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Analysis Effect of Sedimentation at MHP Type Turbine Open Flume on Irrigation Channel

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ABSTRACT: The MHP utilization in irrigation canals wear Plopeler Open Flume turbine type. PLTMH of this type, in the rainy season affects the quality of the electrical power produced, such as the generator voltage V (Volt), turbine / gen n (rpm), and frequency (Hz). This research method is done with 5-step procedure of four variables measured data from three case scenarios ie when there is no rain, the rain and after rain. The result analysis was conducted on all statistical calculations visible negative correlation means that if kosenrtasi sedimentation C increases, the voltage generator, turbine-generator rotation n (rpm), and the frequency f (Hz) of The MHP is going down. From test the hypothesis stated that there is a significant relationship with the t-test of 16.92, then t count> t table at $\alpha = 5\%$. namely 2101. By the time the rain to kosenrtasi sedimentation C (g / lt) C = 1.00 to 2.50 g / l (medium), 2.50 to 5.00 g / l ugly with voltage deviation Vd = 17.6%, deviation Fd frequency deviation = 6.8% and 6.8% round Nd = The MHP abnormal conditions. Given this research can be a reference for the exploitation of MHP by communities around the irigas channel as a reference basis for the development of the National Irrigation Project.

Keywords: MHP, open flume propeller turbine, irrigation, sedimentation.

I. INTRODUCTION

1.1. Background

PLMTH the irrigation channel has a high fall (head) effective relatively low (under 5 meters), where the turbine is used turbine types Plopeler Open Flume that includes type turbine reaction which is a water turbine with the way it works to change the entire energy of water available into torsional energy. From field observations MHP on irrigation channels, it appears that in the event of water turbidity caused by season penghujanan which resulted in the lifting of soil sediments greatly affect the quality of the electrical power produced, such as a variable voltage generator V (Volt), turbine / generator n (rpm) and frequency f (Hz)

1.2. Problem Formulation

From the above it can be formulated permasaalahan exposure of this study are as follows:

1. Is there any influence sedimentation irrigation canals with sedimentation kosenrtasi parameters, in various conditions circumstances against voltage parameter generator, turbine / generator, frequency generator in micro hydro power plant that uses a type turnin Open Flume propeller.
2. How big is the influence formulate relationships during rainy conditions of variable turbine / gen, generator voltage, frequency on Micro-Hydro Power Plant on the type of propeller Open turnin Flume.
3. What recommendations can be obtained from the amount of sediment concentration on the type of turbine Plopeler Open Flume used in MHP utilized in irrigation channels were conducted in this study.

1.3. Objectives Research

From the formulation of the above problems, the purpose of this study are:

1. Obtain the magnitude correlation kosenrtasi sedimentation C (g / lt), with the generator voltage (volts), the turbine-generator rotation n (rpm), and the frequency f (Hz) which may

affect the MHP, in rainy conditions, completed the rain and no rain.
2. Conduct a test analyst in rainy conditions on the effects of sedimentation kosenrtasi C (g / lt), see what percentage deviation of the voltage V (Volt), deviation of the turbine-generator rotation n (rpm) and the deviation of the frequency f (Hz) of the limit of allowable deviation stadar ,
3. Getting a recommendation from the amount of sediment concentration on the type of turbine Plopeler Open Flume used in MHP utilized in irrigation channels were conducted in this study.

1.4. Benefits Research

The benefits of this research are:
1. Can be used as a scientific reference for the utilization of irrigation channels to mikrohydro type turbine generator Plopeler Open Flume nationally
2. Being a program supporting the maintenance and rehabilitation of irrigation canals from the relevant authorities after the irrigation project was completed and handed over to the area.
3. Provide a contribution utilization of electrical energy for electrical machinery in agriculture and also empower the community on environmental aspects, support the government's program on renewable energy utilization.

