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PREFACE

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Effect of Shear Strength of Oil on Lubrication of Cold Strip Rolling in Full-Fil Regime

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Abstract. Cold strip rolling is a major deformation process in industry. The need for high quality products and increased production speed, makes the application of the lubricant important. In the present study, oil property effect is investigated in cold rolling using oil lubricant in full-film lubrication regime. The model predicts decisive role of oil property in rolling parameters.

Keywords : cold rolling, shear strength, non-newtonian fluid

1. INTRODUCTION

Cold strip rolling has been one of the most used metal deformation methods for production of metal sheets which has widespread application in most industries. There is always a need to make this process optimized in order to make it cost efficient and increase the final product quality. Cold strip rolling consists of several thickness reduction passes to make the final plate with desirable thickness. Fig. 1 shows the schematic illustration of cold rolling with 4 stands of reduction [1].

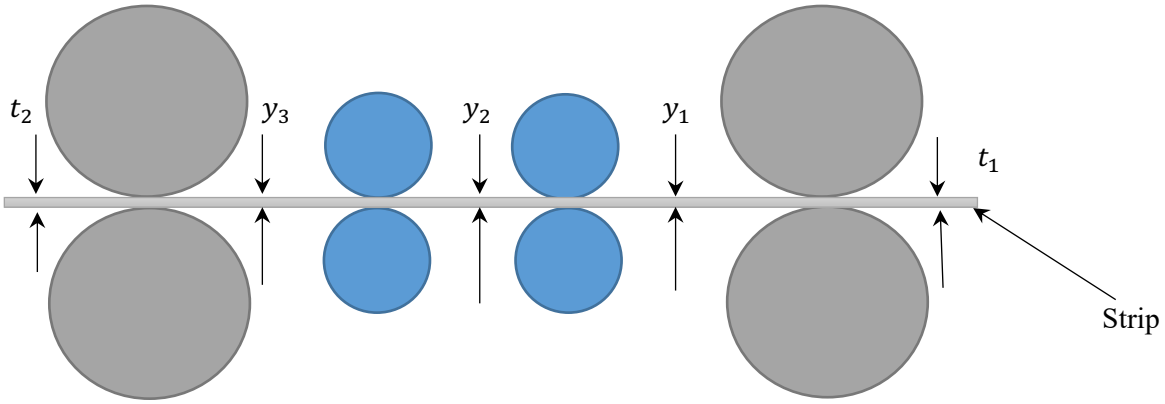

Figure 1. Schematic of a 4 stand tandem mill of lubricate cold rolling

Wilson et. al. [2] developed one of the earliest models for cold strip rolling followed by Yuen et. al.[3] who considered mixed lubrication in their model.

In recent years, cold strip rolling with emulsion has been subject of study. Hajshirmohammadi et. al.[4] developed a model for cold strip rolling with oil and water emulsion.

Recently porous material are being used in the rolling lubrication [5].

For the purpose of reduction in energy consumption, oil is sprayed on the contact line of rolls and strips. Depending on the rolling speed and normal force applied on the rolls, different lubrication regimes prevails. If a thick layer of oil forms between the rolls and the strips, the regime of lubrication would be full-film. This regime is more common in high speed rolling or rolling with high viscosity lubricants. Fig. 2 shows this type of lubrication regime.

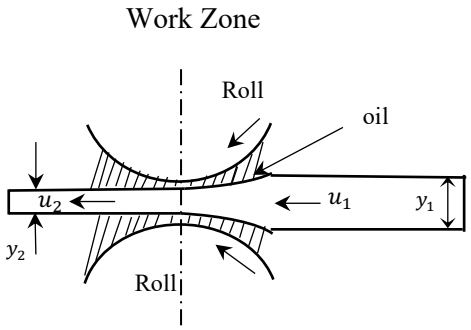

Figure 2. strip rolling in full-film regime

It can be seen in Fig. 2 that the strip goes under the rolls with the initial thickness of y1 and speed u1 and after reduction, thickness is y2 and the strip speed is u2. As it is depicted, the oil forms as a barrier between the rolls and the strip. The thickness of this layer of oil decides on the properties including the friction and consequently torque on needed to be applied on the rolls. This film thickness is affected by both rolling properties and the oil characteristics. The following model is used to study the oil viscosity effect on the properties of rolling.

2. METHODS

2.1 Strip plastic behavior

Plastic deformation in the work zone under the rolls is the reason for thickness reduction. To model the plastic respond of the strip, an element of the plate in the direction of rolling is isolated under the rolls as it is shown in Fig. 3.

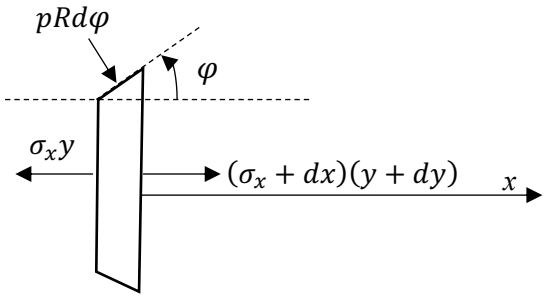

Figure. 3. An element of strip and the stresses acting on it

The strip element is subjected under back and forward tensions as shown by σ_x in Fig. 3. The equilibrium of the forces on the element is given by Eq. 1.

$$(\sigma_x + d\sigma_x)(y + dy) - \sigma_x y - 2\tau \cos\varphi \, Rd\varphi + 2p \sin\varphi \, Rd\varphi = 0 \quad (1)$$

where p is pressure on the strip, τ denotes the shear stress, the normal stress on the strip is given by σ_x and R. is the rolls radius.

$$ydx + \sigma_x dy - 2\tau dx + pdy \quad (2)$$

If the force equilibrium is considered in y direction the results would be:

$$-\sigma_z dx - (p \cos\varphi + \tau \sin\varphi) Rd\varphi \quad (3)$$

In which σ_z is the vertical stress. Because $Rd\varphi \cos\varphi = dx$, Eq. 3 will be in the following form.

$$p + \tau \tan \varphi = -\sigma_z \quad (4)$$

For most cases of rolling the angle of plastic zone is small which means $\tan \varphi \cong 0$ thus $p = -\sigma_z$
Using von Mises criterion leads to the following relation.

$$\sigma_x - \sigma_z = \sigma_k \quad (5)$$

The final relation used for quantifying plastic behavior will be as:

$$\sigma_k \frac{dy}{dx} + y \frac{d(\sigma_k - p)}{dx} - 2\tau = 0 \quad (6)$$

2.2. Shear stress

In the case of full-film lubrication, the shear force between the rolls and the strip is only due to the viscosity of the oil. This means that there is no direct contact between the two metal surfaces [6].
The relation between the shear stress and speed gradient in a Newtonian fluid is linear and described as:

$$\tau = \frac{\mu(u_r - u_w)}{h} \quad (7)$$

In this relation, u_r and u_w represent the roll and work piece velocity and h is the film thickness between the roll and strip. Plastic flow rule is used to make a relation between the inlet and outlet thickness and velocity of the strip. This is given by the following equation.

$$u_w y = u_{w1} y_1 = u_{w2} y_2 \quad (8)$$

The index 1 and 2 in the last relation denote the inlet and outlet.

2.3. Oil condition in the inlet and outlet

To solve the relation of oil lubrication, this is needed to find the oil pressure in the inlet and outlet.
The assumption is that oil pressure increases from the ambient pressure to the what is imposed on it in the work zone. This means that the pressure is zero in the inlet. If the elastic deformation of the strip is neglected in the outlet, the pressure of the oil will be zero in the outlet as well.

$$x = x_1 \qquad p = \sigma_y - s_1 \quad (10)$$

$$x = 0 \qquad p = \sigma_y - s_2 \quad (11)$$

2.4. Viscosity-pressure relation

Oil viscosity is directly related to its pressure. This means that shear force of oil and consequently the rolling parameters are largely affected by the oil pressure. Specially in cold rolling, due to this fact that oil pressure increases rapidly from zero to a considerable value under rolls, it is needed to consider the viscosity as the function of the oil pressure. In this regard, several empirical relations have been proposed. One of the most well-known relations was given by Baruse.

$$\eta = \eta_0 e^{\alpha p} \quad (12)$$

The pressure coefficient is shown by α and η_0 is the oil viscosity in ambient condition.
Another relation which is widely used is the Roeland's equation.

$$\eta(p,T) = \eta_0 \exp\left((\ln(\eta_0) + 9.67) \left\{ \left(1 + \frac{p}{p_r}\right)^z - 1 \right\} \right) \quad (13)$$

in this relation, p_r is a constant given as 1.963×108 and z stands for the viscosity-pressure power that has the following relation with α as:

$$\alpha = z \left[\frac{1}{p_r} (\ln \eta_0 + 9.67) \right] \quad (14)$$

The other important property of the lubricant is its shear strength (τ_{max}). Shear strength is the maximum shear stress that a fluid can stand. This means that any higher velocity gradient cannot produce a higher shear stress in the oil

after it reaches its strength.

2.5 Numerical Procedure

A MATLAB code is written to solve the equations of lubrication and plasticity of the strips. The procedure of solution is comprised of several steps to find the pressure distribution of oil as a function of location I the work zone under the rolls. In each step, the boundary conditions are satisfied for plastic flow of strip and the oil pressure in both inlet and outlet of the work zone. Fig. 4 shows the flow-chart of the solution. One dimensional differential equation of lubricant is solved by applying shooting method and Runge-Kutta approach.

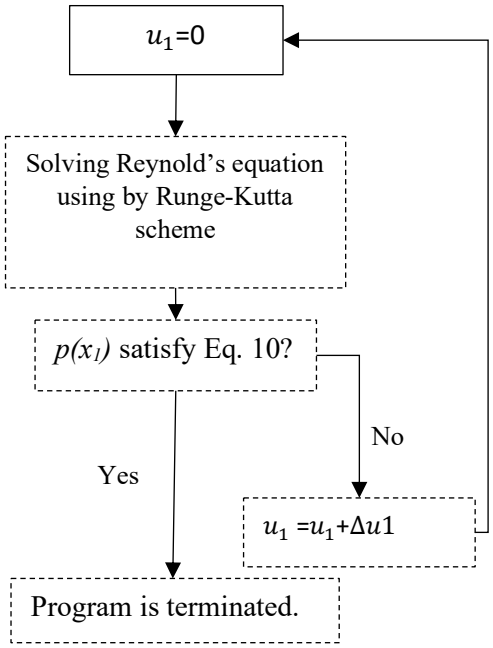

Figure 4. Numerical procedure flow chart for full-film regime.

3. RESULTS AND DISCUSSION

Fig. 6 shows the present study solution for rolling parameters listed in Table.1

Table 1. Rolling parameters used for simulation of cold rolling

Parameter	η_0 (mm)	α(1/Pa)	R(mm)	σ_y(MPa)	y_1(mm)	y_2(mm)
Value	0.02	6.2e-8	0.126	97.75	1	0.8

The maximum pressure in Fig. 6 corresponds to the neutral point where the roll speed is equal to the strip speed. Before this point, the rolls circumferential speed is more than the trip speed. After the neutral point, the rolls speed is lower than the strip's. This notion is seen in the shear stress plot of Fig. 6 which shows that at the neutral point the sign of shear stress changes due to change of sign of relative speed.

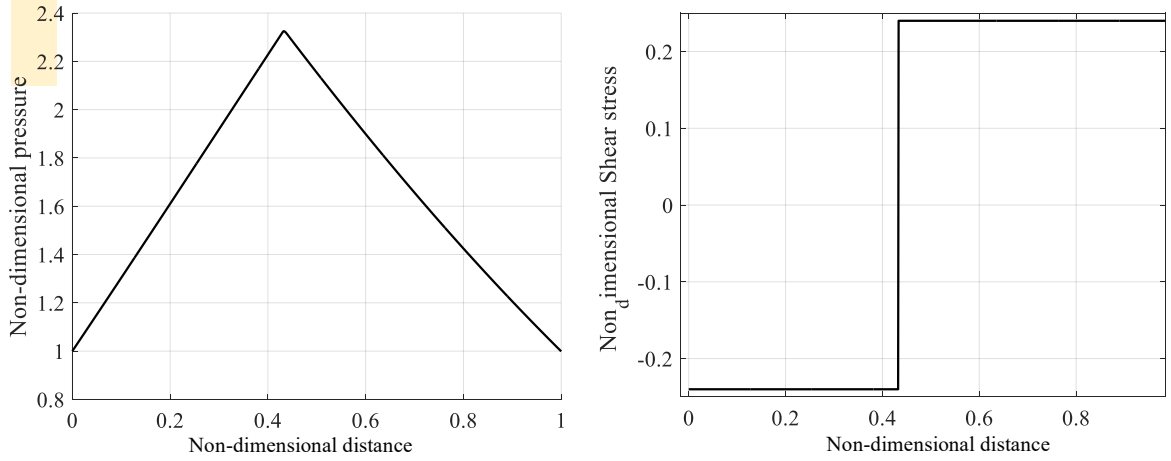

Figure 5. Non dimensional pressure and shear stress in the work zone.

Fig. 6 shows the rolling force and rolling torque for different shear strengths.

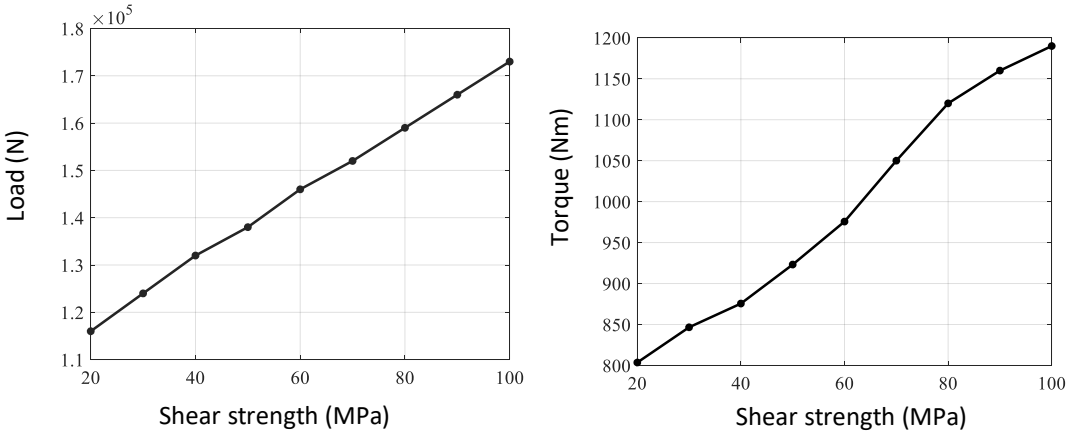

Figure 6. Rolling load and torque in different shear strengths of oil as lubricant.

It is seen that the rolling load and torque is directly affected by lubricant shear strength.

4. CONCLUSION

Effect of shear strength on cold rolling in hydrodynamic full-film regimes is investigated. The solution shows a direct relation between Load and torque needed for rolling. The reduction in torque is favorable for energy efficiency of cold rolling stands.

5. NOMENCLATURE

x	coordinate along the rolling direction	σ_y	yield stress
x_1	Roll contact length	τ	Shear stress

u_{w1}	Strip speed in the inlet	u_{w2}	Strip speed in the outlet
u_w	work-piece inlet speed	c	adhesion coefficient
u_r	roll speed	R	roll radius
y_1	Strip thickness in the inlet	η	(dynamic) viscosity of oil
y_2	Strip thickness in the outlet	S	non-dimensional roll speed $S = \frac{r\alpha\eta_0(u_r + u_{w1})}{\sigma_0 R_q x_1}$
h	surface separation	η_0	oil viscosity at ambient temperature.
α	viscosity pressure coefficient	E	Elastic modulus
p	interface pressure	s_1	backward tension
y, y_1, y_2	inlet, Exit and local strip thickness	s_2	forward tension

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FUEL CONSUMPTION ANALYSIS OF INJECTION SYSTEM AND CARBURETOR SYSTEM ON HONDA BEAT FI 2013

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Abstract. An injection system is a process of burning fuel on an internal combustion engine by using an electronic system to inject fuel with air into the combustion chamber. The carburetor system uses a nozzle to blur the fuel mixture with the combustor air. The purpose of this study was to determine differences in the value of fuel consumption from the injection system with the carburetor system. This research was conducted by the experimental method. Research methods at least describe the approaches used in research, population and research samples, explain the operational definition of variables along with data measurement tools or how to collect data, and data analysis methods. If the data measurement tool uses a questionnaire, it is necessary to include the results of the validity and reliability of the research instrument. The results of the analysis showed that the average value of fuel consumption even with the injection system was 51.53ml, while the mean value of the carburetor system was 90.40 ml, this meant that the injection system was more efficient compared to the carburetor system of 44.89 ml or 47%. Conclusion injection system at any rotation is more economical than the carburetor system. It is recommended to conduct further research by taking real data that is distance and travel time.

Keywords: fuel consumption, injection system, carburetor system

1. INTRODUCTION

The development of technology in the field of automation is currently very rapid, one of the things that is widely used by the public is the motorcycle. Motorbikes are used as a means of transportation. Fuel combustion on a motorcycle both injection system and carburetor system can both produce pure gas [1]. In a two-wheeled vehicle, a component that serves as a place for combustion or a mixture of air and fuel is the carburetor [2]. The injection system on gasoline motors or often called injection motors functions to mix fuel and air in the intake manifold [3].

There are two kinds of suppliers of air and fuel mixture in a gasoline motor namely injection system and carburetor system. Please note that the carburetor system with the injection system has a completely different working principle. Carburetor is a device that mixes air and fuel for internal combustion engines [4]. Can be shown in Figure 1.

Figure 1. Carburetor System

While the injection system is a technology used in an internal combustion engine to mix fuel and air before burning, shown in Figure 2.

Figure 2. Injection System

The advantages and disadvantages of the injection system and carburetor system. The advantages of the injection system are as follows; The mixture of air and fuel is always accurate (ideal ratio on engine speed, pull is more responsive, the engine is easily started without being affected by changes in weather conditions, and environment friendly. Lack of injection system as follow; maintenance must be in a special workshop, the price of spare parts is more expensive, more sensitive to the quality of the fuel, and the electrical system is very complicated [3] The advantages of the carburetor system are as follows: cheaper compared to the injection system, the number of components is less, maintenance is easier and simple. The disadvantages of the carburetor system are as follows; done manually and can only be done once, requires more precise adjustments for all conditions, cannot cope with every different rotation condition, it needs additional components so that the carburetor works to adjust conditions such as an acceleration pump [4].

At present the carburetor system technology has arguably been abandoned by automotive manufacturers, especially motorcycles, while the injection system that is applied to motorcycle engines today is quite modern. But in fact, this relatively modern injection system cannot yet be fully understood by some people or motorbike users the value of fuel consumption between the injection system and the carburetor system. Based on these problems, researchers are interested in discussing "Analysis of Fuel Consumption Against the Injection System and Carburetor System on Beat Motorcycles in 2013. In an effort to overcome the problems that arise or are poorly understood injection systems by motorcycle motor users, especially beat 2013 motorcycle users. this needs to be explained experimentally through research.

The objectives in this study can be divided into two types: (1) The general objective to be achieved in this study is to determine the value of fuel consumption in the injection system and carburetor system, (2) The specific objectives to be achieved in this study are as follows: (a) Knowing how much the value of fuel consumption with the injection system at 2000, 2500 3000, 3500, and 4000 rpm rotation variations, (b) Knowing how much the carburetor system fuel consumption values in the 2000, 2500, 3000, 3500, and 4000 rpm rotation variations (c) Knowing how big is the difference in fuel consumption value between the injection system and the carburetor system in 2000, 2500, 3000, 3500, and 4000 rpm rotation variations.

The benefits in this study can be divided into two types: theoretical benefits and practical benefits. Theoretical benefit are: (a) the results of this study are expected to contribute thoughts in the development of science and technology related to automotive, (b) the results of this study are expected to be used as a reference by other researchers in conducting similar studies. (c) the results of this study are expected to be used as a reference in determining the fuel supply system to the combustion chamber. Practical benefits are: (a) useful for motorcycle users to change the fuel supply system to be more efficient, (b) the results of this study can be used as a reference in choosing a fuel supply system, whether using an injection system or using a carburetor

system, (c) useful for readers to increase knowledge about the injection system and the carburetor system, can find out the fuel consumption on the beat motorcycle 2013, from both types of systems.

Based on the description of the background, objectives and benefits above, this research is deemed necessary.

2. METHODS

2.1 Type of Research

This type of research is a research experiment. Research experiment is a study in which there is a treatment of the research object. Research experiments can elucidate explanations about "reasons why". Cause and effect relationships can be known because this study is possible to treat the research object [5].

2.2 Research Location and Time

The place to collect data on the 2013 Honda beat FI motorcycle is at the Global Motor workshop, Taman Griya, South Kuta, Badung. The time of delivery is in January 2020.

2.3 Data Sources

Primary data is data obtained by conducting experiments, then the results are tabulated. Secondary data is data obtained from library studies that are related to the research conducted.

2.4 Research Instruments

Some instruments or tools used in this research process include:

1. Tachometer. Tachometer is used to measure engine speed (rpm). Tachometer is used by directing the laser beam to the rotating machine component parts.
2. Thermometer. A thermometer is used to measure the temperature of the machine before testing. Thermometer is used by attaching the thermometer cable to the engine block being tested.
3. Measuring cup. Measuring cup is used to measure fuel consumption (ml). You do this by looking at the lines on the measuring cup.
4. Stopwatch. Stopwatch is used to measure fuel consumption time.

2.5 Research Procedure

The procedure in this study is as follows:

1. Survey and preparation of tools
2. Retrieval of data

The steps in taking the fuel consumption testing data on the injection system and carburetor are as follows:

a. Prepare the tools used and the ingredients.
b. Place the tools and materials in a clean place.
c. Open the front cover of the engine.
d. Open and release the saddle and trunk parts for comfortable and free data collection.
e. Remove the fan cover on the engine magnet to easily censor the magnet by using a tachometer to find out the rpm.
f. Empty the fuel tank to be completely empty.
g. Fill the measuring cup with Pertamax 200 ml and pour the fuel tank.
h. Start the engine according to rpm 2000, 2500, 3000, 3500, and 4000 rpm.
i. Prepare a stopwatch, with 10 minutes per rpm, with 200 ml of fuel.
j. Data retrieval is carried out three times for each rpm, in order to get maximum results.
k. Make a note of the results of these tests, and tabulated.

2.6 Data Analysis

The data that has been obtained is then processed and analyzed by conducting tests to determine the amount of fuel consumption with the injection system and the carburetor system.

3. RESULTS AND DISCUSSION

From the tests conducted, obtained test data for each of the conditions tested. The conditions of testing carried out include: Fuel consumption by injection system and fuel consumption by the carburetor system, each carried out three times the test.

3.1 Data Testing

Measurement data on fuel consumption by injection system and carburetor system which have been averaged, then used to calculate the magnitude of the differences of the two systems, shown in the table.

Table 1. Fuel Consumption in the Injection System

Engine Speed (rpm)	Fuel (ml)	Time (minute)	Test Results (ml)			Average (ml)
			1	2	3	
2000	200	10	40	40,5	40,5	40,33
2500	200	10	45,5	45,5	40,5	43,83
3000	200	10	50	55	50,5	51,83
3500	200	10	55,5	60,5	60,5	58,83
4000	200	10	60,5	65	63,5	62.83
					Average	51,53

Table 1 shows that the tests were carried out with rotation variations of 2000, 25000, 3000, 35000, and 4000 rpm, with 200 ml of fuel and a time of 10 minutes, with the average value of fuel consumption with the injection system being 51.56 ml.

