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Student Satisfaction with Online-Based Libraries with Methods Structural Equation Modelling

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***Abstract* — online libraries are a development of conventional libraries that can make it easier for readers to get information anywhere without having to come to where the library is located. The existence of this can be the right solution during the current pandemic. Completeness and continuous updates can be an important factor for achieving success in attracting user interest. Structural equation modeling (SEM) is a useful statistical test measure that is useful for being able to complete a study simultaneously through indicators that affect service quality and user satisfaction. The results in this study found that service quality had no effect on user satisfaction with a CR value of 1.246 and a p value of 0.213 while online libraries had an effect on user satisfaction with a CR value of 5.282 and a p value of 0.000.**

Keywords : **Student Satisfaction, Online Libraries, Structural Equation Modeling.**

I. INTRODUCTION

In 2020, the emergence of the corona virus became a pandemic in Indonesia and even in the world. Previously, the community carried out their activities normally, now they are limited. Work and learning are carried out at home to prevent transmission of the virus. Information technology is the most important thing for carrying out activities, both office work and studying, the pandemic has also affected the library as a medium for providing various information that is very useful for students, research students and workers who want to get the information and answers they want to get. Activities in the library have also experienced the impact of the pandemic which forced libraries to be able to provide complete information online.

To support the improvement of institutional quality and academic quality at Muhammadiyah University of Sidoarjo during a pandemic like this, the services and completeness of the information needed by students to obtain information must run well. The lack of complete online libraries is a problem, especially books that cannot be accessed online, only 195 of which are accessible from a total of 9,881 books with a percentage of 1.97% online books. Therefore these problems can be a barrier for students to get answers to the questions they are looking for. The addition of features such as borrowing books, complete theses and journals will attract students' desire to access the online library from home. Continuous updating of online libraries can be an important factor during the current pandemic to maintain or increase individual quality.

The application of the SEM (structural equation modeling) method is a statistical testing tool used by researchers to complete research simultaneously through indicators of the relationship between observed variables and latent variables or commonly called multivariate analysis which is used to analyze the complex relationship between variables.

With an explanation of these problems, improving the quality of services in the library is important for improving academic quality. Improving the quality of conventional or online libraries must always be improved to make it easier for anyone to get complete, easy and fast information so as to improve the quality of the nation's successors so they can compete internationally.

II. MANUSCRIPT PREPARATION

A. Library

The library functions as a medium for organizing education, research, preservation, information and recreation, all of which can help develop knowledge, educate and

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strengthen the country[1]. The existence of a library in one's life can certainly have a significant positive impact on people's lives. Various types of libraries play a role in increasing the capacity of individuals and communities. In the information age, the library is the preferred knowledge center, with various technical tools and access to various information sources, and can serve as a focal point of individual awareness for lifelong learning[2].

B. Online library

A digital library is an online repository of high quality digital object content generated and managed according to international standards. Furthermore, the available collections can be accessed or opened continuously which are supported by the services that users need when utilizing or needing information sources[3]. A new breakthrough in every library is the digital library (digital library), which is a testament to technological advances in the library. Information technology helps everything in the library, including its services, become easier so that it can be reached by many people, according to its purpose, namely a set of tools that facilitate the management of tasks related to data processing, information and communication[4].

C. Quality of service

Service quality is a dynamic condition related to service products, people, processes and the environment that can meet or exceed customer desires. Customer happiness and service quality are inextricably linked. Customers are more likely to create mutually beneficial long-term relationships with the company if the service is of high quality. Companies can better understand consumer expectations and goals when they have an emotional connection. As a result, businesses can increase customer satisfaction by maximizing valuable and enjoyable client experiences while avoiding or minimizing unsatisfactory or unpleasant experiences[5].

D. Customer satisfaction

Customer satisfaction is described as the level of one's feelings after comparing his feelings about performance (or results) with his expectations[6]. Customer satisfaction refers to how satisfied customers are after comparing the performance/results they feel with their expectations[7]. The difference between perceived performance and expectations determines the level of satisfaction. Customers will not be happy if performance falls short of expectations. Customers will be very happy if performance meets expectations[8].

E. Structural equation modeling

SEM is a method for finding, estimating, and assessing the forms of linear relationships between a set of observed variables and a small number of invisible variables[9].

According to[10], in general there are several steps of the SEM (structural equation modeling) method, which are as follows:

1. Improved Theoretical Model.
2. Improved Path Chart.
3. The equation is created using a path diagram.
4. Determine Estimation Techniques.
5. Identify potential problems and analyze them.
6. *Goodness Of Fit* standard assessment .
7. Model Interpretation and Modification.

III. MATHANDEQUATION

A. Conceptual framework

Figure 1 is a conceptual framework in describing this research using the SEM method.

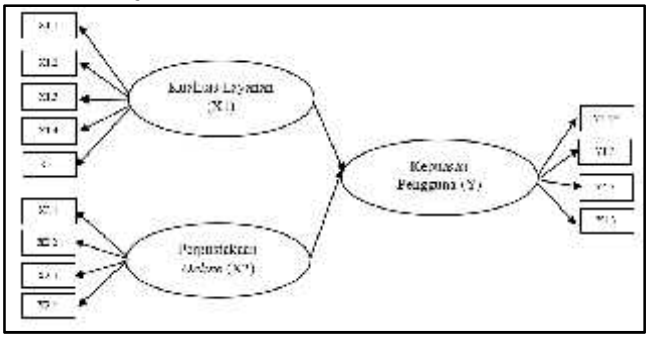

Figure 1: Research conceptual image

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B. Identify variables and indicators

In this study there are 2 (two) independent and dependent variables. The independent variables are service quality (X1) and online libraries (X2), while the dependent variable is user satisfaction (Y1). The following are the variables and indicators used in this study:

Table 1. Operational Research Variables

Variable	*Indicator*	*Indicator Definition*	*Code*	*Adaptation From*
Service Quality	Direct evidence (*Tangible*)	Describes users can more easily access theses, books , journals etc. In softfile form available in the *online library*	X1.1	Prasetyo (2021)
	Reliability _ _	Describes the user feels the conformity of expectations which includes the completeness of the *online library collection*	X1.2	
	Responsiveness _ _	The response speed of the call center in the online library when a problem occurs to a user.	X1.3	
	Guarantee (*Assurance*)	Describes users feel safe and satisfied when accessing the *online library* .	X1.4	
	Empathy (*Empathy*)	Describes how easy it is for users to access the *online library*	X1.5	
Online library (X2)	Need	Describes how much *online libraries are needed* for users to obtain information.	X2.1	Prasetyo (2021)
	Worthy	Describes how feasible the *online library website* can be accessed by users.	X2.2	
	Benefit	Describes how useful the existence of an *online library* is for users to meet the desired information needs.	X2.3	
	Interesting	Describes how attractive the design, features , and completeness of the contents of the *online library* are to users .	X2.4	
User satisfaction (Y)	Expectation	Describe the suitability of the *online library* with what is expected by users.	Y. 1	Prasetyo (2021)
	Recommendation	Describe a willingness to recommend the *online library* to friends and family	Y.2	
	Appearance	Describe how the display conditions of the *online library* for users.	Y.3	
	Information	Providing information quickly if there is a problem in the *online library*	Y.4	

C. Population and sample

In this study, the population was all UMSIDA students who accessed the library online. population is a generalized area consisting of things or people who meet the study criteria set by researchers in terms of quantity and certain attributes[11]. The population in this study is access to the online library of Muhammadiyah University of Sidoarjo.

As for determining the number of samples (n) used is referring to using the Bernoulli formula, which is stated in the formula as follows:

$$n = \frac{Z^2 p}{e^2}$$

Where: N = Number of Samples-Minimum
Z = Normal Distribution Table-Value
p = Proportion of the number of correct questionnaires
q = Proportion of Number of Questionnaires-Incorrect
e = Error Tolerance (10%)

In this study, a 95% confidence level was used which resulted in a value of Z = 1.96, an e (error tolerance) value of 10%, the proportion

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of correct questionnaires p = 50% (0.5), while the proportion of incorrect questionnaires q = 50% (0.5)[12]. Based on the Bernoulli formula above, the results of sample calculations that will be used by researchers are as follows:

$$n = \frac{(1{,}96)^2 \,.\, 0{,}5 \,.\, 0{,}5}{(0{,}1)^2}$$

$$n = \frac{3{,}84 \,.\, 0{,}25}{0{,}01}$$

$$n = \frac{0{,}9}{0{,}0}$$

$$n = 96$$

From the calculation results that have been obtained there are 96. So the number of samples that will be used in this study is 96 respondents.

D. Questionnaire preparation

The questionnaire was carried out by distributing questionnaires to students at the Muhammadiyah University of Sidoarjo which contained questions that contained the variables needed for the research. The Likert scale is used to assess attitudes, views, and perceptions of a person or group of people towards social problems. This social phenomenon has been identified by researchers as one of their special study variables, which is used from now on[11]. Each answer item using a Likert scale has various answers from very positive to very negative. Which is where the respondent must choose one of the answers that have been provided in a list of questions, with a questionnaire value that has been determined as follows:

a. Very dissatisfied = Score 1
b. Dissatisfied = Score 2
c. Neutral = Score 3
d. Satisfied = Score 4
e. Very satisfied = Score 5

After the preparation of the questionnaire was completed, the initial stage that was carried out was to spread 30 questionnaires first which served as a trial sample to find out whether the data was valid or not, after the data was valid and reliable then proceed to the data processing stage using SPSS software. If it is valid and reliable, then the next step is to distribute 66 questionnaires, then the next data processing uses the SEM method.

E. Data collection

Data collection is obtained through:

1. Interview

The use of this interview technique was carried out by librarians to look for variable indicators needed for distributing questionnaires.

2. Distribution of Questionnaires

The use of this questionnaire distribution technique is only aimed at students of Muhammadiyah University of Sidoarjo. With a minimum of 96 respondents obtained from sample calculations.

IV. UNITS

A. Validity test

This validity test functions to measure whether the questionnaire is valid or not. This process is carried out per attribute and aims to find out whether the existing attributes can be said to be valid, and if they are said to be invalid, the questionnaire must be distributed again until each attribute or R count value is greater than R table. It is declared valid if the questions posed adequately represent or reveal something to be measured or examined in the sense that the correlation coefficient R count is greater than the critical value obtained from r table. This validity test process uses SPSS software.

The results of testing the validity of the sample with N (number of samples) as many as 96 respondents and α 5% will obtain the value of d (degree of reedom) = n - 2 so that d is 94. Obtained an R table of 0.2006. Table 4.1 describes the results obtained from calculating the validity test of performance questions and consumer expectations using SPSS software.

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Table 2. Validity test results

Variable	*Attribute Code*	*R Count*	*R Table*	*Information*
Quality of Service (X1)	X1.1	0.719	0.2006	Valid
	X1.2	0.578	0.2006	Valid
	X1.3	0.593	0.2006	Valid
	X1.4	0.688	0.2006	Valid
	X1.5	0.513	0.2006	Valid
Online Library (X2)	X2.1	0.451	0.2006	Valid
	X2.2	0.654	0.2006	Valid
	X2.3	0.652	0.2006	Valid
	X2.4	0.468	0.2006	Valid
User Satisfaction (Y)	Y. 1	0.568	0.2006	Valid
	Y.2	0.619	0.2006	Valid
	Y.3	0.649	0.2006	Valid
	Y.4	0.654	0.2006	Valid

B. Reliability test

The reliability test on a research instrument is a test used to find out whether a questionnaire used in collecting research data can be said to be reliable or not. In the reliability test of this study was carried out using Cronbach's Alpha analysis. Where if a variable shows a Cronbach Alpha value > 0.6, it can be concluded that this variable can be said to be reliable or consistent in measuring. In this test also using SPSS software. Table 3 describes the results obtained from the calculation of the reliability test results of the questionnaire as many as 96 respondents with SPSS software.

Table 3. Reliability test results

Variable	*Number of indicators*	*Cronbach alpha*	*Information*
Quality of service (X1)	5	0.821	Reliable
Online Library (X2)	4	0.756	Reliable
User Satisfaction (Y)	4	0.807	Reliable

From the table above, the results of the reliability test on all variables are reliable. Because Cronbach alpha shows greater than 0.6. Therefore all indicators can be used for research.

C. Analysis of respondents' responses

From the analysis of respondents' responses, they can find out a descriptive description of the responses given by respondents to the questions given or questionnaires and an overview of the services provided by the online library through each indicator of each research variable that has been used. By knowing the average value of the interval calculation, it can facilitate the assessment[12]. The following is an interval search formula according to:

$$P = \frac{R}{Si \quad .K \qquad h}$$

Information :
Range : Highest Score – Lowest Score
Many Interval Classes : 5
From the explanation of the formula above, the result of the interval is as follows:
P = (5-1)/5=0.8
From these calculations it is determined that 0.8 is used for the interval of each category, therefore the categories can be determined as follows:
1 to 1.79 describes the very unfavorable category.
1.80 to 2.59 describes the category is not good.
2.60 to 3.39 describes the moderate category.
3.40 to 4.19 explain the good category.
4.20 to 5 describes the very good category.

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D. Analysis of respondents' responses to service quality

Analysis of respondents' responses to the service quality variable can provide information regarding the amount of data, frequency, total score and average score of respondents on each of the indicators as shown in table 4.

Table 4. Analysis of Service Quality Respondents Responses.

Indicator	*Scale*					*N*	*Score*	*Average*	*Category*
	1	2	3	4	5				
X1.1	3	13	31	41	8	96	326	3.40	Good
X1.2	3	17	32	34	10	96	319	3.32	Currently
X1.3	5	18	31	33	9	96	311	3.24	Currently
X1.4	2	6	33	43	12	96	345	3.59	Good
X1.5	0	7	30	44	15	96	355	3.70	Good
MEAN							1656	3.45	Good

Table 4 explains the results of the calculation that all respondents received a score of 3. Meanwhile, the lowest score was found in the X1.3 indicator (call canter response) which scored 3.24, which means that the response of the call center owned by the online library is still lacking for users, while the highest score found in the X1.5 indicator (ease of access) with a value of 3.70 which means the ease of accessing online libraries for users. As for the overall average value of the variable 3.45 with a very good category, so that the quality of services contained in the online library has met the expectations of the respondents.

E. Analysis of respondents' responses to online libraries

Analysis of respondents' responses to online library variables provides information about the amount of data, frequency, total and average scores of respondents for each indicator as shown in table 5.

Table 5. Analysis of Respondents' Responses to the Online Library.

Indicator	*Scale*					*N*	*Score*	*Average*	*Category*
	1	2	3	4	5				
X2.1	2	11	34	42	7	96	329	3.43	Good
X2.2	3	6	31	46	10	96	342	3.56	Good
X2.3	2	5	28	39	22	96	362	3.77	Good
X2.4	2	9	42	31	12	96	330	3.44	Good
MEAN							1363	3.55	Good

Table 5 explains that the average score is 3. And the lowest score is found in indicator X2.1 (online library needs) with a value of 3.43 which means the library is not really needed for some users, while the highest score is found in indicator X2.3 (benefits of online libraries) has a value of 3.77 which means that online libraries are beneficial for some users. For an overall average of 3.55 with a very good category, the online library at the Muhammadiyah University of Sidoarjo has fulfilled the expectations of the respondents.

F. Analysis of respondents' responses to user satisfaction

Analysis of respondents' responses to the user satisfaction variable provides information about the amount of data, frequency and average score of respondents on each indicator as shown in table 6.

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Table 6. Analysis of user satisfaction respondents.

Indicator	*Scale*					*N*	*Score*	*Average*	*Category*
	1	2	3	4	5				
Y1	2	9	33	42	10	96	337	3.51	Good
Y2	5	6	38	44	3	96	322	3.35	Currently
Y3	1	11	36	38	10	96	333	3.47	Good
Y4	3	12	40	36	5	96	316	3.29	Currently
MEAN							1308	3.41	Good

Table 6 gives the result that the average score is 3 of all indicators. And the lowest value is found in indicator Y4 (providing information) with a value of 3.29 where the provision of information about online libraries is still lacking for users, while the value is found in indicator Y1 (user expectations) with a value of 3.51 which means the online library has fulfilled expectations for users. For the overall average variable Y has a value of 3.41 with a very good category, so that user satisfaction that has been given the Muhammadiyah Sidoarjo university online library has met the expectations of respondents.

G. Test measurement models

In testing the SEM model, a CFA (Confirmatory Factor Analysis) test will first be carried out to find out the indicators used have sufficient ability to define latent or construct variables or test whether the model is fit or good with the data it has. Furthermore, a model fit test was carried out for CFA (Confirmatory Factor Analysis) to ensure that the model obtained was fit or good as seen from the results of the goodness of fit measure.

H. Confirmatory factor analysis test of service quality variable (X1)

The CFA (Confirmatory Factor Analysis) test for the service quality variable in this study is shown in Figure 2.

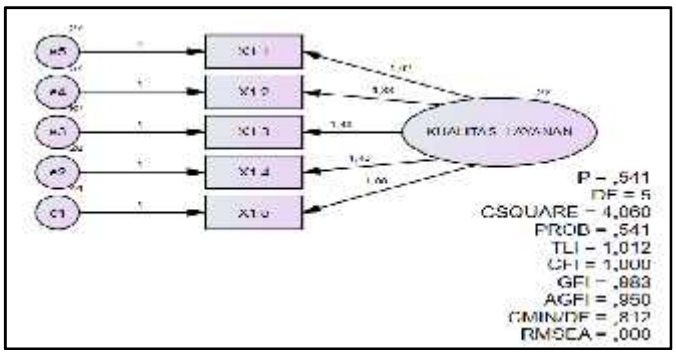

Figure 2. Service Quality Variable CFA Model

Based on Figure 2 which is the result of the CFA test with AMOS 22 software with maximum likelihood estimation, all criteria are good, shown in Appendix 3 Table 1. Where the chi-square value is 0.812 which is still below 2, meaning that the chi-square meets the cut-off value requirements . While the value of GFI, CFI, TLI, and AGFI is greater than 0.9, which means that they have fulfilled the requirements and are of good value or fit. RMSEA has a value of 0.000 which means that it has a value ranging from 0 to <0.08 with a good fit value, which has been explained[13]. And this model is declared fit and suitable for further discussion.

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Table 7 Standardized Regression Weights of Service Quality Variables.

			Estimates
X1.5	<---	QUALITY_SERVICES	,580
X1.4	<---	QUALITY_SERVICES	,788
X1.3	<---	QUALITY_SERVICES	,644
X1.2	<---	QUALITY_SERVICES	,642
X1.1	<---	QUALITY_SERVICES	,828

Furthermore, from table 7 it can be seen that the results of the loading factor located in the estimation column show the value of the indicator of the product quality variable, where the largest value is found in X1.1 with a value of 0.828. And the lowest value is 0.580 of X1.5. This shows that X1.1 is a direct evidence indicator that is part of forming a service quality model.

I. Confirmatory factor analysis test for online library variables (X2)

The CFA (Confirmatory Factor Analysis) test for online library variables in this study is shown in Figure 3.

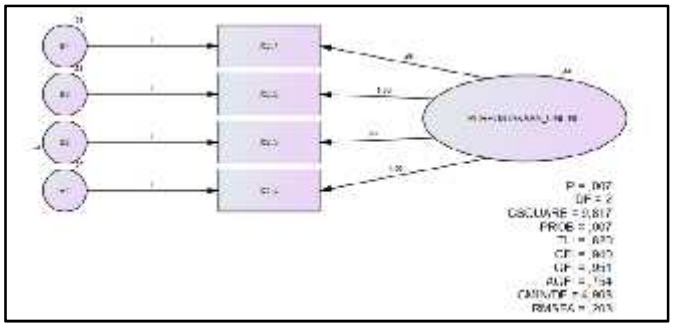

Figure 3. Online Library Variable CFA Model.

Figure 3 shows the results of the test using the AMOS 22 software with maximum likelihood estimation which results in not all criteria showing fit or good as shown in Appendix 3 table 2. Therefore it is necessary to modify the software suggested by the modified indices (MI) values. has the highest value by correlating (two arrows) between indicators which results in a decrease in the chi-square value of the modification indices (MI) of that number. Following are the results of model modifications which can be seen in Figure 4:

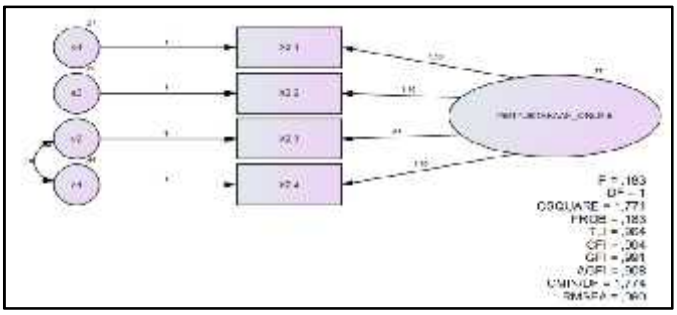

Figure 4. Modified Model of the Online Library Variable CFA.

Based on Figure 4 which is the result of the CFA test with AMOS 22 software with maximum likelihood estimation, all criteria are good, shown in Appendix 3 Table 4. Where the chi-square value is 1.774, which is still below 2, meaning that the chi-square meets the cut-off value requirements. . While the value of GFI, CFI, TLI, and AGFI is greater than 0.9, which means that they have fulfilled the requirements and are of good value or fit. RMSEA has a value of 0.090 which means that it has a value ranging from 0 to <0.08 which is good fit. And this model is declared fit and suitable for further discussion.