II. BASIC THEORY

2.1. Power Genereted

The power that can be produced into electrical energy where power is generated in turn were able to move the processing tool farmland, agricultural products processing tool for facilities or other electrical appliances for household use during the day, and for lighting at night, Power generated by a MHP is :

$$P = k \cdot h \cdot Q \cdot \eta_t \cdot \eta_g \ [kW] \qquad (1)$$

Where; P = power [kW], h = high effective fall (m) maximum [meter], Q = discharge (m3/s), tη = turbine efficiency, gη = efficiency of the generator, k = constant (9.8)

2.2. Type Turbine on MHP Irrigation

MHP in the irrigation channel has a high fall (head) effective relatively low (under 5 meters), where the turbine is used turbine types Plopeler Open Flume is included type reaction turbine which is a water turbine with the way it works to change the entire energy of water available into torsional energy. as show the Fig. 1.

2.3. Generator on the MHP

Direct current flow in the rotor coil is rotated by a turbine, it will be product the electromagnetic force generating in the stator coil. As a result of the magnetic field will cause a rotating magnetic field surrounding the stator coil changes continuously..

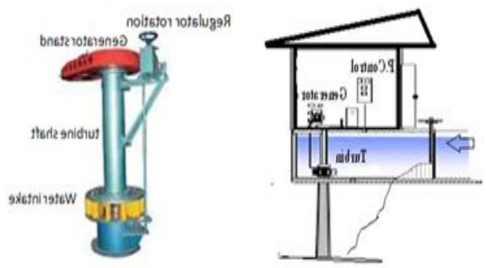

Fig. 1 Open flume propeller turbine type

The induced voltage will be sinusoidal and extent of which depends on the strength of the magnetic field and the rotation speed of the rotor. For three-phase generator, the stator coils placed three separate as far as 120^o from each other, In general, also on Power Mikrohydro (MHP) for small-scale uses 1-phase synchronous generator its output voltage as shown in Figure 2 with the illustrations as follows:

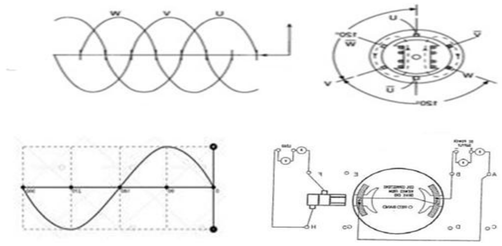

Fig. 2. Output voltage 3-phase and one phase synchronous generator

In the design 1-phase synchronous generator, sometimes there is a phenomenon in which waves generated not a pure sinusoida, because distortion occurs in the output waveform so-called harmonics. water turbine rotating synchronous generator reaches the actual speed by the prime mover, the field coil is excited by dc currents which cut the field flux conductor induce emf voltage (Ea). Then out in the stator winding terminal which amount is given by the equation:

$$E_a = cn\Phi_a \qquad (2)$$

Where ; c = constant engine, n = synchronous rotation ,Φ_a = flux generated by field current induced voltage Ea generated in the phase synchronous generators are not equal to the voltage at the terminals of the generator, it is due to their resistance and reactance sync anchor.Equation voltage on the generator is

$$Ea = V + I.Ra + jIXs \qquad (3)$$

In the power supply system, generally the power supply voltage deviation voltage (Vd) is permitted varies (+ 5%) and (-10%) according to the standard of PLN (Indonesian electricity company),

. The frequency is characteristic of the sinusoidal wave voltages and currents generated by the generator. Generator rotation speed is equal to a turbine wheel where the frequency is obtained:

$$f = \frac{P\,n}{60} \qquad (6)$$

Where; f = frequency, n = speed (rpm), p = number of pole pairs generator.50 hz frequency used, and for the allowable frequency deviation can change the magnitude of ± 2%.

2.4. Sedimentation

Factors reciprocity between the properties of water flow and sediment properties were affected by the rains cause the lifting of sediment to gravitate. Sedimentation contained in irrigation channels may also affect the specific energy due to irrigation canal irrigation canals dimensional change. Concentration of sediment can be obtain from ratio of dry sediment weight and the total volume of the water sample is given by:

$$C = \frac{BK\ (mg)}{V(lt)} \qquad (7)$$

Where; BK dry sediment weight (mg), V = Volume of sample water (liter).