Table 2. Fuel Consumption in the Carburetor System

Engine Speed (rpm)	Fuel (ml)	Time (minute)	Test Results (ml)			Average (ml)
			1	2	3	
2000	200	10	80	75	75	77
2500	200	10	85	85	80	83
3000	200	10	95	100	95	97
3500	200	10	105	110	105	107
4000	200	10	120	115	120	118
Average						96,40

Table 2 shows the tests carried out with variations of the rotation of 2000, 25000, 3000, 35000, and 4000 rpm, with 200 ml of fuel and a time of 10 minutes, with the average value of fuel consumption with the carburetor system is 96 ml.

Table 3. Average Fuel Consumption in the Injection System and Carburetor System

Engine Speed (Rpm)	Average Fuel Consumption Results (ml)		The mean difference (ml)
	Injection System	Carburetor System	
2000	40,33	77	36,67
2500	43,83	83	39,17
3000	51,83	97	45,17
3500	58,83	107	48,17
4000	62,83	118	55.17
Average	51,53	96,40	44,87

Table 3 shows that the average value of fuel consumption with the injection system is 51.53 ml, while the average value of fuel consumption with a carburetor system is 96.40 ml, there is a difference in the value of fuel consumption by 44.87 ml, or by 47%. Means that the use of the fuel system with an injection system on a 2013 beat motorcycle is more economical compared to a carburetor system.

3.2 Discussion

Subjects in this study were 2013 beat FI motorcycles, OHC 4-stroke engine type, 110 cc stroke volume, 9.2: 1 compression ratio, 3.7 liter fuel tank capacity, premium fuel [6].

In the test data the results of data calculations showed that there was a difference in the value of fuel consumption between the injection systems by 51.53 ml, whereas with a carburetor system of 96.40 ml, the difference was equal to 44.87 ml or 47%. Means that the use of the fuel system with an injection system on a beat motorcycle in 2013 is more economical than the carburetor system.

The injection system is more economical, because the injection system is more economical, because the injection system is equipped with an electronic system that functions to regulate the injection work system, namely the ECM (electronic control module) which has standardized controls and controls from the manufacturer. This ECM can automatically control the amount of fuel and air mixture that fits in certain engine speed conditions [3]. In the injection motor system there is also air control, this sensor helps ECM to circulate the right AFR (air-fuel ratio) according to the ideal mixture of fuel and air which is 14.5: 1 or 14.5 grams of air versus 1 gram of material burn [3].

In the carburetor system the results of the calculation of data are more wasteful, because in the carburetor system mixing fuel and air still experience many processes in the carburetor, unlike the injection system which directly sprays a mixture of material and air into the combustion chamber. In the carburetor system the mixture of fuel and air that will enter the combustion chamber depends on the piston stroke [7]. In the carburetor system an optimal setting is needed so that the fuel mixture burns completely and is not wasted which causes wasteful fuel consumption and poor exhaust emissions [4].

4. CONCLUSION

Based on the results of the changes made, it can be concluded that with the injection system the average value of fuel consumption is 51.53 ml, whereas with the carburetor system the average value of fuel consumption is 96.40 ml, this means that there is a difference between the average value of fuel consumption in the injection system with a carburetor system of 44.87 ml or 47%. So that the talent material injection system is more economical than the carburetor system, because the injection system is equipped with an ECM (electronic control module), which functions to directly control the fuel mixture in the engine chamber at certain engine speeds.

In the carburetor system is more wasteful, because the supply of a mixture of fuel and air into the combustion chamber undergo a working process of piston movement.

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THE EFFECT OF Mg ADDING IN RECYCLED ALUMINUM CASTING ON TENSILE STRENGTH AND MICROSTRUCTURE

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Abstract. The problems faced are aluminum (Al) waste from industries that damage the environment and scarcity of Al raw materials that need to be recycled from used Al. The research objective was to determine the effect of adding magnesium (Mg) to used Al casting on the tensile strength and microstructure and to determine the comparison of the tensile strength of the Al material used by the piston to the brake lining and drum of motorcycles. The research method includes casting Al used pistons, brake lining and drum, testing the tensile strength and microstructure due to the addition of 0.1; 0.2; 0.5 and 1.0% by weight Mg to the tensile strength and microstructure. The results showed that the addition of Mg 0.5% by weight could increase the tensile strength of 92.96% from 71 MPa to 137 MPa for brake lining as the optimum value which further decreased the tensile strength by 19.7% at the addition of 1% Mg to 110 MPa. Drum material also experienced an increase in tensile strength of 33.71% from 89 MPa to 119 MPa as the optimum value where the tensile strength decreased by 5.88% for the addition of 1% Mg to 112 MPa. The two values of the tensile strength of the brake lining and drum components are lower than those of the piston component valued at 147 MPa, and with the addition of Mg, Mg_2Si is formed which can reduce the porosity of the microstructure, thereby increasing its strength.

Keywords : used aluminum, aluminum casting , microstructure, tensile strength, hardness value, motorcycle pistons, motorcycle brake linings, motorcycle drum

1. INTRODUCTION

The increasing use of Al in the industrial sector results in its waste having a bad impact on the environment, so it is necessary to do recycling to tackle Al waste, scarcity of raw materials, and save more natural resources. Many automotive components are made of Al alloys, including pistons, engine blocks, cylinder heads, valves and so on.

Several related studies have been conducted to determine the effect of chemical elements on the physical properties of aluminum and its microstructure.

The use of recycled aluminum can save at least 5% of the energy required for primary aluminum production, and high-quality casting depends on chemical elements, both on the quality of the melt and the casting process [1]. Si combines with Mg to form a hardening phase of Mg_2Si which can increase strength [2]. The tensile strength and elongation of Al-10Si-2.5Cu-0.8Fe alloy increase first, then decreases with the increase in Mg content where at 1.38% Mg content, the tensile strength of the alloy reaches a maximum of 289 MPa with an elongation of 2.24% and the grain size decreased from 19.8 µm with a content of 0.18% Mg to 11.3 µm at 1.38% Mg [3]. The addition of Mg (0, 5, 10, 15%) to the Al-Si alloy obtained the highest average hardness number at the addition of 15% Mg of 95.44 HB [4]. High Pressure Die Casting (HPDC) on waste aluminum with the addition of 0, 2, and 3% weight of Mg elements produces a microstructure with Mg_2Si precipitates which indicates porosity in the chassis product [5]. The addition of Mg to the used Al-Si alloy wheels cast by the lost foam casting (LFC) method affects the microstructure to be evenly distributed and the formation of Mg_2Si intermetallic compounds which improve its mechanical

properties [6]. Added Mg of 1, 1.5, 2 and 2.5 % to the Al-SiO_2 composite with SiO_2 mass fraction of 9% with stir casting method showed the results of SiO_2 uniform distribution along with the addition of Mg [7]. The more Mg is added to the Al-Si alloy, the more its phase tends to form flakes and the grain size becomes denser and homogeneous [8]. The recycled tensile strength of used aluminum from 1st, 2nd, and 3rd stage motorcycle pistons is decreased by 191, 118, and 117 MPa respectively; shrinkage from the 2nd recycled casting compared to the 3rd recycling was 25 and 33% smaller, and the elements lost during the 1st, 2nd, and 3rd recycling were Si, Cu, and Fe [9]. The main problem of aluminum recycling practice is the control of chemical composition for alloy quality [10]. The eutectic temperature can decrease by about 10°C in increments of 0.8 wt.% Mg [11]. The addition of Mg, Cu, Ag, Ni, Zn, and Sr increased the TS (tensile strength) and YS (yield strength) values, but the % elongation value decreased in base alloy 413.0 after heat treatment at 510°C for 8 hours [12]. The specific impact strength of the scrap piston with an addition of 15% Mg is 0.035 J/mm^2 which is an increase of 66% from 0.021 J/mm^2 without the addition of Mg [13]. Aluminum recasting causes high porosity with 43.22% for 43 g clusters, 41.85% for 48 g, and 40.55% for 49 g clusters where aluminum has never been used for construction materials, but can be used to inhibit corrosion by coatings on other metals [14].

2. METHODS

2.1 Aluminum Casting

The stages of casting carried out on the tensile test specimen are as follows:

1) Preparation of equipment for melting furnaces, LPG fuel, moulds, and Al materials from pistons, brake linings and drum of motorcycle,
2) Put the used Al and Mg materials into the furnace when they reach a temperature of 660 °C.
3) Pouring Aluminum liquid at a pouring temperature of 720 °C into the prepared specimen mould,
4) Remove the specimen from the mould,
5) Finishing each cast according to the standard dimensions of the specimen, and
6) Coding on all specimens.

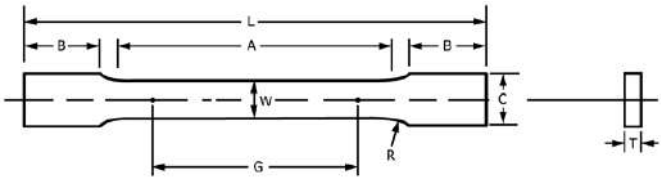
2.2 Composition Testing

The composition of Al castings was tested by X-ray Fluorescent (XRF) shown in Figure 1 for the piston, brake lining and drum materials.

Figure 1. Fluorescent X-ray Equipment

2.3 Tensile Testing

The ASTM E8/E 8M-08 standard specimens used for used Al castings are shown in Figure 2 [15].



Specification: Specimen width (W): 12.5 mm
Gauge length (G): 92 + 0.1 mm
Specimen thickness (T): 10 mm
Fillet radius (R): 12.5 mm
Overall length (L): 200 mm
Clamping length by grips (B): 50 mm
The width of the clamped part of the grips (C): 20 mm

Figure 2. Tensile Test Specimen Standard ASTM E8/E 8M-08 [15]

The tensile test performed with the universal testing machine is shown in Figure 3.

Figure 3. Universal Testing Machine

The tensile strength, σ is calculated by Eq. (1).

$$\sigma = F/A_0 \quad (1)$$

where,
σ: Stress (N/mm^2)
F_{max}: Tensile force (N)
A_0: Cross-sectional area of the tensile specimen (mm^2)

2.4 Hardness Testing
The hardness test was carried out using the Vickers microhardness tester is shown in Figure 4.

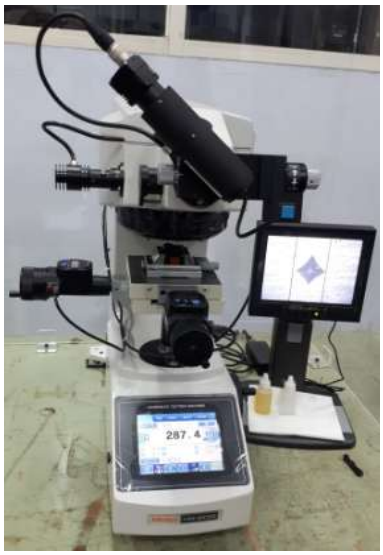


Figure 4. Microhardness testing machine

2.5 Observation of microstructure
The microstructure was prepared metallographically starting from cutting the specimen, mounting the specimen handle, grinding, polishing, etching and observing with an optical microscope.

3. RESULTS AND DISCUSSION
3.1 Composition Test Results
The results of the composition test contained in the used Al castings are shown in Table 1.

Table 1. Composition Test Results of used Aluminum Castings

Piston		Brake lining		Drum	
Element	(%)	Element	(%)	Element	(%)
Mg	0.2	Mg	0.09	Mg	-
Al	60.1	Al	64.0	Al	62.8
Si	15.9	Si	12.8	Si	13.2
P	0.4	P	0.46	P	0.46
Ca	1.3	Ca	1.64	Ca	1.94
Ti	0.08	Ti	0.11	Ti	0.09
Cr	0.53	Cr	0.53	Cr	0.70
Mn	3.8	Mn	6.3	Mn	4.9
Br	15.1	Br	12	Br	14.2
Zr	0.37	Zr	0.56	Zr	0.41
Ba	1.1	Ba	1.4	Ba	1.4
Pr	0.96				

3.2 Tensile Test Results

The tensile test of the used Al castings before and after the addition of Mg is shown in Table 2.

Table 2.Data of Tensile Test Results (in MPa)

No.	Used Al	Replication	Adding of Mg (%)			
			0	0.1-0.2	0.5	1
1	Piston	1	146.46			
		2	142.02			
		3	153.22			
	Average		**147.23**			
2	Break lining	1	60.49	141.50	121.05	115.91
		2	79.16	137.28	156.36	93.22
		3	73.12	81.14	134.52	120.51
	Average		**70.92**	**119.97**	**137.31**	**109.88**
3	Drum	1	81.06	130.27	129.68	100.85
		2	104.31	98.05	114.21	123.32
		3	81.78	98.97	113.51	112.09
	Average		**89.05**	**109.10**	**119.13**	**112.09**

3.3 Hardness Test Results

The results of the hardness test of the used Al castings before and after the addition of Mg with the Micro Hardness Testing Machine with specimen dimensions of 20x14x10 mm are shown in Table 3.

Table 3. Hardness Test Result Data (in HV)

No.	Used Al	Replication	Adding of Mg (%)			
			0	0.1 - 0.2	0.5	1
1	Piston	1	114.2			
		2	115.4			
		3	116.3			
	Average		**115.3**			
2	Brake lining	1	101.5	108.3	115.1	106.5
		2	105.2	109.6	112.1	110.4
		3	93.9	113.0	114.4	107.6
	Average		100.2	110.3	**113.9**	108.2
3	Drum	1	101.7	106.4	115.8	101.6
		2	96.4	105.2	120.9	102.7
		3	99.8	100.7	122.1	108.2
	Average		99.3	104.1	**119.6**	104.2

3.4 Results of microstructure observations

The results of the microstructure observation are shown in Figures 5 to 9.

Figure 5. The Microstructure of Used Piston Castings (1500x)

Figure 6. The Microstructure of Used Brake Lining Castings with 0% Mg (1500x)

Figure 7. The Microstructure of Used Drum Castings with 0% Mg (1500x)

Figure 8. The Microstructure of Used Brake Lining Castings with 0.5% Mg (1500x)

Figure 9. The Microstructure of Used Drum Castings with 0.5% Mg (1500x)

3.2 Discussion

The piston's tensile strength has a higher value of 147 MPa compared to the brake lining and drum of motorcycles. The tensile strength value of the brake lining and drum of motorcycles increases with the addition of Mg elements from 0 to 0.5% but decreases for the addition of 1% Mg which means that the optimum value of adding Mg is 0.5% is shown in Figure 10.

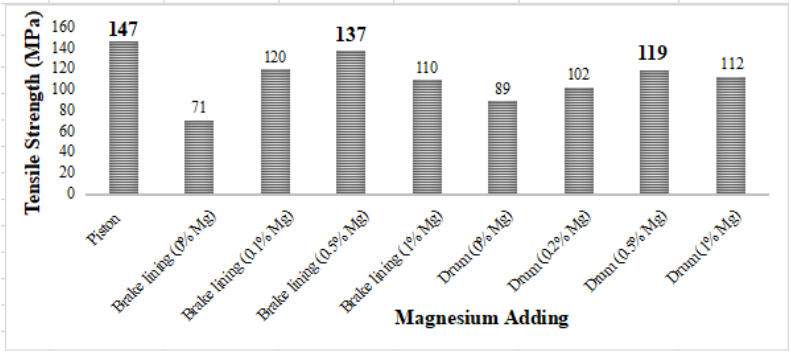


Figure 10. Comparison of tensile strength in used Aluminum castings

Figure 10 shows that the addition of 0.5% Mg to the brake lining and drum castings increases the tensile strength to close to the piston strength at 137 MPa for the brake lining castings and at 119 MPa for drum materials.

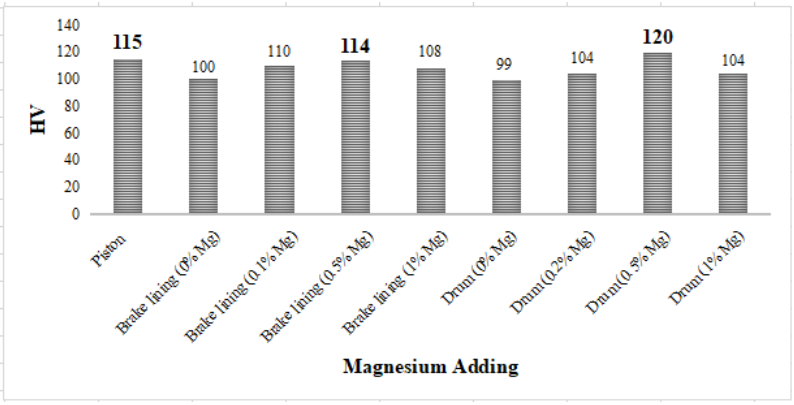


Figure 11. Diagram of comparison of hardness values in used Aluminum castings

Figure 11 shows that the addition of 0.5% Mg to the brake lining and drum castings increases the hardness value. In the cast, the brake lining rises to 114 HV, close to the hardness of the piston, while in the drum material it increases to 120 HV, which exceeds the hardness value of the piston which is possible because Mg has reached 0.7% and the Cr content is higher than the piston and brake lining.

From the results of microstructure photos before and after the addition of the Mg element to the castings of brake lining and drum, it shows a change in the shape of the microstructure because: (a) At 0% Mg, it can be seen that the grain structure is loosely arranged, the distance between the grains is quite far apart, and (b) At 0.1% and 0.5% Mg the shape of the structure tends to be smaller and denser so that the strength increases.

The addition of the Mg element to the brake lining and drums castings makes the phase shape tend to form slender flakes, then the shape and grain size becomes denser and homogeneous which affects the tensile strength and hardness value. The addition of Mg element can result in the formation of a lot of Mg_2Si precipitates which can close the space in the increasingly dense alloy.

The tensile strength of certain types of motorcycle aluminum pistons for the first, second and third recycling decreases from 376 MPa to 191 MPa, and continues to 118 MPa, because Cu, Si and Fe elements cannot melt with LPG fuel [16], while addition Mg up to 0.5% increases the tensile strength, meaning that in the recycling there is an simultaneous increase and decrease in competitive tensile strength.

4. CONCLUSION

The conclusions from the research results are obtained as follows:

1) The results of the tensile test show that the tensile strength of the piston castings specimen is 147 MPa. The highest tensile strength was in the brake lining cast specimens valued at 137 MPa and drum castings valued at 119 MPa in the addition of 0.5% Mg.
2) The results of the hardness test show that the hardness value of the piston castings specimen is 115 HV. The highest hardness value was found in the brake lining cast specimens valued at 114 HV and drum castings valued at 120 HV with the addition of 0.5% Mg. The value of drum hardness is higher than the piston is possible because the Mg content reaches 0.7% and the Cr drum composition is higher than that of the piston.
3) The addition of Mg to the brake lining and drum castings has a significant effect on the addition of 0.5% Mg which increases the tensile strength of the two materials due to the formation of Mg_2Si precipitates which can

cover the empty spaces in the alloy structure, causing the structure to be tighter and more homogeneous, but has decreased in 1% Mg increments.

5. ACKNOWLEDGEMENT

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DESIGNING A ROTARY COMPOSTER TOOL WITH AN ERGONOMIC APPROACH TO THE ORGANIC GARBAGE PROCESSING PROCESS

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Abstract. Garbage is one of the problems facing the Indonesian society. The production of garbage resulting from various individual activities is increasing each day. University of Ahmad Dahlan (UAD) Yogyakarta as one of the colleges in Yogyakarta has the potential to produce garbage of large amounts. Under the strategic plan of environmentally insightful campus development, garbage processing will be carried out by the institutions of University of Ahmad Dahlan and academic civitas. The average garbage produced by UAD 4 campus activities is 170 kg/day with an organic waste composition of 22.57 kg and non-organic 147.43 kg. During this time the garbage was directly distributed to the Piyungan landfill without being processed first, as the campus party had not been available garbage processing devices. The purpose of the study was to design organic garbage processing tools into compost fertilizers. The study used an ergonomic approach by utilizing anthropometric data in the determination of size from the design. Anthropometric data used in this study are *Tinggi Bahu Duduk (TBD)* or Shoulder High Sitting, *Lebar Pinggul (LP)* or Hip Width, *Pantat Popliteal (PP)* or Popliteal Butt, *Tinggi Siku Berdiri (TSB)* or Standing Elbow Height, *Panjang Lengan Bawah (PLB)* or Lower Arm Length, *Lebar Bahu Atas (LBA)* or Upper Shoulder Width, and *Tinggi Lutut (TL)* or Knee Height. The result of the study was an ergonomic Rotary Composter tool design operated by one person manually with dimensions 115 cm long, 148 cm wide, 115 cm tall, 60 cm barrel diameter, seat rest height 58.75 cm, 41.23 cm seat width, seat base length 45.39 cm, the distance between seats, tool height 114.94 cm, with tool 37.33 cm wide, seat rest 50 cm, 13 cm, seat width, and seat height 59.08 cm.

Keywords : garbage, ergonomic, anthropometric, compost, rotary composter.

1. INTRODUCTION

One of the environmental problems facing Indonesian society is garbage. The production of garbage resulting from a wide variety of individual activities is increasing each day. The life patterns and cultures of people who tend to be consumptive are concerned with problems that arise from the garbage. Therefore, the garbage management system must be done precisely and systematically by involving the means and infrastructure of the slaughter [1]. Yogyakarta is one of the destination areas of many, be it with educational purposes or tourism. The large number of migrants who come to Yogyakarta impacts an increase in the amount of garbage each day. Garbage is an item already unused and discarded by its owner. By its nature, the garbage is divided into 2 types that are organic garbage and inorganic garbage. Organic waste is a decomposing litter whereas inorganic litter is a litter that is not easily decayed by nature. So that it does not matter seriously, garbage processing should be done well. Organic garbage processing into compost fertilizers will be more useful than burned which results in pollutants for air [2].

The general of an increasing population will be followed by the increase in garbage capacity generated. Increasing population is a good quality of life, accompanied by the advancement of science impacts shifting the life patterns of communities that tend to be consumptive will go along with increasing amounts of garbage produced [1]. The University of Ahmad Dahlan (UAD) with a student count of 20 thousand more potentially produces garbage of great capacity. Following the strategic plan of developing the environmentally insightful in the University of Ahmad Dahlan, garbage processing will be carried out by the University component and student to reduce the amount of garbage present in the UAD campus environment.

Based on the first observations, the amount of garbage produced by activities in campus 4 of the University of Ahmad Dahlan averaged 170 kg/day, with an organic garbage composition of 22.57 kg and non-organic garbage of 147.43kg. This observation aims to find out the amount of organic garbage produced by everyday campus activities. Observations are also conducted at the DLH of Yogyakarta which aims to see the process of processing organic garbage into compost fertilizer.

The absence of facilities or tools to process garbage in UAD campus 4 neighborhoods impacted the garbage pile of campus activities proceeds directly distributed to the Piyungan landfill without being processed first. That because it is not yet optimal utilization of the garbage present in the UAD campus environment, both organic and non-organic garbage.

The resulting impact of some of those factors is that the volume of garbage in the Piyungan landfill continues to grow every day. In general, organic waste will be treated into compost fertilizers to be used as organic fertilizer for plants. The process of processing organic garbage into compost fertilizer takes approximately 4 weeks if done without using the machine.

