PIKOHYDRO DESIGN STRATEGY FOR OPTIMIZING HAVERSTING AND ENERGY EFFICIENCY USING GENETIC ALGORITHM

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Electrical energy is a primary need at this time. In Indonesia itself, there are still several areas that still have problems with electricity supply. There is a need for innovation related to alternative energy to help overcome problems related to electrical energy. Pico hydro power plants are an alternative. The Piko Hydro Power Plant is a plant designed on a small scale and using hydropower. This research is about the design of a pico-hydro power plant, as well as strategies for seeking optimization of haversting and energy efficiency so that the energy produced from a pico-hydro power plant is more effective and maximizes its use, whether used for street lighting or other purposes. In this research, genetic algorithm solutions are used. A genetic algorithm is an optimization method that searches for a certain value of several parameters with the principle that only the best solution can survive and produce quality offspring. Where the genetic algorithm utilizes a natural selection process known as the evolutionary process. In the process of evolution, individuals continuously experience changes in their genes to adapt to their environment. The selection of the genetic algorithm in this research was deemed appropriate to adjust existing conditions. The pico hydro design uses a cross flow turbine. A cross-flow turbine is a small pressure turbine whose injection is tangential to the rotation of the channel about a horizontal axis. Therefore, research is interested in examining this matter, namely entitled "Pycohydro Design Strategy in seeking optimization of haversting and potential energy efficiency using genetic algorithms". The results of this research are from several data entered into the data processing software, namely the program is able to identify the calculation results of the parameter values entered and find out which data or calculations are efficient to use for the construction of pico hydro power plants. From the two data taken in different seasons, parameters were input, namely water discharge, height difference, turbine and generator along with the calculated values in these parameters. The results obtained were that data collection in the rainy season was more efficient because the water discharge was abundant and with sufficient irrigation flow, pico-hydro development could be carried out.

Key words: Picohydro, Electrical Energy, Haversting, Cross flow

INTRODUCTION

Electricity is one of the most important needs in everyday life today. Technological developments and population growth require more electricity supplies. Its availability in nature is decreasing, therefore alternative energy is urgently needed as a renewable energy source. Indonesia actually has a lot of potential renewable energy sources such as geothermal, biodiesel, solar, wind and hydropower. Therefore we must be able to analyze and see the possible uses of potential energy around us.

Pico hydro power plants are one that is included in the classification of hydro power plants based on power capacity. Where the Piko Hydro Power Plant is a small scale power plant producing less than 5 kW of power. This technology can be used at low speeds and currents. Piko hydro is a generator with high efficiency and quite cheap compared to others. So Piko Hydro is considered very effective as an alternative renewable energy in Indonesia

This research is to design a design for a pico hydro power plant which aims to optimize the haversting or loading of the pico hydro and its energy efficiency which is packaged using a genetic algorithm. Genetic algorithms are used for solution selection, as the goal of the algorithm is to apply an understanding of natural evolution to the problem solving task. The approach of this algorithm is to randomly combine different choices from a collection of best solutions to obtain the next generation of best solutions, namely in the space that maximizes fitness, or often called fitness. This generation represents an increase from the original population. If this process is repeated many times, the algorithm is expected to simulate the development process.

A cross-flow turbine, which is a radial flow type pulse turbine, was used in this study. A cross-flow turbine is a small pressure turbine whose injection is tangential to the rotation of the channel about a horizontal axis. Cross flow turbines are used at heights of 2 to 200 meters. The operation of a cross-flow turbine is based on water entering through the blades and starter or turbine fan. After that, the water passes through the nozzles, the water flows out of the free body of the turbine and through the tube under the turbine. The advantages of cross flow turbines are simple, easy to manufacture, cheap, durable construction and longer service life.

From this explanation, the formulation of the research problem is: What is the picohydro design strategy for optimizing haversting?; What is the picohydro design strategy for energy efficiency using a generic algorithm? From the problem formulation it can be obtained that the aim of this research is to determine the Pikohidro design strategy in seeking optimization of haversting and energy efficiency using genetic algorithms. The benefits of this research are understanding and knowledge related to picohydro power plants and optimization and efficiency efforts using genetic algorithms as well as contributing to the progress of the world of education and being useful as a source of inspiration and reference material in conducting further research related to this research. Urgency of Research The urgency of this research is based on current conditions, namely in Indonesia electricity is a primary need so the use of electrical energy is very necessary therefore innovation is needed, namely renewable energy to help overcome problems related to saving electrical energy, one of which is hydroelectric power plants. namely picohydro and strategies for optimizing and energy efficiency.