Sedimentation rate can be obtained from multiplying the water discharge and sediment concentration by the equation:

$$Q_S = 0{,}0864\ C\ Q \qquad (8)$$

2.5. Effect of the sediment concentration, voltage frequency and rotation.

The influence of sediment concentration (C) of the MHP Open Flume Propeller turbine type of parameter voltage (V), rotation (n) and frequency (Hz) of this research is to use the statistic test because by theoretically not yet developed.As for the statistical testing is as follows:

a. Make sediment concentration data summary table (as a function of the variable x), while voltage generator (v), rotating turbin-generator (n), frequency (Hz), (as variables y_1, y_2, y_3).

b. Determining the regression model with the following formula:

$$y = b_O + b_1 x. \qquad (9)$$

$$b_{1=}\frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{n\sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)} \qquad (10)$$

$$b_o = \bar{y} - b_i\bar{x} \qquad (11)$$

c. Looking Correlation Coefficient

$$\rho = \frac{Cov\ (x,y)}{S_x S_y} \qquad (12)$$

a. covariance can be searched using the formula:

$$Cov\ (x,y) = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{n-1} \qquad (13)$$

Then the correlation coefficient obtained:

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)(N\sum Y^2 - (\sum Y)^2)}} \qquad (14)$$

Next to test the hypothesis of correlation

Ho: There is no significant relationship between concentration sedimentation c (mg / lt) by, Voltage, Frequency and rotating turbine / gen n (rpm)

H1: There is a significant relationship between cosenrtation sedimentation c (mg / lt) with Round turbine / generator (rpm)

To test the hypothesis in correlation with the search for the value of the correlation coefficient t statistic is then compared with t-table

$$t_o = \left|\frac{r\sqrt{n-2}}{\sqrt{1-r^2}}\right| \qquad (15)$$

d. coefficient of Determination

To consider the regression model accuracy can be checked by calculating the coefficient of determination:

$$r_{xy} = \frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{\sqrt{n\sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)^2}\sqrt{n\sum_{i=1}^{n} Y_i^2 - (\sum_{i=1}^{n} Y_i)^2}}$$

(16)

$$R^2 = \frac{SS_R}{SE_{\gamma\gamma}} = \frac{\sum_{j=1} n(\bar{y}_i - \bar{y})^2}{\sum_{j=1} n(y_i - \bar{y})^2} \qquad (17)$$

R2 value is $0 \leq R2 \leq 1$ which is the amount of variability in the data obtained in the model regreasi.

III. RESEARCH METHODS

As this study can be carried out following the draft as follows:

1. Sampling sediment taken with a sampling drift. Type USDH 48 to get water containing sediment drift.
   a. Measurements of water containing sediment floating on sediment concentrations to get kosenrtasi sedimentation C (g / lt).
   b. Measurement output generator to get Gener ator voltage variable V (Volt)
   c. Measurement output turbine / generator to get the variable turbine / generator n (rpm).
   d. Measurement output generator to get a variable frequency (Hz).
2. sampling and measurement in the rain (high sediment concentrations) procedures a through c are recorded in Table 1
3. The sampling and measurement upon completion rain (concentration of sediment being) the procedures a through c are recorded in Table 1.
4. The sampling and measurement at the time there was no rain (small sediment concentration)) with a procedure to c noted in Table 1.
5. The sampling and measurement in the rain as much as 20 samples with a procedure to c. noted in Table 2 Correlations between variables were observed in the MHP system based on test statistics. The flow chart as shown in the figure .