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Table 8. Standardized Regression Weights of Online Library Variables.

			Estimates
X2.4	<---	LIBRARY_ONLINE	,674
X2.3	<---	LIBRARY_ONLINE	,529
X2.2	<---	LIBRARY_ONLINE	,813
X2.1	<---	LIBRARY_ONLINE	,796

Furthermore, from table 8 it can be seen that the results of the loading factor located in the estimation column show the value of the indicator of the product quality variable, where the largest value is found in X2.1 with a value of 0.852. And the lowest value of X2.3 is 0.529. This shows that X2.1, namely the need indicator, shows part of the online library model builder.

J. Confirmatory factor analysis test of user satisfaction variable

The CFA (Confirmatory Factor Analysis) test for user satisfaction variables in this study is shown in Figure 5.

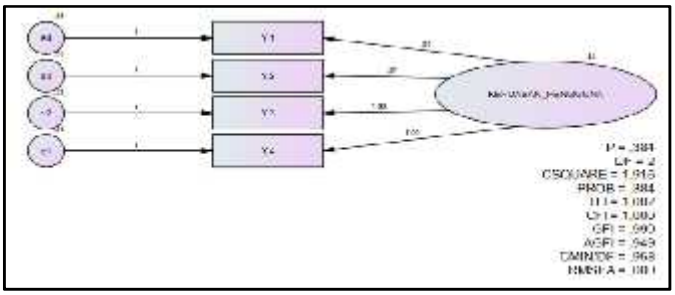

Figure 5. CFA Model of User Satisfaction Variables.

Based on Figure 5 which is the result of the CFA test with the AMOS 22 software with the maximum likelihood estimation, it can be seen that all criteria are good, shown in Appendix 3 Table 5. Where the chi-square value is 0.958 which is still below 2, meaning that the chi-square meets the cut-off value requirements . While the value of GFI, CFI, TLI, and AGFI is greater than 0.9, which means that they have fulfilled the requirements and are of good value or fit. RMSEA has a value of 0.000 which means that it has a value ranging from 0 to <0.08 which is good fit. And this model is declared fit and suitable for further discussion.

Table 9. Standardized Regression Weights Variable User Satisfaction.

			Estimates
Y4	<---	USER_SATISFACTION	,768
Y3	<---	USER_SATISFACTION	,765
Y2	<---	USER_SATISFACTION	,694
Y1	<---	USER_SATISFACTION	,633

Furthermore, from table 9 it can be seen that the results of the loading factor located in the estimation column show the value of the indicator of the product quality variable, where the largest value is found in Y4 with a value of 0.768. And the lowest value of Y1 is 0.633. This shows that Y4, namely the information indicator, shows part of the forming of the user satisfaction model.

K. Model structural test

The structural model test is a continuation of the stage after the measurement model test. In this test it is still the same, namely using maximum likelihood. The overall structural test explains how much the hypothesized exogenous variables in the equation are able to explain the endogenous variables. The test results can be seen in Figure 6:

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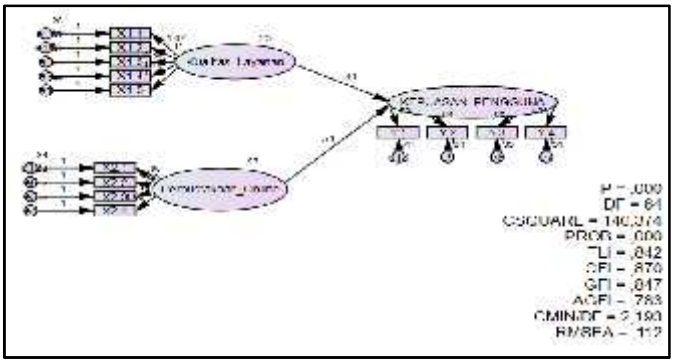

Figure 6. Structural Model

After making and testing the structural model, it can be seen in Figure 6 and Appendix 3 Table 6 that not all of them are in a fit or good condition, such as a p value that is less than 0.05 and the CFI, GFI, TLI and AGFI values are less than 0.9 which means where the value does not meet the criteria of fit. So it is necessary to make modifications to the model.

L. Model modification

The purpose of this modification is to reduce the chi-square value, where the value will get better if the value is smaller, which means it can be said to be fit. Modifications are made by repeating the estimation process by receiving recommendations for improvement from the AMOS 22 software which are found in the modification indices (MI) which have the greatest value which causes the improvement indicators to be correlated which will cause the chi-square value to fall by the modification indices (MI) numbers. The results of model modification can be seen in the following figure:

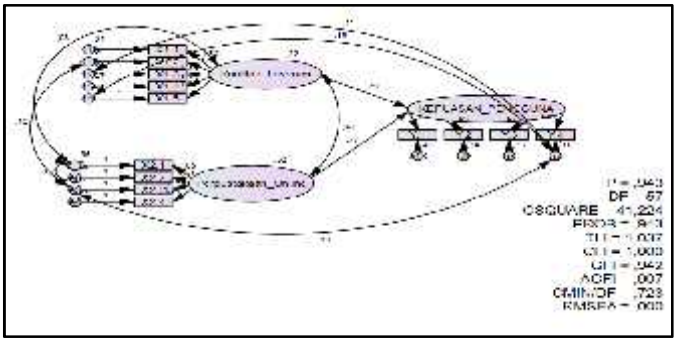

Figure 7. Modified Structural Model

In Figure 7 is a structural model that has been modified on suggestions or recommendations from the AMOS 22 software where the model does not have all the criteria indicating a fit model as seen in Appendix 3 table 10. That from the chi-square criterion is 0.723 it meets the cut-off requirements value that is less than 2, CFI and TLI values that exceed 0.9 and an RMSEA value of 0.000 which is less than 0.05 which means that this model is fit or can be stated as good.

M. Hypothesis test

For the next stage after the model has been declared fit or good, then the hypothesis testing stage is carried out with the aim of knowing the effect of the independent and dependent relationships. The results of the hypothesis test can be accepted or significant if the CR (Critical Ratio) if the value exceeds or equals 1.96 or the p-value <0.05[14]. The following are the results of the hypothesis test shown in table 10.

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Table 10. Hypothesis Test Results

hypothesis	*Connection*	*CR*	*P*	*Information*
H1	Service quality has an effect on user satisfaction	1,246	0.213	Not significant
H2	*Online* library , influence on user satisfaction	5,282	0.000	Significant

Based on the results of the hypothesis testing that has been done, it can be concluded that each hypothesis in this study is as follows:
1. Hypothesis 1: Service quality affects user satisfaction.

Based on table 10 the results of testing service quality on user satisfaction with the condition that the CR value is 1.246 which is less than 1.96 and the probability value (p) is 0.213 which is greater than 0.05 and it can be concluded that service quality is not effect on user satisfaction. In this case, it shows that the online library has provided services, namely information in the form of accessing contents such as books, theses or journals which are deemed satisfactory enough for users to access.
2. Hypothesis 2: Online libraries have an effect on user satisfaction.

According to table 10, the results of the online library hypothesis test have an effect on user satisfaction, which has a CR value of 5.282, which value is greater than 1.96 and a probability value (p) of 0.000 which is less than 0.05, it can be concluded that the library online effect on user satisfaction. From these results it is found that online libraries, in terms of appearance, security or otherwise will give an impression to users who will later be evaluated by the feelings of users who are used to decide whether the user is satisfied or not.

N. sem model analysis

In this study, the model obtained explains that not all variables have an influence, therefore the model obtained from research results like this is shown in Figure 8.

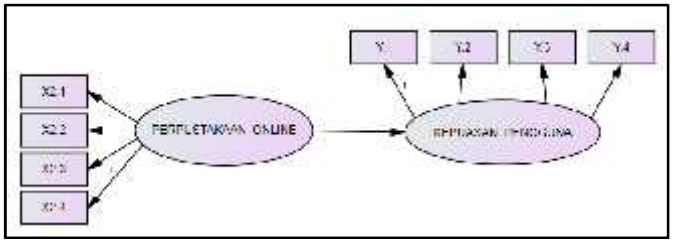

Figure 8. Final Research Model

Of the 2 variables that have been determined and have their respective indicators that affect the variable user satisfaction, only 1 (one) has an influence on the variable user satisfaction, as seen in table 10, namely the online library.

O. Loading factor

From the research that has been done, found results and there are several suggestions related to the variables of service quality, online libraries and user satisfaction obtained from the results of the estimation of the loading factor which has the lowest value in each variable, including the following.

1. The lowest loading factor in the service quality variable is found in indicator X1.5, namely ease of access. There are several factors that are felt to be lacking for access, it would be even better if it was equipped with more accurate and updated information. So that it can be easier to make adjustments to various new conditions in accordance with developments in information needs now and in the future[15].
2. In the Online Library variable that has the lowest loading factor value, X2.1 is the need for online libraries for users. Several factors are very influential for users to make online libraries a necessity, including by forcing lecturers to use online libraries by incorporating into the current

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curriculum the importance of online libraries in a tertiary institution, as well as the influence of social interaction that will lead to an idea. using an online library will be useful to support lecture activities and influence interest in using it to be able to convince users to access it[16]

V. CONCLUSION

1. The online library has an effect on user satisfaction which has a CR value of 5.282 which exceeds 1.96 and a probability value (p) of 0.000 which is less than 0.05. It can be concluded that online libraries have an effect on user satisfaction.
2. The lowest loading factor on the service quality variable is the X1.5 indicator, namely ease of access. Whereas the online library variable that has the lowest loading factor is found in the X2.1 indicator, namely the need for an online library

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Application of Overall Equipment Effectiveness and Failure Mode Efffect and Criticality Analysis Methods to Improve Machine Performance Effectiveness

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***Abstract*— PT XYZ is a company that produces hot rolled coils (HRC) steel products. One of the machines used in the process is a rough mill machine in the milling process. The problem is downtime on the rough mill machine that disrupts the production process time. The purpose of this study is to determine the value of the effectiveness of the machine, find the largest losses that affect the value of the effectiveness of the machine, identify the cause of the biggest losses and provide recommendations for improvement steps. The methods used are overall equipment effectiveness (OEE), six big losses, and the failure mode effect and criticality analysis (FMECA). The results show that the average OEE value of PT XYZ is 80%,but this value was still not following the ideal standard. By identifying the six big losses, the most significant losses are reduced speed losses, with a total percentage value of 86% and an average time lossof 5,020minutes. FMECA results obtain three components that cause the biggest losses: the engine motor, gearbox, and spindle. Recommendations for improvement include making and setting schedules, implementing predictive maintenance and preventive maintenance on rough mill machines, and regularly checking and replacing component spare parts.**

***Keywords*: Machine effectiveness, FMECA, OEE, Six big losses**

I. INTRODUCTION

Machines are equipment or tools with energy conversion (Tang et al., 2018) that greatly help and simplify human work (Dellermann et al., 2019). Machines exist in almost every human life, from home to the workplace (Sadowski, 2020). On the production floor, the role of machines, especially production machines, is vital (Ding et al., 2019). Equipment or machines that do not perform optimally can cause the production process to stop (Christi and Yuliawati, 2020). Therefore, maintenance of the machine needs to be carried out so that the production process in the company can run smoothly and increase the machine's effectiveness(Cachada et al., 2018). Maintenance itself is a series of activities in which it is related to how to maintain all systems on equipment or tools so that they can continue to work as expected(Setiawan et al., 2019) and (Manik, 2018).

PT XYZ is a company engaged in manufacturing that produces HRC steel products. The raw material is billet (raw steel). The manufacturing process includes several processes: cutting, burning, grinding, finishing/thinning material, and rolling or packaging. In the process of making HRC products, several machines are also used, one of which is a rough mill machine in the grinding process. The problem faced by PT XYZ at this time is the frequent downtime or downtime on

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the rough mill machine, so the production process time is disrupted. Downtime on rough mill machines does not affect product quality but the machining process time required in a cycle of the product production process. According to (Pontiana and Singgih, 2021), equipment or machinery is said to be good if it has a downtime percentage value of less than 3%. In contrast, the percentage of downtime on the rough mill machine has an average value of 5.12%. Therefore, it is essential to choose the correct method to increase effectiveness and provide recommendations for improvements to the rough mill machine.

The Overall Equipment Effectiveness (OEE) method was chosen to calculate the effectiveness of the rough mill machine and analyze the most significant or influential losses with the six big losses (Herry et al., 2018). Overall Equipment Effectiveness (OEE) is an instrument that can be used to identify the level of productivity of equipment or performance facilities (Rusman et al., 2019). OEE is a method that describes the product of six big losses on machines or facilities. The OEE method can help measure by involving three factors: availability, performance, and quality. The OEE method has the main objective, namely tool to measure the performance of the maintenance system. This method indicates the availability of equipment or machine, production efficiency, and the quality of the output of facilities or equipment (machines). The six big losses strongly influence the OEE of a system. Six big losses are activities carried out to prevent disruptions in facilities or equipment and minimize downtime in a facility or equipment. Six big losses consist of 6 categories: equipment failure or breakdown loss, set-up and adjustment losses, idle and minor stoppage, reduced speed, defects in the process, and reduced yield (Rozak et al., 2019). This research employs the failure mode effect and criticality analysis (FMECA) method to identify the cause of the biggest losses. Then, propose recommendations for corrective measures to increase the effectiveness of the rough mill machine (Prabowoand Sulistyowati, 2020). FMECA method is often used in determining the failure rate of each component and identifying overall problems that can minimize or eliminate factors that affect the production process both in the process and the equipment (Suharjo et al., 2019). FMECA is an integration of two methods, namely Failure Mode and Effect Analysis (FMEA) and CA (Criticality Analysis) (Wang et al., 2022). FMEA is an engineering method used to define and recognize problems, errors, and some of the systems, designs, processes, or services before a product or service is received by consumers (Safaatand Fatimah, 2022). While CA is a method to identify critical analysis by assessing and classifying the risk of system failure, the chance and severity of each failure are grouped into several categories at the specified criticality analysis value (Hegdeand Rokseth, 2020).

OEE and FMECA are methods that are often used in previous research. The OEE method has been applied to analyze the effectiveness of line production machines (Tsarouhas, 2019; Dobra and Jósvai, 20210; Lakho et al., 2020). FMECA has been widely applied in several systems, such as wind turbine systems (Wang et al., 2021) and railway systems(Catelani et al., 2021). The integration model of FMECA with the OEE framework has been proposed by (Sassanelli et al., 2021). In contrast, the combination of the two methods has also been able to overcome the problems that occur in reducing the system's effectiveness(Antonius, 2021)and (Kristian et al., 2021).

II. METHODOLOGY

The research method there are several stages, as follows:

A. Data Collection Stage

At this stage, the data sources used include (1) primary data involving a general description or profile of PT XYZ, identification of rough mill machines, production processes of HRC (hot rolled coil) products, and how rough mill machines work. (2) Secondary data includes data on operating time/work hours of rough mill machines, data on the number of HRC products produced, data on machine downtime, data on set-up and adjustments, and data on defects on HRC products. Secondary data was taken from July 2020 to December 2020.

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Table 1. Rough mill machine downtime data from July to December 2020

No	Month	*Downtime* (m)	Percentage of *Downtime* (%)
1	July	245	2,78
2	August	515	3,8
3	September	782	5,6
4	October	1057	6,9
5	November	681	4,4
6	December	1207	7,26
	Total	4487	30,74
	Average	747,83	5,12

Table 2. Operation time dan loading time 2020

No	Month	*Operation time* (m)	*Loading time* (m)	*Planned downtime* (m)	Working days (days)
1	July	31.315	31.560	120	22
2	August	31.645	32.160	960	23
3	September	11.278	12.060	2.340	10
4	October	31.103	32.160	960	23
5	Nopember	40.419	41.100	660	29
6	December	38.153	39.360	960	28
Average		30.652	31.400		

Table 3. Set up and adjustment and breakdown time 2020

No	Month	*Set up and adjust rough mill* (m)	*Breakdown time rough mill* (m)
1	July	120	125
2	August	240	275
3	September	360	422
4	October	388	669
5	November	320	361
6	December	480	727
	Average	318	430

B. Data Processing

`In the initial data processing, the OEE calculation will be carried out with the following equation [19]:

OEE = *Availability rate* × *Performance rate* × *Quality rate* …… (1)

The second is to calculate the six big losses to analyze losses that affect the effectiveness of the machine.The six big losses include equipment failure or breakdown losses, set-up and adjustment losses, idle and minor stoppage, reduced speed losses, processed defect losses, and reduced yield losses. It uses equations (2)-(7) to calculate the equipment failure or breakdown losses.

Equipment failure or breakdown = downtime/loading time ×100% …(2)

The equation for Set up and adjustment losses is as follows:

Set up and adjustment losses = set up and adjustment time/loading time×100% ……(3)

The equations for Idle and minor stoppage losses are as follows:

Idle and minor stoppage losses = non productive time/loading time×100% ……... (4)

The Reduced speed losses equation is as follows:

Reduced speed losses = operating time – (ideal cycle time×output)/loading time …….(5)

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The equation for Processed defect losses is as follows:

Processed defect losses = (ideal cycle time×total defect amount)/loading time×100% ……..(6)

The equation for Processed defect losses is as follows:

Reduced yield losses = (number of initial defectsproduksi×ideal cycle time)/loading time×100% …….. (7)

The third stage identifies the causes of the biggest losses using the failure mode effect and criticality analysis (FMECA) method. FMECAcombines failure mode and effect analysis (FMEA) and criticality analysis (CA) and provides recommendations for corrective steps. In the FMECA method, the severity, occurrence, and detection values will be determined, whereas the RPN value will be obtained bymultiplying the three parameters. After getting the RPN results, the level of criticality analysis will determine the most significant value, whether it is included in the acceptable, tolerable, and unacceptable categories for that component. Based on that and recommendations for corrective steps are given. The following is a rating table for severity, occurrence, and detection values, namely:

Table 4. Severity Rating

Consequence	Criteria	Scale
No effect	There is no effect of the failure mode on print quality	1
Minimal repercussions	The quality characteristics are not compromised	2
Little effect	As a result, little to the quality	3
The result is small	Quality suffers minor hiccups	4
Enough effect	The failure resulted in some dissatisfaction with the quality	5
Enough effect	Failure causes discomfort	6
The consequences are big	Print quality is not satisfactory	7
Extreme	Print quality is very unsatisfactory	8
Serious	Potentially adverse effects on molding	9
Very risky	The effect on the failure mode is fatal to quality	10

Table 5. Occurance Rating

Consequence	Criteria	Scale
Almost never	Indicates no failures	1
Seldom	The probability of failure is extremely rare	2
Very small	The probability of failure is minimal	3
a little small	Several possible failures	4
Low	There is a possibility of failure	5
Currently	Moderate probability of failure	6
High Enough	The likelihood of failure is relatively high	7
High	A high number of possible failures	8
Very high	A very high number of possible failures	9
Almost certainly	Failure is almost certain	10

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Table 6. Detection Rating

Consequence	Criteria	Scale
Almost certainly	Controls can definitely bedetected	1
Very high	control almost certainly detects	2
High	controls have a high chance of being detected	3
High Enough	controls may detect high enough	4
Currently	Controls may detect moderate	5
Low	low detect control	6
A little	control has a slightly slight chance of detection	7
The least	control has very little chance to detect	8
Seldom	Control may not detect	9
Almost	Undetectable	10

Criticality analysis assesses and classifies the risk of system failure, the chance of failure, and the severity of each failure in several categories at a specified value. The following is a criticality analysis table (Yssaad et al., 2014):

Table7. Criticality

CRITICALITY		*Risk of*
Degree of Criticality	*Value*	*Hazard*
Minor	0 - 30	*Acceptable*
Medium	31 - 60	*Tolerable*
High	61 - 180	
Very high	181 - 252	*Unacceptable*
Critical	253 – 324	
Very critical	≥ 324	

III. RESULT AND DISCUSSION

The first stage of data calculation is the OEE value by multiplying the availability, performance, and quality rates. Table 8shows the OEE value from July to December 2020.

For example, the calculation of the average OEE value in July 2020 is as follows:

OEE = Availability rate × Performance rate × Quality rate

OEE = 99%×86%×97% = 82%

Table 8. Overall Equipment Effectiveness (OEE) Result

No	Month	*Availability*	*Performance*	*Quality*	OEE
1	July	99%	86%	97%	82%
2	August	98%	85%	96%	81%
3	September	94%	66%	96%	59%
4	October	97%	110%	97%	104%
5	November	98%	79%	98%	76%
6	December	97%	85%	98%	80%
	Average	97%	85%	97%	80%

The OEE standard value set by the company must comply with a world-class standard of 85%. Based on Table 8, it can be seen that the lowest OEE value is 59%, which occurred in September 2020. Table 8 shows that the OEE value reached the company's ideal standards in October 2020at 104%. In comparison, the OEEs of other months are still below the criteria. Moreover, the average OEE value on a rough mill machine is 80%, which is still less than the ideal standard according to World-class standards.Thusit is necessary to carry out further identification by calculating six big losses.

The second stage is to determine the biggest losses by calculating six big losses from the average OEE value results that still do not meet the standard. Table 9 shows the six big

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loss percentage values from July 2020 to December 2020.