LITERATURE REVIEW

Pico Hydro Power Plant

Picohydro (Picohydro) is one of the hydropower production technologies that is categorized by capacity. grouped by capacity, where picohydro can only produce less than 5 kW, which is the lowest type of electricity production. less than 5 kW, which is the lowest type of electricity production. most efficient option, taking into account environmental, economic and social aspects. Its implementation has been successfully developed around the world.

The principle of operation is that by directing part of the water flow through the the main water pipe, water is diverted, which then enters the generating system. This system has a lower head than the main flow, it then passes through a turbine before returning to the main watercourse.

Haversting the Potential of Pico Hydro Electricity

Almost all large-scale hydroelectric potential is already utilized in developed countries. Increasing sustainable hydraulic energy production requires the development of technologies dedicated to small-scale harvesting of hydroelectric potential. The condition for meeting economic profitability with pico power plants below 25 kW is to minimize capital expenditure requirements while maximizing the efficiency of installed hydraulic machinery. installed. While the environmental impact of the hydropower technology applied should be negligible given the small output power provided. Harvesting the potential of hydropower generation on existing installations such as the water utility networks limits the investment and environmental impact of new infrastructure or other infrastructure or any other

Water Flow Theory

Flowing water contains energy that can be used to rotate turbines. Hydroelectric power plants can be divided into two groups, namely high-pressure hydroelectric power plants and low-pressure hydroelectric power plants. The height of the water fall (h) is obtained from the difference between the upper and lower water levels. Fluid mechanics formulas can be used to determine turbine power, channel cross-sectional area and other turbine part dimensions, and the energy form of water flow.

Power is known from turbine physics, every object on earth has potential energy which is expressed as:

$$E = m.g.h \qquad (1)$$

where E is potential energy, m is mass, g is acceleration of of gravity, and h is the height relative to the ground. Formula 1 can be written:

$$dE = dm.g.h \qquad (2)$$

where dE is the energy produced by an element mass dm traveling a distance h. traveling a distance h. If Q is defined as water flow with the following formula as follows:

$$Q = dm/dt \qquad (3)$$

where Q is the water flow, dm is the mass element of water, and dt is the element of time, then it can be written:

$$P = dE/dt \qquad (4)$$

$$P = dm/dt.g.h \qquad (5)$$

$$P= Q.g.h \qquad (6)$$

The power generated by the turbine is calculated by equation 7 without considering the efficiency of the turbine used.
Considering the efficiency of the turbine used. Equation 7 takes into account turbine efficiency, it can be written in the equation below:

$$P = \eta t .\gamma. Q. h \qquad (7)$$

Where P is the power generated by the turbine (kW), ηt is the efficiency of the turbine, γ is the specific gravity of water (9). turbine, γ is the specific gravity of water (9.18 kN/m3), Q is the flow capacity (m3/s), h is the net height difference (m)

Cross Flow Turbine

Cross flow turbines or often known as Banki turbines consist of two main parts of the turbine, namely the nozzle and runner. The nozzle is the stationary part while the runner is the moving part. The runner is made of two parallel disks connected to each other with curved blades. In the research, mathematical analysis and experimental models were carried out on site. The modeling is based on data such as; turbine diameter (D1), turbine width (W), number of blades (N), water discharge (Q) and generator load, blade curvature angle. The jet flow through the turbine assuming that its center point at point A in the figure below V1 is the absolute velocity of the water forming an angle α1 with the tangent of the wheel edge. The velocity of the water flow before entering is:

$$V_1 = C\sqrt{2gh} \qquad (1)$$

Where V1 = absolute velocity of water (m/s), C = nozzle coefficient, g = gravity (m/s2), h=height (m)

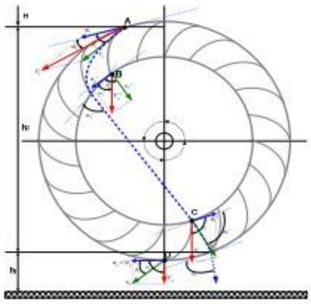

Figure 1. Water path through the turbine

The relative speed of the incoming water v1 can be found, when the circumferential speed u1 of the wheel at that point is known. β1 is the angle of the forward direction of the two speeds v1 and u1. To make the efficiency maximum, the angle of the blade must be equal to the value of β1. If the curved line AB represents the blade, then at point B v2' is the relative velocity at which water exits the inner blade. The angle β2' is the angle formed between the blade exit relative velocity v2' and the wheel circumferential velocity u2' at point B. The absolute velocity of water at blade exit, V2' can be calculated from the values of v2', angle β2' and velocity u2'. The angle between the absolute velocity of water (V2') and the wheel speed (u2') at point B is α2'. The absolute path of water flowing over blade AB can be calculated, at the actual point where the water leaves the blade. Assuming the absolute velocity of water does not change V2', at point C, where water re-enters the wheel, can be found. V2' at this point will be V1', and the path of water remaining over blade CD from flowing from point C to D can be ascertained. Thus it follows that