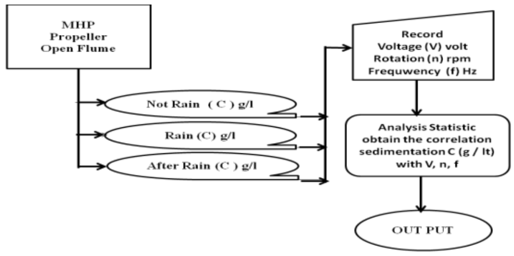

Fig. 3. Flowchart research

IV. DISCUSSION AND ANALYSIS

4.1. Overview of Research Object of MHP Tulabolo**.**

Based of field conditions in this study with the parameter on measurements were obtained: A = 2.48 m^2, V = 0789 m/s, it is obtained: Q = 2.48 m^2 x 0789 m/s = 1.96 m^3/s, with k = 9.8 and higher draft tube h = 1.75 m, from equation 1.2, 3. theoretical power P = k. h. Q = 33.614 [KW]

This power is divided into 6 generating units so that each plant produces theoretically power of 5.6 KW, the efficiency of each ie:.η draftube 0.95, η turbine 0.7, η generator 0,95, turbine power is P = 3.92 [kW] So that the power generator the calculation results P = 3.5 [kW] per unit.

Generator MHP on the research capacity of 3 KW per unit. with existing data as follows:

Type	: ST – 10	Cos φ	: 1.0
Power	:3 KW	Exitasi Volt	: 80 Volt
Voltage	:220 Volt	Exitasi current	: 2 ampere
Current	:13,6 A	Frekuency	: 50 Hz
Rotation	:1500 rpm	Standar	: Q/MDl001- 1998

The influence of sediment concentration (C) of the voltage (volts) on the MHP of the test statistic. the table I can be explained through correlation and regression equations.

4.2. Determining the model

To determine the equation of model linear regression using equations 11, 12 and 13 as follows

$y = b_O + b_1 x$. Where

$$b_1 = \frac{20(7954.76) - (42.762 \text{ x}3873.45)}{20(115.303) - (42.762)}$$

$$b_1 = \frac{-6541.2689}{2263.298} = -2.89$$

$$b_o = \bar{Y} - b_i\bar{X} = 199.85$$

Then the linear regression equation model the influence of sediment concentration on voltage generator is:

Y = -2.89 + 199.85 X

Tabel I. Data of sedimentation Concentration againts voltage, rotationand frequency generator that circumstances rains and after rains and not rains.

No	Concentration sedimentation c (g/lt), X	Voltage Gen V (Volt) Y_1	Rotation tur/gen n(rpm), Y_2	Frekuency (Hz) Y_3	Information Condition
1	2.551	182.94	1412.98	47.11	Rains (12/01/2015).
2	2.329	189.68	1427.68	47.57	After raining (12/01/2015).
3	0.451	219.87	1500.00	50.00	No Rains (21/01/2015).
4	2.756	182.14	1412.26	47.05	Rains (13/02/2015).
5	2.363	188.86	1426.96	47.48	After raining (13/02/2015).
6	0.487	218.57	1496.85	49.87	No Rains (22/02/2015).
7	2.875	181.44	1411.42	46.97	Rains (14/03/2015).
8	2.397	188.25	1426.31	47.42	After raining (14/03/2015).
9	0.55	216.65	1494.68	49.79	No Rains (23/03/2015).
10	2.987	180.78	1410.73	46.91	Rains (15/09/2015).
11	2.429	187.43	1425.43	47.34	After raining (15/09/2015).
12	0.598	215.45	1490.45	49.72	No Rains (24/09/2015).
13	3.467	179.86	1409.86	46.85	Rains (16/10 /2015).
14	2.454	186.84	1424.64	47.26	After raining (16/10/2015).
15	0.651	215.39	1485.67	49.65	No Rains (27/10/2015).
16	3.663	179.24	1409.28	46.78	Rains (17/11 /2015).
17	2.587	183.91	1423.89	47.18	After raining (17/11/2015).
18	0.832	214.14	1476.51	49.57	No Rains (28/11/2015).
19	3.843	178.76	1408.42	46.73	Rains (18/12 /2015).
20	2.495	183.25	1423.25	47.12	After raining (18/12/2015).