Table 9. Six Big Losses

No	Month July	*Six Big Losses* (%)					
		Equipment Failure	*Set up and Adjustment losses*	*Idling and Minor Stoppage*	*Reduced Speed*	*Process Defect*	*Reduced Yield*
1	August	0,4%	0,4%	1,2%	14%	3%	0%
2	September	0,9%	0,7%	4,6%	14%	3.3%	0%
3	October	3,5%	3%	25,9%	32%	2.5%	0%
4	November	2,1%	1,2%	6,3%	10%	3%	0%
5	December	0,9%	0,8%	3,3%	20%	1.5%	0%
6	Month	1,8%	1,2%	5,5%	15%	2%	0%
	Average	2%	1,2%	7,8%	14%	3%	0%
	Total	9,6%	7,3%	46,7%	86%	15%	0%

Based on the results in Table 10, the largest time losses were obtained in the rough mill machine, namely reduced speed losses with a total lost time of 30,120 minutes with an average of 5,020 minutes.

The third stage identifies the cause of the biggest losses from the six big losses with FMECA. Determination of severity rating criteria (S), occurrence (O), and detection (D) from the results of brainstorming with the company, namely maintenance technicians on rough mill machines. The following is a table for calculating the FMECA method, namely, as follows:

Table10. Total Time Losses and Six Big Losses

No	Six big losses	Total time losses rough mill (m)	Average time losses rough mill (m)
1	Equipment failure	2.592	430
2	Set up and adjust losses	1.900	318
3	Idling and minor stoppage	10.529	1.755
4	Reduced speed losses	30.120	5.020
5	Process defect losses	4.678	780
6	Reduced yield losses	0	0

Table1. FMECA Result

No	Compo nent	Failure Mode	Failure Effect	Failure cause	Criticality (C)				Degree Of criticality	Risk Of Hazard
					S	O	D	RPN		
1	Guide	The size of the guide is not as specified	Crash material cannot enter	The selection of guides is not as needed	5	4	7	140	High	Tolerable
		Guide entry porous	The material broke and had to be welded	The guide is damaged and failed due to too long use	5	5	6	150	High	Tolerable
		Broken exit guide	Material exits through the line	Components wear out	6	5	3	90	High	Tolerable
				Broken guides must be re-welded	5	4	6	120	High	Tolerable
2	Motor	The motor drive fails to function, so it cannot operate	The machine can not run	Electrical current problem	8	9	2	144	High	Tolerable
				Engine component failure	9	10	4	360	Very Criticality	Unacceptable
				Incorrect machine activation code	6	4	5	120	High	Tolerable

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No	Compo	Failure Mode	Failure	Failure cause	Criticality (C)				Degree	Risk
3	Gearbox	There was a miss alignment between the gear and the engine motor	The steering gearbox is loud and noisy	The gearbox is wearing out	9	9	3	243	Very high	Unacceptable
				loose fixing bolts or gearbox screw	5	7	4	140	High	Tolerable
4	Spindel	A jam occurs, and it stops suddenly	Roll can not run	The spindle components are worn	7	7	4	196	Very high	Unacceptable
				babet spindle down or dropped	6	6	4	144	High	Tolerable
5	Roll	Experiencing a missed roll	The material does not enter the guide entry	The tip of the material is bent so that it catches on the guide	7	6	4	168	High	Tolerable
				Broken roll	7	4	4	112	High	Tolerable
6	Layar	Broken and worn out	So that the material is out of line	The age of use is too long	5	4	6	120	High	Tolerable
				Materials go fast	5	5	6	150	High	Tolerable
7	Temperature heater	The engine temperature is too hot	The engine has overheated	The temperature sensor is broken	5	5	6	150	High	Tolerable
				Hot room temperature	4	4	7	112	High	Tolerable

Based on the hazard risk in Table 11, corrective steps should be determined for components with RPN values in the category unacceptable. The corrective actions include three recommendations. (1) The first recommendation is for motor failure function. The root cause of the failure is too long usage time and oil leak into the rotor. After discussion with the management, it is found that maintenance techniciansmust make and set a schedule for routine maintenance, especially for engine components that often have problems. Besides, clean the oil that leaksfromthe motor so that it does not spill over to other components. (2) The second recommendation is related to the failure of the engine gearbox component. The root cause of the failure is the excessive use of gears, which erodes due to excess material load. The corrective steps that should be taken after discussing with the company, namely maintenance technicians on the failed component, are implementing periodic and continuous predictive maintenance, carrying out routine checks, and replacing gearbox gears. (3) The third recommendation is related to the spindle component, jamming, and sudden stopping, which has an impact that the spindle component's experience of wear and tear. The root cause of the failure is the engine working time that exceeds the limit, the presence of dust or dirt adhering to the spindle components, and the negligence operator in component checking. Corrective steps that should be taken after discussing with the company, namely maintenance technicians on the failure component are implementing preventive maintenance activities when scheduling maintenance activities on spindle components as well as checking and replacing component spare parts regularly and providing training or training to all machine operators both new employees and existing employees.

IV. CONCLUSION

From the research conducted, it was concluded that the results of calculations using the OEE method, namely the average OEE value of 80%, still do not meet the ideal standard according to world-class for OEE, which is 85%. Therefore, it is necessary to identify the cause of the decrease in the effectiveness of the rough mill machine. From the analysis of the six big losses, the results are obtained, namely the losses that

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have an impact, which is in the category of speed losses, namely reduced speed losses with an average percentage of 14% and a total percentage value of 86%, total time losses (lost time) caused by reduced speed losses in July 2020 to December 2020 amounted to 30,120 minutes with an average time loss of 5,020 minutes. FMECA identification results show three components of failure: the engine motor, gearbox, and spindle. This is based on RPN values that are included in the Unacceptable category. Recommendations for improvements obtained results, namely engine motor components with motor drive failure modes fail to function so that they cannot operate,resulting in engine components' failure. There are three corrective steps recommended. The firstis making and setting schedules for routine maintenance, especially on machine components that are often problematic, and cleaning oil that leaks on the motor so it doesn't spill over to other components.The second recommendation is to regularly implement regular and continuous predictive maintenance, checking and replacing gearboxes. The third recommendation is to regularly implement preventive maintenance, especially when performing maintenance on the spindle. The maintenance procedure should include regularly checking and replacing component spare parts and providing training to all machine operators, both new and permanent employees.

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Analysis of Photocopy Service Queue System in "Sustainable Photocopy" Using The FIFO Queue Method

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***Abstract*—Photocopying services are services that are always sought by students, students, teachers, lecturers, and even office people for the need to duplicate school assignments, theses, document files, etc. "Sustainable" Photocopy Services are rarely empty of customers. And for a certain time, there are a lot of customers from "Sustainable" Photocopies. With this research, we can find out whether the queuing system at Sustainable Photocopy Services is optimal, and with the analysis of this queuing system by calculating the queuing formula it can be seen the call arrival rate, employee utility level, the average number of customers to be served, the number of customers in the system, the number of customers in the queue, the average time in the queue, the average time in the system, and the probability of waiting.**

***Keywords*: Queue Formula; Queuing System Analysis; Queuing System for Copy Services.**

I. INTRODUCTION

Photocopying services are services that are always sought by students, students, teachers, lecturers, and even office people for the need to duplicate school assignments, theses, document files, etc. This photocopy service business opportunity is quite promising considering its needs as a support for the smooth running of schools and offices. This service will be very easy to find in schools, campuses, and offices, especially if it's thesis season, surely any place for photocopies will be filled with students. Photocopy services are an alternative source of income for communities around school areas and residential areas. This business is very tempting with a wide market coverage and many people who need it. In addition to photocopying, this service also provides binding, scanning, typing, printing, photo printing, and laminating, so the benefits of services have enormous opportunities.Of course, this photocopying service is becoming a business that is increasingly mushrooming in society.

Customer satisfaction is the main thing to achieve big profits in this business. Customer satisfaction is defined as how much the level of one's feelings is generated based on the cognitive and emotional aspects of comparing one or more types of products or services. Based on this definition, it can be seen that the comparison of services is a consideration for customers to use a service. Differences in services offered based on service quality often make perceptions and judgments on customers to reconsider using these services[1], [2], [3]. Customer satisfaction will create interest in making repeat transactions on the products or services offered. Customer engagement is a behavior from customers who contribute voluntary resources that focus on a product, occurs in interactions between consumers and product or service providers, the result of consumer motivation towards interest in an existing product or service. Customer engagement is closely related to service contexts characterized by high customer/brand interactivity[4]. Customer engagement behavior

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results from aspects of an individual's motivational drive such as word-of-mouth activity, customer-to-customer (C2C) interaction, and/or blogging activity[5].Customers tend to seek pleasurable experiences in the customer engagement process, and positive consistency towards pleasurable experiences will lead customers to engage further[6].

This "Sustainable" Photocopy Service has a strategic location. Photocopy "Lestari" provides several services, including photocopying, laminating, binding,
"Lestari" Photocopy Services are open from 07:00 to 22:00. The "Lestari" Photocopy Service employs 2 employees. The average time needed to serve customers is 15 minutes. And for the average number of customers, the average number of customers who come is 20 people (Saturday, Sunday) and 25 people (Monday to Friday).

Stationery, etc. "Lestari" photocopy services are generally quite busy, causing queues for customers.The queue appears because the existing requests temporarily exceed the capacity of a server or facility so that customers who come cannot be served right away[7].Queuing is not a strange event, almost every day we are often involved in queuing events, such as when we want to pay at a supermarket cashier, pay tolls while driving, during visits to hospitals, and when we want to wash our vehicles at a washing machine, even in a wider industrial scope, queuing is applied to production management, inventory management, business management, transportation, banking, medical services, computer design, etc[8], [9]. Generally, events to be served immediately have very little chance[9]. Queuing is the process of waiting on a system to be served to ensure a reduction of waiting time with extra planning and investment by the company concerned [10], [11]. This queuing process is closely related to the arrival of a customer in a system, queuing if the queue cannot be served, being served, and finally leaving the facility after being served[12].

A queue, of course, has a close relationship with time, giving rise to the question of whether a system is running efficiently in terms of the time the customer queues in the system.The queue process is a stochastic event, both for system time and service time by the system[13]. To retain consumers, large or small companies certainly must provide the best service for their customers, one of which is by providing fast service and reducing consumer waiting time[14].

To be able to find out whether or not the existing queuing system is optimal, queuing theory is needed to study and analyze the existing queuing system.The application of queuing theory to processes involving queues, in general, has been widely used in industry to optimize the supply of fixed resources under variable demand conditions[16].This theory supports managers to calculate the resources needed to be able to meet customer demands[17]. Queuing Theory is a mathematical method for analyzing various types of systems and observing their behavior related to system performance and service quality. This includesanalysis of the service chain to complex queues. Usually used to analyze probability distributions in a continuous state space[18]. Because it requires only a small amount of data and provides more general results than simulations, this queuing model is considered simpler[19].

In the queuing system known various methods that can be applied in an industry. Of course, the chosen method is adjusted to the product or service offered. One of the queuing methods is the First In First Out method.

In the field of warehousing, the First In First Out method or abbreviated as FIFO is defined as a method of inventory management, in which the first purchased goods are the first goods used or sold. In simple terms, First In First Out is a method for products or services that are the first to enter and the first to leave[20], [21].
Within a service, server services or facilities can be single or multiple in batch size. The service process depends on the number of customers waiting to be served. If the queue is long, the server is required to work faster so that queue buildup does not occur which causes the system to become inefficient [15]. In photocopying services, of course, you will experience all conditions from the number of customers. Sometimes a few customers arrive and for a certain time, there are many customers from "Continuous" Photocopying. With this as a basis, I made a queuing system analysis that will find out whether this copy service is optimal or not.

II. RESEARCH METHOD

The method used is the quantitative method. This quantitative method is a method used to examine a particular population or sample. For

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this study, the form of the sample is proportional sampling. Data were obtained from interviews with owners and employees of Lestari Photocopy Services. The research variables used were the number of employees, length of service, length of time the store was opened, and the average number of customer visits per day.

III. RESULT AND DISCUSSION

In this photocopy service, for the arrival of customers, namely the arrival pattern is random or customers come randomly. And for queue discipline, this photocopy service includes a First Come First Served / First in First Out queue where customers are served first, namely customers who come first. Meanwhile, the queue structure model includes Single Channel - Single Phase because there is only oneservice station. And this photocopy service does not limit customers who come.

QUEUE ANALYSIS (QUEUE FORMULA):

A. Saturday - Sunday

Hiring 2 Employee(s) Working time 15 hours
There are 20 customers per day Service time is about 15 minutes

- Call arrival rate
  μ = 60 / 15 minutes
  = 4 customers/hour
  λ = 20 / 15
  = 1.34 customers/hour

- Employee utility rate
  P = λ / s μ
  = 1.34 / 2(4)
  = 1.34 / 8
  = 0.1675

- The aTheverage number of customers waiting to be served

$$P0 = \frac{1}{1 + \frac{(1{,}34/4)}{1!} + \frac{(1{,}34/4)^2}{2!}\left(1(1{,}34/8)\right)}$$

$$= \frac{1}{1 + 0{,}335 + 0{,}675}$$

  = 1/2,01
  = 0,4975

- The number of customers in the queue

$$Lq = \lambda\mu \left(\frac{\lambda}{\mu}\right)^s Po$$

$$= \frac{(1{,}34 \times 4)\,(1{,}34/4)^2\,(0{,}4975)}{(2-1)!\,(8-1{,}34)^2}$$

$$= \frac{(5{,}36)\,(0{,}1122)\,(0{,}4975)}{1!\,(87{,}2356)}$$

  = 0,0034 customers

- The number of customers in the system
  $L = Lq + \frac{\lambda}{\mu}$
  = 0.0034 + 1.34/4
  = 0.0034 + 0.335
  = 0.3384 customers

- Average time in queue

$$Wq = \frac{P}{\mu\, s\,(s!)\,(1-\lambda/s\,\mu)^2}\,(\lambda/\mu)^s$$

$$= \frac{0.4975}{4\,(2)\,(2)\,(1-1.34/8)^2}\,(1.34/4)^2$$

$$= \frac{0.4975}{16\,(0.6930)}\,(0.1122)$$

$$= \frac{0.4975}{11{,}088}\,(0.1122)$$

  = (0.0879) (0.1122)
  = 0.0099 hours or0.594 minutes or35.64 seconds

- The average time in the system
  W = Wq + (1 / μ)
  = 0.0099 + (1/4)
  = 0.0099 + 0.25
  = 0.2401 hours or14.406 minutes or864.36 seconds

- Probability to wait

$$Pw = (\lambda/\mu)^s \frac{Po}{S!\,[1-(\lambda/S\,\mu)]}$$

$$= (1.34/4)^2 \frac{0.4975}{2!\,[1-(1.34/8)]}$$

$$= (0.1122)\frac{0.4975}{2\,[0.8325]}$$

  = (0.1122) (0.2988)
  = 0.03352

B. Monday - Friday

Hiring 2 Employee(s) Working time 15 hours
There are 20 customers per day Service time is about 15 minutes

- Call arrival rate
  μ = 60 / 15 minutes

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= 4 customers/hour
λ = 25 / 15
= 1.67customers/hour

- Employee utility rate
P= λ / s μ
= 1.67 / 2(4)
= 1.67 / 8
= 0.20875

- The average number of customers waiting to be served
$P0 = \frac{1}{1 + \frac{(1.67/4)}{1!} + \frac{(1.67/4)^2}{2!\,(1-(1.67/8)}}$
$= \frac{1}{1 + 0.4175 + 0.1101}$
= 1 / 1.5276
= 0.6546

- **The number of customers in the queue**
$Lq = \frac{\lambda\mu \left(\frac{\lambda}{\mu}\right)^s Po}{(S-1)\ (S\,\mu - \lambda)^2}$
$=\frac{(1.67 \times 4)\,(1.67/4)^2\,(0.6546)}{(2-1)!\,(8 - 1.67)^2}$
$=\frac{(6.68)\,(0.174)\,(0.6546)}{1!\,(40.0689)}$
=0.0190 customers

- The number of customers in the system
$L = Lq + \frac{\lambda}{\mu}$
= 0,0190 + 1,67/4
= 0,0190 + 0,4175
= 0,4365 customers

- Average time in queue
$Wq = \frac{P}{\mu\, s\, (s!)\,(1 - \lambda/s\,\mu)^2}\ (\lambda/\mu)^s$
$= \frac{0{,}6546}{4\,(2)\,(2)\,(1 - 1{,}67/8)2}\ (1.67/4)^2$
$= \frac{0{,}6546}{16\,(0{,}0436)}\ (0{,}1743)$
$= \frac{0{,}6546}{0{,}6976}\ (0{,}1743)$
= (0.0879) (0.1122)
= 0,1636 hours or9,816 minutes or588,96 seconds

- The average time in the system
W = Wq + (1 / μ)
= 0,1636 + (1/4)
= 0,1636 + 0.25
= 0,4136 hours or24,816 minutes or1.488,96 seconds

- Probability to wait
$Pw = (\lambda/\mu)^s \frac{Po}{S!\,[1 - (\lambda/S\,\mu)]}$
$= (1,67/4)^2 \frac{0{,}6546}{2!\ [1 - (1,67/8)]}$
$= (0{,}1743)\frac{0.4975}{2\ [0{,}79125]}$
= (0,1743) (0,4136)
= 0,0721

IV. CONCLUSION

From the overall results of queue analysis. Lestari Photocopy Services employs 2 employees, with a working time of 15 hours, and a service time of 15 minutes for each customer. It can be concluded, on weekends such as Saturdays and Sundays, the calculation for the employee utility level is 0.1675, the average number of customers waiting to be served is 0.4975, the number of customers in the queue is 0.0034 customers, and the number of customers in the queue is the result is 0.3384 customers, and the average time in the queue is 0.0099 hours, while the average time in the system is 0.2401 hours. And the last calculation, the probability of waiting for the results obtained is 0.03352. And on weekdays such as Monday to Friday the calculation for the utility rate of employees obtained results of 0.20875, the average number of customers waiting to be served obtained results of 0.6546, the number of customers in the queue obtained the results of 0.0190 customers and the number of customers in the queue obtained the results 0.4365 customers, and the average time in the queue is 0.1636 hours, while the average time in the system is 0.4136 hours. And the last calculation, the probability of waiting for the results obtained is 0.0721

Based on these calculations, it can be concluded that the performance of the service system at Sustainable Photocopying Services

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with the FIFO method is quite good.

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Optimizing Company Performance Through Industrial Coordinator Training : A Practical Needs Assessment

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Abstract -- The study of performance is incredibly fascinating. One of them is how mid-level management functions as both a conduit for information to top management and the person in control of subordinates. This study aims to enhance the coordination of the industrial department's performance. This study's data processing and analysis procedure employs a qualitative approach by carrying out an analysis using the TNA (Training Need Analysis) method. At electromotor engine repair service firms in East Java, this method is used to assess the variables that contribute to delays in the completion of repairs of goods as well as the kind of training provided to coordinators to prevent delays in the completion of repairs of goods. The outcomes showin the study, it was discovered that the absence of effective communication between division coordinators in the industrial department, skill gaps, and workers who are not suited for the job are the main causes of delays in the completion of goods. Because the percentage is still low for corporate performance and still less productive, the performance value in each division, such as industrial repair, is 6.1%, vacuum pump 6.6%, blower 6.2%, fabrication 7.4 and rewinding 7.5% to complete the items.

***Keywords*: Performance, Coordinator, Training Need Analysis, Assessment**

I. INTRODUCTION

The globalization period is expanding and changing with the times, therefore every business must make various preparations to deal with upcoming changes as well as invent using current human resources [1]. For every business, human capital is the most important asset and resource. To advance business growth, every business must have innovative and creative staff [2].The purpose of personnel as a corporate resource is to manage workplace dynamics in a way that allows for productive and efficient employee performance and the achievement of corporate objectives. Of course, to enhance their performance, every organization looks for qualified and competitive staff [3].Therefore, human resources are the strength of the company and must be managed as well as possible so that their performance is maintained, because the success or failure of a company can be seen from how these human resources can complete the tasks assigned by the company properly and on time [4].

Achieving these goals requires a fairly good strategy of increasing the best performance of each employee, and that is what every company expects in increasing its success [5]. High performance enables businesses to create a variety of strategies to meet their objectives. Performance is the outcome of employees' efforts to reach work objectives that were established at the beginning of the workday[6]. The number, quality, and accomplishments of each employee in raising the standard of employee work are all indicators of efficiency [7]. Moreover, performance is crucial for the business because it enables it to achieve its objectives and compete with other businesses. Achieving these objectives and being competitive requires strong, consistent performance from the business [8]. Moreover, performance is crucial for the business because it enables it to achieve its objectives and compete with other businesses. Achieving these objectives and being competitive requires strong, consistent performance from the business [9]. Therefore, the factors that

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affect employee performance are work quality, quantity, work speed, effective use of human resources, independence, and work readiness [10]. One method to enhance each employee's performance is to do performance reviews [11]. Companies must also conduct work evaluations to improve performance. If performance starts to deteriorate, work evaluations will be conducted when activities related to product repair slow down or when there are numerous failures brought on by employee error, which results in significant losses for the company [12]

This company in East Java offers repair services for electromotor engines, which serve as a machine propulsion device. The issue that the industrial department is currently dealing with is the regular occurrence of delays in the completion of product repairs. Due to this, a study was done to determine what caused delays in the production of goods, how each division coordinator in the industrial department performed, and what tactics were being used to boost productivity in the industrial department.