$$\alpha 1' = \alpha 2', \beta 1' = \beta 2', \beta 1 = \beta 2 \qquad (1)$$

relation when the angles of the blades are equal.

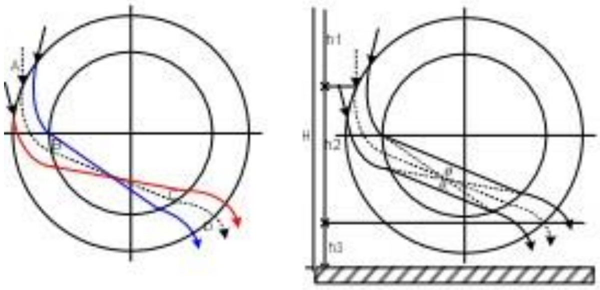

Figure 2. Interference of water flow through the wheel

The power of a Banki turbine can be calculated based on the output power equation. The following is the power equation for the turbine:

$$P = \left(\frac{\gamma Q}{g}\right)(V_1 \cos\alpha_1 + V_2 \cos\alpha_2)u_1 \qquad (2)$$

equation (2) can be derived from the velocity triangle figure shown in Figure 1. The movement of turbine water from point A then through point B and pushes back at point C and exits through point D. An illustration of the water movement is shown in Figure 2.

Genetic Algorithm

Genetic algorithm is an optimization method that searches for a certain value of several parameters with the principle that only the best solution can survive and produce quality offspring. quality offspring. Meanwhile, optimization is defined as the process of obtaining the function. the function.

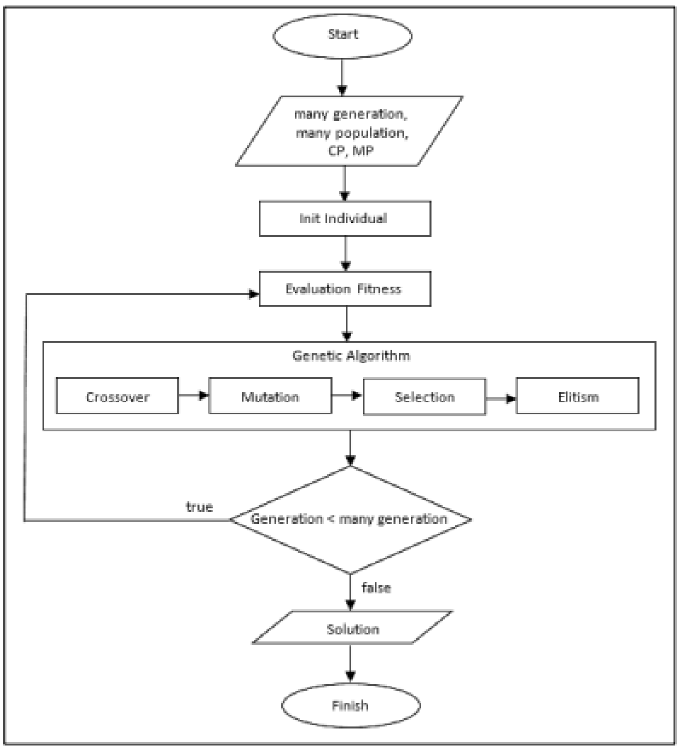

Figure 3. Flowchart of program development with
Genetic Algorithm method

Broadly speaking, the steps in this procedure begin with establishing a set of potential solutions and making changes with several iterations with the Genetic Algorithm to achieve the best solution. The set of potential solutions set at the beginning and is called a chromosome. These chromosomes are formed randomly and then the chromosomes will evolve in several iteration stages called generations. New generations are generated by crossover and mutation techniques. Crossover involves splitting two chromosomes and then combining half of each chromosome with other pairs. Mutation, on the other hand, involves replacing one half of a chromosome with another half of its partner chromosome. These chromosomes then evolve to a specified best solution (fitness) is determined and the best result is selected while the others are ignored. others are ignored. Furthermore, the process is repeated until a chromosome that has the best fitness chromosome that has the best fitness will be taken as the best solution to the problem. as the best solution to the problem.