2. METHODS

The research was conducted at the Campus 4 in University of Ahmad Dahlan Yogyakarta. The research object is an ergonomic design of rotary composter tools to process organic waste into compost. The manufacture of tool design is done by studying human limitations, excesses, as well as characteristics and utilizing that information with the primary purpose of achieving a good quality of work without ignoring aspects of its user's health, safety, as well as comfort [3]. Research began by conducting preliminary observations for issues related to trash handling.

The collection of anthropometric data was performed directly, further used as the primary data in the study. Data processing uses SPSS software to determine tests of normality, uniformity tests, and adequacy tests. The design of the rotary composter tool aims to process organic waste. The next stage has conducted an analysis by considering the percentile value for the design of the appliance to be conveniently used.

3. RESULTS AND DISCUSSION

3.1 Data of Anthropometric

Anthropometry is one branch of ergonomic science relating to the dimension measurement of the human body that can be used to design ergonomic facilities. The importance of applying ergonomics to all matters related to humans has to do with the people's comfort of the surrounding environment [4]. Anthropometry comes from the word “Anthro” meaning human, and “Metron” meaning size [5]. Anthropometric data is used to know and establish the size of the designed tool. Anthropometry will essentially concern the physical size or function of the human body, including linear size, weight, volume, motion space, etc. The one function of anthropometry is to be used as an ergonomic consideration in requiring human interaction [6]. The absence of uniformity between size, form of means, as well as job infrastructure. It becomes a performance-limiting factor of labor [7]. Anthropometric data is obtained directly from measurements against 15 office boy workers who will use this product as well as additional from Industrial Engineering or FTI UAD student data of 15 undergraduates. The measured anthropometric data among them are, *Tinggi Bahu Duduk (TBD)* or Shoulder High Sitting, *Lebar Pinggul (LP)* or Hip Width, *Pantat Popliteal (PP)* or Popliteal Butt, *Tinggi Siku Berdiri (TSB)* or Standing Elbow Height, *Panjang Lengan Bawah (PLB)* or Lower Arm Length, *Lebar Bahu Atas (LBA)* or Upper Shoulder Width, and *Tinggi Lutut (TL)* or Knee Height. The measurement results data can be seen in Table 1:

Table 1. Data of Anthropometric

Using (cm) in DATA OF ANTHROPOMETRIC							
	TBD	LP	PP	TSB	PLB	LBA	TL
1	60	35	45,9	101,8	44	40	51
2	55,9	40	55	115	41	45	57
3	50	40	42	106	41	47	52
4	55	40	42	117	35	48	54
5	45	39	44	119	37	47	55
6	56	38,5	38	108,5	37,5	47	55
7	60	38	46	123	45	43	56
8	56	32	41	103	40	46	57,5
9	56	38	49	114	41	46,5	54
10	61	34	48	105	44	55	52
11	63	34	49	121	45	43	53
12	58	32	45	106,5	45	44	56
13	58	33,4	51	106	39	42	56,4
14	57	38	45,4	107,4	43	45	55
15	57	31,7	46,7	117,8	38,8	45	54
16	62,3	40	42,6	124,3	38	42,3	54
17	65,2	32,4	56,6	123	35,4	44,3	57
18	61	35	41	107	37	43	57
19	59	36	37,2	116,4	39	42	52
20	53,34	33	44	117	38	42	55
21	55,88	33	40	104	36	43	55
22	58,42	29	46	116	44	44	55,7
23	56	39	52	106	42	45	55
24	55	28	44,5	127	39	48	57
25	63	31	56	118	36	45	52
26	59	33	54	135	44	44	57
27	60	37	47,3	115	45	41	53
28	56	37	43	124	35	46,5	51
29	61	37	65	123	42,5	45	57
30	55,5	40	45	121,5	36	48	54

4.2 Anthropometric Data Testing

a. Normality Test

Normality tests are conducted to find out whether or not the data already collected is a normal distribution. Normality tests are conducted using the help of SPSS software. In testing, using the Kolmogorov–Smirnov Z test, as for the test procedures as follows [8]:

1) The hypothesis:
   H_0 : Normally distributed data
   H_1 : Data is not normally distributed
2) $\alpha = 0,05$
3) Critical area: H_0 accepted if Sig. > α

Data processing results using SPSS software in full can be seen in the following Table 2:

Table 2. The Result of Normality Test

	N	SIG.	α	Description.
TBD	30	0,057	0,05	Normal
LP	30	0,165	0,05	Normal
PP	30	0,091	0,05	Normal
TSB	30	0,089	0,05	Normal
PLB	30	0,148	0,05	Normal
LBA	30	0,079	0,05	Normal
TL	30	0,16	0,05	Normal

b. Data of Uniformity Test

Anthropometric data uniformity tests are performed so that all data used is within the predetermined control limit. Here's a step in performing the uniformity of the data:

1) Searching for the average value of the data with the following (1) equation:

$$\bar{X} = \frac{\Sigma Xi}{n} \quad (1)$$

Description:
$\bar{X}$: Average observation result data
Xi : 1-th measurement result data
n : Data amount

2) Calculating the standard deviation by following equation (2):

$$\sigma = \frac{\sqrt{\Sigma(xi-\bar{x})^2}}{n-1} \quad (2)$$

Description:
σ : Standard deviation of the population
N : The data amount of observations
xi : 1-th measurement result data

3) Affirmative Specifies the *Batas Kontrol Atas (BKA)* or upper control limit and the *Batas Kontrol Bawah (BKB)* or lower control limit used as limiters of extreme data discard using the following equations (3) and (4):

$$\text{BKA} = \bar{X} + k\,\sigma \quad (3)$$
$$\text{BKB} = \bar{X} - k\,\sigma \quad (4)$$

Description:
$\bar{X}$: Average observation result data
σ : The standard deviation of the population
k : The index coefficient of the confidence level.

Based on the above equation, the recapitulation results of the uniformity test of data of each anthropometric dimension are displayed in Table 3 below.

Table 3. The Result of the uniformity Test

Dimension	N	×	σ	BKA	BKB	Description
TBD	30	57,6	4,01	65,64	49,59	Uniform data
LP	30	35,47	3,50	42,47	28,46	Uniform data
PP	30	46,74	6,10	58,94	34,54	Uniform data
TSB	30	114,94	8,40	131,73	98,15	Uniform data
PLB	40	40,11	3,43	46,97	33,24	Uniform data
LBA	30	44,89	2,87	50,63	39,15	Uniform data
TL	30	54,65	1,97	58,59	50,72	Uniform data

c. Data Adequacy Test

Data adequacy tests are conducted to test whether the data taken is sufficient by knowing the magnitude of the value of N'. When N'<N. Then the measurement data is considered sufficient that there is no need for data retrieval anymore. Equation (5) is an equation used to perform data adequacy tests.

$$N' = \left[\frac{\frac{k}{s}\sqrt{N(\Sigma_{i=1}^{n} Xi^2) - (\Sigma_{i=1}^{n} Xi)^2}}{(\Sigma_{i=1}^{n} Xi)}\right]^2 \quad (5)$$

Description:
N' : The number of observations that should be made
Xi : 1-th measurement result data
s : The degree of rigor desired
k : Confidence level index

The results from data adequacy tests are displayed in the following Table 4.

Table 4. The Result of Data Adequacy Test

	x	x^2	Result	Description
TBD	1728,54	100062,02	8	Adequate
LP	1064	38092	15	Adequate
PP	1402	66619	26	Adequate
TSB	3448,2	398381,04	8	Adequate
PLB	1203,2	48598	11	Adequate
LBA	1346,6	60683,28	6	Adequate
TL	1639,6	89722	2	Adequate

d. Determining Percentile Measures for Design

Percentile values from anthropometric data measurements are used as consideration for ergonomic product design [9]. Information about this percentile is important for determining the percentage of the user population that will be accommodated by the product being designed. Three percentile values are usually used in the design, namely small percentile, large percentile, middle percentile. Because anthropometric data are often assumed to be normally distributed, the middle percentile (50th percentile) is equal to the average value of a distribution. The selection of percentiles depends on the characteristics of the design dimensions. Typically, the 5th percentile is used as the minor percentile value and the 95th percentile is used as the large percentile value, to accommodate 95% of the population [3]. The percentile sizes used in this study were 5-th for small percentile sizes, 50-th for mean percentile sizes, and 95-th for large percentile sizes. Equations (6), (7), and (8) are the equations used to determine percentiles:

$$P_5 = \bar{x} - 1{,}645\,\sigma \quad (6)$$

$$P_{50} = \bar{x} \quad (7)$$

$$P_{95} = \bar{x} + 1{,}645\,\sigma \quad (8)$$

The results of the percentile calculations used can be seen in Table 5 below.

Table 5. Percentile Determination

Dimensions	P5	P50	P95
TBD	51,02	58,75	65,96
LP	29,7	35,47	41,23
PP	38,86	45,38	51,9
TSB	101,13	114,94	128,75
PLB	28,76	37,33	45,75
LBA	37,65	43,89	50,13
TL	51,39	55,24	59,08

4.3 Formulation of Design Concepts

A product is a technical object that is produced from engineering work, starting from designing, manufacturing, and other related activities [10]. Design starts from human thinking of a problem that requires a solution, be it a new solution or an old solution, but in a different way. The design concept of designing this rotary composter tool is an outline that is used to simplify the design process. The specifications of this design are:

1) The anthropometric data used to determine the height of the operator's seatback is the dimension of *Tinggi Bahu Duduk (TBD)* or Shoulder High Sitting using the 50th percentile, namely 58.75 cm.
2) The anthropometric data used to determine the operator seat width is the *Lebar Pinggul (PL)* or Hip Width data using the 95th percentile, namely 41.23 cm
3) The anthropometric data used to determine the length of the operator's seat base is *Pantat Popliteal (PP)* or Popliteal Butt using the 50th percentile, namely 45.39 cm.
4) The anthropometric data used to determine the height of the rotary composter is the *Tinggi Siku Berdiri (TSB)* or Elbow Height Standing using the 50th percentile, namely 114.94 cm.
5) Anthropometric data used to determine the distance between the operator's seat and the handle on the tool is the *Panjang Lengan Bawah (PLB)* or Forearm Length with the 50th percentile, namely 37.33 cm
6) The anthropometric data used to determine the seat back width is the *Lebar Bahu Atas (LBA)* or Top Shoulder Width with the 95th percentile, namely 50.13 cm.
7) The anthropometric data used to determine chair height is *Tinggi Lutut (TL)* or Knee Height using the

95th percentile, namely 59.08.

a. *Rotary Composter Design*

The design of the rotary composter tool uses anthropometric data that has been previously processed in 2D and 3D as shown in Figures 1, 2, and 3.

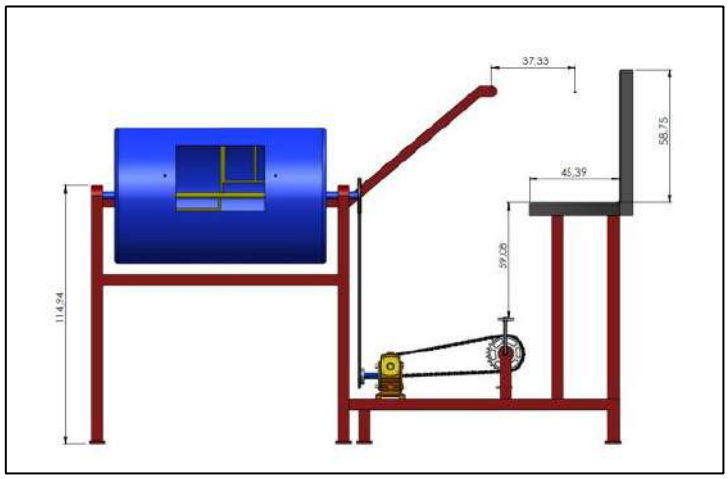

Figure 1 Design Front View

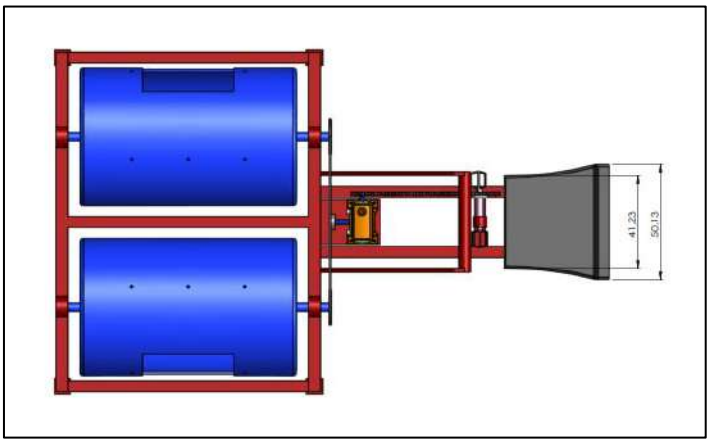

Figure 2 Design View Top

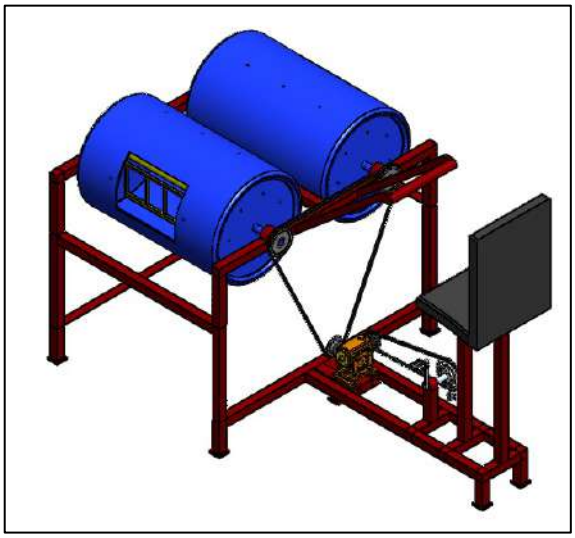

Figure 3 Design Perspective

b. Tool Specifications

Based on Figure 1,2,3 it can be explained that the specifications of the rotary composter tool are as follows:

1) The frame uses a 4cm hollow iron. The total length of the frame is 115 cm, width 148 cm, and height 115 cm.
2) The size of the drum used has a diameter of 60 cm, totaling 2 units. Drums are used to collect organic waste.
3) The gearbox used is the WPA 50 type with a ratio of 1:10. The gearbox is used to change the direction of the pedal rotation.
4) Pedals and chains used to move the drum.
5) The stirrer iron has a fin shape with a length of 40 cm and a width of 240 cm. The stirring iron is used to stir the organic waste in the drum.
6) The chair has a base width of 41.23 cm, a back width of 50.14 cm, and a chair height of 58.75 cm. The material used on the chair is plate iron. The chair is used by the operator in operating the rotary composter.

4. CONCLUSION

The results of the proposed rotary composter tool design using the *Tinggi Bahu Duduk (TBD)* or Shoulder High Sitting with the 50th percentile, namely 58.75 cm for the seat back size. *Lebar Pinggul (LP)* or Hip Width with the 95th percentile is 41.23 cm for the seat width. *Pantat Popliteal (PP)* or Popliteal Butt with the 50th percentile, namely 45.39 cm for the length of the seat base. *Tinggi Siku Berdiri (TSB)* Elbow Height Standing with the 50th percentile, namely 114.94 cm for the height of the frame. *Panjang Lengan Bawah (PLB)* or Forearm Length with the 50th percentile is 37.33 cm for the distance between the chair and the handle on the tool. *Lebar Bahu Atas (LBA)* or Top Shoulder with the 95th percentile, namely 50.13 cm for the width of the seatback. *Tinggi Lutut (TL)* or Knee Height with the 95th percentile is 59.08 cm for chair height.

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PREHEAT TEMPERATURE ANALYSIS OF CUTTING KNIFE COATING VIOLENCE IN THE HARD FACING PROCESS OF AISI A35 CARBON

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Abstract. The hard facing process is the welding process of SMAW by using a hard facing DIN 888 electrode as a hard facing to replace conventional cutting tool material. Research method is designed using factorial experiment design with 2 factors, 3 levels, and 4 iterations. The purpose of this analysis is to determine the effect of preheating temperature on the welding of hard coatings on AISI A35 low carbon steel. The results of this study are expected to obtain optimum hardness on coated steel, from variations in the temperature of the preheating. there will be a change in the hardness of the welding deposit, the deposit will be used as cutting tools. The results of this study can be used as guidelines for making cutting tools.

Keywords: temperature, ampere, deposition

1. INTRODUCTION

Wear and crack often happen on cutting edge of cutting tool that is used on high impact load e.g plastic, wood, or composite waste crusher which is used in industrial applications. These wear and crack are unavoidable thus maintenance of the cutting tool in form of resharpening process is needed. Resharpening process is generally done by grinding. Problems will usually arise if the cutting tool suffers some fatal problems like chipping on the edge of the tool due to an impact with a hard surface. Repair procedure for a chipped cutting tool will take a considerable amount of time, and more cutting material will be wasted therefore reducing its lifetime

There are several approaches in making a cutting tool [1]-[4] i.e (1) insert method, which is inserting a hard material as the cutting edge into a softer material which act as the holder. The bonding between the two material uses Brushing and Silvering process. If damage occurs on the cutting tool, the cutting edge can be disassembled and replaced with the new cutting edge. Materials that are generally used are HSS, Cemented Carbide and Tungsten Carbide. (2) Hard layering method, this method is easier to do if SMAW welding is applied, using hard facing electrode to add layer to a soft material as a holder for the hard material which act as the cutting edge. The sharpening of the edge usually done by grinding.

2. METHODS

2.1 Research Design

Research is designed using factorial experiment design with 2 factors, 3 levels, and 4 iterations. Two of the influencing factors are (1) magnitude of the hardness level, (2) magnitude of electrical current and geometrical structure of the test subject (Figure 3.1). Both of the treatments are assumed to affect the hardness of the deposit within two categories of experiments.

First experiment is determining significant factors from altering cutting parameters, or the setting of parameters in EDWC, whether cutting process duration (ANOVA) is affected significantly by type of material being cut. The second experiment is conducted to analyze the optimization of the resulting cutting process duration (Factorial Experiment Design).

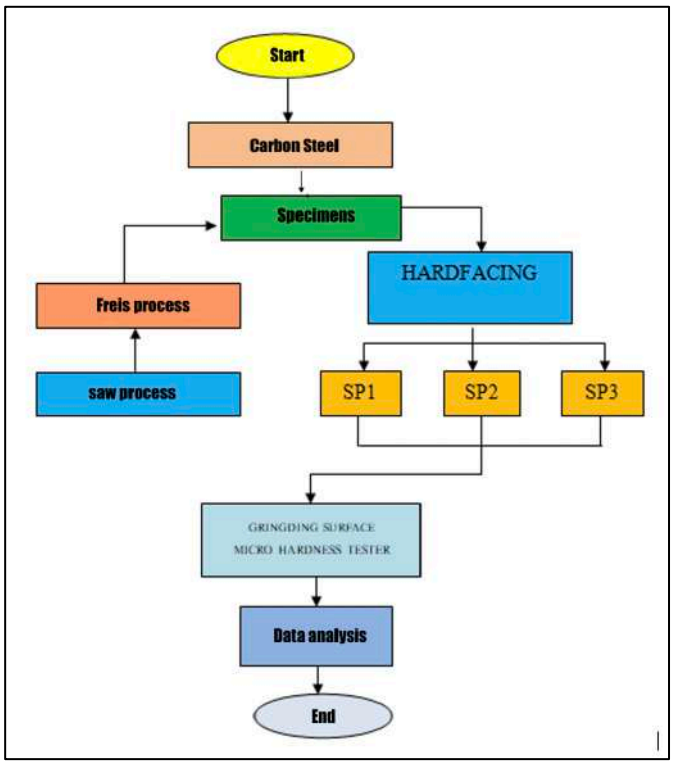

Figure 1. Research Flowchart
Note: Hard facing process (1, 2 dan 3) with SMAW welding

2.2 Testing specimen

Testing speciemen with size according to Figure 2 with AISI A 36 as the material, which is made using milling machine in the amount of requires sample needed for data sampling .

Figure 3.2 Testing specimen

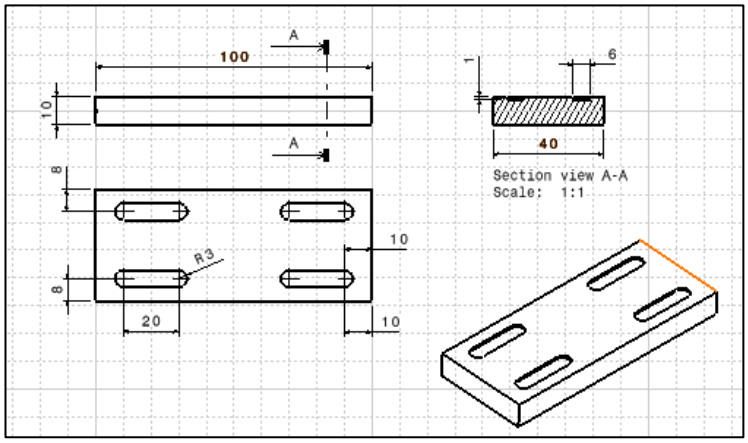

Figure 2. Testing specimen

3. RESULTS AND DISCUSSION

3.1 Heating and Welding Process

Heating process which is used is pre-heated specimen with varied temperature ranging from: no preheat, 100°C, 200°C, and 300°C. Welding process that is used is hard deposit forming with SMAW welding using hard-facing electrode DIN 8555. Electric current magnitude used in this experiment ranges from 80A, 90A, and 100A. Deposit forming with SMAW welding is done after the specimen temperature reaches 100°C, 200°C, and 300°C, respectively

Figure 3. Preheat and SMAW Welding

3.2 Deposit Hardness Measurement

Measurement is done by using micro hardness toward each specimen with each treatment i.e preheat process and electric current used during the welding process

Figure 4. Micro hardness test

The result data of micro hardness test toward hard-layering specimens is listed in Table 1.

Table 1. Micro hardness test

Temp. Preheating	Electric Current 80 A	90 A	100 A
0˚	54	53,5	49,2
	55	56	48,5
	53	55	49,4
	53,5	56	49,1
100˚	51,2	51,2	51,6
	51,6	53,6	51,5
	51,2	52,2	54
	50,2	53,2	52,2
200˚	57,4	57,4	47,3
	52,2	44,2	55,6
	53,2	56,2	56,2
	54,5	56,6	57,2
300˚	46,2	48,5	47,9
	49,2	56,5	59,1
	47,6	52,2	58,2
	48,1	52,1	58,6

3.3 Factorial Design Analysis

Minitab software simplifies the creation of factorial design, using Table 1 as a reference. The data from Table 3 are used for factorial analysis, factorial design output interpretation, and ANOVA interpretation.