II. METHOD

TNA (Training Need Analysis) is the research methodology used in this study; it is an analysis used to carry out training and skill development for firm employees [13]. The implementation of the company's personal training programs benefits greatly from analysis of how this training was put into practice. To ascertain what training is required by employees to receive and complete all responsibilities assigned by the organization, a training analysis is carried out. [14]. Every company will organize training to train employees and provide them with specific knowledge about their work. Training is a process carried out by the company to obtain and improve skills in each employee [15] with training, the company hopes that employees can improve their skills in the jobs offered by the company, while development is an activity carried out by the company, where each employee is trained to fulfill their respective duties. The purpose of further training is to develop the mental abilities and personality of each employee so that every company that wants to develop and train its employees must get further training to improve their performance [16].

According to [17] training needs analysis is the right method used to conduct employee training to realize good performance quality. The following steps that can be taken when conducting training need analysis as follows:

1. Performance Analysis

The first step in conducting training need analysis is to analyze employee work by looking at their performance and skills by comparing current employee performance with the productivity desired by the company.

2. Root Cause Analysis

The second step is to analyze what is the root of the problem. An effective way to identify the cause of the imbalance between performance and skills possessed by employees. The aspects that are seen to analyze are human resources, skills possessed, incentives, and work motivation.

3. Needs Assessment

The third step is to analyze in depth what is the need for each problem that has been identified. At this stage, the analysis includes employee work, workload, work environment conditions, and benefits that employees get from the company.

III. RESULT AND DISCUSSION

The amount of arriving products (input), processed goods (Process), finished goods (output), and items in the queue are among the main firm statistics that were used to collect data for this study (queue). The following information is relevant to each division's industrial department :

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Table 1. Division Data in 2022

Division	Amount			
	Input	Process	Output	Queue
Industrial Repair	524	336	32	56
Vacuum Pump	542	356	36	50
Blower	530	352	33	45
Fabrication	556	359	41	56
Rewinding	560	377	42	41

Source: Company Data Year 2022

A. Analytic Performance

Performance evaluation in light of is analyzed to identify as many company-wide issues as feasible to think about resolving any future issues. The intended standard is also determined through performance calculations and calculations of restrictions in finishing repairs from each division.

$$\frac{O}{I} x1 \ \% \quad \text{The Performance Value} \quad (1)$$

$$\frac{Q}{I} x1 \ \% \quad \text{The Constraint Value} \quad (2)$$

Table 2. The Result Performance Value and Constraint Value

Divisi	Performance Value	Constraint Value
Industrial Repair	6,1%	30%
Vacuum Pump	6,6%	28%
Blower	6,2%	27%
Fabrication	7,4%	28%
Rewinding	7,5%	25%

Based on the calculation table above, it is known that the performance value for finishing repairs to goods is still less productive because the percentage is still relatively small for the company's desired performance, whereas the obstacles encountered are significant enough to result in higher performance and constraints, the value of which is greater than the value of performance for each coordinator of each division in the industrial department.

B. Root Cause Analysis

According to the performance analysis, insufficient skill levels and ineffective coordination lead to delays in the manufacture of these commodities. So, the following can be stated to be the main contributing factor to this issue:

1. The organizer is typically inexperienced and young, thus decisions and solutions are solely dependent on personal knowledge.
2. The coordinator's education level is still quite poor, which prevents him or her from knowing what causes machine damage.
3. The coordinator's work experience of less than ten years makes it difficult for him to recognize the boundaries of his competence, the lack of cooperation between coordinators, and the very poor communication that delays the handling of difficulties.

C. Needs Assessment

After a problem is identified, a needs analysis must be planned to determine the competency training requirements the business must meet to boost employee performance. The steps in

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this analysis are as follows:

Table 3. Employee Training Needs

Division	Needs for Competence Training
Industrial Repair	Gearbox Proficiency
Vacuum Pump	Competency with carbon dioxide and tooling
Blower	proficient roots blower
Fabrication	competency with baseplate frames
Rewinding	Powerful electric motor

IV. CONCLUSION

The following findings are based on studies done at electromotor engine repair facilities in East Java:

1. Delays in the completion of goods repairs can be brought on by a shortage of skilled workers, people who are not suited for the job, and poor communication amongst division coordinators in the industrial department.
2. After measuring performance, it is found that the performance of each industrial department coordinator needs to deepen skills to prevent delays in completing goods. In the industrial repair division, the performance is 6.1%, the vacuum pump 6.6%, the blower 6.2%, fabrication 7.4 and rewinding 7,5% to complete the goods because the percentage is still small for the company's performance and is still less productive.
3. The techniques used to raise performance include:
   a. The industrial repair division needs greater in-depth training in gearbox repair and maintenance.
   b. The section that deals with vacuum pumps needs training in areas like fixing carbon vane damage and maintaining vacuum pumps.
   c. Roots blower talents require extensive training in the blower sector.
   d. The fabrication division needs training in the creation of sketches and work designs, welding. Instruction, and the selection of materials required for fabrication repairs.
   e. The rewinding division requires training in motor rewinding, including proficiency with electrical measurement devices and other auxiliary mechanical equipment, as well as the ability to perform electromotor repairs and repairs

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Analysis of time and cost using time cost trade off method in pressure vessel project

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Abstract **- One of the construction companies got a Pressure Vessel project job. During the process of working on the project, it was delayed from the predetermined date so that the company had to pay a fine of 0.2% every day. So it is necessary to analyze project scheduling in order to get the optimal time and cost of working on this project. The methods used in this research are Time Cost Trade Off (TCTO), Precedence Diagram Method (PDM) and crashing. Acceleration is carried out on all critical paths contained in fabrication activities. This study uses alternatives to accelerate the addition of 50% and 75% labor. The results of this study obtained the optimal time and cost with the alternative of adding 75% labor. The resulting acceleration duration is 75 days faster than the actual duration, with costs incurred of Rp. 161,386,836, -, resulting in a 56% decrease from the actual duration cost of Rp. 286,961,745, -. Analysis of the S-curve found that the accelerated duration can be completed faster than the actual duration because, the curve line on the accelerated duration is more sloping closer to the y-axis indicating greater progress each week.**

Keywords**; Crashing, Pressure Vessel, Project Management, Time Cost Trade Off**

I. INTRODUCTION

According to Dannyanti (2010) a construction project is an activity that aims to erect a building that requires resources, both costs, labor, materials and equipment.Meanwhile, according to Andhika (2017) a project is an effort to achieve certain goals that are limited by time and available resources.In a construction project, there are three important things that must be considered, namely time, cost, and quality (Kerzner, 2006). Scheduling is very necessary in the work of a project to manage the length of time of the project process, so as not to experience delays and avoid cost overruns.Project scheduling is an activity to determine each stage of work related to the resources needed by the project, which includes the number of workers, costs and the amount of supplies needed for certain activities and those related to other activities (SofjanAssauri, 2016). Project management is needed in the work of a project as for the functions of project management are as Planning, Organization, Actuating and Controlling (Dimyati and Nurjaman, 2014).

In this study will discuss the pressure vessel project where in actual workmanship this project actually experienced delays from the deadline that has been set,the delay resulted in the company having to pay a fine of 0.2% per day and a decrease in client confidence inthe company's performance. There are many factors that cause delays in the project, for example a lack of labor and the company running several projects at one time. Therefore, it is necessary to analyze the actual time and cost. In this study, the Time Cost Trade Off method, Precedence Diagram Method (PDM) and crashing were used. In order to get the optimal time and cost, the alternative used in this study is the addition of Labor. Then after acceleration, compare the time and cost before and after acceleration using the S-curve.

In this research does not discuss the addition of machines, when working on the project the state of the machine is in a normal position, crashing is carried out in the fabrication process.

II. RESEARCH METHODOLOGY

According to Satrijo&Habsya (2012) a pressure vessel is a place or container to store or hold a fluid, either in the form of a gas or a liquid. place or container to store or

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accommodate a fluid, either in the form of a liquid or gas. liquid or gas.

2.1 Work Breakdown Structure *(WBS)*

The first step is to group the project into a more detailed form in the form of smaller sub-components or activities to make it easier to work on. work breakdown structure is a fundamental management tool that defines projects through a level of activities that can be clearly identified, managed and controlled (Benny,2004).After analyzing the WBS, then analyze the dependency relationship of each activity or called the Work Network. According to Muhardi (2011) Network planning or work network is a project planning and control that describes the dependency relationship between each job described in the network diagram (Network Planning)

2.2 Precedence Diagram Method (PDM)

Precedence Diagram Method (PDM) is a work network that is included in the classification of activity on node (AON) where in the AON network nodes indicate an activity and arrows indicate the relationship between the activities concerned (Soeharto, 1999) which are generally square nodes. According to Ervianto (2005), the advantages of Precedence Diagram Method (PDM) compared to CPM is that PDM does not require dummy so that making the network simpler. This is because different overlapping relationships can be created without increasing the number of activities (Arianto, 2010). In PDM, there is also aconstraint that one constraint can only connect two nodes, because each node has two ends, namely the initial end or start (S) and the final end or finish (F).

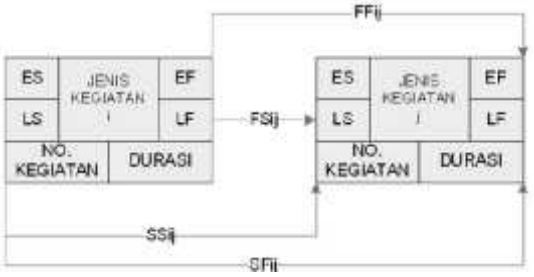

Figure 1. Relationship between activities i and j (Ervianto, 2005)

Based on Figure 1, it can be seen that in the PDM method there are 4 constraints, which consist of: Finish to Start (FS), Start to Start (SS), Finish to Finish (FF), and Start to Finish (SF).

To accelerate the duration, a new duration calculation is carried out for each activity with equations 1,2,3.

$$\text{Normal productivity} = \frac{W \quad V_i}{N \quad D} \quad \ldots(1)$$

$$\textit{Crash Producticvity} = \frac{p \ (m \quad n \quad + m \quad C \quad h)}{m \quad n} \ldots(2)$$

$$\textit{Crash Duration} = \frac{W \quad V_i}{C \quad h \, P_i} \ldots.(3)$$

2.3 Project Cost

Project costing is a written and systematic plan of activities that require the expenditure of costs for all activities used to achieve a project.According to Soeharto (1995) there are several types of costs associated with financing a construction project, namely:

1. Direct cost.
   Direct costs are all costs directly related to the implementation of construction project work in the field.
2. Indirect Cost.
   Indirect costs are project costs that are not directly related to the project, in this case not directly in contact with project work activities.

2.4 Cost Slope

Cost Slope is the ratio between the increase in cost and the acceleration of project completion time, The way to calculate the cost slope is as follows:

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Cost Slope $= \frac{C \quad hc \quad -n \quad c}{N \quad D \quad -cr \quad hD}$ …(4)

2.5 Time Cost Trade Off

Time cost trade off method is analytical method used to accelerate the project completion time by compressing the schedule to get a more profitable project in terms of time (duration), and cost (Florensia, 2016). This scheduling acceleration aims to find how much time and cost it takes to complete the project according to the target efficient and best plan.The alternative used in this study is the addition of 50% and 75% labor of the normal labor force.The optimum addition of labor will increase work productivity due to too narrow an area to work (Wibowo, 2020).With minimum resource utilization and optimum completion time, activities will be completed at normal cost and normal duration (Pratama, 2015).In addition, it must also be noted that the emphasis is only on activities on the critical path (Mahapatni 2019).

2.6 S-curve

Husen (2010) argues that the S-curve can determine progress based on activities, time and work weights that are represented as a cumulative percentage of all project activities. all project activities S-curve visualization can provide information about the progress of progress of the project by comparing it to the schedule.

III. RESULT AND DISCUSSION

3.1 Work Breakdown Structure

In this final project, we will discuss the work of the pressure vessel project weighing 1913 kg because this work has experienced delays that must be rescheduled and optimized. The following is the Work Breakdown Structure (WBS) of the work on the pressure vessel projectcan be seen in figure 2.

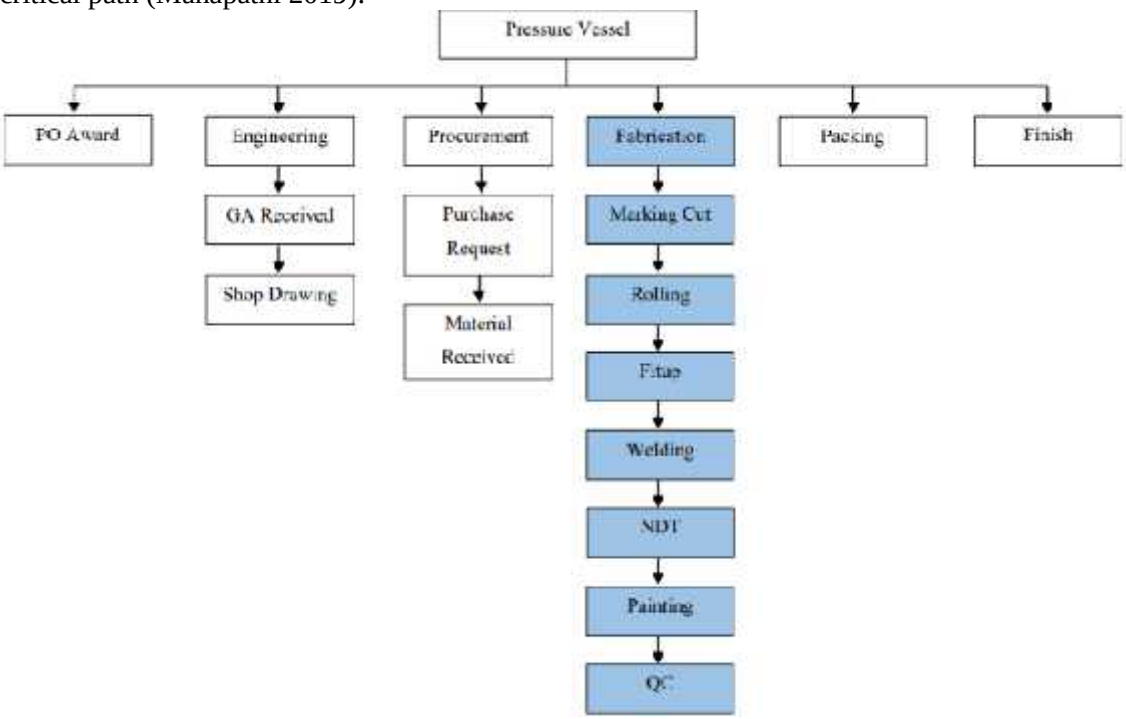

Figure 2. Pressure vessel WBS

3.2 Precedence Diagram Method (PDM)

In planning and working on a project, each company has a different planning system. Table 1 below is a grouping of Pressure Vessel project activities and durations based on the actual duration of the project.

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Table 1. Activity Grouping and Actual Schedule Duration

Kode	Nama Kegiatan	Durasi (Hari)	*Predecessor*
	Pressure Vessel	171	
A	PO *Award*	1	
B	*Engineering*		
	GA Received	7	A
	Shop drawing	18	B1
C	*Procurement*		
	Purchase request	15	B1 FS
	Material received	40	C1 FS - 2
D	*Fabrication*		
	Marking Cut	38	C1
	Rolling	41	D1 FS - 16
	Fitup	44	D2 FS - 13
	Welding	22	D3 FS - 15
	NDT	5	D4 FS
E	*Painting*		
	Blasting Primer	2	D5FS – 1
	Top Coat	1	E1 FS - 1
F	QC	71	D1 SS + 7
G	*Packing*	1	E2
H	*Delivery (Finish)*	2	G

According to Render and Jay (2006), the critical path is a series of activities of a project that cannot be delayed and shows an interrelated relationship with each other.. So that activities that are on the critical path have more attention than non-critical activities. The critical path is characterized by a slack or float value equal to zero.The slack value can be calculated using :

LF EF = LS ES = 0

Forward and backward calculations for activities with sequential actual durations can be seen in Table 2.

Table 2. Critical Activities on the Actual Schedule

code	Duration	Earliest ES	Earliest EF	Latest LS	Latest LF	Total Slack	Description
	171						
A1	1	0	1	0	1	0	Kritis
B1	7	1	8	1	8	0	Kritis
B2	18	8	26	53	71	45	Tidak
C1	15	5	20	5	20	0	Kritis
C2	40	31	71	30	71	0	Kritis
D1	38	61	99	61	99	0	Kritis
D2	41	83	124	83	124	0	Kritis
D3	44	111	155	111	155	0	Kritis
D4	22	140	162	140	162	0	Kritis
D5	5	162	167	162	167	0	Kritis
E1	2	166	168	166	168	0	Kritis
E2	1	167	168	167	168	0	Kritis
F	71	68	97	139	168	29	Tidak
G	1	168	169	168	169	0	Kritis
H	2	169	171	169	171	0	Kritis

Can be known the total completion time pressure vessel project on the actual schedule in the field reached 171 days experiencing a delay of 75 days from the actual duration. On

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the critical path with activities: A-B1-B2-D1-D2-D3-E-F-G-I. Figure 3 below is the critical path contained in the pressure vesse project.

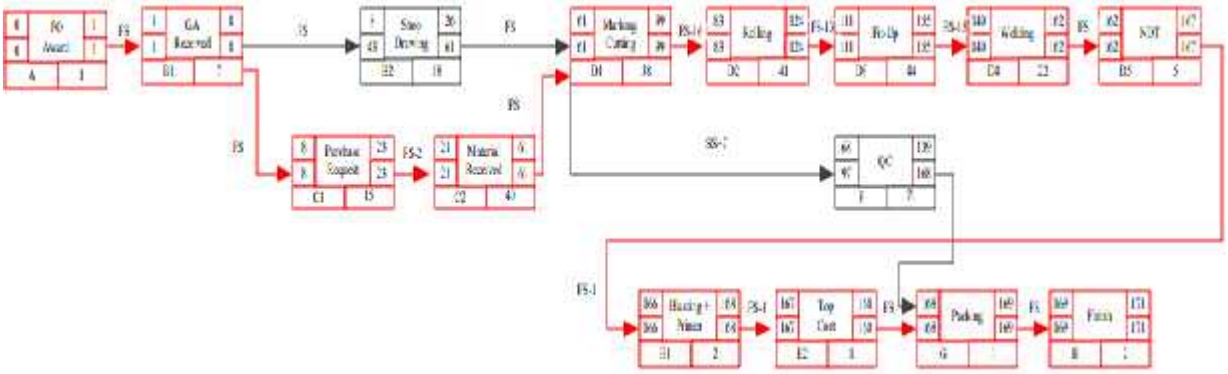

Figure 3. PDM Network for Actual Schedule

3.3 Additional manpower

The ideal project work area for each labor is defined as follows:

Ideal Working Area = $\frac{1 + 2}{2}$ = 150 ft²/manpower

= 150 ft²/manpower x 0,0929

= 13,935 m²/manpower

From the work area, it can be known how many additional ideal workers for each activity Can be seen in table 3.

Table 3. Ideal manpower Quantity

code	Working Area (m²)	Ideal workforce (people)
A	-	-
B	-	-
	-	-
C	-	-
	-	-
D1	82,500	5,92 ≈ 6
D2	115,525	8,3 ≈ 8
D3	108,512	7,8 ≈ 8
D4	78,612	5,6 ≈ 6
D5	112,548	8,08 ≈ 8
E1	65,672	4,7 ≈ 5
E2	54,237	3,9 ≈ 4
F	-	-
G	-	-
H	-	-

1. Crash Duration with Alternative Manpower Addition.

After getting the ideal additional labor for each activity, then calculate the new duration for each accelerated activity. The calculation of the new duration is done by calculating productivity first.The calculation uses equations 1, 2, 3 and the results can be seen in table 4 below. Not all activities can be accelerated.Table 4 is the result of the new duration of the additional 50% manpower.

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Table 4. Crash Duration Calculation with 50% Manpower AddAlternative

code	Normal Man power	*Crash* Man power	Produktivitas Normal	ProdukTivitas *Crash*	*Crash Duration*
D1	2	3	50,34	75,51	25,3 ≈
D2	2	3	46,659	69,99	25
D3	2	3	43,477	65,22	69,3 ≈
D4	2	3	86,955	130,43	27
D5	4	6	382,6	573,9	29,3 ≈
					29
					14,7 ≈
					15
					3,33 ≈ 3
E1	2	3	956,5	1434,75	1,33 ≈ 1
E2	1	2	1913	3826	0,5 ≈ 1

The new duration with 75% additional manpower can be seen in Table 5.

Table 5. Crash Duration Calculation with 75% Manpower AddAlternative

code	Normal Man power	*Crash* Man power	Produktivitas Normal	ProdukTivitas *Crash*	*Crash Duration*
D1	2	4	50,34	100,68	19,0 ≈
D2	2	4	46,659	93,32	19
D3	2	4	43,477	86,95	20,5 ≈
D4	2	4	86,955	173,91	21
D5	4	7	382,6	669,55	22,0 ≈
					22
					11,0 ≈
					11
					2,9 ≈ 3
E1	2	4	956,5	1913,00	1,0 ≈ 1
E2	1	2	1913	3826,00	0,5 ≈ 1

2. Crash Cost with Alternative Addition Manpower.

After getting the next acceleration duration, namely calculating the crash cost of the alternative addition of manpower by multiplying the total workers by the hourly rate of the manpower concerned. According to Frederika in (Ariyanto et al, 2020), using the Crash Schedule of course the cost will be much greater than the Normal Schedule.The calculation results for the addition of 50% manpower can be seen in Table 6.