4.3. Coefficient correlation

coefficient correlation can be calculated using equation 16 as follows:

$$r_{xy} = \frac{-6541.2689}{\sqrt{(477.471356)(94851.4975)}}$$

$$r_{xy} = \frac{-6533.522}{\sqrt{45288873.12995561}} = -0,97$$

From the calculation, the negative correlation coefficient of -0.97 indicates a negative relationship between cosentration sedimentation C (g / lt) with the generator voltage (volts), so when the cosentration sedimentation C increases, the generator voltage will drop.

4.4. Compatibility of Model

To test the hypothesis in correlations is to find the value of the correlation coefficient t statistic is then compared with t-table, so do the calculation in advance of t-count value correlation with the equation 15 so magnified by the following calculation:

$$t_o = \left|\frac{r\sqrt{n-2}}{\sqrt{1-r^2}}\right| \quad t_o = \left|\frac{-4.115}{\sqrt{1-0.9409}}\right| = 16,92$$

T-table value obtained from a table t obtained the value t-table (0:05, 18) is equal to 2,101, the value when compared with t-test of 16.92, then t count> t table at α = 5%, so dinyataka that there a significant relationship between cosenrtation sedimentation c (g / lt) with the generator voltage (volts). In the same way, the obtained three relational equation Y2 (round) and Y3 (frequency).and the Characteristics of the equation relationship as shown in the Fig. 4.

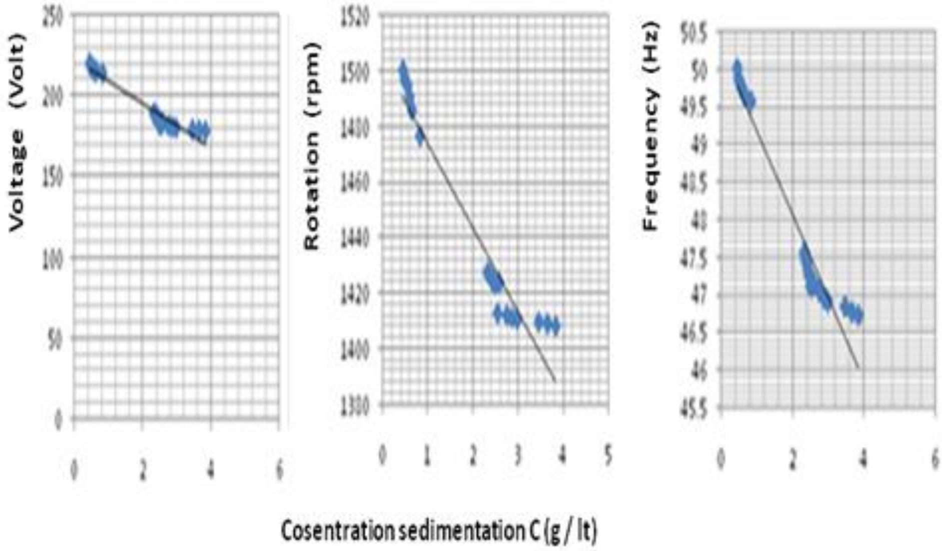

Fig.4: Characteristics of sedimentation Concentration againts voltage,rotation and frequency generator that circumstances not rains, rains and after rains

2. Observations the MHP in the rain.

During the rainy season from field observations seen that happen turbidity caused by the lifting of soil sediments greatly affect the quality of the electrical power produced. Linear regression model the effect of concentration of sedimenn row against voltage generator, turbine-generator and frequency generator when it rains. From table 2 are:

Y_{1h} = - 0.07 + 181.56 X ; Y_{2h} = - 1.06 + 1401.45 X ; Y_{3h} = - 0.04 + 46.72 X

The characteristic shape image sedimentation concentration and voltage generator on table II

Tabel II. Data of sedimentation Concentration againts voltage, Rotation and frequency generator that circumstances rains