3.3.1 Factorial Analysis, Factorial Design Output Interpretation

Figure 5 shows factorial design output analysis, started with notes regarding factors, each with 3 levels of treatments. The temperature levels are: 100°C, 200°C, and 300°C, while welding current levels are 80A, 90A, and 100A. ANOVA table is depicted below. ANOVA table can be used to observe the effect of each factors or interaction between factors and response variable (deposit hardness)

General Linear Model: Kekerasan versus Temp, Preheating; Amphere

Factor	Type	Levels	Values
Temp, Preheating	fixed	3	1; 2; 3
Amphere	fixed	3	80; 90; 100

Analysis of Variance for Kekerasan, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Temp, Preheating	2	5,029	5,029	2,514	0,49	0,617
Amphere	2	38,617	38,617	19,309	3,77	0,036
Temp, Preheating*Amphere	4	183,599	183,599	45,900	8,96	0,000
Error	27	138,238	138,238	5,120		
Total	35	365,483				

S = 2,26272 R-Sq = 62,18% R-Sq(adj) = 50,97%

Figure 5. Factorial design output analysis

In this case there are 2 factors and 1 interaction, therefore 3 hypotheses are to be formulated, that is hypothesis testing in order to determine the influence from the preheat temperature, the influence of the magnitude of electrical current used in welding (ampere), and the influence of interaction between the preheat temperature and the magnitude of electrical current for welding. Usually there is the influence of the preheat temperature [5][6], the influence of the electric current used in welding (amperes) [7][8], and the influence of the interaction between the preheat temperature and the amount of electric current for welding [9].
Observing the influence of the preheat temperature on the magnitude of the hardness value of the deposit. Conducting hypothesis testing to observe the influence of preheat treatment on the magnitude of electrical current for welding.
Hypothesis
H0: $\tau 1 = \tau 2 = \tau 3 = 0$
(preheat temperature does not impact the hardness value of the deposit)

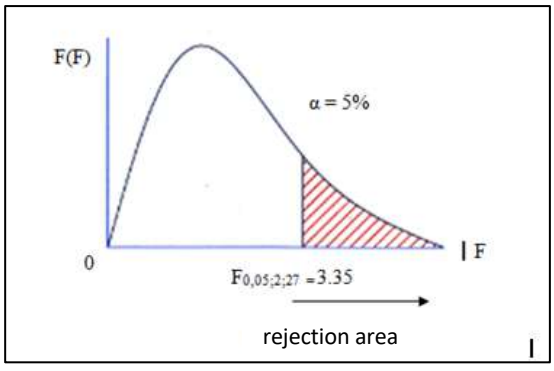

Figure 6 Rejection area for F distribution on 5% tolerance levels [10]

Rejection Area

As long as statistic of F exceeds F0,05; 2; 36 = 3.35, then reject Ho or if p value is less than α, then reject Ho. The area of rejection could be found on Figure 3.4

3.3.2 Interpretation of ANOVA Output for Testing the Influence of Preheat Temperature

From output it is known that statistic of F for preheat temperature from Figure 4.4 is 0.49 and p value is 0.0617 and it is concluded that the original hypothesis, which states that the average of all levels on preheating temperature factor is the same, is rejected; in other words, the alternative hypothesis is accepted. This means there

is a significant difference amongst the levels in preheating temperature factor or there is a significant impact from preheating temperature on the value of hardness of the welds deposit.

Determining The Influence from Electrical Current of Welding (Ampere) on Preheat Temperature

Hypothesis

Hypothesis for this test states

H0 : $\beta 1 = \beta 2 = \beta 3 = 0$

(The magnitude of electrical current of welding does not impact the hardness of the deposit)

Ho : At least one $\beta j \neq 0$

the magnitude of electrical current of welding impacts the hardness of the deposit.

Where j = 1,2,3

Rejection Area

As long as F statistic exceeds F0,00;2;36 (3,35) or p-value is less than α it is concluded that H0 is rejected.

Interpretation

From output it is determined that F statistic for the magnitude of electrical current is 3.77 and the p-value is 0.036. The conclusion is the original hypothesis, which states that electrical current of welding does not impact the hardness of deposit, is rejected. It is then accepted that the factor of electrical current of welding possesses a significant influence on the value of hardness.

Determining the Influence of Interaction Between Factors on Hardness Value of Deposit

Hypothesis

The Hypothesis states:

H0: $(\tau\beta)ij = 0$ for all ij

(Iteration between factors doesn't impact the hardness value of deposit)

H1: $(\tau\beta)ij \neq 0$ deposit layer

(interaction between factors affects the time of deposit hardness value)

Rejection Area

If F statistic exceeds F 0,05;4;36 (2,73) and p-value is less than α then H0 is rejected.

Interpreting the Result

From output it is known that F statistic amounts 8.96 and p-value is 0.00. The conclusion is, a significant impact from iteration between material type and magnitude of electrical current is present.

4.1.3 Graphs for Factorial Design

In order to evaluate the levels of each factor, a plot is drawn with the following results

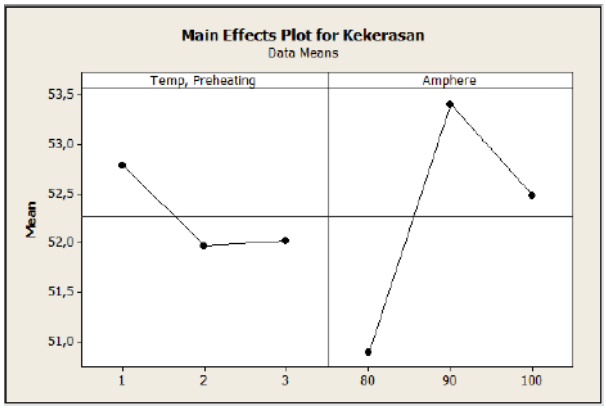

Figure 7. Main effects plot for hardness

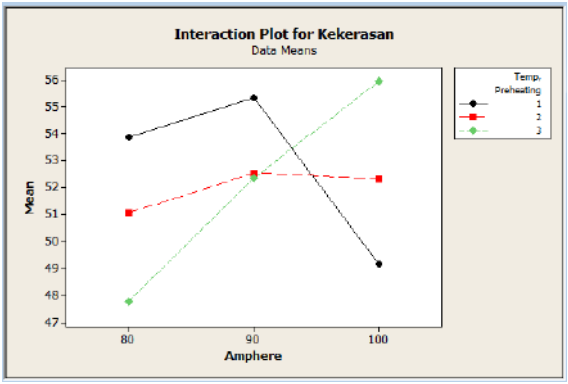

Figure 8. Iteration plot f or hardness

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusion

The result of the study of The Impact of Preheat Temperature on The Layer Hardness of Cutting Knife during Hard facing Process of Carbon Steel AISI A36 is as follows:

1) From hypothesis testing in order to determine the impact of preheat temperature on the welds deposit hardness time

   H0: $\tau 1 = \tau 2 = \tau 3 = 0$

   (preheat temperature doesn't affect the hardness value of welds deposit)

   H0 : minimum of one $\tau \neq 0$ $\quad i = 1, 2, 3$

   (Material type affects the time of cutting process for wire cut)

2) From output it is determined that F statistic of preheat temperature is 0.49 and p-value is 0.0617 and the conclusion is that the original hypothesis, which states that the average of all levels on the factor of preheating temperature is the same, is rejected. In other words, the alternative hypothesis is accepted. This means, that a significant difference between levels in factor of preheating temperature is present, or there exists a significant impact from preheating temperature upon hardness value of welds deposit.

3) Determining the Influence Between Factors on Value of Deposit Hardness

   From output, it is determined F statistic with the amount of 8.96 and p-value is 0.00, which leads to the conclusion that there is an impact of interaction between material type with the magnitude of electrical current in significant amount.

4) The plot of the graphs for main factors Figure 4.16 shows that preheat temperature and electrical current of 90 ampere inflicts a large influence upon the hardness value of deposit. Both types of factor have contradicting values; the increase of the level of material type also increases its influence on the process time; on the other hand increasing the electrical current will give bigger influence towards the hardness of the deposit which means the optimal electrical current for welding ranges from 90 A up to 100 A.

5) In the table of research data Table 4.1 it is shown that the magnitude of electrical current and preheat treatment results in high mean hardness value.

4.2 Suggestions

After conducting the study Analysis of Preheat Temperature's Influence on Layer Hardness of Cutting Knife during Hard facing Process of Carbon Steel AISI A36, the following are suggested:

1) Further studies regarding the impact of microstructure on HAZ hard facing process on low carbon steel is needed.

2) The hardness analysis of deposit after flat grinding process during implementation on cutting knife is required.

3) Analysis for effects from heat treatment of deposit upon deposit hardness is needed.

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PROPOSED CONTROL OF RAW MATERIAL INVENTORY IN CONDITION OF NOT REQUIRED WITH FUZZY MAMDANI METHOD IN CV. PINUS BAG'S SPECIALIST

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Abstract. CV. Pine Bag's Specialist is a business engaged in the manufacturing of various types of bags. One of the bags made in the form of a backpack. Parachute fabric is the main raw material for making backpacks. Uncertain demand causes a lot of accumulation (over stock) of raw materials in the storage area, so we need a method of supporting raw material inventory control to determine the optimal order. The research objective determines the optimal ordering of raw materials using variable raw material demand, raw material inventory variables and ordering variables in January the first week to March the fourth week. The Fuzzy Mamdani method used in this study because it has a flexible nature and can overcome the problem of uncertainty. The data processing of the Fuzzy Mamdani method carried out in several stages (a) the formation of the Fuzzy set, (b) the application of the implication function, (c) the composition of the rules, (d) Defuzzification. Defuzzification in research uses the centroid method. The results of Fuzzy Mamdani's manual calculation in January of the first week with input of raw material demand of 666 meters and 126 meters of inventory resulted in an optimal prediction of ordering raw materials of 876 meters. Calculations for January the second week to March the fourth week are performed with the help of the Matlab R2013a Fuzzy Toolbox software. The results of prediction data evaluation on the number of raw material orders Fuzzy Mamdani with actual data on the raw material number ordering CV. Pine Bag's Specialist, it is known that the average absolute error (MAE) is 193.8 meters with an average percentage of absolute error (MAPE) of 22%. So, it is said that the level of accuracy of predictions is reasonable. Future research is expected in the Fuzzy Mamdani method can be used more than two inputs and one output and the addition of linguistic variables. Combine the Fuzzy Mamdani method with other raw material inventory control methods so that the results obtained are getting better.

Keywords: fuzzy mamdani, inventory control, uncertain demand, MAE, MAPE

1. INTRODUCTION

CV. Pin Bag's Specialist is a company engaged in the manufacturing industry of various types of bags. Backpack is one type of bag that made. The main raw material used in the manufacture of backpacks in the form of cloth called parachute fabric. Companies in making decisions using simple methods manually and based on experience in determining the ordering of raw materials for parachute fabric needed. The simple method used in determining the ordering of parachute fabric raw materials by estimating the amount of demand for parachute

fabric raw materials ordered is adjusted to the number of bags production requested by consumers, but the parachute fabric raw material from the rest of the production results is not a consideration factor.

Negative impact if the control of parachute fabric raw materials do not use the right decision support methods in determining the optimal order will cause the accumulation of parachute fabric raw materials (over stock) in the storage area. Parachute fabric raw material that was over stock for the last three months from January 2019 to March 2019 with an average amount of 74.9 meters and a percentage of 12.8% per week. Parachute fabric raw materials that have accumulated in storage for a long time and are not considered causing a decrease in quality that is not suitable for reuse, causing losses for the company.

Based on previous research conducted by Abdurrasyid, et al. [1] resulted in the application of the Fuzzy Mamdani method in determining the predictions of procurement of goods to provide suitable alternatives to meet all user needs, and the application of the Fuzzy Mamdani Method can produce predictions of procurement of goods by looking at the inventory of goods and quantities demand for goods. Research conducted by Rahakbauw, et al [2] resulted in the application of Fuzzy Logic using the Mamdani Method effectively applied in the Matlab software application to assist the company in predicting the determination of the amount of rubber production in liters per day with a percentage of truth value of 87.82706% which means it is very close good. Fuzzy Mamdani method can be used as a decision support in controlling inventory of parachute fabric raw materials based on the amount of raw material demand and inventory of existing raw materials to get optimal ordering predictions in the CV. Pine Bag's Specialist. Proposed inventory control of parachute fabric raw materials using Fuzzy Mamdani method as a decision support is expected to be able to overcome the problem of uncertain demand.

2. METHODS

Fuzzy Logic

Fuzzy Logic is a component of soft computing. Fuzzy logic is an appropriate way to map an input space into an output space. Fuzzy logic uses Fuzzy set theory which considers the degree of membership as a determinant of the state of the elements in a Fuzzy set. Fuzzy is a vague value that can be considered true or false simultaneously. Fuzzy truth and error values depend on the degree of membership possessed by a Fuzzy set. The degree of membership in Fuzzy has a value of zero to one. Fuzzy membership degree with a set that has a zero or one value (yes or no). In a firm set (crisp), the membership value of item x in a set A, which is often written as μA (x), has two possibilities, namely the value of one which means that an item is a member of a set and a zero value which means that an item not become a member in a set. Fuzzy membership has a different probability of having a value at intervals of zero to one but the interpretation of values is very different between the two cases. Fuzzy membership provides a measure of opinion or decision, while probability indicates the proportion of the frequency of an outcome that is true in the long run [3].

Mamdani Method

The Mamdani method is also known as the Min-Max method. Ebrahim Mamdani introduced this method in 1975. Output was obtained through four stages [3].

1. Formation of Fuzzy Association

Mamdani method input variables and output variables divided into one or more Fuzzy sets, and in each input and output variable there are linguistic variables

2.Application Function Implications

Input and output variables are used to determine the function implication. The function implication used in the Mamdani method is to take the minimum value (Min).

IF x is A THEN y is B (1)

3. Composition of Rules

The composition of the rules obtained from the implication function, which is determining the composition of each rule and the method used in conducting the Fuzzy System Inference, which is the maximum method (Max). In the maximum method (Max) the Fuzzy set solution is obtained by taking the maximum value of the rule, then used to modify the Fuzzy area and applied to the output using the OR (union) operator. If all propositions evaluated, the output will contain a Fuzzy set that reflects the contribution of each proportion.

$$\mu_{sf}(x_i) = \max(\mu_{sf}(x_i), \mu_{kf}(x_i)) \quad (2)$$

Description:

$\mu_{sf}(x_i)$ = Fuzzy solution membership value up to rule i;
Fuzzy solution membership value to the i-th rule;

$\mu_{kf}(x_i)$ = Fuzzy solution membership value is the consequence rule i;
Fuzzy consequence membership value i-th rule;

Defuzzification

Input from the defuzzification process is a set of Fuzzy obtained from the composition of Fuzzy rules, while the output produced is a number of Fuzzy set domains. If a Fuzzy set is given from a certain range, then a certain crisp value is taken as output. In this method crisp solution is obtained by taking the center point of the Fuzzy area. The formula of the Centorid (Composite Moment) method is as follows:

$$z^* = \frac{\int z\mu(z)\,dz}{\int \mu(z)dz} \quad (3)$$

Description:
z* = The central point value of the Fuzzy area
zμ(z) dz = Area of moments
μ(z) dz = Total area

Calculating the Level of Accuracy Forecasting Prediction

There are several calculations commonly used to calculate forecast errors (Forecast Error). Mean Absolute Error (MAE), and MAPE (Mean Absolute Percentage Error) can measure forecast errors.

MAE (*Mean Absolute Error*)

MAE is a model of calculating the error value by calculating the difference between the predicted value and the actual value, which is then authenticated (regardless of positive or negative signs). Results from MAE values in the same form (size) as actual data [4].

$$\frac{1}{n}\sum_{t=1}^{n} |\, F_t - A_t \,| \quad (4)$$

Description:
F_t = actual data; A_t = prediction data; n = lots of data

MAPE (*Mean Absolute Percentage Error)*

MAPE is a model of calculating the error value by calculating the difference between the predicted value and the actual value which is then absolute and then calculated in the form of a percentage of the original data (Chang, et al, 2007).

$$\frac{1}{n}\sum_{=1}^{n} \left|\frac{F_t - A_t}{A_t}\right| \times 100\% \quad (5)$$

Description:
F_t = actual data; A_t = prediction data; n = lots of data

Evaluation of the level of MAPE performance from a forecasting model divided into four categories, namely:

a. <10% = Very good forecasting ability
b. 10% - 20% = Good forecasting ability
c. 20% - 50% = Fair forecasting ability
d. >50% = Bad forecasting ability

3. RESULTS AND DISCUSSION

The data taken is data of black parachute fabric raw material that includes data on raw material demand, raw material inventory data and raw material ordering data for three months from January 2019 to March 2019 can be seen in Table 1.

Table 1. Raw Material Demand Data, Raw Material Inventory Data and Raw Material Order January-March 2019

No.	Month	Week	Demand of Raw Material (Meters)	Stock of Raw material (meters)	Booking of Raw Material (Meters)
1	January	1	666	126	771
2		2	846	105	1071
3		3	486	225	531
4		4	1791	45	1881
5	February	1	621	90	621
6		2	1408,5	0	1476
7		3	733	67,5	733,5
8		4	396	0,5	441
9	March	1	1971	45	2061
10		2	666	90	771
11		3	306	105	306
12		4	756	0	846

Based on Table 1 above, it can be explained that the largest number of fabric raw material requests reached 1971 meters per week and the smallest number of fabric raw material requests reached 306 meters per week. The largest amount of fabric raw material inventory reaches 225 meters per week and the smallest amount of fabric raw material inventory reaches 0 meters per week. The largest number of fabric raw material orders reached 2061 meters per week and the smallest number of fabric raw material orders reached 306 meters per week.

Fuzzy Association Formation

The first step is to determine the variables associated in the process that are determined by the appropriate fuzzification function. This research has input parameters, namely the demand for raw materials and supply of raw materials. Output parameters (orders) are ordered raw materials ordered. In this study there are three variables that are modeled, namely:

1. Demand variable

$$\mu\text{PmtSEDIKITfunctional demand}(x) = \begin{cases} 0 & ;x \leq 306 \\ \frac{(1138{,}5-x)}{(1138{,}5-306)} & ;306 \leq x \leq 1138{,}5 \\ 1 & ;x \geq 1138{,}5 \end{cases}$$

$$\mu\text{PmtSEDANGmedium demand}(x) = \begin{cases} 0 & ;x \leq 306 \; atau \; x \geq 1971 \\ \frac{(x-306)}{(1138{,}5-306)} & ;306 \leq x \leq 1138{,}5 \\ \frac{(1971-x)}{(1971-1138{,}5)} & ;1138{,}5 \leq x \leq 1971 \end{cases}$$

$$\mu Pmt\text{BANYAKmany demand}(x) = \begin{cases} 0 & ;x \leq 1138{,}5 \\ \frac{(x-1138{,}5)}{(1971-2238{,}5)} & ;1138{,}5 \leq x \leq 1971 \\ 1 & ;x \geq 1971 \end{cases}$$

The FUNCTIONAL, MEDIUM, and MANY Fuzzy set membership functions of the request variable are represented in Figure 1.

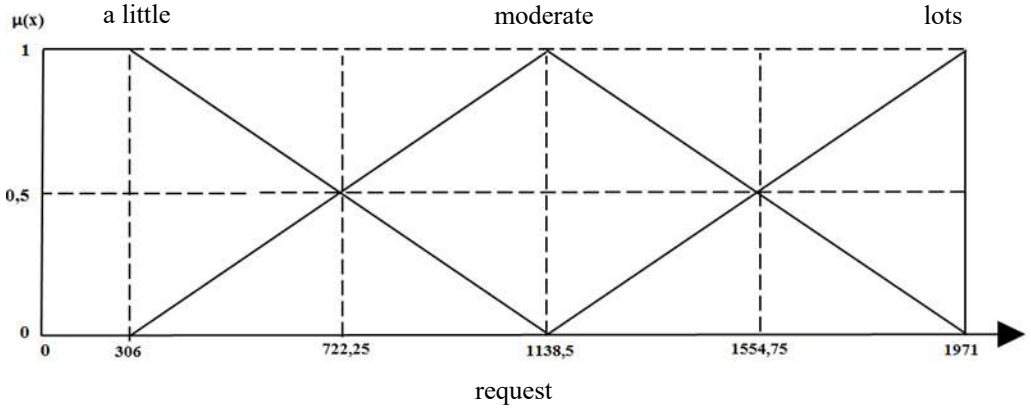

Figure 1. Membership Function Variable Demand

2. Inventory variables

$$\mu P\text{sdSEDIKITfunctional inventory(y)} \begin{cases} 1 & ;y \leq 0 \\ \frac{(112{,}5-y)}{(112{,}5-0)} & ;0 \leq y \leq 112{,}5 \\ 0 & ;y \geq 112{,}5 \end{cases}$$

$$\mu P\text{sdSEDANGmedium inventory(y)} \begin{cases} 0 & ;y \leq 0 \; atau \; x \geq 225 \\ \frac{(y-0)}{(112{,}5-0)} & ;0 \leq y \leq 112{,}5 \\ \frac{(225-y)}{(225-112{,}5)} & ;112{,}5 \leq y \leq 225 \end{cases}$$

$$\mu P\text{sdBANYAKmany inventory(y)} \begin{cases} 0 & ;y \leq 225 \\ \frac{(y-112{,}5)}{(225-112{,}5)} & ;112{,}5 \leq y \leq 225 \\ 1 & ;y \geq 225 \end{cases}$$

The FUNCTIONAL, MEDIUM, and MANY Fuzzy set membership functions of the inventory variable are represented in Figure 2

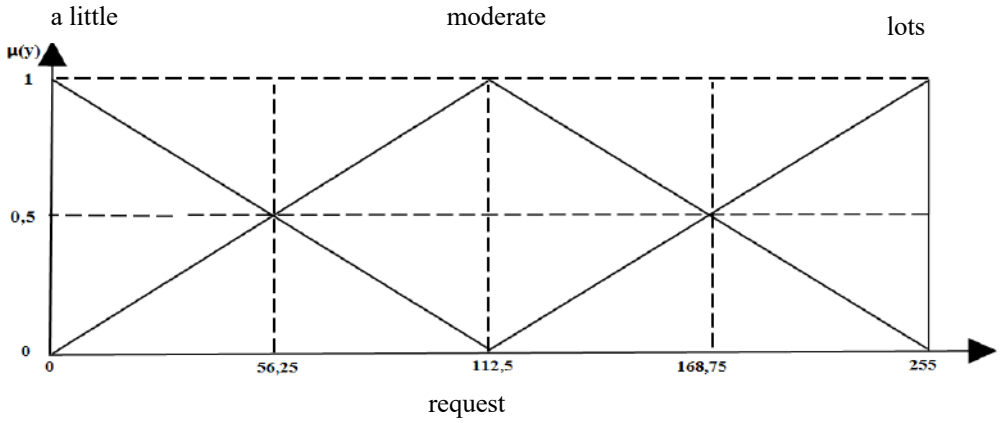

Figure 2. Inventory Variable Membership Function

3. Order variable

$$\mu Pm\text{sSEDIKITfunctional order(z)} \begin{cases} 1 & ; z \leq 306 \\ \frac{(1183{,}5-z)}{(1183{,}5-306)} & ; 306 \leq z \leq 1183{,}5 \\ 0 & ; z \geq 1183{,}5 \end{cases}$$

$$\mu Pm\text{sSEDANGmedium order(z)} \begin{cases} 0 & ; z \leq 306 \; atau \; z \geq 2061 \\ \frac{(z-306)}{(1183{,}5-306)} & ; 306 \leq z \leq 1183{,}5 \\ \frac{(2061-z)}{(2061-1183{,}5)} & ; 1183{,}5 \leq z < 2061 \end{cases}$$

$$\mu Pm\text{sBANYAKmany order(z)} \begin{cases} 0 & ; z \leq 1183{,}5 \\ \frac{(z-1183{,}5)}{(2061-1183{,}5)} & ; 1183{,}5 \leq z \leq 2061 \\ 1 & ; z \geq 2061 \end{cases}$$

The FUNCTIONAL, MEDIUM, and MANY Fuzzy set membership functions of the ordering variable are represented in Figure 3

