times. Develop multi-skilled and flexible workers.

OEE = Availability x Performance Rate x Quality Rate.

According to (Nakajima, 1988):

Availability is the ratio between operation time (loading time – downtime) and loading time.

Performance Efficiency is the result of multiplying the amount of production by the setting time (ideal cycle time) divided by the length of operating time.

Quality is the effectiveness of production based on the quality of the product produced.

Six Big Losses

Actions taken at TPM do not only focus on prevention by minimizing the occurrence of damage to machines but also on factors that cause losses that lead to low efficiency and productivity of machines. The low productivity of the machine results in losses because the machine cannot work optimally.

According to (Nakajima, 1988) six major disadvantages can cause low performance of machines and equipment, which are referred to as Six Big Losses.

Downtime:

Equipment failure, (losses due to equipment breakdown) Sudden machine breakdowns result in low production volumes.

Setup and adjustment losses (tuning and adjustment loss) allsetup times include adjustments.

Speed losses:

Idle and minor stoppage: loss because the machine operates without load or stops for a momentdue tominor damageto the machine (minor stoppage), stops repeatedly, or the machine operates without producing a product.

Reduced speed losses: Losses due to a decrease in operating speed. Production speed decreases if the actual operating speed is less than the speed the machine is designed to operate at normal speed.

Defect:

Defect losses (losses on product defects in the process) are losses caused by defective products or repeated processing.

Reduced yield losses: losses from the start of production until it reaches a stable condition.

2.1 SEM-PLS

SEM is a type of multivariate analysis in the social sciences. Multivariate is a statistical application method that can be used to analyze several research variables simultaneously. (Sholihin&Ratmono, 2021).

In research with the CB-SEM and SEM-PLS approaches used in different contexts, it is necessary to understand the differences between the two to apply the right method in a study.

The use of the SEM-PLS method has several advantages, including it is considered powerful because it is not based on various assumptions, it can work efficiently with small sample sizes, and with complex models, it is able to test the SEM-PLS model. The weakness of SmartPLS is that it can only read Excel data in CSV form (Hair et al., 2014).

3. METHODOLOGY

Data collection in research was done at the government-owned Training Institute located in the city of Serang Banten Indonesia. Data Noted during the training process from April 4 to June 3, 2022. The data includes training data, machine work data, and production data.

Data processing was carried out using the Partial Least Square (PLS) type smartPLS 3.2.9with the formative model. Processing the data is to examine the losses that dominantly affect the performance of the welding machine. A review of the research instrument literature is presented in Table1.

Table 1. Research Instruments

Variable	Indicator	code
Availability (X1)	Equipment failure	X11
	Setup and adjustment	X12
Performance (X2)	Idle andMinor stoppage	X21
	Reduced speed losses	X22
Quality (X3)	Defect losses	X31
	Reduced yield losses	X32

The research hypotheses contain three variables, namely Availability (X1) Performance (X2) and Quality (X3) to (OEE). The research hypotheses are as follows:

- H1: The Significant effect of Availability (X1) with OEE
- H2: The Significant effect of Performance (X2) with OEE
- H3: The significant effect Quality (X3) with OEE

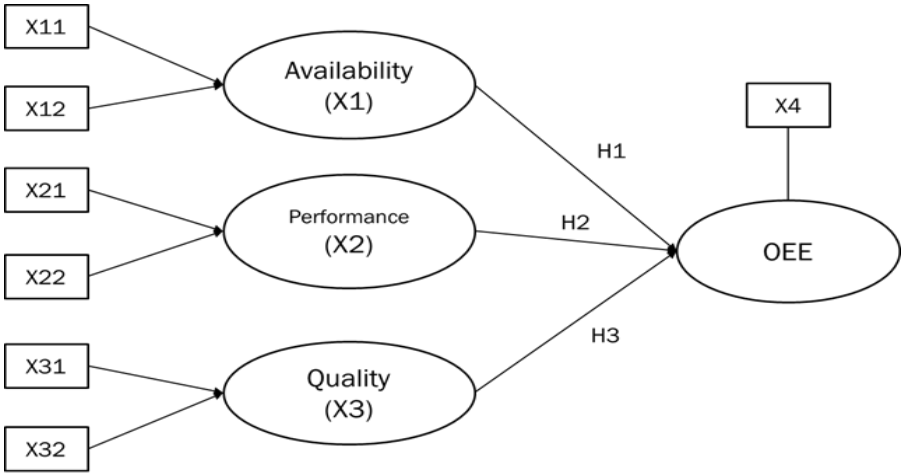

Figure 1: MeasurementModels SEM PLS

4. RESULT AND DISCUSSION.

In this section, an evaluation of measurements is carried out using the SEM PLS method with the Formative measurement model including the Outer model and Iner model.

4.1. Outer model measurement.

Collinearity Issue (VIF) is a measurement to see the relationship between each indicator(multicollinearity).High correlations between indicators are considered problematic because they can affect the estimated weight and statistical significance. Measurement. Collinearity Issue (VIF) is met if the value ofVIF measurement is < 5. In this study, there was no multicollinearity relationship because all VIF measurement values were <5 Table 2

Table 2 Value Outer VIF

Variable Manifest	VIF	Explanation
X11	1.261	< 5
X12	1.261	< 5
X21	1.004	< 5
X22	1.004	< 5
X31	1.741	< 5
X32	1.741	< 5
X4	1.000	< 5

Significance and Relevance Indicators.

To see significant indicators can be measured using variables P-value Outer Weights Table 3 Outer weight value < 0.05. If it is more than 0.05 then the examination is continued with outer Loading. Value loading must be > 0.5, if it is less than0.5examination is continued with a significant outer loading. If the outer loading is < 0.5 then it can be considered for deletion (Hair et al., 2014).