No sampel	Concentration sedimentation c (g/lt), X	Voltage Gen V (Volt) Y_1	Rotation tur/gen n(rpm), Y_2	Frequency (Hz)Y_3
1	3.864	178.41	1354.2	45.14
2	2.987	181.78	1402.8	46.76
3	3.843	179.53	1357.8	45.26
4	3.267	180.64	1398.3	46.61
5	2.965	180.95	1404.9	46.83
6	3.864	178.84	1359.6	45.32
7	3.663	181.24	1371.9	45.73
8	3.683	178.97	1365.3	45.51
9	2.875	183.44	1415.1	47.17
10	2.792	182.64	1416.3	47.21
11	2.889	181.34	1409.4	46.98
12	2.776	183.87	1422.9	47.43
13	3.643	179.53	1376.7	45.89
14	2.756	184.14	1425.3	47.51
15	3.487	181.24	1388.4	46.28
16	2.586	182.54	1430.4	47.68
17	3.467	179.86	1391.1	46.37
18	2.562	183.72	1435.5	47.85
19	3.447	181.24	1397.4	46.58
20	2.551	182.94	1437.6	47.92

Retrieved voltage deviation Vd = 17.6%, Fd frequency deviation = 6.8% and the deviation rotation Nd = 6.8% in sediment concentration C = 1.00 to 2.50 g / l (medium), 2.50 - 5.00 g / l and the linear regression equation obtained shown in the Fig. 5.

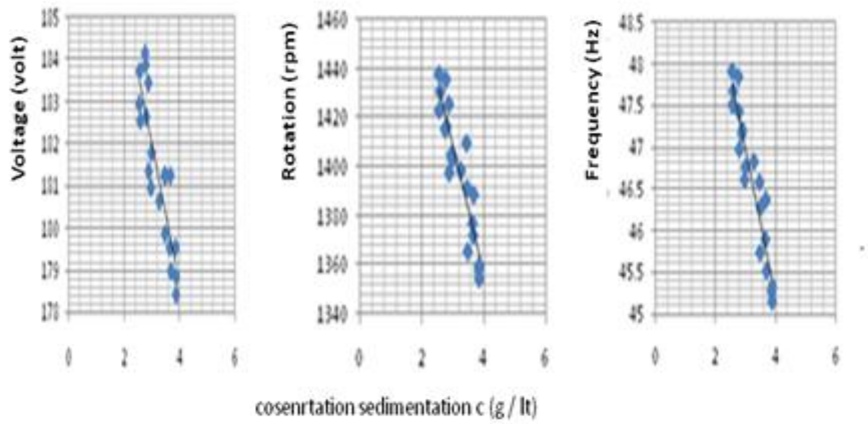

Fig. 5. Characteristics of sedimentation Concentration againts voltage, rotation and frequency generator that circumstances rain

rotation Nd = 6.8% in sediment concentration C = 1.00 to 2.50 g / l (medium), 2.50 - 5.00 g / l ugly. MHP running condition is not normal on the boundary voltage parameters, rotation and frequency that is not permitted where the voltage of > 5% and the frequency and rotation > 2%.

V. CONCLUSION

1. The existence of a negative correlation between kosenrtasi sedimentation C (g / lt) with the generator voltage (volts), the turbine-generator rotation n (rpm), and the frequency f (Hz) of the MHP meaning if kosenrtasi sedimentation C increases, the voltage generator, rotation turbine-generator n (rpm), and the frequency f (Hz) of the MHP is going down.
2. At the time of the MHP rainy conditions without setling basin modeling obtained voltage deviation Vd = 17.6%, Fd frequency deviation = 6.8% and the deviation rotation Nd = 6.8% at a concentration of between 2.551 sedimentation C (g / l) and 3864 (g / l) where the value of C category (C> 2.5 (g / l) Ugly) MHP operating conditions are not normal,
3. Provide recommendations concentration sedimentation can take affect turbine type Plopeler Open Flume conducted in this study, therefore, need their setling modeling to reduce the influence of the sedimentation basin

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