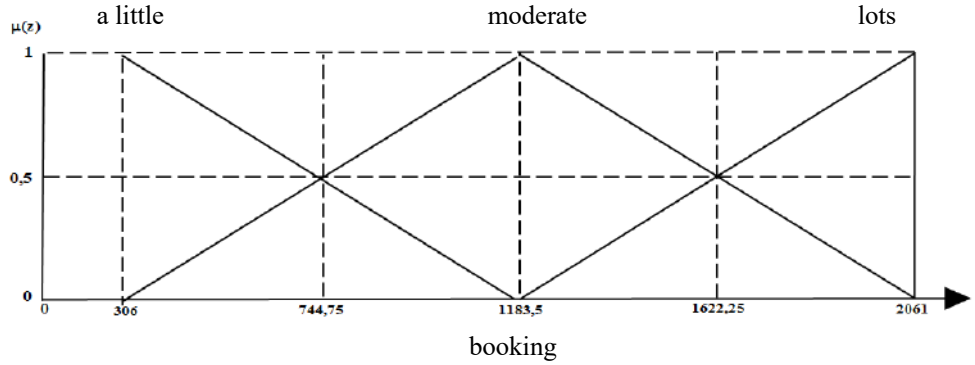

Figure 3. Ordering Variable Membership Function

Application Function Implications

Based on data analysis of the limits of each set of Fuzzy on each variable, the rules are formed in accordance with the knowledge base as follows:

R1] If the Request is LITTLE, and the supply IS LITTLE, Then the Order IS LITTLE
[R2] If the request is MEDIUM, and the supply is LITTLE, then the order is MUCH
[R3] If the demand is MUCH, and the supply is LITTLE, then the order is MUCH
[R4] If the Request is LITTLE, and the Supplies ARE MEDIUM, then the Order is LITTLE
[R5] If the request is MEDIUM, and the supply is MEDIUM, then the order is MEDIUM
[R6] If MANY Requests, and Supplies ARE ON, Then Order A LOT
[R7] If the Demand is LITTLE, and the Supplies are MUCH, then the Order IS LITTLE
[R8] If the demand is MEDIUM, and the supply is MUCH, then the order is LITTLE

[R9] If the demand is a LOT, and the supply is a LOT, then the order is a LOT

Determination of the optimal order of parachute fabric raw materials for the first week of January 2019, if the demand for raw materials known to be 666 m, then:

$$\mu PmtSEDIKIT\ functional\ demand(666) = \frac{(1138{,}5-x)}{(1138{,}5-306)} = 0{,}56$$

$$\mu PmtSEDANGmedium\ demand\ (666) = \frac{(x-306)}{1138{,}5-306} = 0{,}43$$

If the raw material inventory is known as 126 m, then:

$$\mu PsdSEDANGmedium\ inventory\ (126) = \frac{(255-y)}{(22\ 5-112{,}5)} = 0{,}88$$

$$\mu PsdBANYAKmany\ inventory\ (126) = \frac{(y-112{,}5)}{(225-112{,}5)} = 0{,}12$$

Rules that have a value or ≠ 0 become the rules chosen for the composition of Fuzzy Rules. The rules chosen as follows:

[R4] If the Request is LITTLE, and the Supplies ARE MEDIUM, then the Order is LITTLE
α-predicate4 = $\mu PmtSEDIKITfunctional\ demand \cap \mu PsdSEDANGmedium\ inventory$
= min (0,56;0,88)
= 0,56
[R5] If the request is MEDIUM, and the supply is MEDIUM, then the order is MEDIUM
α-predicate5 = $\mu PmSEDANG\ medium\ demand \cap \mu PsdSEDANGmedium\ inventory$
= min (0,43;0,88)
= 0,43
[R7] If the Demand is LITTLE, and the Supplies are MUCH, then the Order IS LITTLE
α-predicate7 = $\mu PmtSEDIKITfunctional\ demand \cap \mu PsdBANYAK\ MANY\ inventory$
= min (0,56;0,12)
= 0,12
[R8] If the demand is MEDIUM, and the supply is MUCH, then the order is LITTLE
α-predicate8 = $\mu PmtSEDANG\ medium\ demand \cap \mu PsdBANYAK\ many\ inventory$
= min (0,43;0,12)
= 0,12

Rule Composition

Fuzzy set solution obtained by making a composition between all the rules by taking the maximum value of the rule called the Max method.

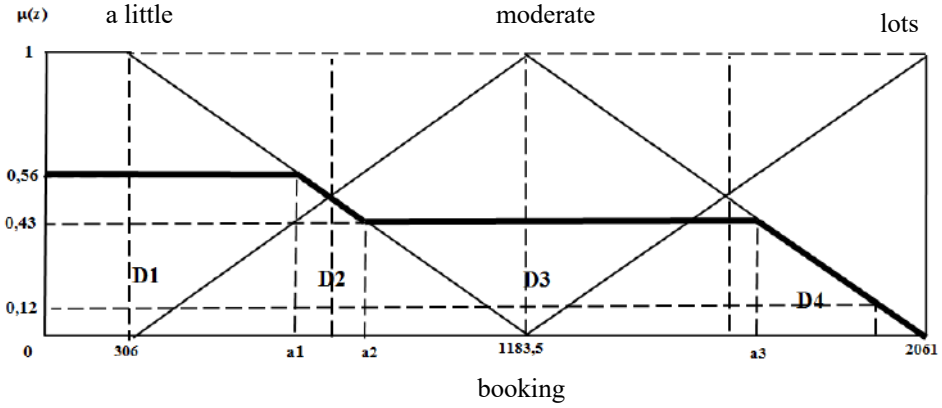

Figure 4. Composition Results Area

The area of the composition of the rules divided into five parts, namely D1, D2, D3, and D4 then look for the values a1, a2, and a3.

$$\frac{1183.5-a1}{1183{,}5-306} = 0{,}56$$

a1 = 692.1

$\frac{1183.5-a2}{1183,5-306} = 0,43$
a2 = 806,1
$\frac{2061-a3}{2061-1183,5} = 0,43$
a3 = 1683,6

The membership function for the results of Fuzzy composition is as follows:

$$\mu Pmsbooking(z)\begin{cases} 0,56 & ;z \leq 692,1 \\ \frac{(1183,5-z)}{1183,5-306} & ;692,1 \leq z \leq 806,1 \\ 0,43 & ;806,1 \leq z \leq 1683,6 \\ \frac{(2061-z)}{(2061-1183,5)} & ;1683,6 \leq z \leq 2061 \end{cases}$$

DEFUZZIFICATION

The input of the Defuzzification process is a set of Fuzzy obtained from the composition of Fuzzy rules, while the resulting output is a number in the Fuzzy set domain. The method used for Defuzzification is the Centroid method. To determine the value of crisp z, it is done by dividing the area into 4 parts D1, D2, D3, and D4 with their respective areas as A1, A2, A3, and A4 and Calculating the Moment of the area against the degree of Fuzzy membership of each M1, M2, M3 and M4. Finding the midpoint by the Centroid method by calculating the area of the moment and the area of the area, as follows:

$$z^* = \frac{\int_0^{692,1}(0,56)z\,dz+\int_{692,1}^{806,1}\frac{(1183.5-z)}{(1183,5-306)}z\,dz+\int_{806,1}^{1683,6}(0,43)z\,dz+\int_{1683,6}^{2061}\frac{(2061-z)}{(2061-1183,5)}z\,dz}{\int_0^{692,1}(0,56)\,dz+\int_{692,1}^{806,1}\frac{(1183.5-z)}{(1183,5-306)}dz+\int_{806,1}^{1683,5}(0,43)z\,dz+\int_{1683,6}^{2061}\frac{(2061-z)}{(2061-1183,5)}dz}$$

$z^* = \frac{792814}{902,4}$
$z^* = 878,5 \approx 879$ Meter

Manual calculation of the Fuzzy Mamdani method for January the first week of 2019 with input of the total demand for parachute cloth 666 meters and input of the total inventory of parachute cloth by 126 meters produces an output prediction of the optimal order of parachute fabric raw material from the results of 879 meters.

Table 2. Predicted Results of Amount of Order of Fuzzy Mamdani raw materials

No.	Month	Week	Demand of Raw Material (Meters)	Stock of Raw material (Meters)	Ordering Raw Materials (Meters)	
					CV. Pinus *Bag's Specialist*	*Fuzzy* Mamdani
1	January	1	666	126	771	879
2		2	846	105	1071	1020
3		3	486	225	531	438
4		4	1791	45	1881	1440
5	February	1	621	90	621	853
6		2	1408,5	0	1476	1750
7		3	733	67,5	733,5	1000
8		4	396	0,5	441	561
9	March	1	1971	45	2061	1740
10		2	666	90	771	895
11		3	306	105	306	418
12		4	756	0	846	1030

Calculate the Accuracy of Predicted Amounts of Raw Material Orders

Based on prediction data obtained from the first week of January 2019 to the fourth week of March 2019, it is determined the extent of the accuracy of predictions using MAE (Mean Absolute Error) and MAPE (Mean Absolute Percentage Error).

MAE (*Mean Absolute Error*)

Table 3. MAE (*Mean Absolute Error*)

No.	Month	Week	F_t (Actual Meter Data)	A_t (Meter Prediction)	F_t- A_t (*Error* Meter)	$\|F_t - A_t\|$
1	January	1	771	879	-108	108
2		2	1071	1020	51	51
3		3	531	438	93	93
4		4	1881	1440	441	441
5	February	1	621	853	-232	232
6		2	1476	1750	-274	274
7		3	733,5	1000	-266,5	266,5
8		4	441	561	-120	120
9	March	1	2061	1740	321	321
10		2	771	895	-124	124
11		3	306	418	-112	112
12		4	846	1030	-184	184
Total						2326.5

$$\text{MAE} = \frac{1}{n}\sum_{t=1}^{n} |\, F_t - A_t \,|$$
$$= \frac{2326.5}{12}$$
$$= 193{,}8 \text{ meter}$$

MAPE (*Mean Absolute Percentage Error*)

Table 4. MAPE (*Mean Absolute Percentage Error*)

No.	Month	Week	F_t (Actual Meter Data)	A_t (Meter Prediction)	F_t -A_t (*Error* Meter)	$\frac{F_t - A_t}{A_t}$
1	January	1	771	879	-108	0,14
2		2	1071	1020	51	0,04
3		3	531	438	93	0,17
4		4	1881	1440	441	0,23
5	February	1	621	853	-232	0,37
6		2	1476	1750	-274	0,18
7		3	733,5	1000	-266,5	0,36
8		4	441	561	-120	0,27
9	March	1	2061	1740	321	0,15
10		2	771	895	-124	0,16
11		3	306	418	-112	0,36
12		4	846	1030	-184	0,21
Total	2,64					

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n} \left|\, \frac{F_t - A_t}{A_t} \,\right| \text{ x } 100\%$$
$$= \frac{2{,}64}{12} \text{ x } 100\%$$
$$= 22\ \%$$

DISCUSSION

The Result of Ordering of Parachute Fabric Raw Materials

The results of data processing using the Fuzzy Mamdani method obtained prediction of the optimal number of parachute fabric raw materials orders in January the first week of 2019 to March the fourth week of 2019 there are differences in the number of orders between CV. Pine Bag's Specialist and processing results of Fuzzy Mamdani method. The difference in the number of bookings is seen every week for three months.

In January, the first week of ordering parachute fabric raw materials made by CV. The Pine Bag's Specialist is 771 meters smaller than the predicted number of raw materials ordered by the Fuzzy Mamdani method by 879 meters. Number of ordering raw materials CV. Pine Bag's Specialist in January the second week of 1071 meters is greater than the predicted number of Fuzzy Mamdani bookings of 1020 meters. Number of ordering raw materials CV. Pine Bag's Specialist in January the third week of 531 meters was greater than the predicted number of Fuzzy Mamdani method bookings of 438 meters. Number of ordering raw materials CV. Pine Bag's Specialist in January the fourth week of 1881 meters was greater than the predicted number of raw material orders for the Fuzzy Mamdani method by 1440 meters.

In February, the first week of ordering parachute fabric raw materials made by CV. The Pine Bag's Specialist is 621 meters smaller than the predicted number of raw materials ordered by the Fuzzy Mamdani method by 853 meters. Number of ordering raw materials CV. Pine Bag's Specialist in February the second week was 1476 meters smaller than the predicted number of Fuzzy Mamdani bookings of 1750 meters. Number of ordering raw materials CV. Pine Bag's Specialist in February the third week was 733.5 meters smaller than the predicted number of bookings for the Fuzzy Mamdani method by 1000 meters. Number of ordering raw materials CV. Pine Bag's Specialist in February the fourth week was 441 meters smaller than the predicted number of raw material orders for Fuzzy Mamdani method by 561 meters.

In March, the first week of ordering parachute fabric raw materials made by CV. The Pine Bag's Specialist of 2061 meters is greater than the predicted number of raw material orders for the Fuzzy Mamdani method by 1740 meters. Number of ordering raw materials CV. Pine Bag's Specialist in March the second week was 771 meters smaller than the predicted number of Fuzzy Mamdani bookings of 895 meters. Number of ordering raw materials CV. The Pine Bag's Specialist in March the third week was 306 meters smaller than the predicted number of Fuzzy Mamdani method reservations by 418 meters. Number of ordering raw materials CV. Pine Bag's Specialist in March the fourth week was 846 meters smaller than the predicted number of raw material orders for Fuzzy Mamdani method by 1030 meters.

Results of Evaluation Amount of Ordering Parachute Fabric Raw Materials

The results of the evaluation of predictive data on the amount of ordering raw materials Fuzzy Mamdani Method with actual data ordering the number of raw materials for parachute fabric CV. Pine Bag's Specialist which is used to support raw material inventory control decisions in conditions of uncertain demand formed from January the first week of 2019 to March the fourth week of 2019 obtained an average absolute error (MAE) value of 193.8 meters, and the average percentage of absolute error (MAPE) of 22%. According to [5] MAPE is at a value of 20% -50% indicating the level of accuracy of the prediction of the amount of ordering raw materials for parachute fabric with Fuzzy Mamdani said to be reasonable and acceptable.

CONCLUSION

From the results of data processing and discussion conducted, the following conclusions can be drawn:

1. Calculation results of raw material inventory control using the Fuzzy Mamdani method that is done manually, obtained prediction of the number of parachute fabric ordering materials in January the first week of 2019 with a large demand for parachute fabric raw material of 666 meters and 126 meters inventory produces predictions of the number of material orders parachute raw cloth for 879 meters.
2. The evaluation results between the prediction of the amount of ordering parachute fabric raw materials with Fuzzy Mamdani with the actual data ordering fabric raw materials CV. Pine Bag's Specialist from January the first week of 2019 until March 2019 is known to have an average absolute error (MAE) of 193.8 meters with an average percentage of absolute error (MAPE) of 22% so it is considered reasonable to make predictions parachute fabric raw material orders in conditions of uncertain demand in the CV. Pine Bag's Specialist.

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DRAINAGE HANDLING SYSTEM IN TAMBOLAKA CITY

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Abstract. A City which is lovable by the society is a livable city, productive and has good spirit Tambolaka City is the capital city of southwest Sumba, like other cities which focuses alsoon the city itself towards the desirable community. Tambolaka city is a small city with an area of 9,605 acre has population about 19,241 people with an average population growth is 4% (Central Bureau of Statistics in Soutwest Sumba,2010). One of the basic urban infrastructure which is considered quite important in Tambolaka City is the sewerage of the drainage system of the city. A good city needs to consider the condition of the culverts because if the water is stagnant, it will geatly affect the life of the city i. e buildings become easily damaged, unhealthy environments, and dirty houses. The drainage systems in Tambolaka City include the trade area, offices, housing, and other areas. The rapid growth of the city is trying to be balanced by make urban infrastructure, one of which very important related to infrastucture is in relation to drainage problems. The drainage conditions in the region are already organized to mitigate the effects of flooding and stagnant water, in some locations there are problems such as unavailability of drainage, inadequate of drainage, stagnant water, and so on.

Keywords: tambolaka city, drainage, flood

1. INTRODUCTION

Tambolaka city with an area of 9,605 hectare, has a population of around 19,241 people with an average population growth of 4 percent. Rapid population growth should be followed by the provision of adequate urban basic infrastructure and facilities [1]. Limited funds and development programs can hamper the provision of basic infrastructure and facilities of the city, so that the needs generally go beyond the provision that can be provided. That's when there is an imbalance, between the large needs while the limited supply. The planned infrastructure and facilities can no longer meet the needs. As a result, traffic jams, floods, municipal waste are not well managed, waste water disposal is not in place, the community is difficult to get clean water services and others [2].

So far, city development in order to answer the challenges and needs of basic urban facilities is aimed at the community to increase economic development. One of the basic infrastructure and facilities of the city which is considered quite important is drainage.

A good city really needs to pay attention to the condition of its drainage channels because if a settlement is inundated it will greatly affect the life of the city buildings become easily damaged, the environment becomes unhealthy and settlements become slums. Drainage channel is a channel that functions to dry surface water, both sourced from rain water, tide water, flood submissions, water puddles, etc.

The area to be handled in Tambolaka City is the trade, office and settlement area in Tambolaka City and its surroundings.

The speed of growth of this region has been offset by the provision of urban infrastructure and facilities [3]. One very important infrastructure and facility is drainage. The condition of drainage channels in this area

has generally been managed well.

In some locations there are drainage problems such as unavailability of drains, inadequate canals, standing water and so on. To improve the drainage system in this area it is deemed necessary to conduct a technical study for the Tambolaka City area and prepare a technical plan for priority areas / areas.

2. METHODS

2.1 Research Design

The outline of research is carried out in the form of information gathering (secondary and primary data collection), field surveys, problem analysis, and formulation of development.

2.2. Surveys, field observations and data collection

Conduct a field survey to determine the condition of existing drainage facilities, including among others: to identify and inventory data and information on the development of infrastructure and drainage facilities that already exist (built / existing) in the Study Area, to identify and inventory areas that have the potential for flooding and areas waterlogging, identifying environmental components (bio-geophysical and social communities around waterlogging and flooding areas), which are predicted to be affected by a large and important impact due to the development of drainage systems, make a mapping to get an overview of the drainage / river channel area.

2.3. Inventory of existing drainage systems and identification of locations of flood prone points

This inventory and identification of flood-prone points is an analysis relating to the cross-section capacity of existing channels, the current utilization / function of channels, and the function of complementary buildings. Inventory and identification activities include the collection of drainage channels, flow patterns and existing drainage network systems.

2.4. Analysis

The analytical work carried out includes analysis as the basis for preparing this study as a whole. The analysis included: hydrological analysis, hydraulics, drainage systems and plan handling patterns.

2.5 Determination of Service Level

Determination of the appropriate level of service for a drainage system, also plays a role in preventing the failure of the function of the drainage system. The optimal level of service will reduce the investment costs invested, in addition to ensuring the functioning of the drainage system for the planned service life. For micro drainage systems it is recommended that the re-design period be taken between 1 to 5 years. The 1-2 year return period can be used for drainage system planning is for settlements, while the above two year return period is used for commercial and industrial areas, as well as transportation facilities. For the primary development system, the annual flood is taken again.

2.6. Compilation of drainage handling patterns

The study must produce a basic pattern of the exhaust system as outlined in a plan that shows the basic pattern and the disposal systems and subsystems and is an integrated whole.

3. RESULTS AND DISCUSSION

3.1 Drainage in Urban Areas

Urban drainage such as those in the City area like Tambolaka has its own characteristics compared to other regions.

The beginning of the problem of drainage systems in urban areas is the development of a population with a relatively high rate [4].

The increase factor is not only due to birth factors but also due to migration factors from other regions.

Population growth affects many things such as residential land, cultivated land and land for production. Further impacts that occur next are an increase in the amount of waste, changes in land use, reduced absorption areas, increased erosion, reduced channel capacity, irregular flow systems, coupled with excessive land acquisition will cause subsidence and lead to floods and inundation. which occurs in the rainy season [5].

3.2 Hydrological Analysis

Hydrological analysis is an analysis that aims to calculate the potential of water that exists in certain regions, to be able to be used, developed and control the potential of water for the benefit of the community around the

area. This hydrological analysis is very important in the study stage especially for irrigation buildings. The purpose of the hydrological analysis in this study is to obtain the design rain value, and the design flood which will later be used as a reference in calculating channel or river capacity [6].

3.2.1 Design Rainfall

Design rainfall is the largest annual rainfall with a certain likelihood of occurrence [6]. To analyze the frequency of rainfall in order to get the design rainfall, there are several methods that can be done. The choice of the design rain analysis method depends on the suitability of the relevant statistical basic parameter data from the distribution selection test conducted or can also be chosen based on other technical considerations. The rainfall design in this study was analyzed using the Gumbel and Log Pearson methods, according to the characteristics of the rainfall that is owned.

1. Gumbel Method

The Gumbel method of getting a rainfall plan is as follows [7]

$$Rt = R + S.K \quad \text{..... (1)}$$

Where :

Rt = design rainfall for the "t" period of the year
R = average maximum daily rainfall
S = standard deviation
K = The frequency factor is a function of the "t" year return period

2. Log Pearson Method

To calculate the design rainfall using the Log Pearson type III method, the data must first be converted into a logarithmic form, then calculate the statistical parameters [7]

$$Log\overline{Rt} = Log\, R + K.S \quad \text{..... (2)}$$

3.2.2. Design Flooding

Design flood is the maximum discharge in a river or channel with a predetermined return period [3]. If the design flood is used as the basis for planning, the flood can occur without jeopardizing the stability of the building. Based on the analysis of planned rainfall from the maximum daily rainfall data, the magnitude of the planned flood discharge can be calculated with a 1, 2, 5, 10, 25, 50, 100,200 and 1000 year return period [8]. Determination of the magnitude of the flood recurrence plan depends on several things such as risks that must be accepted, socioeconomic conditions of the affected community, budgeted costs and other factors [9].

Design flood analysis distinguishes between flooding in a river and flooding in a drainage channel. Floods in drainage channels are analyzed using rational formulas while floods in rivers use the unit hydrograph analysis of the Nakayasu method [7].

1. Flood Analysis with Rational Methods Surface runoff calculated in urban drainage channels is in the form of rainwater runoff that falls in the drainage area, which is the part of rain water that becomes surface flow, calculated by the rational formula [7].

$$Qp = 0{,}00278 \cdot C \cdot I \cdot A \quad \text{.....(3)}$$

Where :

Qp = flood surface runoff discharge (m3 / sec)
C = surface runoff coefficient
I = rainfall intensity during concentration time (mm / hour)
A = drainage area (ha)

2. Synthetic Unit Hydrograph Method Nakayasu Method

Because there is no AWLR (Automatic Water Level Recorder) installed, then to determine the hydrograph of a watershed unit at the study site, a Nakayasu synthetic hydrograph is used [4].

The Nakayasu synthetic unit hydrograph formula is [10]:

$$Qp = \frac{C \times A \times Ro}{3{,}6\ (0{,}3\ Tp + T_{0,3})}$$

Where :
Qp = flood peak discharge (m3 / sec)
Ro = unit rain (mm)
Tp = grace period from the beginning of the rain to the peak of the flood (hour)
$T_{0,3}$ = The time required by the reduction in peak flow to 30% of the peak flow

3.3 Hydrological Analysis

Hydrological analysis is an important analysis in conducting studies in the field of irrigation. This analysis will produce a design rain value which will then be the basis for determining the design flood [10].

3.3.1 Design Rain Analysis

In the rain analysis the design uses the Labuhan Bajo rain station data, the position of the rain post is in Labuhan Bajo Regency. Rainfall data used is maximum daily rainfall data with a long range of rainfall observations for 13 years from 2007 to 2019. The initial analysis method used in the design rain analysis is the Log Pearson Type III method. The results of the design rainfall analysis are shown in Table 1.