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Table 6. Crash cost with 50% manpower Addition Alternative

code	Normal duration	manpower	Manpower cost (Rp)
D1	25	3	15.000.000
D2	27	3	16.200.000
D3	29	3	17.052.000
D4	15	3	9.300.000
D5	3	6	3.708.000
E1	1	3	572.000
E2	1	2	384.000

Table 7 is the direct manpower cost in accelerating the duration with the addition of 75% manpower.

Table 7. Crash cost with 75% manpower Addition Alternative

code	Normal duration	manpower	Manpower cost (Rp)
D1	19	4	15.200.000
D2	21	4	16.548.000
D3	22	4	17.072.000
D4	11	4	9.020.000
D5	3	7	4.272.000
E1	1	4	760.000
E2	1	2	384.000

3. Cost Slope

Cost Slope is the ratio between the increase in cost and the acceleration of project completion time,To find the cost slope value, equation 4 is used, Table 8 is the result of the cost slope calculation for additional manpower of 50%.

Table 8. Order of Cost Slope and Duration Acceleration with 50% Manpower Addition

code	**Cost Slope (Rp)**	**Normal Duration**	**Crash duration**	**Crash duration**
E1	- 188.000	2	1	170
D5	- 156.000	5	3	168
D1	- 15.385	38	25	155
D3	- 1.333	44	29	140
D2	20.857	41	27	126
D4	58.857	22	15	119
E2	192.000	1	1	119

The cost slope value on accelerating the project duration with the addition of 50% manpower can be seen in table 9.

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Table 9. Order of Cost Slope and Duration Acceleration with 75% Manpower Addition

code	Cost Slope (Rp)	Normal Duration	Crash duration	Crash duration
D1	0	38	19	152
D3	0	44	22	130
E1	0	2	1	129
D4	12.000	22	11	118
D2	32.000	41	21	98
D5	84.000	5	3	96
E2	192.000	1	1	96

In the addition of 75% labor, the normal duration of 171 days becomes 96 days or the same as the planned duration. In this study, the software used for duration calculation is Microsoft Project. So in this study, an alternative 75% of additional manpower is taken for the optimum time and cost.

3.4 Total Cost

The total direct and indirect costs for normal duration can be seen in table 10.

Table 10. Total Cost of Normal Duration

No	Direct Costs	Total Cost (Rp)
1	Direct manpower Cost	62.040.000
2	Material Cost	12.603.000
	indirect Costs	
3	Indirect manpower Cost	149.854.545
4	Machine Operating Cost	4.975.000
5	Other Additional Cost	1.117.800
6	Consumable Cost	18.871.400
	Cost Penalty	37.500.000
	Total Cost	286.961.745

The accelerated duration with 75% additional manpower can be seen in Table 11.

Tabel 11. Total Durasi BiayadenganPenambahan Tenaga Kerja 75%

No	Direct Costs	Total Cost (Rp)
1	Direct manpower Cost	63.256.000
2	Material Cost	12.603.000
	indirect Costs	
3	Indirect manpower Cost	60.563.636
4	Machine Operating Cost	4.975.000
5	Other Additional Cost	1.117.800
6	Consumable Cost	18.871.400
	Total Cost	161.386.836

From the results of the calculation, a new duration is obtained with an alternative of adding 75% of the manpower, the results for the crash duration are the same as the planned duration of 96 days. In the acceleration duration there is a difference of 75 days from the actual duration. The total cost incurred on the alternative of adding 75% of the manpower has decreased by 56% from the total cost on the actual schedule with a difference of Rp.125,574,909, -.

3.5 S-curve.

Husen (2010) explains that the S-curve is graphically a depiction of cumulative work

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progress (weight %) on the vertical axis against time on the horizontal axis. The actual duration curve line slopes closer to the x-axis, indicating that progress each week is slower and not in accordance with the planned schedule. An accelerated duration curve line sloping closer to the y-axis indicates greater progress each week and the accelerated duration curve line is not much different from the plan curve line. If an S-curve is above another S-curve, it indicates a greater volume of work completed until the end of the project, which can accelerate the project completion duration.

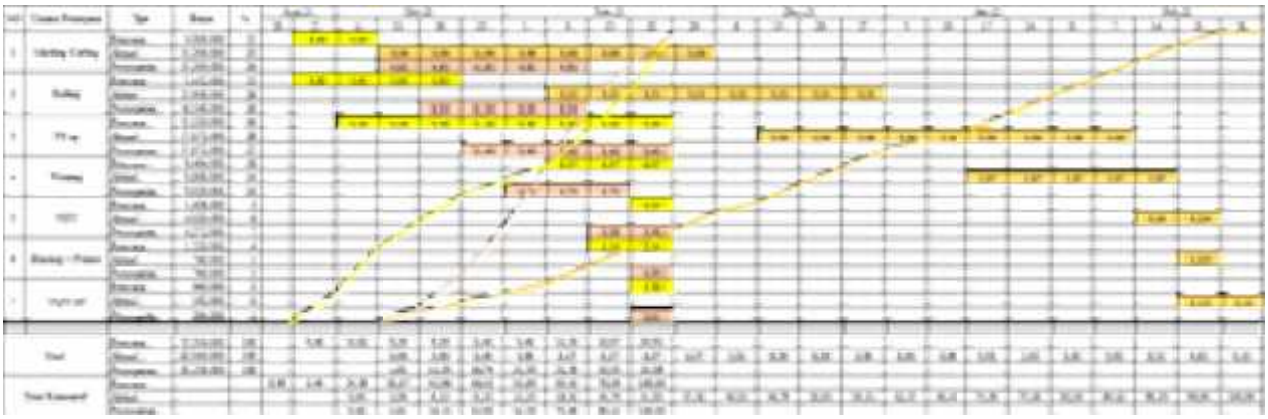

Figure 4. S curve of Pressure Vessel project

IV. CONCLUSION

Based on the results of the analysis that has been carried out and discussed, the following conclusions are obtained:

1. From the analysis obtained using the PDM method, the entire fabrication process is a critical activity that can be accelerated.
2. From the calculation results, the optimal time and cost is obtained with an alternative of adding 75% of the manpower, the resulting duration is the same as the plan duration of 96 days. In the acceleration duration there is a difference of 75 days from the actual duration. The cost incurred from the alternative of adding 75% of the manpower is Rp.161,386,836, - a 56% decrease from the actual duration cost of Rp. 286,961,745,-
3. Comparison of Pressure Vessel progress using the S-curve obtained the results of the actual duration curve line sloping closer to the x-axis shows the development of each week is not in accordance with the plan schedule. The curve line on the accelerated duration schedule is more sloping close to the y-axis indicating the development of each week is greater and the slope of the accelerated duration curve line is not much different from the plan curve line indicating the progress of work progress each week is greater.

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Implementation of Material Requirement Planning (MRP) in Controlling Raw Materials for Shoes Products at PT.XYZ

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***Abstract*— PT. XYZ is an industry in East Java that produces products made from animal skins as raw materials. The product produced by this industry is loafers. So far, this industry has had problems with leather raw materials which often experience excess supply requiring high investment, although at certain times they also experience shortages which result in not fulfilling consumer demand. MRP is a system specifically designed to ensure the availability of materials, items or components when needed to meet production schedules and ensure the availability of finished products for consumers in situations of surging demand. MRP can answer exactly what material, how much, and when (what, how much and when) is needed so that the production process can run according to schedule. The results of this study indicate that the Material Requirement Planning (MRP) method has a total raw material inventory control cost of Rp. 189,646,600 and by using the company's method, the raw material control value is Rp. 323,325,500 Savings in raw material control costs that can be obtained by applying the MRP method are Rp. 17,416,700 or about 0.94%.**

***Keywords*: Inventory, Material Requirement Planning, Raw Material Control**

I. INTRODUCTION

The industrial world is increasingly advanced along with the development of science and knowledge, which has created intense competition between companies. Companies do various ways to survive and excel. The methods used to increase the company's capabilities, for example, arrangements in the fields of raw materials, production, personnel, and finance, so that an optimal way or method is needed in handling every part of the company.

The production process is the core activity of a manufacturing company. Companies are required to produce quality products to satisfy consumer desires. Therefore, to support production activities, good raw materials must be available and meet production needs effectively and efficiently (Wahyuni&Syaichu, 2015). includes planning what, how, when, and how much of a product is to be produced. Meanwhile, control means control over the production process so that the continuity of the company can continue. One of the planning and control activities within the company is the control of raw materials. (Anggriana, 2015).

Supply is a general term that denotes everything or organizational resources that are stored in anticipation of fulfilling requests (Pandu & Febryanto, 2022). One way that can be done is to control the supply of raw materials to prevent inventory problems from occurring (Rafi &Ngatilah, 2022). Meanwhile, according to (Lahu et al., 2017) raw materials are initial materials or inputs that will be processed to make finished products so that the production process can run smoothly, there is no shortage of inventory (out of stock), and minimal inventory costs are obtained.

Lack of available raw materials will result in the cessation of the production process due to running out of raw materials for production. Currently, the competition in the manufacturing industry is increasing, so a good production

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strategy is needed to win the market. Very tight competition in the business world causes companies to be required to have competitiveness that has more value for consumers. (Kusumahati&Widiasih, 2022).

Silitonga& Moses, (2021) developed a multi-item economic order quantity inventory model by considering expiration factors, all unit discounts, and capacity constraints. The model that has been developed will be tested by making changes to the model parameter values to see its sensitivity. From the results of the sensitivity analysis that has been carried out, it is found that the total cost of inventory is sensitive to the purchase price of a unit of goods. Meanwhile, the ordering time is sensitive to changes in warehouse capacity.

Hikam, (2022) researched how MSME craftsmen control supplies so that MSMEs get the maximum profit. The results showed a savings of 29% with a total inventory cost of Rp. 108,907,812 and safety stock of 30 units.

PT. XYZ is a manufacturing company engaged in the manufacture of shoes. The shoes that are produced are office shoes and various models of shoes for daily needs. PT. XYZ makes shoes based on direct orders from consumers or orders from online websites and online shops that work with companies, so the need for raw materials often fluctuates. Therefore, PT. XYZ needs to plan for the right raw material requirements so that in the procurement of raw material materials an optimal supply is obtained.

MRP (Material Requirement Planning) is a system designed specifically for period demand situations and is independent. MRP is a logical procedure in the form of decision rules and computer-based transaction techniques designed to process a master production schedule into "net requirements" for all items (Utama et al., 2022))
This study aims to plan the raw material requirements for shoes and perform inventory cost calculations so that minimal inventory costs are achieved using the Material Requirement Planning (MRP) method.

II. METHODOLOGY

Material Requirement Planning (MRP) is a technique used for planning and controlling item items (components) that depend on items at a higher level. MRP was first discovered by Joseph Orlicky from J.I Case Company around 1960. The MRP method is a Computer Oriented Approach which consists of a set of procedures, decision rules and a set of recording mechanisms designed to describe a Master Production Schedule (MPS).

Meitriana et al., (2014), MRP has three necessary information inputs, namely Master Production Schedules (MPS) which are used to plan in a phase that determines how much and when the company plans, makes each final product, Product Structure (Bill of Materials (BOM) which is a list of items needed to make or assemble a unit of finished product and Inventory Records File which is a record of inventory items in stock and which have been ordered but not yet received .

The type of research used in this study is a descriptive method with a quantitative approach.

The data used in this study include shoe production data, ordering costs, purchasing costs and storage costs.

Methods of data collection using interviews/interviews and documentation while to analyze the data using the Material Requirement Planning (MRP) method.The MRP steps taken are:

a. Netting
   a calculation process to determine the amount of net requirements, where the value is the difference between the gross requirements and the state of the inventory (those in stock and those being ordered or just waiting for the receiving schedule).
   Formula:
   $Q = \sqrt{\frac{2A}{I,C}}^{0}$
   (1)
   If D_t-I_{t-1}-Q_t> 0
   If $D_t - I_{t-1} - Q_t <= 0$
   Where:
   Rt: Net requirements in a period t
   Dt: Gross requirement in a period t
   I_{t-1} : Inventory at the end of period t – 1
   Q_t : Planned receipt of goods in period t
b. Lotting
   Techniques for determining the optimal order quantity for each item of material or material.
   $E \quad = Q = \sqrt{\frac{2}{C}}^{0}$ (2)
c. Offsetting
   The technique determines when ordering activities are carried out so that efforts to meet net demand levels can be achieved immediately.

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d. Explosion
Calculation of the needs of each item, where the calculation assesses the lower level of the available product structure, and the ordering plan that was previously prepared in the offsetting process.

III. RESULTS AND DISCUSSION

Data collection in this study can be seen in table 1, table 2 and table 3 below:

Table1. Demand for Leather Shoes 2020 – 2021

Period(Month)	Demand(Unit)
June2020	653
July2020	578
August2020	698
September2020	365
October2020	451
November2020	235
December2020	563
January2021	679
February2021	385
March 2021	397
April2021	249
May2021	247
Total	**5.500**

Raw Material Type	Raw Material Prices(Rp)	10% of Raw Material Prices (Rp)
Cow-Hide	37.000	3.700
Outsole	20.000	2.000
Insole	15.000	1.500
Total	72.000	7.200

Table2. Storage Costs Raw Material for Loafer Shoe

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Table 3.Order Cost Raw Materials for Loafers

No.	Raw Material Type	Order Cost
1.	Cow-Hide	Rp.915.000
2.	*Outsole*	Rp.915.000
3.	*Insole*	Rp.32.000

Table4. *Bill Of Materials* (BOM)

Raw Material Type	Quantity	BOM
Leather Shoes	1	Unit
Cow-Hide	4	Feet
Outsole	1	Pair
Insole	1	Pair
Yellow Glue	0,4	Liter
Fox Glue	0,4	Liter
Thread	2	Meters

Table5. Inventory of Loafer Type Shoes Raw Materials

Period	Inventory		
	Cow-Hide(ft)	*Outsole* (pair)	*Insole* (pair)
June2020	528	127	62
July2020	716	179	84
August2020	924	201	106
September2020	1.164	416	121
October2020	1.460	595	170
November2020	1.620	810	205
December2020	1.768	1.017	252
January2021	2.052	1.188	273
February2021	2.312	1.333	318
March2021	2.624	1.556	331
April2021	2.828	1.647	382
May2021	2.940	1.750	415
Total	20.936	10.819	2.719

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Table 6. Master Production Schedule

Month	1	2	3	4
June 2020	41	41	27	27
July 2020	35	87	35	18
August 2020	49	49	33	33
September 2020	58	144	58	29
October 2020	45	45	30	30
November 2020	45	45	30	30
December 2020	18	36	36	89
January 2021	96	39	39	20
February 2021	45	45	30	30
March 2021	42	42	28	28
April 2021	44	44	30	30
May 2021	45	45	30	30

Table 7 Order Frequency and Order Quantity Company method

Period	Cow-Hide		Outsole:Tapak		Insole	
	Freq (x)	Quantity	Freq (x)	Quantity	Freq (x)	Quantity
June 2020	8	2.900	6	720	5	670
July 2020	6	2.500	3	630	3	600
August 2020	10	3.000	7	720	8	720
September 2020	5	1.700	4	580	7	380
October 2020	6	2.100	4	630	5	500
November 2020	4	1.100	5	450	4	270
December 2020	9	2.400	8	770	10	610
January 2021	12	3.000	13	850	11	700
February 2021	4	1.800	3	530	5	430
March 2021	6	1.900	4	620	7	410
April 2021	3	1.200	5	340	2	300
May 2021	4	1.100	3	350	5	280
Total	77	24.700	65	7.190	72	5.870

The calculation results in Table 7 shows that every year the total quantity of orders for cow leather raw materials is 24,700, 7,190 orders for outsole raw materials, and 5,870 orders for insole

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raw materials. From the data obtained it can be seen that the number of orders made when using the company method is very large, this certainly has an impact on increasing the cost of ordering raw materials. The total cost of handling raw materials using the company's method is IDR 323,325,500.

Lot for Lot

The following is the MRP calculation for Lot for Lot (LFL) costs:

$$\text{Saving (\%)} = \frac{\text{The cost system} - \text{The cost system}}{\text{The cost system}} \text{X100\%}$$

$$\text{Saving (\%)} = \frac{11.3.3.5 - 11.1.6.6}{11.3.3.5} \text{X100\%}$$

savings with the Lot for lot (LFL) method = 41%

MRP calculation using the Economic Order Quantity (EOQ) method can be seen in the explanation below:

Economic Order Quantity (EOQ)

$$\text{Saving (\%)} = \frac{\text{The cost system} - \text{The cost system}}{\text{The cost system}} \text{X100\%}$$

$$\text{Saving (\%)} = \frac{11.3.3.5 - 11.1.4.7}{11.3.3.5} \text{X100\%}$$

savings with the Lot for lot (LFL) method =94%

From the steps that have been taken, the following results can be obtained.

Table 8. Comparison of Total Cost of each method

Raw Material	Company Method(IDR)	Lot for Lot(IDR)	*EconomicOrder Quantity*(EOQ)(IDR)
Cow-Hide	192.873.200	125.072.100	13.067.700
Outsole	95.781.000	54.832.000	3.281.000
Insole	34.671.000	9.742.500	1.068.000
Total	323.325.500	189.646.600	17.416.700

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So from the comparison of the two methods above, it can be concluded that the best method to use is the Economic Order Quantity (EOQ) method because the EOQ method calculates the smallest total cost, which is IDR 17,416,700. When compared with the Lot For Lot (LFL) calculation, which is IDR 189,646,600. Because the EOQ method can minimize ordering costs and holding costs so that the total costs incurred are small compared to the LFL method and the Company method.

IV. CONCLUSION

The cost savings that can be obtained by the company after applying the Material Requirement Planning method are Rp. 189,646,600 or around 41% using the Lot for Lot (LFL) method. If you use the Economic Order Quantity (EOQ) method, the savings cost is Rp. 17,416,700 or about 94% of the company's methods that have been applied so far. Companies can determine alternative methods of raw material inventory control techniques, namely the MRP method with LFL and EOQ techniques.

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Analysis of Improved Work Posture to Reduce Musculosceletal Disorders using the Rapid Upper Limb Assessment and Ovako Work Posture Analysis System methods (Case Study : Employees in the Warehouse of PT. AFS Maros, South Sulawesi)

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***Abstract*— PT. AFS is a Limited Liability Company engaged in catering services. One of the most important divisions in this field is the warehousing department. Receiving is the place where the goods are entered, while the store is the place where the goods are stored for some time regarding the expiration date of the product. Goods collection is done when receiving incoming goods, moving goods from the receptionist to the store, and when requesting goods from the production room. Body posture is a determining factor in analyzing the effectiveness of a warehouse operator's work. If the operator's work attitude is wrong or not ergonomic, the employee will tire easily and bone abnormalities can occur. Complaints of Musculoskeletal Disorders are complaints of skeletal muscles that are felt by a person from very mild to severe complaints. For the RULA and OWAS methods, posture analysis is only carried out in the main warehouse. The final Rapid Upper Body Limb Assessment (RULA) score for both workers was Score 7 (Action Level 4) which indicates that this condition is dangerous and requires immediate inspection and changes (on the spot). And the Ovako Work Posture Analysis System (OWAS) shows Category 4 (This attitude is very dangerous for the musculoskeletal system. Needs to be corrected immediately/currently) and Category 1 (in this system problems in the musculoskeletal system don't need to be fixed).**

Keywords: **Musculoskeletal Disorders, OWAS, RULA, Warehouse.**

I. INTRODUCTION

Ergonomics is defined as the study of human influence on the work environment based onpsychology, engineering, anatomy, anagement, and planning and design. In addition, ergonomics is also related to optimization, efficiency, safety, and health as well as human comfort in the work environment [1].

PT. AFS is a Limited Liability Company that focuses on catering services. This company was founded in 1996 and initially only served the needs of "airlines catering". With growing market demands, this company also serves catering for the needs of companies, such as Education and Training Centers, or seminars, as well as other events held by companies in Maros, South Sulawesi.

This company has its warehouse as a place to store goods, namely in the receiving and store sections. Receiving is a place where goods enter, while a store is a place for storing goods for a long time until the product is used for the production process regarding the product's expiration date. Lifting of goods is carried out when receiving incoming goods, transferring goods from receiving to stores, and when requesting goods from the production room or each division such as hot kitchen, bakery, pastry, meal prepared, cold kitchen, hot dishing, and others.

Body posture is a determining point in analyzing the effectiveness of a job. If the work attitude is good and ergonomic, certainly that the results obtained by the workers will also be good, but if the operator's work attitude is wrong or not ergonomic, the workers will easily tire and abnormalities in bone shape can occur [2].

Rapid Upper Limb Assessment (RULA) is a method developed in the field of ergonomics that invests and assesses the work position

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performed by the upper body [3]. The Ovako Work Posture Analysis System (OWAS) is a work attitude analysis method that defines the movement of the body parts of the back, arms, legs, and the weight lifted. Each member of the body is classified into a working attitude. Theattitude of theobserved bodyparts is the back, arms, legs, and the weight of the worker's load[4].