Table 3 Outer Weight Examination Results

Indicators to variables	Outer Weight	P-Values Outer Weights
X11 -> Availability	0.643	**0.022**

X12 -> Availability	0.527	0.064
X21 -> Performance	0.966	**0.002**
X22 -> Performance	0.206	0.303
X31-> Quality	0.657	0.221
X32 -> Quality	0.438	0.305

From the results of checking with outer weight, 4 indicators have P-value outer weight above 0.05, so it needs to be checked outer loading like in table 4.

Table 4 Outer Loading Inspection Results

Indicators to variables	Outer Loading	P-Values Outer Loading
X11 -> Availability	0.883	**0.000**
X12 -> Availability	0.820	**0.000**
X21 -> Performance	0.979	**0.006**
X22 -> Performance	0.265	**0.278**
X31 -> Quality	0.943	**0.000**
X32 -> Quality	0.867	**0.000**

From Table 4 indicator X22 –performance with a value outer loading of 0.265 does not meet the criteria and is considered for deletion due to outer loading < 0.5.

4.2. Structural Measurement (Inner Model).

The Collinearity Assessment measurement is fulfilled if the VIF inner model value is <5 measurement data shows that the VIF inner model is fulfilled Table 5

Table 5 VIF inner model

Variable	OEE
Availability	1,000
Performance	1,000
Quality	1,000

Measurement of the Structural Model Path Coefficient has a significant T-statistic value greater than 1.96 and P-value <α (0.05) Table 6 and Figure 3 show a significant relationshipbetween Availability and OEE, and Quality rate and OEE, but between Performance rate and OEE, there is no significant relationshi

Table 6. Coefficients and Structural Model Influence Tests

Variable	Standard Deviation	T Statistics	P- Values
Availability -> OEE	0.213	2.556	0.005
Performance -> OEE	0.231	0.935	0.175
Quality -> OEE	0.210	2.535	0.006

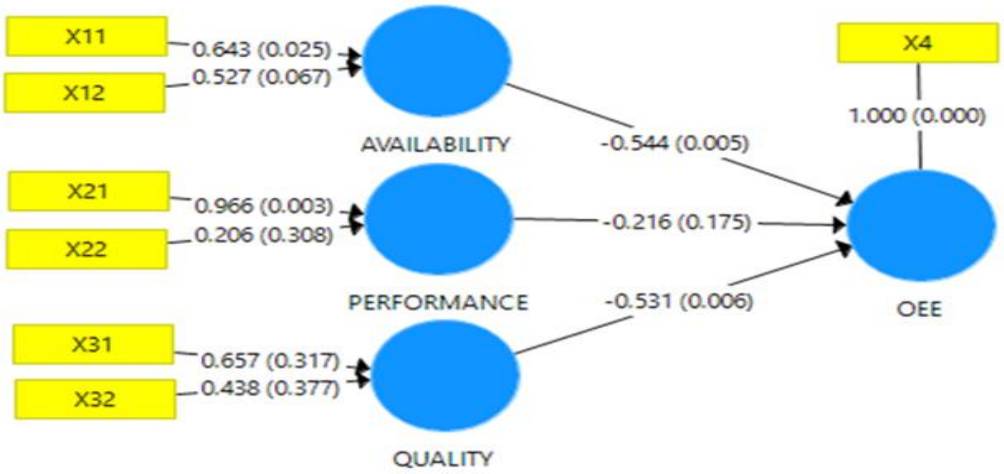

Figure 2: Structural model

Coefficient of Determination (R^2)

The next stage is the measurement of determination (R-square). R2 of 0.75 generally has a large prediction accuracy. Table 7 shows the Coefficient of Determination (R2) with an OEE value of 0.938 indicating that the magnitude of the OEE from the Availability, Performance, and Quality variables is 93.8%. It can be concluded that the accuracy of OEE estimation has a large estimation accuracy.

Table 7. Coefficient of Determination (R2)

Variable Manifest	R-squared
OEE	0,938

Effect Size (f2)

Measurement of Effect Size (f2) is more specific for each exogenous variable. If the value is 0.02 the effect size is small, 0.15 is the effect size is medium, and 0.35 is the effect size is large. The test results show that of three variables, the effect size is large. Table 8

Table 8.The Effectsize (f2)

Variable	OEE
Availability	4,237
Performance	0,629
Quality	3,735

Predictive Relevance (Q^2)

The predicted value of Q2 as an accuracy criterion, uses the Stone-Geisser Q2 value. A value of 0.02 is considered to have little predictive relevance, a value of 0.15 has a high predictive relevance and a value of 0.35has high predictive relevance. The results of calculating the predictive relevance value (Q2) of 0.834 in Table9show a large OEE predictive relevance value.

Table 9. Predictive Relevance (Q^2)

Variable	Q^2
OEE	0,834

5. CONCLUSION

Results Hypotheses from SEM-PLS testing show:

1. H1: Availability is significant to OEE. A negative value indicates a decrease in Availability has a significant effect on decreasing the OEE value.
2. H2: OEE performance is not significant. Negative values indicate a decrease in performance does not significantly affect the decrease in OEE values.
3. H2: Quality is significant to OEE. Negative values indicate a decrease in quality has a significant effect on decreasing the OEE value.

To improve the performance of the GMAW welding machine, the priority for repairs that must be done is to eliminate the five-six big losses.

1. Breakdown Losses(X11)
2. Setup and Adjustment Losses(X12
3. Idling and Minor Stoppages (X21).
4. Defect losses (X31)
5. Reduced yield losses (X32)