Table 1. Rainfall Data from Labuhan Bajo Station

Year	Labuhan Bajo Station	Date of incident
2007	110	November 25th
2008	199	April 17
2009	184	December 25th
2010	82	January 31st
2011	92	January 5
2012	192	January 25th
2013	147	5 May
2014	126	December 27th
2015	231	April 10th
2016	139	March 19th
2017	99	March 2
2018	78	February 20th
2019	120	January 3

Data source : BMKG, Labuhan Bajo

Table 2. Rainfall Area Log Method Pearson Type III

Reset Period (T) (Year)	G	Price Extrapolation (Xt) (mm)
2	0,0010	130,64
5	0,8420	175,99
10	1,2850	205,90
20	1,5990	230,12
25	1,7560	243,29
50	2,0550	270,47
100	2,3280	297,94
200	2,5770	325,42
1000	3,1000	391,66

3.3.2 Design Flood Analysis

Design flood analysis was carried out to determine the magnitude of flooding that occurred in the main drainage system in Tambolaka City especially the Loko Paredawa River and the Loko Tuba River.

3.4 Existing Drainage Systems and Flood Handling Solutions

The main drainage systems in Tambolaka City are two rivers, Loko Paredawa and Loko Tuba.

a. Loko Paredawa

Loko Paredawa is a large channel in Tambolaka City with some of its tributaries such as Loko Mata, Loko Kaki and Loko Mara. Loko Paredawa has a watershed area of 55.03 Km2 with a river length of 19.3 Km. From the analysis of the slope of the river bed (sloope) which is owned by the river is classified as a river with a small slope of 0.0064. With the slope of a small river like this, what is normal for natural river occurrences is meandering in some parts of the river. With a channel that is not too steep in the upstream will form tributaries that are fused in the downstream. n the upper reaches of Loko Paredawa, three tributaries are formed, namely Loko Mata, Loko Kaki and Loko Mara. Loko Mata is located in the hilly area of Weebou at an altitude of about 150 m above sea level . Leg Loko is located in the hilly area of Rakotera at an altitude of about 100 m above sea level . Whereas Loko Mara is the longest tributary of Loka Paredawa, which is located in the hilly area of Kalemburawo at an altitude of about 100 m above sea level . These watersheds are mostly dry land, little forest and a small part of settlements. The downstream Loko Paredawa empties into the Waikelo Bay region in the northern part of Sumba Island.

b. Loko Tuba

Loko Tuba is located east of Tambolaka City and also east of Loko Paredawa. This river also consists of several tributaries which are located in the mountainous area, namely in the Ponorongo area. Likewise with the hills in the mountains, there are some small grooves which then become a channel or tributary in Loko Tuba. LokoTuba has a Watershed Area of 55.31 Km2 with a river length of 19.6 Km. From the analysis of the slope of the river bed (sloope) which is owned by the river is classified as a river with a small slope of 0.0076. Similar to the condition of Loko Paredawa with the slope of a small river like this, what is common in natural rivers is the meandering in some parts of the river. With a channel that is not too steep in the upstream will form tributaries that are fused in the downstream. These watersheds are mostly dry land, little forest and a small part of settlements. The downstream Loko Tuba empties into the Waikelo Bay region in the northern part of Sumba Island.

3.4.1 Causes of Floods and Puddles

Tambolaka City with the current conditions has the potential for flooding and standing water in several places. The main causes of flooding and inundation are irregular drainage systems and very limited and slow absorption by soil because soil types are soils with low absorption and are quickly saturated. Specifically the causes of flooding and standing water in this region are the causes:

a. The system is not organized
   Good flow is not yet organized from the upstream drainage to the primary (river) drainage.
b. Soil type with a small typical absorption.
   The type of soil in Tambolaka City is soil with a small absorption capacity so that it does not significantly reduce the potential for inundation and flooding that might occur.
c. Limited channel / culverts capacity
   The capacity of the existing channel / culvert is very limited compared to the flood discharge and standing water
d. Sedimentation in the channel channel / culvert
   This condition triggers a reduction in channel capacity / culvert

3.4.2. Solution to Handling Floods and Puddles

Based on the area of potential floods and inundations that occur it is necessary to do an effort to deal with inundation and flooding by looking at the characteristics of the drainage area in the City of Tambolaka. The complete flood management solutions carried out in the Tambolaka Region are as follows:

a. Create or enlarge a new path to Loko Mata which is a tributary of Loko Paredawa
b. Make a new path to the Loka Tuba

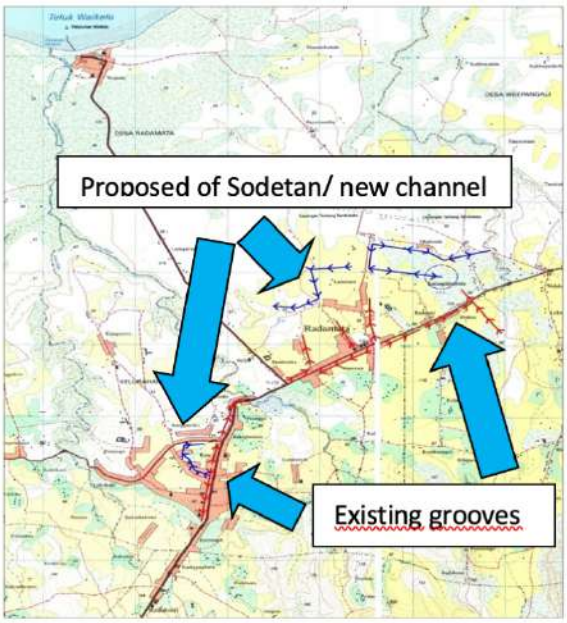

Figure 1. Solution to the handling of floods in the city of Tambolaka

4. CONCLUSION

4.1. Conclusions

From what has been said, it can be concluded as follows:

a. The drainage system in Tambolaka City has not been well organized because it does not yet have a clear system
b. Siltation that occurs in river bodies as a result of the sedimentation process
c. The existing river capacity (Loko Paredawa River and Loko Tuba River) is very inadequate

5.2. Suggestions

a. Need to make a new channel / sodetan in an effort to reduce water faster
b. Maintenance of the function of the channel as a carrier of water discharge during the rainy season needs to be improved

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INFORMATION TECHNOLOGY BLUE PRINT DESIGN USING ENTERPRISE ARCHITECTURE PLANNING IN POLITEKNIK NEGERI BALI

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Abstract. The Information Technology (IT) blueprint basically contains a strategic plan of the company / institution in implementing and developing information technology / information systems in the company / institution. This study aims to design the IT Blueprint model in terms of data architecture, application architecture and technology architecture using the Zachman Framework enterprise architecture, where the blueprint is a comprehensive and integrated information technology system design. The methodology used in this study refers to the framework of Enterprise Architecture Planning. The results of this study obtained data architecture design, applications and technology along with data entities, business entities and business processes and business process functions so that they can illustrate the IT blueprint model along with the implementation roadmap that serves as a reference and guideline campus of Politeknik Negeri Bali (PNB).

Keywords: enterprise architecture planning, design, blueprint

1. INTRODUCTION

Various studies show that information technology plays a very important role in the continuity of an organization. The results of the gap analysis of governance conditions will be used as the basis for future strategies for improving information technology governance. In the development of information systems, integration factors also need to be considered to reduce gaps in the system development process. To reduce this gap, it is necessary to improve business processes and design information system technology such as (data), design of application infrastructure and design of network infrastructure (technology) so that universities are obliged to develop and implement and take advantage of advances in information technology to improve their ability to manage their enterprises.

Information technology provides various business opportunities to improve efficiency and effectiveness as well as provide a competitive edge. The impact of the existence of information technology forces a company to change in the face of technological developments grow so fast. Digital transformation is the right term to describe these conditions. Digital transformation encourages companies to adapt to digitalization and be able to create more value for the company. Digital transformation has an impact on more efficient business operations, better supply chain management, reduced cost and resource requirements and is able to generate better profits.

There is no planning for the development of further integrated Information Technology and Information Systems such as HR information systems, research information systems, scholarship information systems, career alumni information systems, paperless information systems, asset information systems, plagiarism information systems, library information systems, other information systems needed by the related institutions and work units in PNB will result in weakness in accelerating to obtain the required data information, such as during accreditation study programs, where existing data information must be accurate and connected to other data. Therefore, designing an information technology blueprint / blueprint is needed to become a new foundation in planning, implementing, implementing, implementing and developing information technology in PNB. Through the information technology blueprint, it will be able to describe in detail the direction and needs of information

technology development both in terms of software and hardware needed, and it is hoped that all work unit activities will be integrated and effective.

Various studies have shown that information technology has played an important role in the sustainability of an organization. The results after analyzing the conditions of governance will form the basis of future information technology governance management strategies [1]. In the development of information systems, integration factors also need to be considered to reduce crises in the system process. To overcome this, it is necessary to improve business processes and design information technology such as information infrastructure design (data), application infrastructure design and network infrastructure design (technology) so that universities are obliged to develop and implement and take advantage of advances in information technology to improve the capabilities of enterprise enterprises - her [2].

The absence of planning for the development of further integrated Information Technology and Information Systems such as HR information systems, Research information systems, scholarship information systems, career alumni information systems, paperless information systems, asset information systems, plagiarism information systems, library information systems, other information systems needed by related institutions and work units in PNB will result in weakness in accelerating to obtain the required data information such as during the accreditation process for study programs and institutional accreditation, which are required to provide accurate and fast data information and digitally recorded on the server.

Therefore, the design of an information technology blueprint / blueprint is needed by the SIM Unit to become the basis and guideline for planning, structuring, implementing, utilizing and developing information technology in PNB today and in the future. Through the information technology blueprint, the SIM Unit can describe in detail the direction and needs for the development of information technology needed and it is hoped that all activities of the university work unit will be integrated and efficient.

2. METHODS

In this study, the stages used to analyze the IT Blueprint design use the Enterprise Architecture Planning (EAP) method, which is a blueprint for organizing all enterprise business processes, required information and supporting technologies. In enterprise architecture, it consists of defining the present state, a vision of the future status of the business as well as technology, and other ways of managing complexity [3]. According to Marc and Lankhorst [4], enterprise architecture is part of the principles, methods and models used in the design and realization of enterprise organizational structures, business processes, information systems and infrastructure.

Spewak defines Enterprise Architecture Planning (EAP) as "the process of defining an architecture for the use of information to support a business and plans to implement that architecture"[5]. Enterprise Architecture Planning is based on the Business Systems Planning (BSP) approach developed by John Zachman in 1980 [6]. It takes a business-oriented approach to architectural planning to provider: data quality, access to data, adaptability to changing requirements, interoperability and data sharing, and containment. cost.

The ultimate goal of Enterprise Architecture is to define practical and applicable technology applications and projects along with the projects needed to prepare an organization for the IT environment of the future. This view counters the more traditional view that applications must be defined before data requirements are determined or provided. [7].

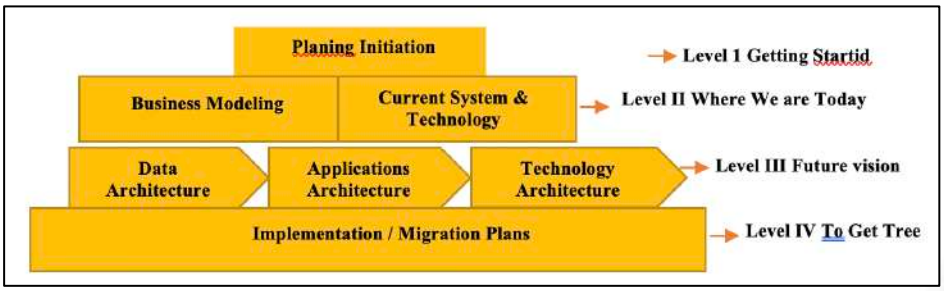

Figure 1. Layer Enterprise Architecture (Spewak)

The Enterprise Architectural Planning Model consists of four levels:

Level 1 - getting started: This layer leads to the creation of an EAP work plan and emphasizes the need for a high level of management commitment to support and resources the next six components (or steps) of the process. This consists of Initiation Planning, which includes in general, decisions about the methodology to be used, who should be involved, what support is needed, and what tools to use.

Level 2 - where we are today: This layer provides a baseline for defining the eventual architecture and long-term migration plans. Consists of: Business process modeling, compilation of a knowledge base of business functions, information used in conducting and supporting various business processes, Latest Systems and Technologies, definitions of current application systems and supporting technology platforms.

Level 3 - the vision in which we want to be: Arrows describe the basic definition process lines: data architecture, application architecture, and technology architecture. Consists of: Data Architecture - Defines the main types of data required to support a business. Application Architecture - Defines the main types of applications required to manage that data and support business functions. Technology Architecture - The definition of the technology platform required to support applications that manage data and support business functions.

Level 4 - how we plan to get there: It consists of an Implementation / Migration Plan - Definition of the sequence of application deployments, implementation schedule, cost / benefit analysis, and clear migration path.

The stages of this research begin with analyzing the main activities of the Teaching and Learning Process, Research and Community Service. Then analyze supporting activities, namely financial management, human resource management, and so on. The results of the analysis of the main and supporting activities will be carried out by realizing planning, reviewing current systems and technology by modeling business processes, designing technology architectures, application and data architectures and implementation plans in the form of IT Roadmaps and Blueprints.

3. RESULTS AND DISCUSSION

3.1 Analysis of the Existing Condition of the SIM Unit

The Management Information System Unit (MIS) at Bali State Polytechnic has an important role in planning, designing and implementing computer network infrastructure. Starting 2017, the internet network uses a bandwidth of 300 Mbps (1: 1) with a National ISP. The implementation of the information system that has been developed by the SIM Unit began in 2016, namely the Online Information System (SION) and in 2018 it has been used but has not been maximized because there are still things that need to be refined and developed according to needs, so that in 2020 the utilization can be maximized. In 2020, the SIM unit will design and implement an integrated payment model for UKT with Bank BPD Bali, payment for new student registration online, online student re-registration, PBM reporting with Pider Dikti, lecturer reporting for promotion and lecturer certification with SISTER, Registration of online lecturer research profiles, Mobile lecturer absence, implementing the Online Journal Application and e-learning.

3.2 Blueprint Design

a. Business Process Development

Based on the results of observations, interviews and analysis carried out on business processes at the PNB Campus, an overview of the problem is obtained, so it is necessary to develop and integrate data between existing information system data and information system data needed for the short and long term. These problems are as illustrated in Table 1.

Table 1 Business Problems in PNB Campus Process

Business Process Activities	Problem
New Student Admission / Admission	There is no integration with the Partner Bank when payment for registration for obtaining User and PIN
Student UKT Payments	There is no partner bank to support UKT payments
Data Reporting Higher Education	There is no feeder information system that connects the Campus Academic Information System with the Central PDDikti Information System when reporting academic data.
Lecturer Workload	There is no administrative management available. Lecturer workload online
Human resources	There is no optimal management of personnel data. There is no integrated fingerprint management
SKP	There is no web-based information system management available for input and reporting of employee SKP
Repository	There is no university repository for presenting and storing digital data from theses, researches and scientific journals.
Research	There is no university repository for presenting and storing digital data from theses, researches and scientific journals. There is no research theme search feature that is used to prevent recurrence of research themes.
Alumni and Career	Unavailability of alumni and career data management which is one of the important information for universities and the general public
Access to Information Report data to leaders	The unavailability of provision of information for reporting that can be accessed by the leadership to be used as material in decision making for executives regarding all activities that occur within the university
Data Cloud	System Unavailability of online data storage resources for lecturers, employees and students
Libraries	Data Cloud System Unavailability of online data storage resources for lecturers, employees and students
BLU	Unavailability of management of BLU transactions The unavailability of recording income from borrowing and leasing assets, borrowing and leasing space and buildings and technology assets

b. Data Entities and Business Entity Relationships

The characteristics of the data have been defined so that the next process is the identification of the characteristics of the identification and clarification of data for the business processes in the training high. This can be done by referring to Table 2 as follows:

Table 2 Identification of Data Entities and Business Entity Relationships

Data Entity	Business Entity
New Student Admission Payment	User, Pin, Partner Bank H2H
UKT Payments	Student Payments, Partner Bank H2H
Data Reporting of Student Colleges	Lecturers NIP, Student Study Results, Historical Teaching Lecturers, Alumni
Budget	Budget code, Name of budget
SDM	NIP Employee, Employee Name, Transfer, History, Education, Rank, Class, Position
Paperless	Letter code, letter name, disposition, incoming mail, outgoing mail
SKP	Employee NIP, Employee Name, Rank, Class, Position, Performance
Repository	Code repo, Students, Lecturers, Employees, Thesis, Thesis, Research, Scientific Journal
Research	Code, Lecturer-Employee NIP, Name, Research
Alumni and Career	NIM , Name of Student, Address, Job
Access to Data Report information to leadership	NIM, Student Name, Address, Work, Employee NIP, Employee Name, Rank, Class, Position, Performance
Library	NIM , Student's Name, Biodata
BLU	Transaction Code, BLU Code, Building, Asset
Business Dashboard system	Academic System, Portal, Registration, Payment, Scholarships, HR, BKD, SKP, Research, Budget, BLU

c. Candidate Application and Application Gap Analysis

There are 14 candidates for new information system applications that will be developed in the short and long term. Namely, 1) Research, 2) Human Resources, 3) BKD, 4) SKP, 5) Feeder, 6) Repository, 7) Scholarships, 8) Career Alumni, 9) Paperless, 10) BLU, 11) Assets, 12) Budget, 13) Busines Dashboard System, 14) Access to data report information to the leader.

The application comparison between the current application architecture and the application to be developed is obtained a total of 34 applications. There are 14 new applications that will be developed, and 6 customized applications, while 10 applications are integrated.

d. Technology and Technology Gap Analysis

The implementation of a computer network topology that has been used is to use a Star Topology where all connections are centralized on one Switch node (Manager switch). The current technology architecture that will be used to support the business functions of developing information systems in PNB is as follows:

a. The hardware that is owned is adequate for the technology architecture
b. The existence of a centralized server room so that all servers and routers as well as microtic and other network devices are located in one special room. (SIM unit).
c. It allows the addition of servers and rack servers for long-term information system implementation
d. Allows for the development of networks in new buildings to support business functions for the development of new information systems.

3.2 Implementation Plan

a. Order of Application Implementation

Determining the sequence of application architecture implementation to be developed based on the current business process needs and based on an organizational perspective so that the order of the application architecture is as follows:

Table 3. List of Application Implementation Sequences

Serial Number	Application Candidate Name
1	Repository Information System Application
2	Information System Applications
3	Research Information System Applications
4	BKD Information System Application
5	Applications for Career Alumni Information Systems
6	SKP Information System Application
7	Feeder Information System Application
8	Paperless Information System Applications
9	Information System Applications Data reports to leaders
10	Businnes Dashboard System Information System Applications
11	Budget Information System Applications
12	Asset Information System Applications
13	BLU Information System Applications
14	Library System Applications

b. IT Blueprint Design Model in PNB

The IT Blueprint Business Process Architecture at PNB consists of 2 process domains. First, the Main Domain (Tri Dharma Perguruan Tinggi), namely Education, Research and Community Service and Second, namely the Support Domain. The following is a drawing of a blueprint design model.

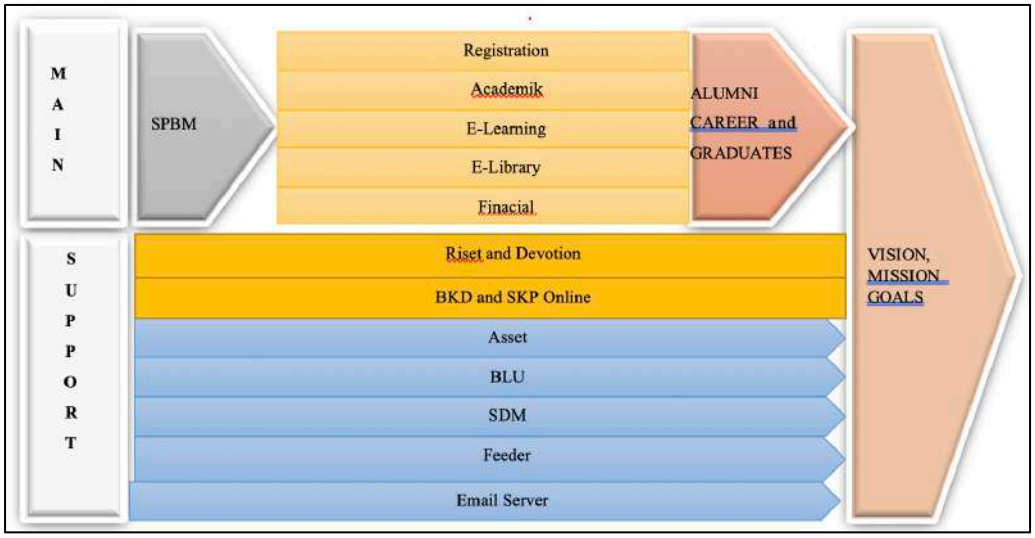

Figure 2. Model blueprint design.

c. Implementation Roadmap

The stages of the Road Map for Application Architecture Implementation are prepared based on the perspective of institutions and budgets that have a priority scale for the implementation of technology on the PNB campus. The following is the Roadmap for the information system implementation plan from 2016 to 2020

Figure 3. Road Map of the Information System Implementation Plan

4. CONCLUSION

Based on the results of the discussion of enterprise architecture design using the Zachman Framework, conclusions can be drawn, namely:

a. There are 14 global business process problems that have not been developed to achieve the vision, mission and objectives of PNB
b. There are 34 application architectures with details of 14 candidate applications that need new development, 6 applications that need to be customized, and 10 applications that are integrated,
c. Obtain a conceptual overview of the current network architecture and an overview of the technology architecture that will be upgraded to support the main business functions of higher education and a list of the implementation sequence of application candidates to be developed which are grouped into Resource Management System, Knowledge Management System, Community Management System, Executive Dashboard System.

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USABILITY ANALYSES ON THE DAILY EVALUATION SYSTEM APPLICATION WITH POTENTIAL GAIN CUSTOMER VALUE METHOD AND CUSTOMER SATISFACTION INDEX METHOD

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Abstract. The advantage use of information technology is not only limited to individuals, but also organizations, especially government organizations. In 2003 the Indonesian government issued Presidential Instruction No. 3/2003 concerning national policies and strategies for e-government development. Based on this, a usability analysis is performed on the Daily Evaluation System (DES) application with the Customer Satisfaction Index (CSI) method and the Potential Gain Customer Value (PGCV) method. The User Centered Design (UCD) is used as an indicator of the questionnaire and the results are analyzed using the CSI and PGCV methods. The results of CSI analysis of the satisfaction level showed the value of 70.95% for female respondents, while it is 70.84% for male respondents. The value of the level of satisfaction is equal to 67.42% for respondents aged 20-30 years, 72.07% for respondents aged 31-40 years, and 73.87% for respondents aged 41-60 years. The level of satisfaction for respondents in structural positions is 72.65% while for respondents in functional positions is 69.73%. Based on the ten UCD indicators, the highest percentage of satisfaction is the consistency indicator which is 77.82% and the lowest is the assistance and documentation indicator which is 63.00%. Based on the results of the PGCV analysis, it is showed that 11 attributes are needed to be the priority for improvement.

Keywords : usability, daily evaluation system application, customer satisfaction index , potensial gain customer value, user centered design.