The workforce working in the warehouse of PT. AFS as many as 4 people. The activity of lifting goods using a carrier. Meanwhile, the transfer of goods from the conveyor to the pallet or the shelves of goods is done manuallynamely the transfer of goods is carried out by interacting directly with the body of the worker (direct lifting of goods).

Musculoskeletal disorder complaints (MSDs) are complaints on the part of the skeletal muscles that a person feels ranging from very mild to severe complaints [5]. The movement of goods is dominated by body movements which will put pressure on the nerves, blood vessels, and muscles in all parts of the body, especially the shoulders, neck, head, arms, wrists, and feet. The result can lead to musculoskeletal disorders in the body.

Therefore it is necessary to research to reduce musculoskeletal complaints using the Nordic Body Map method and to measure the work posture of workers ergonomically using the RULA and OWAS methods.

II. METHODOLOGY

The variables examined in this research are work posture and musculoskeletal complaints. Work posture was measured using the RULA (Rapid Upper Limb Assessment) method and the OWAS (Ovako Work Posture Analysis System) method. Musculoskeletal complaints are measured using the Nordic Body Map.

Musculoskeletal Disorders are one of the injuries that workers often experience in doing Manual Material Handling (MMH) activities, namely injuries to muscles, nerves, tendons, bones, bone joints, and cartilage caused by work activities. When a person works in a standing or sitting position, the movement of the spine, especially the waist is vulnerable to extreme movements that can cause injury [6].

RULA or Rapid Upper Limb Assessment was developed by Dr. Lynn McAttanmey and Dr. Nigel Corlett who investigates and evaluates the work position performed by the upper body. This equipment does not perform special equipment inproviding measurements of the posture of the neck, back, and upper body in line with muscle function and external loads supported by the body.The Ovako Working Posture Analysis System (OWAS) methodisamethod thatevaluates and analyzes uncomfortable work attitudes that result in musculoskeletalinjuries.

The working attitude part that was observed included the movement of body parts from the back, shoulders, hands, and feet. The results of the research show that the OWAS method is effective in assessing, evaluating, and analyzing work attitudes until categories and work method recommendations are obtained[7].

Here are (figure 1) the stages of the process to draw conclusions and suggestions.

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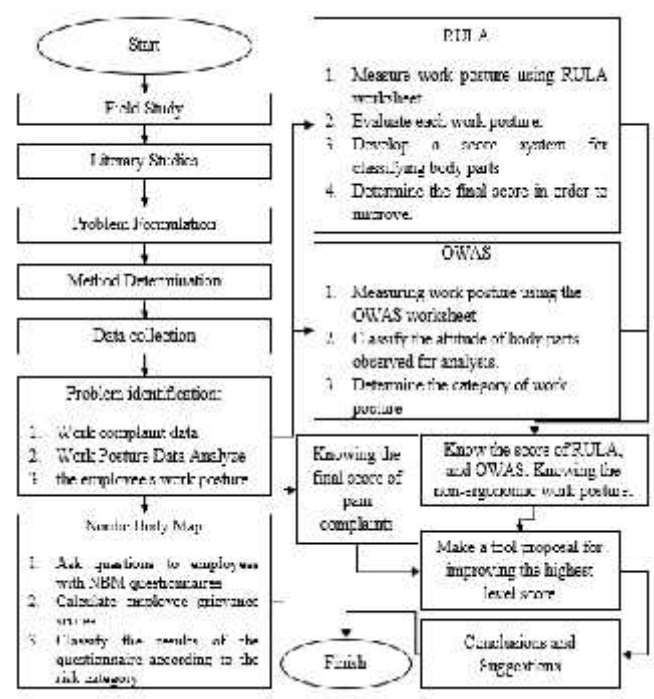

Figure 1. ResearchMethodology

III. RESULTANDDISCUSSION

Based on the interviews conducted with the employees, the data obtained was 1 person over 20 years old (25%), and 3 people over 40 years old (75%) with male sex. With the height of the average worker above 160 cm.

Based on observations and interview results at PT. AFS, shifts from workers are 9 hours and 6 hours. For the 6 hours, go to work from 06.00 - 12.00 WITA, and 10.00 - 16.00 WITA. Then for the 9 hours, it is from 08.00 - 17.00 WITA. The following of table 1 is the characteristics of the research subject:

Table 1. Subject Characteristic

Employee	Job Specification	Working Hours	Age	Length of Work	Height
1st Employee	Warehouse Coordinator	9 jam	41	16	170 cm
2nd Employee	Main Warehouse	6 jam	41	21	165 cm
3rd Employee	Cold Storage	6 jam	48	8	165 cm
Pekerja ke 4	Main Warehouse and Receiving	9 jam	24	2	171 cm

Figure 2 is a graph of pain complaints on the workers' bodies based on the Nordic Body Maps questionnaire:

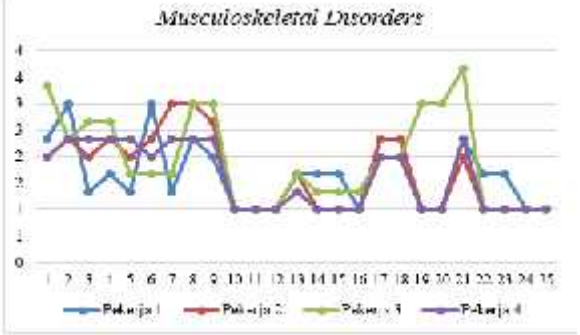

Figure 2. Result of Nordic Body Maps

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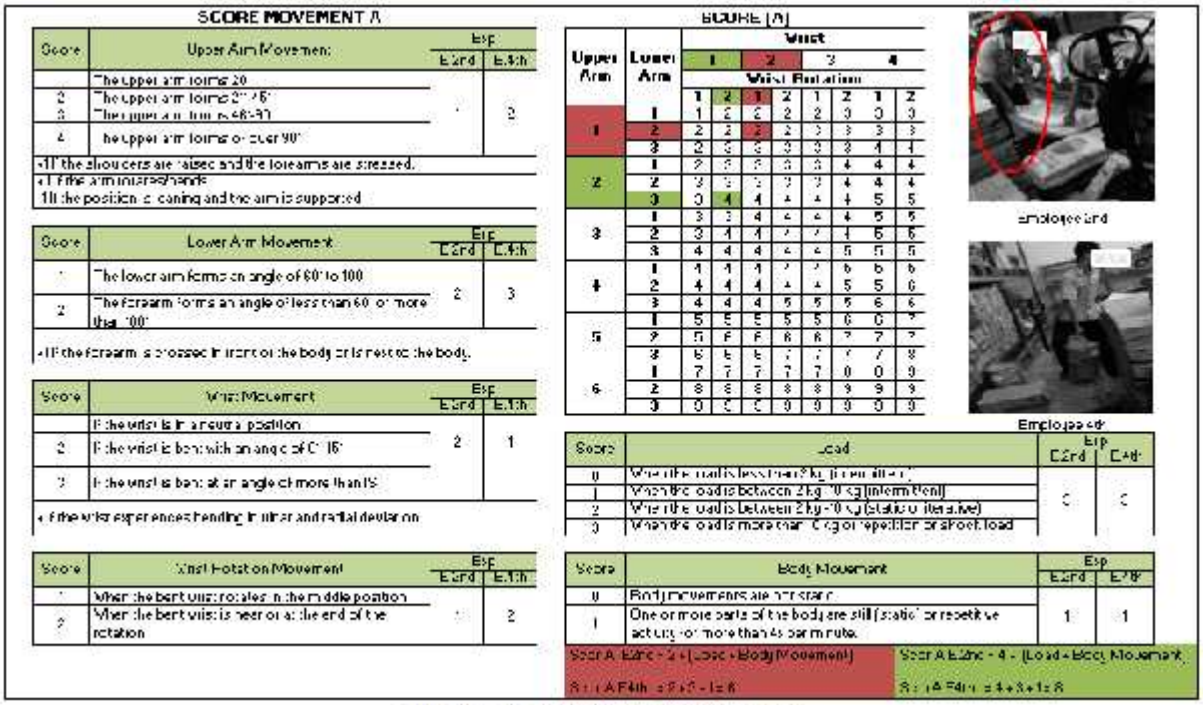

Figure 3. Score Movement A (RULA)

Description :

0	Pain in the upper neck
1	Stiffness in the lower neck
2	Stiffness in the left shoulder
3	Stiffness in the right shoulder
4	Stiffness in the left upper arm
5	Stiffness in the back
6	Stiffness in the right upper arm
7	Stiffness in the waist
8	Stiff in the ass
9	Stiff ass
10	Stiffness in the left elbow
11	Stiffness in the right elbow
12	Stiffness in the right forearm
13	Stiffness in the wrist of the left hand
14	Stiffness in the wrist of the right hand
15	Pain in the left hand
17	Pain in the right thigh
18	Pain in the left knee
19	Pain in the right knee
20	Pain in the right calf
21	Pain in the left ankle
22	Pain in the right ankle
23	Pain in the left leg
24	Pain in the right leg

The graphic aboveshows that the most problematic body part for the four workers is a

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pain in the lower neck and back for worker 1, and pain in the upper right arm, waist, and buttocks for the 2nd Employee. For 3rd employee, there is stiff pain in the neck upper part, stiffness in the left and right shoulders, waist, buttocks, and stiffness in the right calf. 3rd Employee is in charge of moving materials from receiving into the refrigerator room, as well as organizing the materials in the refrigerator room.

For the RULA and OWAS methods, postural analysis is performed only at the main warehouse. Therefore, the analyzed employees are 2 employees, namely the 2nd and 4themployees. The following Figure 3 is the result of data processing for the RULA method on Score A (upper body).

The following Figure 4 is the result of data processing for the RULA method on Score B (lowerbody) and the final RULA score.

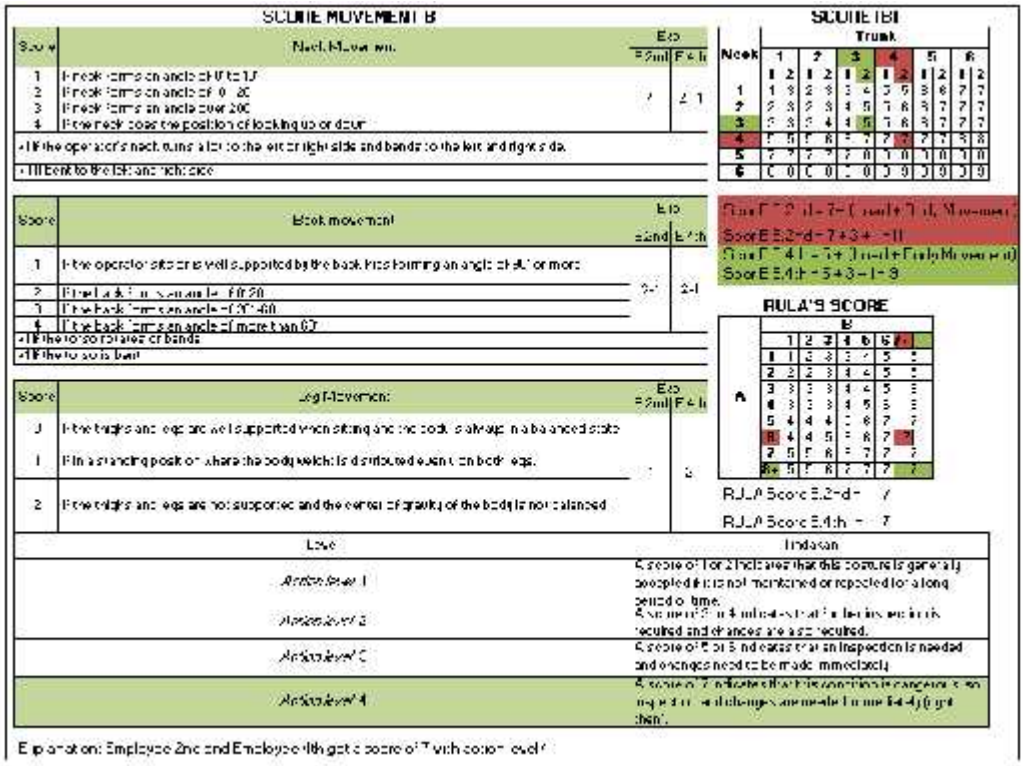

Figure 4. Score Movement B and RULA Score

And for the OWAS score can be seen in Figure 5 below.

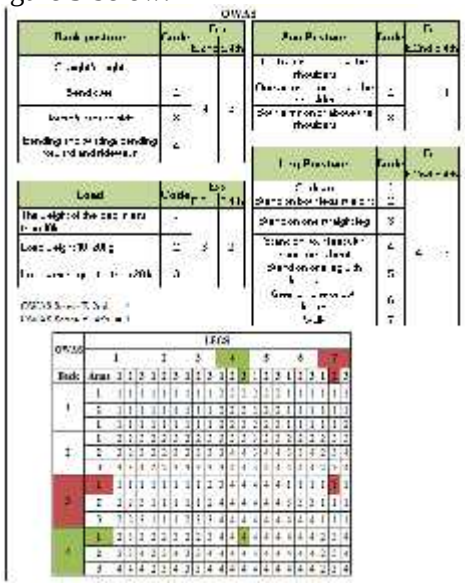

Figure 5. Ovako Work Posture Analysis SystemResult

The OWAS value of the 2nd employee is with a value of 4 andthe 4th employee with a value of 1.Thecategoriesof OWAS resultscan be seen in Table 2 below.

Table 2. Category of OWAS

Category	Description
1	In this system, problems in the musculoskeletal system do not need to be repaired.
2	There is little danger to the musculoskeletal system. Needs improvement in the future.
3	Dangerous for the musculoskeletal system. Need to fix as soon as possible.

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4	Very dangerous for the musculoskeletal system. Need to fix live/currently.

Ovako Work Posture Analysis System (OWAS) for the 2nd employee, shows category 4 (This attitude is very dangerous for the musculoskeletal system. Needs to be corrected immediately/currently) and for the 4th employee, shows Category 1 (in this system problems in the musculoskeletal system don't need to be fixed).The results of RULA and OWAS values can be seen in a recapitulation of Figure 6.

Figure 6. The Result of RULA and OWAS

When workers are standing while the standing elbow height[8].Meanwhile, according to the regulation of the Minister of Manpower, Transmigration and Cooperatives No. Per 01/MEN/1978 concerning Occupational Safety and Health, the maximum allowable lifting load for an adult male is 40 kg if the work is done occasionally, 15-18 kg if work is done continuously. Whereas for young male workers, it is 15 kg once in a while and 10-15 kg if the work is done continuously[9].

IV. CONCLUSION

The final Rapid Upper Body Limb Assessment (RULA) score for both workers was Score 7 (Action Level 4) which indicates that this condition is dangerous and requires immediate inspection and changes (on the spot). And the Ovako Work Posture Analysis System (OWAS) shows Category 4 (This attitude is very dangerous for the musculoskeletal system. Needs to be corrected immediately/currently) and Category 1 (in this system problems in the musculoskeletal system don't need to be fixed).

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Analysis of Clean Water Needs in Soya Village, Sirimau District, Ambon City By Using EPANET 2.2 Software

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Abstract **- Clean water is one of the basic human needs that is needed on an ongoing basis. The use of clean water is very important for household consumption, industrial needs and public places. Because of the importance of the need for clean water, it is only natural that the clean water sector is given top priority for handling because it involves the lives of many people. Fulfilling the need for clean water is highly dependent on the availability of clean water sources, which can be obtained from groundwater and surface water, which can be provided from rivers, springs, weirs and reservoirs/reservoirs. The method of collecting and analyzing the data used in this study was to conduct a survey at the research location to review and see directly the conditions of the research location, then create a piping system that is suitable for the research location, after that calculate population projections and calculate the appropriate water requirements for the project. piping system, and using EPANET 2.2 software to analyze the feasibility of the piping system based on population and water demand. Based on calculations and modeling using Epanet 2.2 software for the distribution of piping network systems in Soya Village, Sirimau District, Ambon City, several conclusions can be drawn, namely the need for clean water needed by the residents of Waisamu Village is 44.45 liters/second, with the total water requirement then modeling the distribution of the piping network system is made using Epanet 2.2 software, and the results obtained are Run Successful, which means the distribution of the piping system runs 100%.**

Keywords **: Water, Hydrolysis, Epanet, Feasibility.**

INTRODUCTION

Clean water is one of the basic human needs that is needed on an ongoing basis. The use of clean water is very important for household consumption, industrial needs and public places. Because of the importance of the need for clean water, it is only natural that the clean water sector is given top priority for handling because it involves the lives of many people. Fulfilling the need for clean water is highly dependent on the availability of clean water sources, which can be obtained from groundwater and surface water, which can be provided from rivers, springs, weirs and reservoirs/reservoirs.

Considering that clean water is an unlimited and sustainable need that must be fulfilled at any time, not only regarding sufficient discharge but in terms of quality it meets applicable standards and in quantity and continuity it must be able to meet the needs of the community it serves. However, in reality what is happening in several regions in Indonesia, the availability of clean water has not been able to meet the needs of the community, this is due to the distribution system that has not been maximized, coupled with population growth which is increasing every year.

Several programs from the Ministry of Public Works and Public Housing have been carried out to assist PDAM in covering areas that have not received clean water to the fullest. As is also the case in Maluku Province, there are several areas on Ambon Island that are still experiencing limitations in the provision of clean water in their villages. Soya Village, Sirimau District is one of the villages whose needs for clean water have not been met properly, even though there has been a clean water program from the Ministry of Labor. Public and public housing which have also entered Soya Village but in reality what has happened has not been sufficient for the daily needs of the people in

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Soya Village. The problem of clean water distribution is also affected by the increasing population that occurs in Soya Village every year, hence the need for a re-evaluation to obtain sufficient water needs for the next few years in Soya Village. And the author also proposes an alternative solution to this problem by using Epanet 2.0 software.

Research Problem

The problems in this paper are:

1. How much clean water do the people in Soya Village, Sirimau District, Ambon City need based on population growth in the next 10 years ?
2. Is the distribution of the piping system able to meet the needs of clean water in Soya Village, Sirimau sub-district, Ambon City ?

Research Objectives

This research has objectives to be achieved, which is:

1. Analyzing the amount of clean water needs in Soya Village, Sirimau sub-district, Ambon City for the next 10 years.
2. Analyzing the distribution of the piping system in Soya Village, Sirimau sub-district, Ambon City.

Research Benefit

This research is expected to provide the following benefits:

1. Can find out the amount of clean water needed in Soya Village, Sirimau District, Ambon City.
2. Can analyze the distribution of the piping system in Soya Village, Sirimau District, Ambon City.

II. LITERATURE REVIEW

A. Water Demand.

Water demand is the amount of water needed for household, industrial and other needs. The priority of water needs includes domestic, industrial, and public service water needs (Pramono & Andana, 2019). Water demand is the amount of water that is reasonably needed for basic human (domestic) activities and other activities that require water. The water requirement determines the size of the system and is determined based on water usage. It is difficult to formulate exact water use by each component (group per house connection), so in planning and calculations assumptions or

Approaches based on city categories are used as shown in Table 2.1. Need Water will be categorized into domestic and non-domestic water needs. Domestic water needs are water needs that are used for household needs, namely for drinking, cooking, bathing, washing clothes and other needs, while non-domestic water needs are used for commercial activities such as industry, offices, and social activities such as schools, hospitals, places of worship and commerce.

B. Terms of Clean Water

In planning a clean water distribution system, of course there are water requirements (Maksum, 2021). these are:

1. Quantity

   The quantity requirement in the supply of clean water is in terms of the amount of raw water available. This means that raw water can be used to meet regional needs and the number of people to be served.

2. Continuity

   Raw water for clean water must be taken continuously with relatively constant debit fluctuations, both during the dry and rainy seasons. Continuity can also mean that clean water must be available 24 hours per day, or whenever needed, water needs are available. However, these ideal conditions can hardly be met in every region in Indonesia, so as to determine the level of continuity water usage can be done by approaching consumer activities towards priority water use. The priority for water use is for a minimum of 12 hours per day, namely during the hours of life activities, namely at 06.00 – 18.00

C. Population Projection

According to the Regulation of the Minister of Home Affairs of the Republic of Indonesia Number 40 of 2012 Population Projection is a scientific calculation of the population in the future based on assumptions about the components of population growth at a

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certain level, the results of which will show the characteristics of the population, births, deaths and migration. Predictions of population in the future are based on the rate of urban development and trends, land use directions and the availability of land to accommodate population growth. It is necessary to know the prediction of the population in the 20-year planning period to determine the clean water needs of the planning area (Taptajani, 2020). By taking into account the rate of development of the population in the past, the statistical method is the closest method for estimating the population in the future.

D. Hydraulic Analysis.

Flow in a pipe or flow in which the entire pipe section is filled with water. If water flows in a pipe but there is a free water surface in the pipe, then the flow is not included in the definition of flow in a pipe (Bratawijaya, 2019).

1. Major Energy Loss

There are several empirical equations that are used each with its own advantages and disadvantages. The Darcy Weisbach equation is most widely used in fluid flow in general. For flows with relatively unchanged viscosity, the Hazen Williams equation is used. Darcy Weisbach's mathematical equation is:

$$Hf = f\,(L.v2 / D.2g)$$

2. Secondary Energy Loss

Local energy loss due to cross-section enlargement, cross-section reduction, diaphragms and pipe bends. Minor energy loss in mathematical language is written as follows:

$$hf = k\,(v2 / 2g)$$

E. Water Pressure Requirements.

According to the DPU (Department of Public Works) standards, water that is channeled to consumers through transmission pipes and distribution pipes is designed to be able to serve consumers to the furthest, with a drinking water pressure of 10mka or 1atm. This pressure figure must be maintained, ideally evenly distributed on each distribution pipe. If the pressure is too high, it will cause the pipe to burst and damage the plumbing tools. The pressure is also kept not too low, because if the pressure is too high (Khotibul, 2021).

1) Brocaptering (Spring Catcher Tub)

Protecting and capturing water from springs to be collected and channeled using transmission pipes to reservoirs.

2) Reservoir (Storage Tub) The function of the reservoir is:
3) As a reserve of clean water when there is damage or repair of the distribution network.
4) As a reserve to meet usage fluctuations.
5) Can function as a pressure relief tub.
6) As a water reserve for fire fighting.

The dimension of power depends on the service reservoir in general, ranging from 17.5% -20% of the average daily water demand. The greater the tamping capacity of the service reservoir, the safer the system is against system damage/repair and fire fighting.

F. Apply Epanet 2.0.

1.Introduction to EPANET 2.0 Software

EPANET is a computer program that provides hydraulic simulations and trends in the quality of water flowing in pipelines. The network itself consists of pipes, nodes (pipe connection points), pumps, valves, and water tanks or reservoirs. EPANET tracks the flow of water in each pipe, the condition of the water pressure at each point and the condition of the concentration of chemicals flowing in the pipe during the flow period. In addition, water age and source tracking can also be simulated (Safitri et al., 2021).

EPANET is designed as a tool to achieve and realize understanding of the movement and fate of drinking water content in distribution networks. Also can be used for various analysis of various distribution network applications. For example for designing, calibrating hydraulic models, residual chlorine analysis, and customer analysis. EPAnet can assist in setting strategies to realize water quality in a system. These include:
Rossman (2000), explains that Epanet is a computer program that describes hydraulic simulations and trends in the quality of water flowing in pipelines. The network itself consists of pipes, nodes (pipe connection points), pumps,

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valves, and water tanks or reservoirs. EPANET tracks the flow of water in each pipe, the condition of the water pressure at each point and the condition of the concentration of chemicals flowing in the pipe during the flow period. In addition, water age and source tracing can also be simulated.

Rossman (2000) also explained that EPANET was designed as a tool to reach and realize an understanding of the movement and fate of drinking water content in distribution networks. Also can be used for various analysis of various distribution network applications.

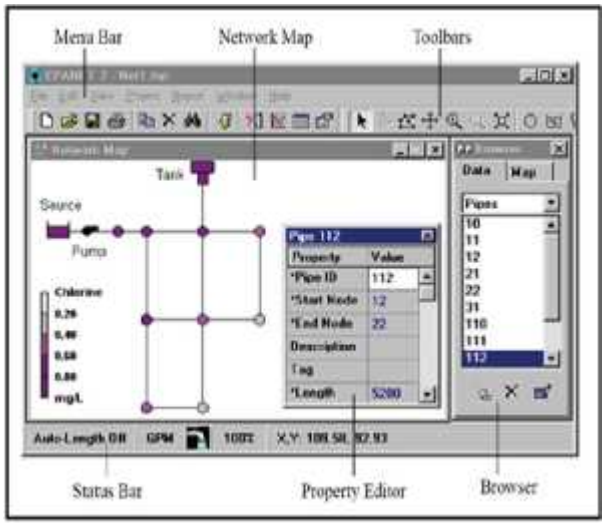

Figure 1. Appearance
(source : Epanet Application 2.0)

The use of software tools makes it easier to analyze the existing conditions of clean water pipelines so as to assist in restructuring existing clean water pipelines.

III. RESEARCH METHODOLGY

A. Data Analysis Techniques

Data analysis was carried out by utilizing methods obtained from literature studies. The steps taken are as follows:

Calculate population projection data for 10 years over the next 10 years.

1. Analyze the demand for clean water for the next 10 years.
2. Analyze piping data using Epanet 2.2 software.

B. Data Collection Techniques

The data collection method used for this purpose includes two parts, namely:

1. Primary Data

Observation, namely data collection by observing the research location directly. Data taken directly at the research location include data, Existing Pipes.

2. Secondary Data

Secondary data, namely data obtained at the village office in the form of population data for the last five years, village maps and other data that supports the research process.

Figure 2. Research Location Map (Source : Google Earth Pro)

IV. RESULTS AND DISCUSSION

A. Pipeline Network Map

Piping Network is a network map that carries water from a reservoir or reservoir to the service network. The following is a map of the pipeline network from Soya Village, Sirimau District, Ambon City

Figure 3. Pipeline Network Map of Soya Village with Background
(Source : EPANET 2.2 Software)

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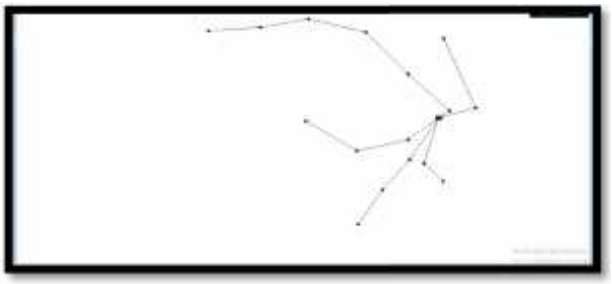

Figure 4. Pipeline Network Map of Soya Village Without Background
(Source : EPANET 2.2 Software)

B. Analysis of Water Needs

Analysis of clean water needs for the future using predetermined calculation standards. Water requirements for socio-economic facilities must be differentiated according to PDAM regulations and taking into account the production capacity of existing sources, level of leakage and service. The main factor in the water demand analysis is the population in the study area. To analyze projections for the following years, Arithmetic and Geometric methods can be used. From this projection, the amount of water demand from the domestic and non-domestic sectors is calculated based on the criteria of the 1996 Directorate General of Cipta Karya.

C. Population Projection

Population projections are scientific calculations based on assumptions about the components of the population growth rate, namely births, deaths and migration. The method used to calculate the projected population for the next 15 years uses the geometric method.

Table 1. Population Data for 2011 – 2021 (Source: Calculation Results)

No	Years	Total Population	Head of Population
1	2011	8049	1829
2	2012	8112	1844
3	2013	8175	1858
4	2014	8238	1872
5	2015	8301	1887
6	2016	8364	1901
7	2017	8427	1915
8	2018	8490	1930
9	2019	8553	1944
10	2020	8616	1958
11	2021	8679	1973

Table 2. Population Growth Projections for 2, 5 and 10 Years (Source: Calculation Results)

No.	Point	Population Projection Geometrik : Pn = Po.(1+r)^n			
		Years 2021	2 Years	5 Years	10 Years
1	MA - A5	3013	3135	3327	3673
2	MA - B1	2126	2212	2347	2592
3	MA - C2	1202	1251	1327	1465
4	MA - D2	1236	1286	1365	1507
5	MA - E1	1102	1147	1217	1343
6	Amount	8679	9030	9582	10580

Table 3. Population Calculation Projection for 10 Years of Soya Village for Each Pipeline and Node (Source: Calculation Results)

No	Pipeline	Node	Total population served (person)	Total population 10 year projection (person)
1	MA-A	A	103	126
2	A-A1	A1	145	177
3	A1-A2	A2	476	580
4	A2-A3	A3	586	714
5	A3-A4	A4	721	879
6	A4-A5	A5	982	1197
	ammount		**3013**	**3673**
7	MA-B	B	934	1139
8	B - B1	B1	1192	1453
	ammount		**2126**	**2592**
9	MA-C	C	26	32
10	C - C1	C1	331	403
11	C - C2	C2	845	1030
	ammount		**1202**	**1465**
12	MA-D	D	56	68
13	D - D1	D1	378	461
14	D - D2	D2	802	978
	ammount		**1236**	**1507**
15	MA-E	E	267	1139
16	E - E1	E1	835	1453
	ammount		**1102**	**2592**
	Total ammount		**8679**	**11828**

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D**.** Calculation of Water Needs

Water demand is the amount of water needed for household, industrial and other needs. Priority water needs include domestic water needs, industry, public services. Water demand is the amount of water that is reasonably needed for basic human (domestic) activities and other activities that require water. The water requirement determines the size of the system and is determined based on water usage.

In calculating the demand for domestic and non-domestic water, peak hour water demand, and the planned volume of the reservoir for the 10th year, you can see the calculation example below:

Table 4. Example of Calculation of Projected Needs for Clean Water in Soya Village for 10 Years

No	Uraian	Satuan	Tahun 2019	2 Tahun	5 Tahun	10 Tahun	Analisa Perhitungan		Kete
							Kode	Cara Hitung	
1	Jumlah penduduk	jiwa	8.679	9.030	9.582	10.580	1		rata2 kenaika
	Pelayanan penduduk	%	100	100	100	100	2		ijuklak 100%
		jiwa	8.679	9.030	9.582	10.580	3		
2	Pelayanan SR	%	90	100	100	100	4		ijuklak / surve
		jiwa	7.811	9.030	9.582	10.580	5	(5)= ((4)*(3))/100	
		jiwa/sb	5	5	5	5	6		ijuklak
		Jmlh. Sb	1.562	1.806	1.916	2.116	7	(7)= (5) / (6)	
	Pemakaian Air	Lt/org/hr	90	90	90	90	8		ijuklak
		Lt/sb/hr	450	450	450	450	9	(9)= (8) x (6)	
		Lt/det	8,14	9,41	9,98	11,02	10	(10)=(5)x(8)/86400	
3	Pelayanan KU / HU	%	10	-	-	-	11	(11)= 100 - (4)	
		jiwa	868	-	-	-	12	(12)=(11)/100*(3)	
		jiwa/HU	100	100	100	100	13		ijuklak
		Jmlh. HU	9	-	-	-	14	(14)=(12)/(13)	
	Pemakaian Air	Lt/org/hr	60	60	60	60	15		ijuklak
		Lt/HU/hr	6.000	6.000	6.000	6.000	16	(16)=(13)*(15)	
		Lt/det	0,60	-	-	-	17	(17)=(12)*(15)/86400	
4	Total Domestik	Lt/det	8,74	9,41	9,98	11,02	18	(18)=(10)+(17)	
5	Total Non Domestik	%	0	0	0	0	19		
		Lt/det	-	-	-	-	20		
6	Total Kebutuhan Air	Lt/det	8,74	9,41	9,98	11,02	21	(21)=(18) + (20)	
7	Kehilangan Air	%	20	20	20	20	22		ijuklak
		Lt/det	1,94	2,09	2,22	2,45	23	(23)=(21)*(22)/90	
8	Kebutuhan Air								
	- Rata-rata	Lt/det	10,68	11,50	12,20	13,47	24	(24)=(21)+ 23)	
	- Harian Puncak	Faktor	1,1	1,1	1,1	1,1	25		ijuklak
		Lt/det	11,75	12,65	13,42	14,82	26	(26)=(24)* (25)	
		M^3/hari	42,30	45,52	48,31	53,34	27	(27)=(26)x3600/1000	
		M^3/hari	1.015,15	1.092,59	1.159,46	1.280,14	28	(28)=(27)*24	
	- Jam Puncak	Faktor	1,5	1,5	1,5	1,5	29		ijuklak (minir
		Lt/det	16,02	17,24	18,30	20,20	30	(30)=(24)*(27)	
9	Kebutuhan Air Baku	Faktor	3,0	3,0	3,0	3,0	31		faktor keama
		Lt/det	35,25	37,94	40,26	44,45	32	(32)=(26)*(31)	Besarnya del
									3X kebutuha
10	Volume Resevoir	M^3	203,03	218,52	231,89	256,03	33	(30)=(0.2)*(28)	Minimum 20
									Kriteria peret

E. Network Modeling E – PANET 2.2

EPANET (Environmental Protection Agency Network) is a computer program (model) that performs hydraulic simulations and water quality behavior in a network of drinking water distribution pipelines (pressure pipes). A drinking water distribution network consists of pipes, nodes (branching pipes), pumps, water tanks or reservoirs and valves. The output generated from the EPANET program includes debit flowing in the pipe (lt/s), water pressure from each point/node/junction which can be used as an analysis in determining installation, pump and reservoir operations.

After the data is entered into the EPANET software, the following results are obtained :

Table 5. Network Table Nodes
(Sumber : Software EPANET 2.2)

Network Table - Nodes							
	Elev	BD	In Q	D	Head	Press	Q
Node ID	m	LPS		LPS	m	m	
Junc J1	144	0.13	0	0.13	154.9	0,479	0
Junc J2	141	1.19	0	1.19	154.85	0,601	0
Junc J3	141	0.03	0	0.03	154.95	0,608	0
Junc J4	140	0.07	0	0.07	154.92	0,647	0
Junc J5	138	0.28	0	0.28	154.96	0,733	0
Junc J6	142	0.18	0	0.18	154.51.00	12.51	0
Junc J7	137	0,042	0	0,042	154.12.00	17.12	0
Junc J8	135	0,051	0	0,051	153.86	0,810	0
Junc J9	132	0,064	0	0,064	153.73	0,926	0
Junc J10	128	1.25	0	1.25	153.68	25.68	0
Junc J11	135	1.51	0	1.51	154.75	0,844	0
Junc J12	138	0.42	0	0.42	154.88	0,728	0
Junc J13	135	1.07	0	1.07	154.84	0,85	0
Junc J14	138	0.48	0	0.48	154.87	0,727	0
Junc J15	137	1.02	0	1.02	154.84	0,767	0
Junc J16	135	0,060	0	0,060	154.95	0,858	0
Resvr MA	155	#N/A	0	- 10.76	155.00.00	0	0

From the results of the analysis of the distribution of the piping network using the EPANET 2.2 software, the result is that the distribution of the piping network gets 100% results.

V. CONCLUSION

The results of data analysis on the distribution of pipeline networks, the following conclusions can be drawn:

The need for clean water for the residents of Soya Village, Sirimau District, Ambon City for the next 10 years is 44.45 liters/second. The distribution of the piping system has been able to meet the needs of clean water in Soya Village, Sirimau District, Ambon City because it has met the water needs of the residents of Soya Village.

For the Government and residents in Soya Village, Sirimau District, Ambon City to pay attention to meeting water needs, and distribution of piping networks for Soya Village residents so that the distribution of water can be maximized, also always check the piping system to avoid the occurrence of factors that can affect the lack of distribution of water demand in the pipeline network.

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CRM (Customer Relationship Management) Effect on Increasing Customer Loyalty (Case Study: Bank X – Pasuruan Branch Officer)

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***Abstract*—This study analyzes the influence of Customer Relationship Management (CRM) Customer Loyalty on the State Savings Bank in Pasuruan. CRM is explained by identifying indicators, differentiation, interaction and customization. At the same time, the indicators are explained by loyalty, satisfaction, emotional ties, trust, behaviour, and history with the company. The analysis results show the effect of increasing CRM on the absolute loyalty of the State Savings Bank in Pasuruan. CRM influences 92.3%, and other factors outside the model influence 7.7%. The most influential factor interaction on height was 73%, followed by identification at 71.1%, Costumize factor at 61.58% and differentiation factor at 51.8%. The conclusion is that CRM, which is explained by these four factors, greatly influences fostering and increasing customer loyalty. Customers need special attention from bank management in making transactions to meet their needs and other services that can be accessed quickly and easily.**

Keywords*: *customer, relationship, management, loyalty, satisfaction

I. INTRODUCTION

The banking industry is currently experiencing changes in the business climate and very tight competition. The situation became even more complex after foreign banks competed for customers in the same market(Murtiningsih *et.al*, 2019). This condition then makes the company make various efforts to serve and fulfil the various needs of its customers related to the company's line of business(Hwang & Choi, 2020). Changing the company to be customer-focused (customer-centric) is one of the business strategies that can be developed to improve service and foster customer loyalty. This strategy is carried out through managing corporate (bank) relationships with customers or Customer Relationship Management (CRM). CRM is a strategy for identifying, attracting, and retaining the most valuable customers for a company(Kumar & Mokha, 2020). CRM concentrates on what customers value, not what the company wants to sell. The emergence of CRM as an alternative solution for managing customer relations is generally triggered by developments in the company's strategic environment(Farida & Jannah, 2022). CRM shows a company's efforts to concentrate on keeping customers (so they don't run to competitors) by collecting all forms of customer interaction, be it via telephone, email, input on the site or the results of conversations with sales and marketing staff, or in other words, CRM is a company's overall business strategy that allows the company to effectively manage relationships with customers(Saputra, 2019).

The application of CRM in establishing communication with customers is seen as very effective in providing services to its customers(Khan *et.al*, 2022). CRM will make it easier for companies to provide services according to customer needs and behaviour. Concerning the concept of CRM, the banking industry is competing to improve customer service by providing facilities that make it easier for these customers to carry out financial transactions(Kahokaew & Nurittamont, 2021). For example, providing convenience for transactions through e-Banking, SMS Banking, or searching for all information on bank products and services through bank features available on the internet. In this way, banks also have access and

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opportunities to acquire, care for, retain and develop customers. CRM can be a good way in the banking industry to ensure that the bank can attract new customers and existing customers will remain loyal(Mokha & Kumar, 2022). CRM can build close relationships between banks and their customers. CRM also helps control customer relationships and improves product and service offerings(Basalamah *et.al*, 2021).

Generally, the goal of any CRM strategy is to develop profitable relationships with customers (Mohamed *et.al*, 2022). This relationship combines business processes and technology to understand customers from various perspectives to differentiate the company's products and services competitively (Bhat *et.al*, 2016). With a good relationship, companies can detect what are the needs and expectations of customers so that, in the end, they become loyal to the company, are willing to become ambassadors to promote the company to other parties and become filters for negative issues launched by competitors (Hikam *et.al*, 2021). Loyalty is a customer's decision to voluntarily subscribe to a particular company for a long time. Loyalty will continue only as long as the customer feels he can receive better value than by switching to another service provider. Loyalty shapes customers' attitudes in determining their choice to continue using products or services from a company (Bank). The attitude of determining the choice is committing and repurchasing the company (Tao, 2014). Customer loyalty can guarantee the company's survival in the long term. Through a commitment to stay in-depth with the products/services that have been chosen by customers and to repurchase consistently in the future, it shows that loyal customers have relatively permanent long-term fanaticism for a product/service or a company that has become their choice.

CRM is a holistic process of identifying, attracting, differentiating and retaining customers by integrating the company's supply chain to create customer value at every value-creation step. MeanwhileCRM manages detailed information about each customer and carefully manages customer touch points to maximize customer loyalty(Hassan *et.al*, 2015). A customer touch point is any occasion where customers encounter brands and products ranging from experience to mass communication to casual observation(Setiawati *et.al*, 2019). CRM enables companies to provide superior customer service on demand by effectively using individual reporting information(Tseng & Wu, 2014). Based on knowledge of customer value, companies can align market offerings, services, programs, messages and media. CRM aims to develop profitable relationships and profitably create value for target customers by integrating internal processes and functions with all external networks(Ngoma *et.al*, 2020). CRM activities include four activities, namely identification, differentiation, interaction, and customize.

Identification is an introduction to customers and understanding that can be obtained through data which includes customer characteristics, responses to products and their attributes, and reasons for purchasing(Malik, 2015). Customer characteristics are data about customer habits, while the response to products and their attributes reflects the product, in ha! This includes the reasons for purchasing the product and the confidence level in guaranteeing safety in using the product(Lee *et.al*, 2018).

Differentiation is an activity of grouping customers based on customer value so that the company can determine the right policy according to customer needs(Aluri *et.al*, 2019). In this case, customer value is divided into four categories: emotional value, social value, quality/performance value, and price/value for money(Murtiningsih *et.al*, 2019). Emotional value is a utility that comes from feelings or affective or positive emotions that arise from consuming a product(Hikam *et.al*, 2021). Social value is a utility derived from the product's ability to enhance consumers' social self-concept(Mohamed *et.al*, 2022). Quality/performance value is the utility obtained from the product due to reducing short-term and long-term costs. Meanwhile, the Price/value of money is a utility obtained from the perception of the expected performance of a product or service(Basalamah *et.al*, 2021).

Interaction is an activity carried out by the company through customer role-switching activities from reactive to proactive. This role-switching process involves communicating

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and establishing good customer relationships through exchange processes and technology(Hassan *et.al*, 2015). The exchange process can be seen from the socialization of products to customers and the quantity and variety of products offered. At the same time, technology reflects the convenience of customers in accessing information about company products and activities, knowledge about company products and services and feedback between customers and companies(Farida & Jannah, 2022).

Customize is the company's ability or effort to adapt to customer habits based on individual needs and customer value(Ngoma *et.al*, 2020). This adaptation is usually done by providing multi-purpose products or partnering with other parties to maximize customer service.Based on the four activities in the CRM activities above, banking and other types of businesses have placed relationships with customers as important to maintain(Kumar & Mokha, 2020). The fluctuating conditions of the business world have made business people aware that business success is not limited to achieving profits. Customer loyalty is a very important factor for companies because loyalty is a continuous process for achieving company goals(Kahokaew & Nurittamont, 2021).