1. INTRODUCTION

The rapid development of technology brings many changes in organizational activities, especially in government organizations. Based on Presidential Instruction No. 3 of 2003 about national policies and strategies for e-government development, the development refers to the use of communication and information technology, including the use of websites, which are expected to increase efficiency, cost effectiveness and government transparency.

The National Civil Service Agency (BKN) as a non-ministerial government agency which in charge of the civil servant personnel management has begun implementing e-government development in accordance with Presidential Instruction No. 3 of 2003. The implementation of e-government in the National Civil Service Agency is the use of the Daily Evaluation System (DES) application. DES is used in organizing the annual Employee Work Goals (SKP), measuring employee's daily performance and measuring employee's performance achievements every year.

The Directorate of Performance of the National Civil Apparatus as the manager of the DES application recorded the number of civil servants who had registered in the database as many as 2719 people. Along with the developments of technology and the increasing of user needs, improvements will be made to the application. Thus, it is necessary to conduct a usability analysis as a basis or guide in the process of the application improvement.

Usability analysis is carried out through an application testing by involving end users. Several studies

related to usability analysis have been conducted, among others; The research focuses on customer satisfaction with the use of quality assurance information systems by applying three indicators in the questionnaire, namely Task Complete Rate, Time On Task and Usability Rate of System [1]. Another study focuses on design indicators and the highest value of saverity rating on the aspects of user flexibility and efficiency [2]. Research on the Information System Usability Analysis conducted in Karanganyar Regency Website using Heuristic Evaluation [3]. This study focuses on the Heuristic Evaluation method in determining indicators and the data collected using a questionnaire method from 112 respondents while the quality scale is measured using the ratting method. The results of this study indicate that there needs to be an improvement in the system, on the aspects of flexibility and efficiency of use and the esthetic and minimalist design which has a large enough percentage value of dissatisfaction. In addition to these studies, usability analysis research obtained a result that showed the quality of the Pro Denpasar website in terms of good quality of the webqual and servqual [4]. Based on some of these studies, this research carry out the usability analysis in the Daily Evaluation System application using indicators in the User Centered Design method, which then the data from questionnaire are analyzes using the Customer Satisfaction Index and Potential Gain Customer Value methods.

2. METHODS

The method used in the data analysis process are the Customer Satisfaction Index (CSI) method and the Potential Gain Customer Value (PGCV) method. The CSI method is used to determine the level of user satisfaction with the DES application, while the PGCV method is used to analyze attributes that need to be a top priority for improvement. The data is collect by questionnaire technique. The questionnaires were distributed online and offline to the Central BKN, 14 Regional Offices and 16 UPT. The number of respondents is determined using the Slovin method, giving the number of involved respondents needed as many as 100 people. Based on the data of the questionnaires that have been filled in by the respondents, two tabulation tables were formed, namely the performance level tabulation table and the importance level tabulation table. The step continued by calculating the average value for performance and importance. This average value is used to determine the Achieve Customer Value (ACV) and the Ultimately Desired Customer Value (UDCV). The last step in the data analysis process is to determine the PGCV value based on the ACV and UDCV values. After the PGCV value is obtained, conclusions are drawn to determine which attributes will be the priority for improvement.

3. RESULTS AND DISCUSSION

3.1 The Analysis of the User Satisfaction Level by CSI Method

Assessment of the questionnaire conducted to 100 respondents consisting of 48 female respondents and 52 male respondents. The result showed that the satisfaction level of DES application usability for the female respondent group is 70.95% while for the male respondent group is 70.84%. These percentages mean that the DES application can still be categorized well and still feasible for use.

Based on the age category, 100 respondents consist of 36 respondents aged 20 - 30 years, 36 respondents aged 31 - 40 years and 28 respondents aged 40 - 60 years. CSI analysis of the respondent satisfaction level of DES application is obtained in terms of UCD usability. The result for the age group 20 - 30 years is 67.42%, 31-40 years age group is 72.07% and for the 40 - 60% age group is 73.87%. These percentages value indicate a good category and the DES application is still feasible for use.

Based on the occupational category, 40 respondents came from structural positions and 60 respondents came from functional positions. The results of the satisfaction level from the CSI analysis based on this category are 72.65% for structural positions and 69.73% for functional positions. These two percentages value indicate that the application is still in the good category and feasible for use.

The CSI analysis results based on each of the ten UCD indicators based on the assessment of 100 respondents showed that all indicators are still in good category. The three indicators with the highest percentage are consistency, ease of use and language use, while the three indicators with the lowest percentage are memorability, flexibility and documentation.

3.2 The Analysis Results by the Potential Gain Customer Value Method

Table 1 is the recapitulation of the Potential Gain Customer Value (PGCV) analysis results which is used to determine the attributes for the top priority improvement.

P value shows the average value of Performance level, while the I value shows the average Importance level. Based on the assessment made by 100 respondents, the average value of AGCV is 13.57 while the average value of UDCV is 19.29. The attributes that consider as the priority in improving the application are those that have the highest PGCV value, the smaller than the average AGCV value, and the greater than the average UDCV value. Based on the PGCV results in table 1, the sequence of improvement needed attributes and the improvement recommendations are as follows.

Table 1. Reseacrh Subjects Characteristic Summary

Attribute	P	I	ACV	UDCV	PGCV
23	3,09	3,86	11,93	19,30	7,37
27	3,16	3,90	12,32	19,50	7,18
22	3,21	3,86	12,39	19,30	6,91
12	3,24	3,86	12,51	19,30	6,79
26	3,25	3,88	12,61	19,40	6,79
9	3,32	3,85	12,78	19,25	6,47
13	3,36	3,87	13,00	19,35	6,35
17	3,41	3,92	13,37	19,60	6,23
21	3,42	3,87	13,24	19,35	6,11
14	3,44	3,86	13,28	19,30	6,02
30	3,41	3,73	12,72	18,65	5,93
16	3,50	3,86	13,51	19,30	5,79
11	3,57	4,01	14,32	20,05	5,73
4	3,56	3,97	14,13	19,85	5,72
32	3,27	3,29	10,76	16,45	5,69
20	3,56	3,94	14,03	19,70	5,67
15	3,57	3,95	14,10	19,75	5,65
6	3,60	4,01	14,44	20,05	5,61
5	3,56	3,88	13,81	19,40	5,59
10	3,60	3,99	14,36	19,95	5,59
18	3,56	3,85	13,71	19,25	5,54
19	3,62	3,98	14,41	19,90	5,49
2	3,63	3,93	14,27	19,65	5,38
24	3,58	3,79	13,57	18,95	5,38
25	3,58	3,79	13,57	18,95	5,38
8	3,61	3,86	13,93	19,30	5,37
1	3,67	4,03	14,79	20,15	5,36
3	3,68	3,96	14,57	19,80	5,23
33	3,57	3,65	13,03	18,25	5,22
35	3,57	3,57	12,74	17,85	5,11
34	3,56	3,47	12,35	17,35	5,00
7	3,77	3,97	14,97	19,85	4,88
31	3,78	3,90	14,74	19,50	4,76
29	3,80	3,92	14,90	19,60	4,70
28	3,98	4,00	15,92	20,00	4,08
	Average		13.57	19.29	5.72

Table 2. Improvement Recommendations for DES Application

Attribute	P	I
23	DES provide an FAQ service to make it easier for users	There is an FAQ service in the DES application regarding common questions that users often ask
27	The user can easily return to the previous page with the 'back' button	There is a back button when adding daily SKP performance data
22	There is a manual book that makes it easy to operate DES	Adding a manual book to the DES application
12	The DES application has a URL address that is easy to remember	The DES application URL address should be changed to http://ekinerja-asn.bkn.go.id
26	New users can easily use the DES application	Adding SKP data processing flow In the manual book
9	Information on employee performance at DES can be trusted	Adding time feature in daily performance data input Assessment of each activity from the direct supervisor When inputting the monthly SKP category, the annual SKP is adjusted to the SKP target structure
13	The process on each DES menu is straightforward	The monthly SKP target in the following month can be withdrawn from the previous monthly SKP Time realization is calculated according to daily performance data
17	DES displays a notification when there is data input errors	A notification appears when there is a mismatch between the target and the realization
21	Displays a loading sign while the process is still carried out	Displays a loading sign when inputting daily SKP data
14	The process flow for using DES is easy to remember and understand	The daily SKP unit result data is adjusted automatically to the monthly target unit The process check box on daily performance data should be changed to a monthly and annual dropdown
16	DES provides personalization facilities for users	There is a roll back button to prevent switching to another account

4. CONCLUSION

Based on the analysis, the conclusions are as follows.

1. The value of the user satisfaction level of DES application is divided into four categories which are gender, age, occupational position and UCD indicators. The satisfaction level value for female gender is 70.95% while for male gender is 70.84%. The satisfaction level value for 20-30 years old group is 67.42%, for 31-40 years old group is 72.07% and for 41-60 years old group is 73.87%. The satisfaction level value for structural positions was 72.65% while for functional positions was 69.73%. All categories showed good scores. The highest percentage value of the satisfaction level based on the ten UCD indicators is the consistency indicator, which is 77.82%, and the lowest is the aid and documentation indicator, which is 63.00%.

2. Based on the results of the PGCV method analysis, there are 11 attributes that consider as the priority improvements. The improvements attribute in sequence is started from DES attribute providing FAQ services to make it easier for users, users can easily return to the previous page with the back button, there is a manual book that makes it easy in operating DES, the DES application has a URL address that is easy to remember, new users can easily use the DES application, employee performance information in DES can be trusted, the process on each DES menu is straightforward, DES displays notifications when inputting data errors, displays a loading sign while the process is being carried out, the DES usage process flow is easy to remember and understand and DES provides personalization facilities for users.

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A DESIGN OF FARMER'S ORANGE FIELD SECURITY SYSTEM USING MICROCONTROLLER BASED DIRECT TELEPHONE TECHNOLOGY

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Abstract. *The development of security system is a positive development on reducing society's anxiety of criminal act such as theft. The security systems that are being developed today are mostly home security systems, motor cycle and cars. So far, the security system for paddy fields or agricultural fields has been minimal studied. So far, security system in farming land has been studied but in minimum frequency, such as in orange field where thefts often occur even farmers had surrounded their farming land with fences. This device made of Pir Sensor that could detect humans, it uses ATmeg328P-PU as the CPU, SIM 800L as media or device in sending messages and battery as power source. Designing this device is easy enough and affordable, this device capable in calling registered phone number in pseudecode that had been input into the program.*

Keywords : orange fild, security, safety, microcontroller.

1. INTRODUCTION

The numbers of research on house and vehicle security system has been spread widely in the market and research, in the other hand farming security system among villagers mainly on orange farmer is very limited in numbers or in other word is there isn't any of it yet. Meanwhile, orange farmers are worried on their ripe oranges that set to be harvesting for being stole by thief. So far, farmers has watched over their farming once every 3 or 4 hours daily.

Unemployment young man from Tegaldlimo, Banyuwang regency was battered after beaten by the villagers because he was caught in stealing oranges in one of orange field belongs to Supriyono, Kalipait Tegaldlimo [1]. theft of orange fruit occurred at the second time, Supriyadi, 50, from Sidorejo Wetan, Yosomulyo village. It begun when Supriyadi the owner suspicious when he realized that the harvest decreased for next day [2]. a man was presumed as thief for his neighbors farm, located in Sidorejo Wetan, Sambimulyo, Bangorejo, Banyuwangi has been arrested by Reskrim Polsek Bangorejo on Tuesday, 11 August 2020 [3].

Security is an important aspect of life. That's why, many developments of technology is designed for offer secures to protect their asset [4]. security system has been an important need for everyone who has cars, house as their belonging. It become need as highly increased criminal act among society [5]. Security is very important for everyone. Homes that are often left the owner can be used by thieves to perform the action. Therefore required an effective home security system so that homeowners can find out information if the house burglarized by thieves [6]. The vehicle's anti-theft system is a module used to protect motorcycle vehicles from theft by using three layers of security [7].

From the descriptions can be concluded, most of study discuss on house security and vehicle's security not in field or farming land security system that so far being ignored, but those needs are needed by the farmer, in this case is orange fruit, so as the need among the farmer, researcher initiate this study in designing farming security system for orange farmer using direct phone based on microcontroller security system.

2. METHODS

Mindset of research as follow:

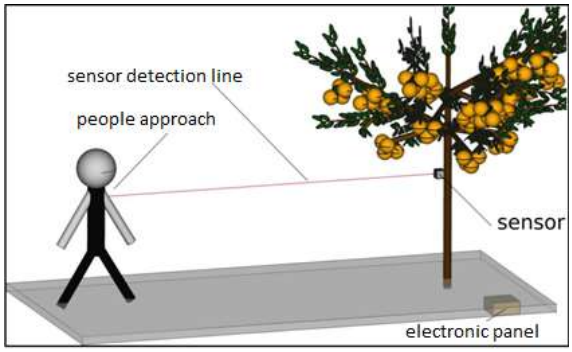

Figure 1. Mindset

Module of direct Telephone electronic panel placed under land surface to hid from anyone out of the farmer or outsider, the sensor placed on a branch of the tree, the sensor can detect the movement of man with perimeter 6 meter by the angle 110^0 x 70^0 after pir sensor detect human or man around it will be processed by ATmeg328P-PU as the CPU and then directed to SIM800L as the connector to dial phone number, diagram will be shown as follow:

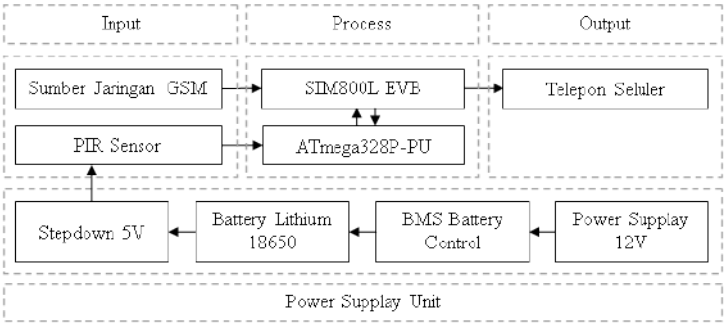

Figure 2. Block diagram instrumen device

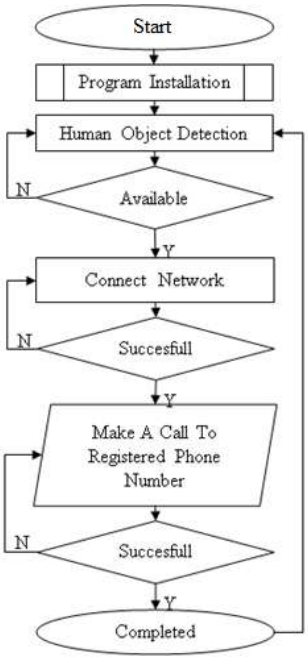

Figure 3. Flowchart of hardware

3. RESULTS AND DISCUSSION

3.1 Figur And Pseudocode

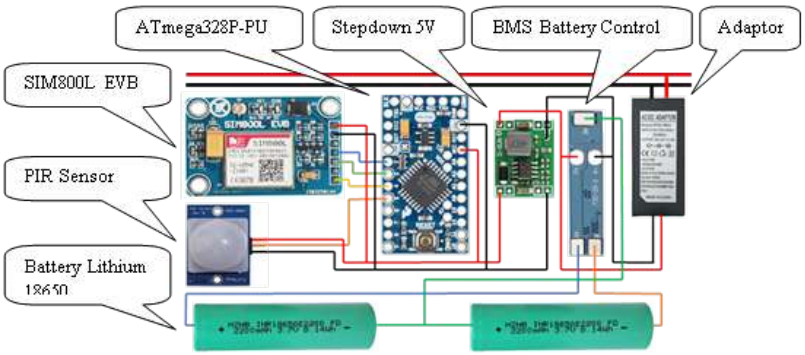

Figure 4. Hardware circuit schematic

Description And Explanation:

Source of network GPRS - as main access for SIM800L so it can be connected via BTS (base Transceiver Station).
PIR Sensor - as the sensor to detect human movement with 6 metre perimeter, angle 110^0 X 70^0.
SIM800L - as a device in sending command to dial phone to the number listed in the device.
Command SIM800L - using AT Command serial sequence.
ATmega328P-PU - as CPU of security system.
Arduino IDE - with compiler AVR-GCC under Library Arduino dependency.
Connection ATmega328-PU with SIM800L - using USART Communication system.
CellPhone - as receiver dial phone sent by the instrument.
Power supply 12 V - charger to recharge battery of the instrument.
BMS Battery control - current controller in using battery Lithium and as security when the battery being charged.
Stepdown 5 V - as the function in decreasing the current from both battery to 5 V DC.

After all devices set then it is needed to be programmed as the diagram above, here the researcher used pseudocode in order to be understandable as follow:

```
#include <SIM800L.h>
SIM800 sim(2, 3, 4);
const char *number = "081234567890";
void setup(void) {
  pinMode(5, false);
  while(!(sim->begin(9600))) {}
}
void loop(void) {
  if (digitalRead(5)) {
    while (!(sim->connect())) {}
    while (!(sim->dialToNumber(number))) {}
  }
}
```

Figure 1. Pseudocode hardware on the Arduino IDE

3.2. Equations

Battery usage

1. Formula of battery using series circuit "Vtot = Vbat1 + Vbat2" (constant ampere)
2. Formula of batter using parallel circuit "Aout = Abat1 + Abat2" (constant voltage)

I = P x V
P = 20,8804 mA
V = 5V
I = 1.0 mA x 5 V
I = 104,402 mAh
Usage time = (Battery capacity/ Batteryload) – efficiency 20%
Usage time = 4500mAh / 104,402mAh – efficiency 20%
Usage time = 43 – (900 x 20%)
Usage time = 43 – 8
Usage time = 35 hours usage

Table 1. Battery consumption

Device Name	Power Consumption (mA)	Voltage Consumption (V)
SIM800L	0,7	5
ATmega328P-PU	20	5
PIR Sensor	0,1	5
Stepdown 5V	0,08	5
BMS Battery Control	0,0004	5
Total	20,8804 (because paralel)	5 (because parelel)

3.3 Working Of The System

The result of the security system design for orange fruit farmer is a an effective solution, by implementing the device, farmer doesn't need to monitor their farming land every hour or regularly in 2 and 3 hours, this device able to minimize the risk of lost by thief as what it is broadcasted by the media. The design of the device is easy enough and affordable for the components and have been enclosed and how to install it. The security system is succeed to connect the owner phone number to warn him. The researcher used pseudecode because it is easier and if it is made by the farmer, the speed in connecting to the owner phone less than 30 second, researcher didn't use short massage service (SMS) because the farmer isn't always fast in responding it, it is said that using SMS is left behind techonology. The problem here is on the usage of the battery, it is counted the battery will last for 35 hours but the fact is the battery last less of it, meanwhile in the specification of the battery on the box said can be used for 35 hours, so it is need to add an extra battery in case of longer usage, or additional battery.

4. CONCLUSION

Base on the design that has been described above so it is concluded that farming security system using direct telephone technology base on micro controller can be used and implemented effectively, if there is any human movement around the set perimeter inside the farm or trees then the device will detect him and directly send a warning to the owner phone or farmer phone less than 30 second, so the farmer will get notification there is someone inside his farming land.

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ANALYSIS FEASIBILITY OF PHOTOVOLTAIC ARRAY DRIVE A MEDIUM TEMPERATURE REFRIGERATOR

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Abstract. Solar power (photovoltaic) is one of the clean energies that is very well developed in a tropical country like Indonesia. This is due to the high intensity of the sun and shining throughout the year so that the annual energy obtained is relatively high. The solar energy system in this research was developed with a photovoltaic array system that can be optimized for angles and facing according to where the experiment was carried out. The solar system using Solar Control Charge (SCC) and an inverter in order to get both alternating and direct current output. This energy output from solar power is used to drive the medium temperature refrigerator system for storing fresh vegetables and fruit. The results obtained from this preliminary study are the best angle and direction is an angle of 15 degrees to the north. And this condition will be determined in the form of a fixed tilt on the solar power system located at the Bali State Polytechnic and its surroundings.

Keywords : photovoltaic array, medium temperature refrigerator, optimum angle and facing.

1. INTRODUCTION

The feasibility of using solar power as an energy source in the refrigerator system has been studied in various countries that are similar to Indonesia's condition. Modi at al. [1] conducted a study on the use of solar power for conventional refrigerator systems. The system was re-designed with the addition of batteries, inverters and transformers with solar panel photovoltaic (SPV) energy sources. The results showed that the performance (COP) of the refrigerator decreased from morning to evening, with a maximum COP of 2.1 at 7 am and economically it still requires a rather high investment cost because the battery price is still relatively expensive. Bilgili [2] investigated by making a solar electric-vapor compression refrigeration (SEVCR) system, this system is very suitable for cooling during the day. Gupta et al [3] conducted research with the development of stand-alone solar panels as an energy source for the refrigerator system, and analyzed the suitable solar panel design for a certain refrigerator capacity and found that solar power was very suitable for the refrigerator system. Daffallah [4] investigation an energy-efficient approach to providing cooling needs is one of the challenges facing most developing countries. This research was conducted to assess the performance of DC 12 V and 24 V photovoltaic refrigerators with / without loading which were operated at 25 ° C and 35 ° C. Experiments were carried out at different thermostat settings in the refrigerator. Daily compressor running time and refrigerator energy consumption are calculated under various operating conditions. Monthly and yearly refrigerator consumption is also carried out. Minimum and maximum increase in compressor running time per day for each degree increased (on average from 25 to 35 ° C) in ambient temperature.

The reduction in energy consumption allows a reduction in the capacity of the PV generator and solar battery. This optimization reduces the cost of autonomous PV installation and helps generalize renewable energy in the domestic refrigeration sector [5]. It has also been observed that AC refrigerators are associated with relatively high power consumption and power spikes compared to DC refrigerators. The economic assessment carried out between an AC refrigerator (with an inverter) and a developed DC refrigerator (without an inverter) are both supported by a solar / photovoltaic electric system showing that DC refrigerators have the potential to reduce the overall system installation costs by 18% because they are compared to AC refrigerators. recommended that for stand-alone cooling using a solar PV system as an energy source, it is more economical to use a DC

refrigerator than an AC refrigerator [6].

Simulation of a solar vapor compression refrigeration system with a variable speed compressor in real weather conditions using data sheets (PV panel and compressor) available from the manufacturer. Compressor operating speed is determined to model the variation in the performance of the refrigeration system per hour. The analysis and simulation results show that the COP of the refrigeration cycle for the selected day is around 2.25 when the compressor is running at low speed, and the COP drops to the lowest value of 1.85 when the compressor operates at the highest speed. Furthermore, the simulation results show that an estimated radiation intensity of 315 W / m2 must be received at the tilt panel to run the compressor with a minimum rotating speed of 1800 rpm. To drive the compressor at its maximum rotating speed (4200 rpm), an estimated radiation intensity of 700 W / m2 is required to fall on the PV panel. Finally, the proposed method can be used to estimate the performance of a solar PV cooling system in direct combination with a variable speed compressor under certain weather conditions [7].

Based on that previous review , study on solar power aimed at driving the refrigeration system has not been widely discussed for the Indonesian region, where solar power is abundant throughout the year and with high intensity. So this research is very urgent to get a solar power system that is in accordance with environmental conditions and loading conditions, namely the refrigerator system.

2. METHODS

In this research, the design of the photovoltaic system was designed to meet the experimental test achievements of the development of a refrigerator prototype with an alternating current (AC) compressor and a refrigerator system with a DC (direct current) compressor which was simultaneously built in this whole research. The photovoltaic design is a full system using a solar energy system (photovoltaic) or a stand alone off-grid system without grid from National Grid (PLN) as shown in Figure 1.