II. METHODS

This explanatory research examines the cause and effect between customer relationship management and increasing loyalty to the State Savings Bank (BTN) Pasuruan Branch. The population is all customers of the Pasuruan Branch of the State Savings Bank (BTN). A sample of 150 customers was taken from the existing population using a proportional cluster sampling technique. The use of this technique aims to represent all elements of the customer. The data obtained comes from primary data, namely through questionnaires distributed to customers and supported by interviews with bank management and observations of bank services received by customers. Answers from questionnaires given by customers are then tested for validity and reliability. After the data is declared valid and reliable, it will be analyzed using multiple regression analysis.

III. RESULT AND DISCUSSION

Based on testing the validity and reliability of the statement items, it is known that several items are invalid. This is shown in Table 1 below:

Table 1. Validity and Reliability Test

Variable	Indicators	Corrected Item Total Correlation	Status	Reliability Coefficients	Status
X_1	P_1	0,699	Valid	0,758	Reliable
	P_2	0,727	Valid		
	P_3	0,869	Valid		
	P_4	0,447	Valid		
	P_5	0,814	Valid		
	P_6	0,790	Valid		
	P_7	0,907	Valid	0,786	Reliable
X_2	P_8	0,043	Invalid		
	P_9	0,923	Valid		
	P_{10}	0,938	Valid	0,763	Reliable
	P_{11}	0,412	Valid		
	P_{12}	0,907	Valid		
	P_{13}	0,805	Valid		
	P_{14}	0,776	Valid		
X_3	P_{15}	0,473	Valid	0,733	Reliable
	P_{16}	0,585	Valid		
	P_{17}	0,305	Valid		
	P_{18}	0,068	Invalid		
	P_{19}	0,649	Valid	0,844	Reliable
X_4	P_{20}	0,722	Valid		
	P_{21}	0,653	Valid		
	P_{22}	0,606	Valid		
	P_{23}	0,805	Valid		
	P_{24}	0,530	Valid		
Y	P_{25}	0,901	Valid	0,891	Reliable
	P_{26}	0,876	Valid		
	P_{27}	0,850	Valid		
Critical Value for Validity (α5% two way test) ± 0.237					
Critical Value for Reliability			≥ 0.600		

Source: Processed Primary Data, Table r.

The test results show that of the 27 statements submitted, 2 items were declared invalid because of the Corrected Item-Total coefficient. Correlation is smaller than the critical value at α 5% two-way test. The statement items are P2 and P18. Invalid items were annulled and not included in further analysis to avoid errors. After that, the valid items were tested for reliability and declared reliable.

The next data analysis is to examine the effect of Customer Relationship Management

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(CRM) on Customer Loyalty by using multiple regression analysis as the model for this research analysis. Calculations use the SPSS for Windows 16 program, the results of which are shown in Table 2 below.

Table 2 The Results of the Regression Analysis

Variable	Unstandardized Coefficients (B)	t calculate	Sig.	Information
Constant	-4.134			
Identification (X_1)	0,711	8,316	0,000	Significant
Differentiation (X_2)	0,518	12,570	0,000	Significant
Interaction (X_3)	0,730	8,542	0,000	
Customize (X_4)	0,616	5,869	0,000	
R		0,961		
R Square		0,923		
Adjusted R Square		0,921		
F calculate		730,011		
Sig. F		0,000		

Source: Processed Data (2022)

Referring to the table above, CRM greatly influences (92.3%), increasing customer loyalty at the Pasuruan Branch of the State Savings Bank. At the same time, the remaining 7.7% is influenced by other factors outside the model. The interaction factor has the greatest influence at 73%, followed by the Identification factor at 71.1%, the Customize factor at 61.6% and the differentiation factor at 51.8%. These four factors have an important role in growing and increasing customer loyalty. Customers want special attention from bank management to meet their needs in transactions and other services that can be accessed quickly and easily.

The results of the analysis of the four CRM indicators, namely Identification, Differentiation, Interaction and Customization, show that: First, identification described by customer characteristic items and product response items and their attributes has a fairly high role in growing customer loyalty(Setiawati *et.al*, 2019). Bank management is required to recognize the characteristics of its customers through the provision of a complete database and knowledge of various customer habits in using banking services and products. Knowledge of customer responses to banking products and their attributes also plays a role in growing customer loyalty. This relates to the reasons customers use the product and confidence in the guarantee of safety when using the product. The lack of knowledge of bank management in identifying customers leads to errors in customer classification according to their respective segments and needs. This also has an impact on errors in determining company policy.

Second, the differentiation explained by items of emotional value, social value, quality value, and price value has an influence of 51.8% on customer loyalty. The customer shows the influence of these four values through the positive feelings that arise in the customer while using the product he chooses(Mokha & Kumar, 2022). The product chosen by the customer is also felt to increase social value concerning actualizing the customer's self-concept. With the use of these products, customers also acknowledge the existence of product quality in terms of use and cost efficiency in the short and long term. The application of competitive interest policies and low taxes is a way that is emphasized by customers(Hwang & Choi, 2020).

Third, the interaction explained by the exchange process and technology indicates a high contribution in increasing customer loyalty by 73%. The exchange process shows that product socialization is intensively carried out, and the quantity of implementation is important for customers in recognizing and understanding the value and quality of the products offered(Bhat *et.al*, 2016). Meanwhile, the technology that can be used to access the information needed by customers to enrich their knowledge of the products purchased has not received special attention from the bank's management. Customers still have difficulty accessing information, and bank management routines updating information on bank products and services are still very small. Limited access to information causes customers to sometimes not be aware of new programs that are being developed or products that have just been launched on the market. Interaction is important and is a big hope for customers who can bridge customer needs and the strategies that will be implemented by bank management(Aluri *et.al*, 2019). Bank management is also expected to be able to develop an integrated information system that can always be accessed by customers and present the latest information on banking products and services, as well as

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interaction forums that can convey complaints and customer expectations.

Fourth, customize has an effect of 61.6% on increasing customer loyalty. Customize is explained by how bank management adapts to customer habits and needs(Saputra, 2019). This relates to efforts to provide multi-purpose products such as ATMs that can have multiple functions, both in facilitating withdrawal transactions that can be made at cash machines and can also be used as a means of payment when shopping at supermarkets. The savings products offered can also be used as credit guarantees for customers. In addition, bank management has also partnered with the government and other banking industries so that the products sold are superior in quality and usage. Customers can make cash transactions at shared ATMs, Link and Maestro. In addition, cooperation is also carried out with other businesses so that the use of bank products in transactions becomes easier and more reliable. The inability of bank management to adapt to the habits and needs of customers and the lack of partnerships with other parties has resulted in customers tending to choose other banks to carry out their financial transactions.By taking into account the matters above, the management of the State Savings Bank needs to develop the right strategy for managing relationships with its customers.

IV. CONCLUSION

Based on the analysis and discussion above, it can be concluded that Customer Relationship Management (CRM) affects increasing customer loyalty to the State Savings Bank (BTN) Pasuruan Branch. This is explained by the interaction factor having the greatest influence, followed by the Costumize Identification factor and differentiation. These four factors have an absolute influence on increasing customer loyalty. However, BTN's management efforts in meeting customer needs are still far from expectations. BTN's management has not paid attention to the importance of CRM functions which are very influential on customer loyalty.

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Application of K-Means Clustering for Detection of Downy Mildew At Madura Corn Plant Using Digital Image Processing

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***Abstract*—The development and cultivation of corn are necessary in line with the increasing consumption of food ingredients and industrial needs, especially food products made from corn. In the development of maize in Indonesia, the main obstacle is the disturbance of Plant Pest Organisms (OPT), especially diseases, one of which is downy mildew. This disease can be identified by a change in color, so we need a way to find out the difference between the color of healthy leaves and the color of leaves that have changed due to downy mildew. One solution that can be used is image processing. Therefore this study aimed to detect downy mildew based on leaf color in corn plants based on digital image processing, to produce precise and objective results. The algorithm used is the K-Means Clustering algorithm. This study uses 50 images of training data and 25 images of test data. Based on the simulation of downy mildew disease identification using K-Means Clustering it achieves an accuracy rate of 85%.**

Keywords: **Madura Corn, Image Processing, Segmentation, K-Mean Clustering.**

I. INTRODUCTION

Corn is one of the superior products in Pamekasan Regency in the agricultural sector. The development and cultivation of this commodity are necessary in line with the increasing consumption of food ingredients and industrial needs, especially food products made from corn. demand for this commodity tends to increase yearly for public consumption and the food industry (Rahman, 2015). Corn is widely used as a feed source and can also be processed into various food products that have economic value such as corn flour, corn oil, and corn snack products (Hermawati, 2016).

Regional mapping to determine the productivity of corn commodities, in general, has been carried out by the research team, especially in Pamekasan Regency. However, production results that tend to fluctuate will certainly disrupt the supply of this commodity. One of the contributing factors is the presence of corn disease, resulting in various growth disturbances such as crop failure which is a direct loss for farmers and for business owners or SMEs whose business is engaged in the processing of corn-based foods.

A common disease of corn that attacks is downy mildew. The emergence of downy mildew in corn plants is due to the fungi Peronosclero spores maydis and P. spores javanica and P. spores philippinensis, which triggers leaf discoloration (Budhi et al., 2019).

When exposed to disease, there will be changes in certain areas, either in the form of color changes or the emergence of different leaf pattern patterns (Budhi et al., 2019). Common symptoms that can be observed are a change in the color of the leaves to yellow and on the underside of the leaves there is white layer of fungal spores (Purwanto et al., 2016). If it continues, it can make the cob change shape and content. On mature plants, there are brown streaks on old leaves. Another disease is leaf blight, which is caused by the fungus Helminthosporium turcicum with symptoms that appear as elongated and regular spots that are yellow and surrounded by a brown tint. The leaves will then turn yellowish brown to dark brown (Ulhaq & Masnilah, 2019).

Based on these problems, this research will detect downy mildew in corn plants by utilizing image processing to find out which leaves are healthy and not from the color changes they experience. Image processing uses the

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CIELab color space. The CIELab color space has been widely used in previous studies, including palm image recognition and image compression (Budhi et al., 2019), as well as image quality improvement based on luminance and saturation components (Giri et al., 2014).

The segmentation process to distinguish colors in the CIELab color space can utilize data mining techniques, namely K-Means which is often used for image segmentation (Zheng et al., 2018). K-Means is the most well-known clustering method and is widely used in various fields because it is simple, easy to implement, and has the ability to cluster large data. K-Means is a partitioning clustering method that separates data into different groups (Prasetyowati & Rofiq, 2016).

A digital image is defined as a two-dimensional image processing with a computer. The basic technology for creating and displaying color in digital images is based on research that color is a combination of three colors, namely red, green, and blue (Red, Green, Blue – RGB). Image segmentation is generally based on the nature of the discontinuity or similarity of the pixel intensity. The discontinuity approach is to partition the image when there is a sudden change in intensity (edge based). The similarity approach is to partition the image into regions that have certain characteristics in common (region-based) (Zheng et al., 2018).

In addition, the authors use K-Mean clustering which is a data mining method that performs the modeling process without supervision (unsupervised) and is one of the methods for grouping data with a partition system. The K-means method attempts to group existing data into several groups, where data in one group have the same characteristics as each other and have different characteristics from data in other groups. This method minimizes variation between data in a cluster and maximizes variation with data in other clusters (Prasetyowati et al, 2023; Lasena Y, 2020).

II. RESEARCH METHOD

This study uses two methods of collecting information and data including:

a. Observation, namely by observing directly, namely by looking at and taking the required data.

Figure 1:Diseased corn leaves

b. Interviews, this method is carried out by way of dialogue and discussion with Farmer Group sources and the Pamekasan Agricultural Service which handles Corn Plants.

Data processing will be divided into two stages, the first is the pre-processing stage, and the second is the processing stage. The output at the pre-processing stage functions to make input data for the second stage. In this system samples of input, BISI corn leaves are taken randomly, through the RGB to CIELab Color Transformation process. The steps to be able to identify downy mildew in bisi corn plants are:

1. Take a picture of a new corn leaf to be used as test data.
2. Enter test data in the form of an image of bisi corn leaves which will be compared with the corn leaf data which was used as the previous training data with a size of 200x200 pixels.
3. From the entered image, the a and b values will be obtained.
4. The results of the a and b values are segmented using K-Means, resulting in the average a and b values of each cluster.
5. The average cluster results will be compared with each data in the database using distance calculations.
6. The value of calculating the distance that is getting smaller indicates that the test image detected by downy mildew is close to the quality of the image in the training data.

Initial data processing begins with RGB (Red-Green-Blue) corn leaf image data, in this initial process there are two stages: 1) RGB image which will be converted to LAB, to simplify the intensity of the image color to facilitate and speed up computational calculations. After that the image will separate the L values (luminance or brightness level), A (green to red) and B (blue to yellow) in this process the L value is not used because it affects the value when shooting; 2) The images converted to the Lab are segmented. The segmentation results are calculated on average

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per cluster, then the Euclidean distance is calculated and matched into the dataset.

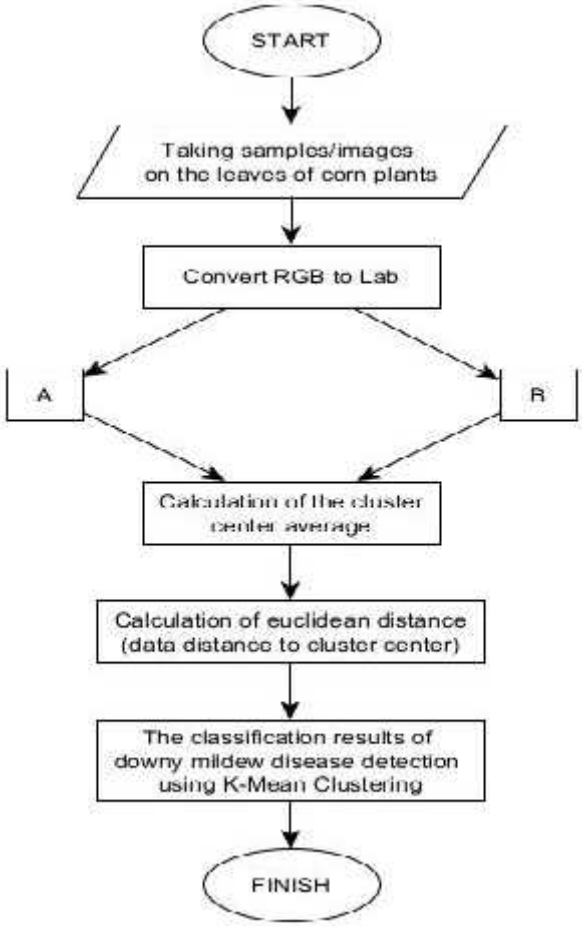

Figure 2:Image recognition process

III. RESULT AND DISCUSSION

The input data is a sample of BISI corn leaves. Where for the program in this study consisted of 25 samples of diseased corn leaves and 25 samples of leaves that were not diseased which would be used as dataset parameters. In this system samples of input, BISI corn leaves are taken randomly, through the RGB to CIELab Color Transformation process.

Before the segmentation process is carried out, the image is pre-processed. The first stage of the process is the Resizing process, which is changing the image size to 256 x 256 pixels. The resized image is then improved by enhancing the image quality by enhancing the contrast. The process of reducing the size of the image and improving the image is carried out to make the input data uniform because the convolution operation can only be performed on image data that has the same dimensions of length and width.

Figure 3: Resizing and enhancement process

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In this study, K-Means clustering is used to separate regions in an image based on differences in image color. The preprocessed image which was originally in the RGB color space is converted to the L*a*b color space and then clustered using the a and b components. The number of clusters used is 3. Cluster 1 is represented by a blue object, cluster 2 is colored cyan, and cluster 3 is colored yellow. Of the three clusters, 1 cluster is selected based on the ROI (Region of Interest) or a certain area/part of the desired image.

From the input image, features have to be extracted. In this case, texture extraction is used in this study. Texture is one of the characteristics that can be extracted from a digital image. Texture can be used as a feature that distinguishes one image from another. The method used is GLCM (Gray-Level Co-Occurrence Matrix). In this study, the extraction was carried out on images that had been segmented. The extracted GLCM features are Contrast, Correlation, Energy, and Homogeneity extracted. And by using the MATLAB statistics command, other properties/formulas are found, namely Mean Standard Deviation, Entropy, RMS, Variance, Smoothness, Kurtosis, Skewness, and IDM. Then the extracted data is used as training data which is entered into a data set to later be used to determine image classification.

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$$G-U = \begin{bmatrix} 149 & 235 & 149235 & 149 \\ 255 & 149 & 147147 & 150 \\ 149 & 235 & 235147 & 235 \\ 235 & 155 & 150150 & 155 \\ 255 & 155 & 147235 & 155 \end{bmatrix}$$

$$B-U = \begin{bmatrix} 150 & 150 & 155149 & 150 \\ 147 & 235 & 149235 & 147 \\ 235 & 147 & 155149 & 235 \\ 147 & 149 & 235155 & 150 \\ 235 & 235 & 147235 & 149 \end{bmatrix}$$

The calculation steps are:

1) Transform the RGB color space into XYZ color space

$$\begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix} = \begin{bmatrix} 0{,}412553 & 0{,}357580 & 0{,}180423 \\ 0{,}212671 & 0{,}715160 & 0{,}072169 \\ 0{,}019334 & 0{,}119193 & 0{,}950227 \end{bmatrix} \begin{bmatrix} R_1 \\ G_1 \\ B_1 \end{bmatrix} \begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix}$$

$$= \begin{bmatrix} 0{,}412553 & 0{,}357580 & 0{,}180423 \\ 0{,}212671 & 0{,}715160 & 0{,}072169 \\ 0{,}019334 & 0{,}119193 & 0{,}950227 \end{bmatrix} \begin{bmatrix} 147 \\ 149 \\ 150 \end{bmatrix}$$

$$X_1 = (0{,}412553 \times 147) + (0{,}357580 \times 149) + (0{,}180423 \times 150) = 140{,}9733$$

$$Y_1 = (0{,}212671 \times 147) + (0{,}715160 \times 149) + (0{,}072169 \times 150) = 148{,}6467$$

$$Z_1 = (0{,}019334 \times 147) + (0{,}119193 \times 149) + (0{,}950227 \times 150) = 163{,}1357$$

2) Determine the value L*,a*, and b*
ause$Y_1 = 148{,}6467 > 0 L^* = L_1 = 116(148{,}6467)^{\frac{1}{3}} - 16 = 598{,}4828$

Next, the calculation obtainsa^*

$$a^* = a_1 = 500(140{,}9733)^{\frac{1}{3}} - (148{,}6467)^{\frac{1}{3}} = 2602{,}2500$$

r get$b^*$is:$b^* = b_1 = 200(148{,}6467)^{\frac{1}{3}} - (163{,}1357)^{\frac{1}{3}} = 33{,}3611$

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This study, the values used are from the $L^*a^*b^*$, color space, namely the values of the a^*,andb^*color components only. The reason the L^* value or brightness value is not used is because the L^* value has no effect on the image segmentation process.

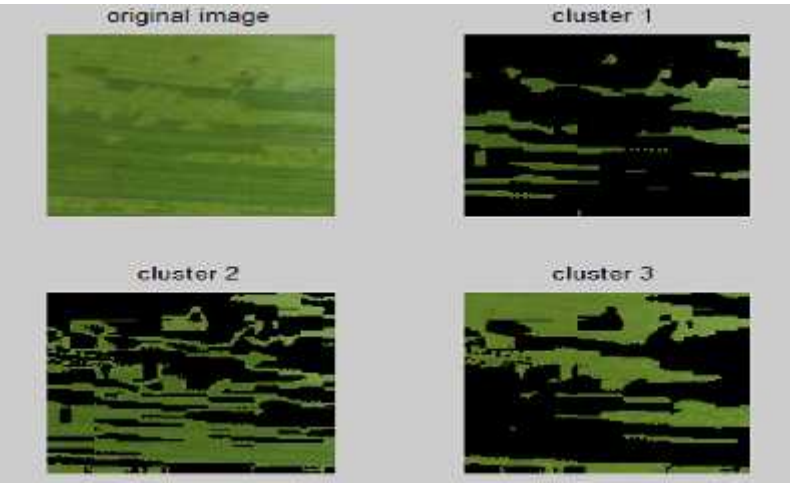

Figure 4:Analyzing process using K-Means

Next is the process of introducing test data which can be seen in the following table 1.

Table 1. Units for Magnetic Properties

Test image	Euclidean distance	Decision	Explanation
	0.191289	diseased	success
	0.190465	healty	success
	0.162174	diseased	success
	0.48225	diseased	success
	0,251525	healty	success
	0.263358	diseased	failed

The test aims to be able to evaluate the programs that have been implemented, especially to be a measure of the extent to which the program can detect corn leaf spot properly. Testing is carried out by measuring the accuracy of the image results from the program with manual images according to expert directions.

From the identification results, it was found that the success rate of the downy mildew disease identification program in corn plants using K-Means Clustering resulted in a total of 20 sample sheets of test data with a result of 85%.

IV. CONCLUSIONS

After testing the program and analyzing the simulation that has been made, the following conclusions can be drawn:

1. The results of program testing can be seen from the input type of corn leaf image, where the accuracy obtained reaches 85%.
2. The function of the K-Means algorithm here is as a clustering which plays a very, very important role in grouping data.

The suggestion for the development of this research is to create a system that does not only consist of color features, so that it can provide better accuracy in making decisions because of the many features involved. This is due to the many types of diseases in corn plants. In addition, it is necessary to add other data mining methods such as K-NN and SVM to support the grouping of images on leaves so that they have more precise accuracy.

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