Solar-Photovoltaic power system which consists of a photovoltaic circuit, Solar Charge Control (SCC), DC / AC Inverters and Batteries / Accu. In this system the output of solar energy is AC and DC currents and can directly drive the AC refrigerator system and the DC refrigerator system. The design of a solar power system begins with a simulation of the calculation of the capacity of the components to be used, namely: solar panels (photvolatic array), solar charge controller (SCC), batteries and DC / AC inverters. The balance of the capacity of each component is simulated with a spread sheet (exel) and the simulation is also assisted by the @PVSys software program. In the simulation also consider the configuration of the solar panel array, for example series, parallel or series-parallel combination and alternative battery voltage systems (for example: 12V or 24V) to be implemented including the type and size of cables required.

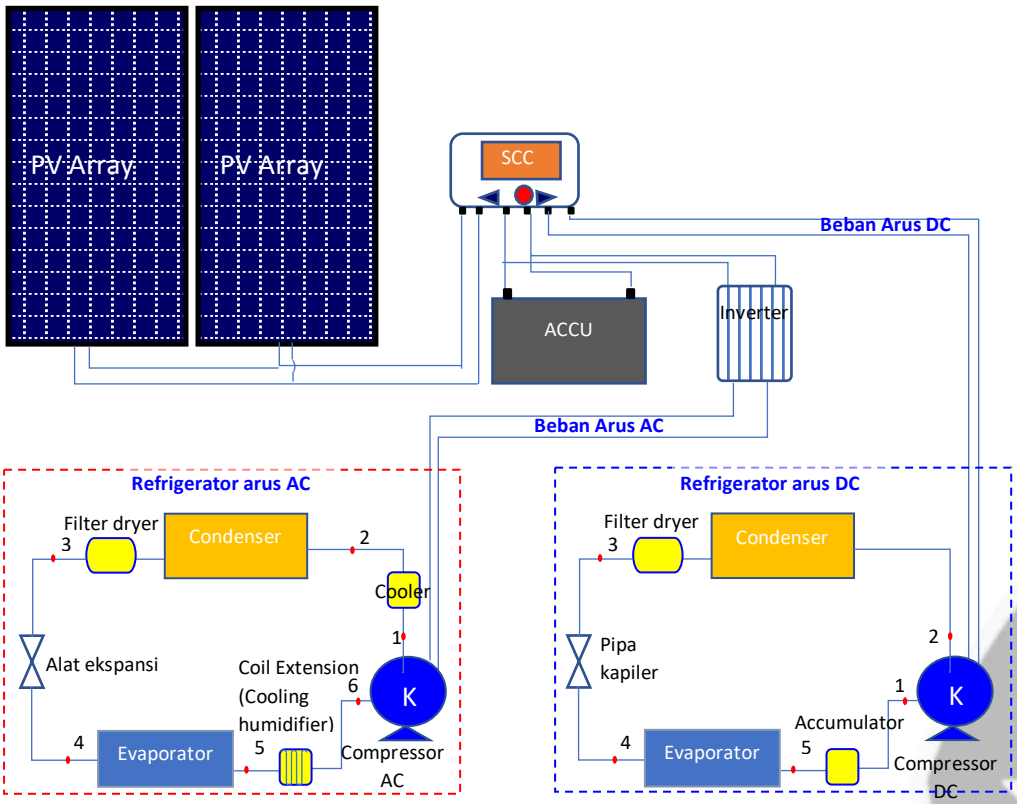

Figure 1. Schematic diagram of PV array drive refrigerators system

Photovoltaic arrays can be simulated according to the needs and the desired optimization. A combination of parallel circuits, series, or a combination of parallel and series of photovoltaics to get the desired current or voltage. Photovoltaic designed to meet the electrical energy load of the prototype refrigerator. Meanwhile, the PVSyst software can be used to simulate an off-grid PV system with a database of components such as solar panels, batteries and SCC.

2.1 Experimental Procedures

In this research period, the solar power system was tested from June to September and the testing will continue until February so that complete data can be obtained throughout the year. The test is carried out from 8.30 to 16.30 local time. To get the photovoltaic tilt angle optimization tested at an angle of 0 degrees (angle of 0 degrees in a horizontal position), 15 degrees, 30 degrees and 45 degrees. Tests are carried out at these angles using the fix tilt method. Measurement of electric current (I) and voltage (V) is measured at each part, namely the Photovoltaic exit, Solar Charge control (SCC) exit, and the inverter entry and exit. Data were taken every 30 minutes on each part with a digital ampere meter and digital voltmeter. The surrounding environment is also measured including temperature, humidity, and dew point because it greatly affects the operational efficiency of the photovoltaic and refrigerator load.

2.2 Data Acquisition and Data Analysis

Login data every 10 seconds and save it on the laptop. All experimental data is imported into a spreadsheet for easier calculation and analysis using simple statistical methods. Data is tabulated in tables as well as in graphs. The calculation of the performance coefficient (COP) of the system uses a computer program @ Cool pack and is analysed under load and no load conditions.

3. RESULTS AND DISCUSSION

3.1 Experimental Data

Environmental data (ambient) is very important to analyze because it is a medium to be conditioned to increase humidity in the cold room. Fresh air is introduced into the chamber periodically by means of a blower mechanism which is controlled by a timer. Meanwhile, for solar panels (photovoltaic), humidity and temperature data on the surrounding air greatly affect the performance of the photovoltaic system itself. One of the environmental data when taking performance data is shown in the following figure.

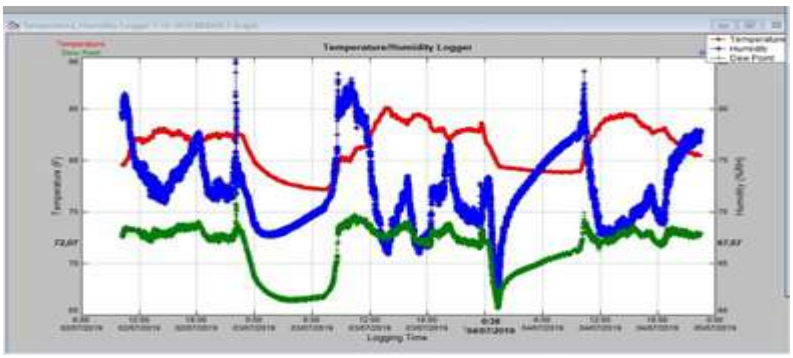

Figure 2. The results of measuring environmental conditions with a data logger

Environmental data is shown by temperature data (red line) 81.4 °F or about 27.4 °C and maximum humidity (blue line) 84.8% and a minimum of 75.34% and dew point data (green line) of 72 °F or around 22 °C. Due to the unsatisfactory environmental conditions of natural humidifiers, a mechanical humidifier that can be controlled according to the desired humidity is added. For product analysis needs, a mechanical humidifier is activated as an additional humidifier to ensure humidity above 85% - 95%.

The solar power in this experiment takes photovoltaic data out to get the optimum voltage and current according to the direction and tilt angle of the solar panel. The data is summarized in all cardinal directions (East, North, West and South) and all angles 0°, 15°, 30°, and 45°. the current according to the direction and angle is shown in the following Figures.

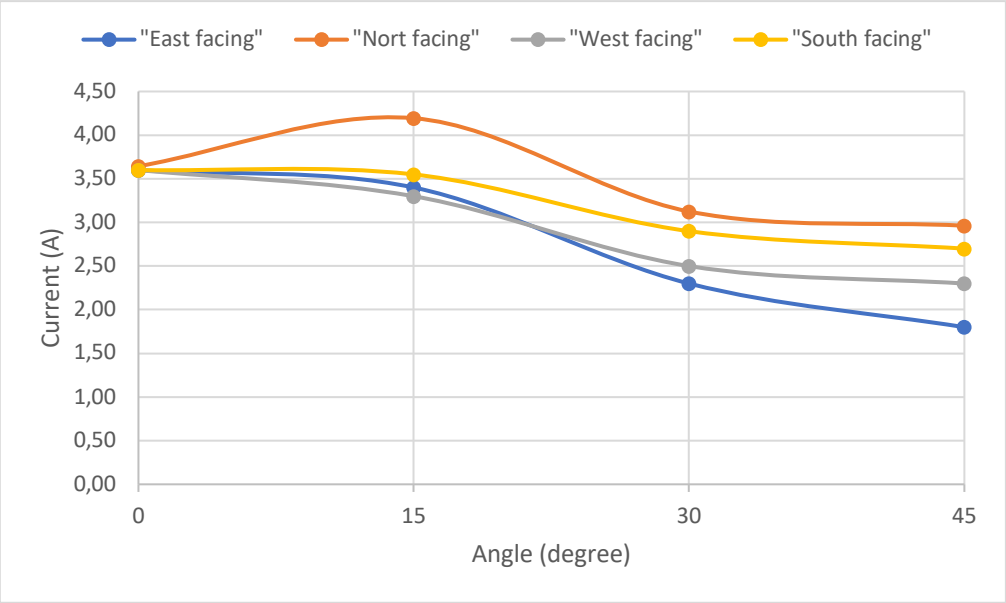

Figure 3. Variation of angle and facing on current output

Figure 3 shows the results of the data in terms of facing and angle that can produce maximal current is north with an angle of 15 degree, so that further data trends show the current output from the photovoltaic along the shining sun from 8.30 WITA to 16.30 WITA (local time) as shown in Figure 4

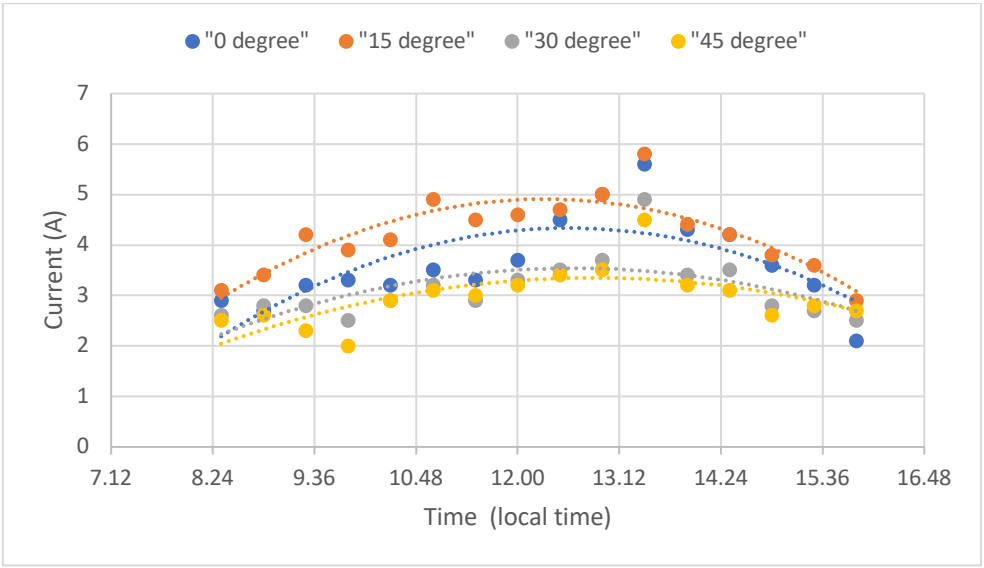

Figure 4. Current (I) output on hourly data

3.2 Refrigeration Operating Condition and Product Quality

Two main condition which are with and without load. Data show operational conditions and COP which has been calculating using @Cool Pack based on data from the state of the refrigeration system after modification. Analysis results found that the COP of 3.5 and 3.3 for without and with load, respectively. This COP is a good performance for the general refrigerator system, in a further study will be examined in the improvement of the COP in detail with the optimization of the humidifier system.

Visually, Figure 5 show the product that was kept refrigerated for 7 days. The vegetables seems still fresh enough, as good as put for early time. The vegetable condition put in the refrigerator is not the best the condition, because it is taken from traditional market that has undergone a lack of quality of cooling previously. In the

advanced study will be tested in the humidity 90% so that the condition optimization is obtained the humidity that best suits the product storage conditions and combined with optimum temperature. Finally, the solar system can drive the refrigerator system properly.

Figure 5. Product visually after 7 days keep refrigerated (temperature set at 5ºC)

4. CONCLUSION

Depend on the analysis has been done , it can be concluded that the configuration of the angle and direction of the solar panel is observed carefully and it is found that the angle of 15 degrees and the north direction gets the greatest output from the solar power system, the trend of solar power output has produced currents from 8.30 to 16.30. at local time. From this configuration, it can also move the refrigerator system, especially at high sun intensity. This is preliminary data from a series of studies carried out and this research will continue to build a DC (direct current) refrigeration system and its performance will be observed according to the energy source from the solar panels. Data on the performance of the refrigeration system and optimization of the use of solar energy will be further analyzed so that it can become a cheap and reliable alternative energy for refrigerator systems in the context of storing fresh fruit and vegetables to increase storage time and quality of healthy and export quality products to improve food security and community health.

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WARM WATER POOL SYSTEM SIMULATION: DESIGN AND MANUFACTURE

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Abstract. Human development and national competitivenes is one of the flagship programs from The Indonesian Government. Bali as one of the best tourist destination in the world is required to have an international standard tourism infrastructure. A swimming pool in a tourism accomodation is a standard facility in a tourist infrastructure. There are several types of swimming pools i.e. public swimming pools and private pools. During its development and demand, private pools develop into swimming pools with additional facilities such as warm water, which is often called a jacuzzi. Another additional facility is added pressure to the water in completing massage, fragrance and foam. The swimming pool is one of facilitity designed to hold water to allow swimming or other recreational activities. Pools can be built in the ground or on the ground as a free construction or as a part of structure and also with a common feature or a free style design. In-ground pools are the most common pools made and constructed from materials such as concrete, natural stone, metal, plastic, or fiberglass. To support comfort and satisfaction when using the swimming pool, the adequate water level in the swimming pool will be maintained by system with several supporting devices such as pumps, dirt filters and maintained at a certain level. Other things that support water quality include temperature, water turbidity, color, odor, pH, chlorine content etc.

Keywords : design, swimming poll simulation, warm water

1. INTRODUCTION

Bali as one of the best tourist destination in the world which visited by many local and foreign tourists. In order to welcoming tourists, the facilities provided must be standard such and accommodation e.g. villas, hotels, spa, etc. where in these facilities will provide a standard facilities as well. One of these facilities is a swimming pool. The pool may consist of a large swimming pool for all hotel guests and small swimming pool for guests in more private villa. Today, there is also a swimming pool that uses warm water, so hotel guests can choose either regular pool or warm water. A swimming pool, wading pool, paddle pool, pond, or simply swimming pool is a structure designed to hold water to allow swimming or other recreational activities. Swimming pool can be built in-ground or on ground as a free construction or as a part of structure and also with a common feature or a free style design [1]. In-ground pools are most commonly constructed from materials such as concrete, natural stone, metal, plastic, or fiberglass and can be a special size and shape or built as a standard sizes while the largest being an Olympic-sized swimming pool.

To support the comfort and satisfaction of guests at the hotel, the hotel will design a safe and appropriate swimming pool for hotel guests according to a comfort location, environment and maintain the quality and quantity of the pool water. The water quality referred to water turbidity, color, odor, Ph, chlorine content and so on [2]. While the water quantity is the amount of water in the swimming pool at the level it should be, so there is no pool leakage or in the pool water circulation system which causes the water level to drop or completely run out.

To get the desired results, it needs knowledge and materials to maintain quality and quantity of pool water. These knowledge here is in the form of how the requirements for pool water standards, like how the actual pool water circulation and what kind of equipment needed to support the pool water circulation system and of course, different from the requirements for drinking water standards. And then, what materials are needed to maintain the quality of water and not to harmed the health of people who swim e.g. cause irritation to the skin or eyes. These knowledge must owned by a person who in charge of handling water treatment and water circulation systems and from that problem, the writer raised the title "Design and Build Simulation of Warm Water Swimming Pool".

2. METHODS

Research methods is explaining the operational definition of variables along with data measurement tools or how to collect data and data analysis methods. If the data measurement tool uses a questionnaire, it is necessary to include the results of the validity and reliability of the research instrument.

This research will be conduct with a simulation design of a warm water swimming pool system. The author carries out a simulation design of a warm water swimming pool system. This design discusses the components will be used for the warm water swimming pool circulation system and their function - each component of the warm water swimming pool circulation, manufacture and how to maintain the swimming pool.

The circulation system that will be used is skimmer system which is a simple swimming pool system for large and small swimming pool and suitable as a tool / simulation. This system is assisted by a skimmer, main drain, jet holes as an inlet, a heater as a water heater and a sand filter that helps to maintain water quality. Figure 1. shows how the system will be made.

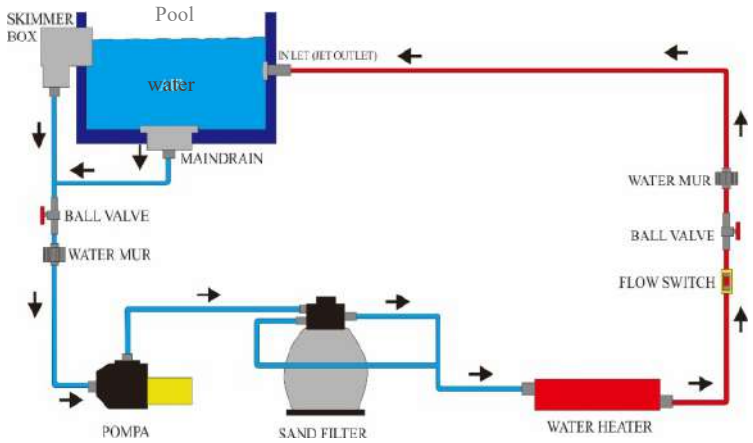

Figure 1. Design of the system

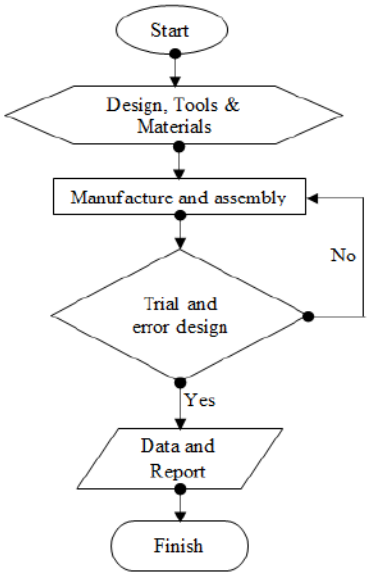

Figure 2. Research flow diagram

The way of this system works is that the water will be pumped by a circulation pump where the suction part is on the skimmer where the water impurities float on the surface of the water and will enter this channel. The heavy dirt under the pool will be sucked up by the main drain. And then the water will be entering the circulation pump and will be pumped into the sand filter to be cleaned by circulating it in the sand filter box. In this device, the water will circulate together with sand and the dirt will be tight in the sand. The water will flow to the water heater, heated and then go to the jet hole as inlet water, back into the pool and thus the water will continue to circulate. The water heater will be heated the water until 32-33^{o}C. For more clearly to see how it works can be seen at figure 2.

3. RESULTS AND DISCUSSION

3.1 Results

The result of this design is a swimming pool simulation tool which later can be used as practical material for Mechanical Engineering students at Bali State Polytechnic as a provision before they do internships at hotels or any other accommodation who had a swimming pool. From the design carried out, after working less than 3 months, the results are:

Table 1. Design result

Tool's Name	Dimension (mm)	Function	Remark
Pool mounting	1250 x 1250 x 315	Mounting of the pool	
Pool's tool mounting	1130 x 1300 x 200	Mounting of the tool's pool	
Pool simulation	Ø 1080, H 360	Water tank	Vol: 1.280 Ltr
Circulation pump	¾ HP, 550 watt	Circulating pool water	Hayward
Sand Filter	Ø 355, H 726	Pool water filter	Emaux 350 ; sand 20 kg
Water heater	Ø 250, L 1000	Heating pool water	3600 watt
Main Drain	Ø 150	Outlet water	Emaux 2"
Skimmer Box	Ø 200	Outlet water	Emaux 1"
Jet Outlet	Ø 100	Inlet water	Emaux 1 ½"
Temperature gauge	Ø 100	Water Temperature	

Figure 3. Design Result

3.2 Discussion

After the design has been completed, it is continued to test the simulation pool system. At this stage the tool functions properly and is followed by data retrieval. Water content testing is carried out using a water tester as it is commonly used in pool water tests. From the initial test, it appears that the Ph level shows a value of 7.8 - 8.2 and the HCL level shows a value of 1.0 - 1.5, as shown below.

Figure 4. Data water initial

According to the Regulation of the Minister of Health of the Republic of Indonesia [1] which applies where the addition of chlorine in 1m³ of pond is added as much as 2.5 grams. It means when pool volume is 1.28m³ then it is added as much as 3.2gram and for 100m³ is added 1 litre of HCL. From the data that has been collected for 10 days and taken at the same time (10.28 AM, 11.38 AM and 02.06 PM) tables and graphs can be made as below.

Table 2 Data of testing

Temperature	Ph	HCL
28.30	7.67	0.87
28.70	7.80	0.87
29.53	7.40	0.73
30.97	7.80	1.00
30.97	7.80	0.60
31.13	7.80	1.00
31.16	7.67	0.87
32.57	7.80	1.00
32.80	7.60	0.80
33.00	7.50	0.94
33.67	7.50	0.90

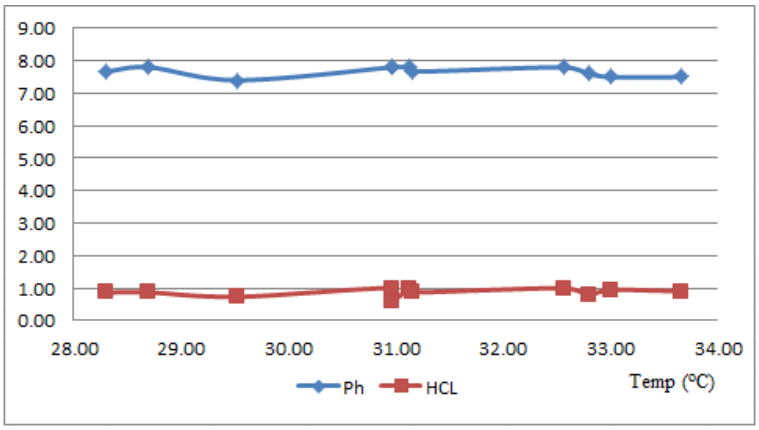

Figure 5. Data of testing

From the graph above, it can be said that the average Ph is 7.72 where the value is slightly above the normal limit. For chlorine levels it has not met the requirements too, where the average chlorine content for 7 days is 0.87, 0.3 point less than the ideal value that must be met.

According to the results of interviews we conducted with several people who had an experience in pool maintenance, the Ph and chlorine levels in the swimming pool are strongly influenced by the initial water conditions. Other things that affect are:

a. The intensity of using the pool
b. Number of pool users
c. Pool layout
d. Pool environment e.g. plants, wind, intensity of the sun
e. Time for cleaning and administering pool drugs
f. As well as the medicinal quality of the pool

4. CONCLUSION

From the results and discussion above, several conclusions can be drawn in the process of designing a heated swimming pool simulation, such as:

1. The process of designing a swimming pool is a lesson for students before his/her internship.
2. Increasing the number of pool drugs is a new knowledge / provision for students before doing his/her internship
3. Environmental temperature (intensity of the sun light) has a major effect on water conditions in the swimming pool.

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