METHOD

The method in this research is to use experimental methods with laboratory scale design and testing. The flow diagram in this research can be seen in Figure 4.

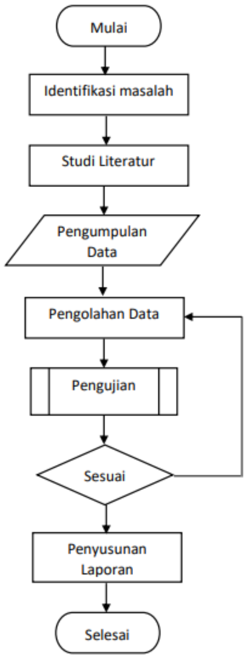

Figure 4. Research flow diagram

The detailed steps that will be taken are as follows:

a) Problem identification, this is done to determine the topic and title to be researched
b) Literature Study, this aims to collect as many references as reference material for research.
c) Data Collection, this is done to determine the parameters used during the research. For example, what turbine will be used in the design, etc
d) Data Processing, This is done by designing pico hydro power plants and making efforts

to optimize the haversting and energy potential efficiency which is carried out using genetic algorithms

e) Testing, this is carried out to determine the feasibility of the design modeling and test the feasibility of the parameters, and after the testing is complete and declared feasible by experts, data analysis is carried out

f) Preparing the Report, this is done after all stages have been completed. The results of data analysis, suggestions, conclusions, etc. are outlined in reports in the form of final reports, thesis manuscripts, and scientific articles which will later be journalized and held in conferences.

MAIN RESULTS

Observations were made of the ditches where it would be possible to build a pico hydro power plant and looked at the surrounding conditions so that a suitable pico hydro design was carried out by planning and calculating the turbine used, namely the crossflow turbine.
Planning or calculating cross-flow turbine parameters using Mockmore equations, namely as follows:

1) Outer diameter (D) and blade width (L) of the turbine runner

$$LD = \frac{2{,}62\,Q}{\sqrt{H}}$$

2) Turbine runner inner diameter (D1)

$$D_1 = {}^{2}/_{3}\,D$$

3) Distance between blades (K)

$$K = 0.174\,D$$

4) Nozzle spray thickness (M)

$$M = 0{,}22\,\frac{Q}{L\sqrt{H}}$$

5) Radius of curvature of the blade (r1)

$$r1 = 0.163$$

6) Number of blades (N)

$$N = \frac{\pi \,.\, D}{K}$$

Water power used (Pwater)

$$P = \rho.g.H.Q$$

Power produced by the turbine (Pt)

$$Pt = T \,.\, \omega$$

With,

$$T = F \,.\, D/2 \text{ or } T = F \,.\, r$$

And,

$$\omega = 2\,\pi\,n/60$$

Turbine mechanical efficiency (ηt)

$$Pturbine = Pwater \,.\, \eta t$$

So

$$\eta_t = \frac{P_{turbin}}{P_{air}}$$

Turbine Roving Speed

$$v = \frac{2 \, . \, \pi \, . \, n}{60} \, . \, r_{run}$$

Power produced by the generator (Pg)

$$P_g = V \, . \, I$$

Transmission Efficiency

$$P_g = . \, P_{t \, .} \, \eta_g \, . \, \eta_{trans}$$

So

$$\eta_{trans} = \frac{P_g}{\eta_g \, . \, P_t}$$

Based on the results of these calculations, the appropriate design drawing results are:

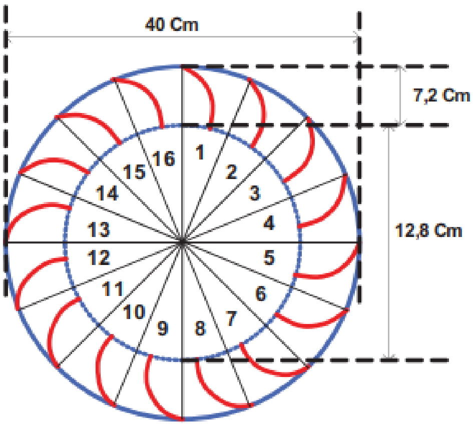

Figure 5. Runner design of a crossflow turbine

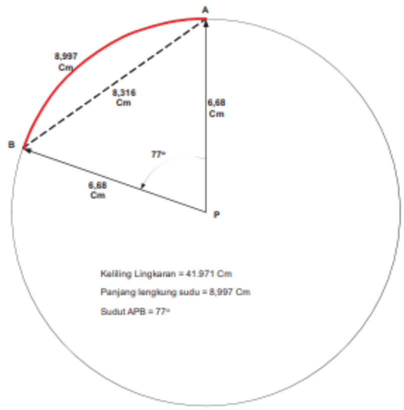

Figure 6. Angle of curvature of the cross flow turbine blade

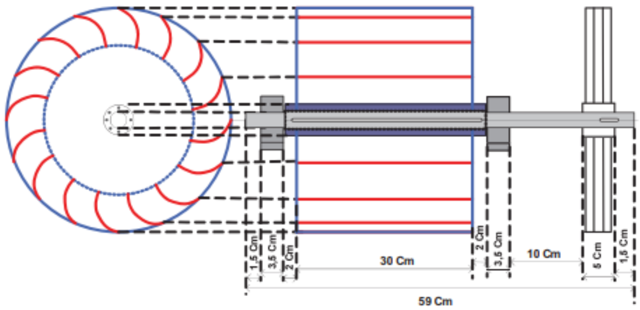

Figure 7. Crossflow Turbine Design

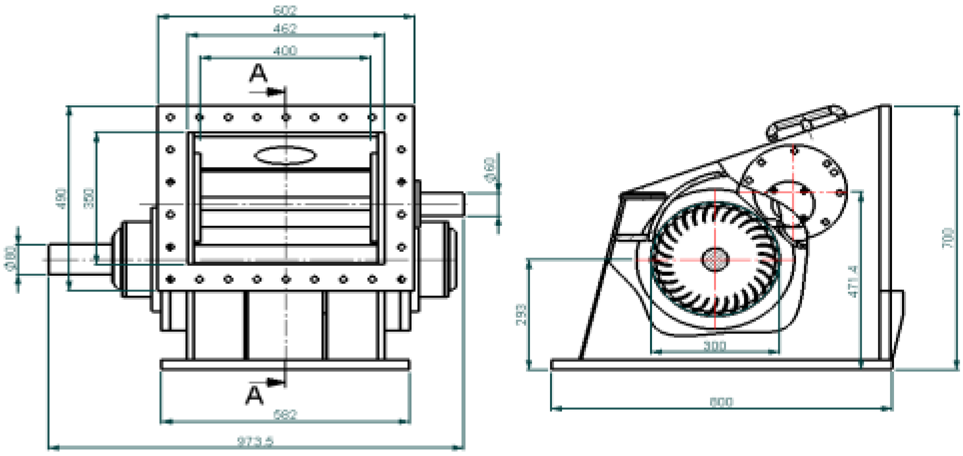

Figure 8. Generator Design

And for genetic algorithm processing, the parameters that will be input to the program are determined, that is, several parameters are obtained, namely:

a) Water Discharge

$$Q = A \times V$$

Where:

Q = Water discharge (in liters per second or cubic meters per second, depending on the units used) (L/s)
A = Cross-sectional area of the water flow path (in square meters) (m^2)
V = Water flow speed (in meters per second) (m/s

b) Height Difference

$$H = H1 - H2$$

Where:

H = height difference (in meters, m).
H1 = height of the water source above the turbine (in meters, m).
H2 = turbine height above the water surface (in meters, m).

c) Turbine

Mechanical Power (Pm):

$$Pm = \rho * g * Q * H$$

Where:

Pm = mechanical power in watts (W).

ρ = density of water in kilograms per cubic meter (kg/m^3).

g = acceleration due to gravity (approximately 9.81 m/s^2).

Q = water discharge in cubic meters per second (m^3/s).

H = water fall height (turbine depth) in meters (m).

Electric Power (Pe):

$$Pe = \eta * Pm$$

Where:

Pe = electric power in watts (W).

η =turbine efficiency (usually expressed in decimal, e.g., 0.86 for 86% efficiency).

Pm = mechanical power that has been calculated previously.

d) Generator

Picohydro Generator Power:

$$P = \rho * g * Q * H * \eta$$

Where:

P = Electric power (watts)

ρ = Water density (kg/m^3)

g = Acceleration due to gravity (m/s^2)

Q = Water flow rate (m^3/s)

H = Height of falling water (meters)

η = Efficiency (turbine and generator)

Torque on Generator Shaft:

$$T = P / (2\pi * n)$$

Where:

T = Torque (Newton-meter)

P = Electric power (watts)

n = Rotation speed (revolutions per second)

The parameters obtained are input to the program created, namely:

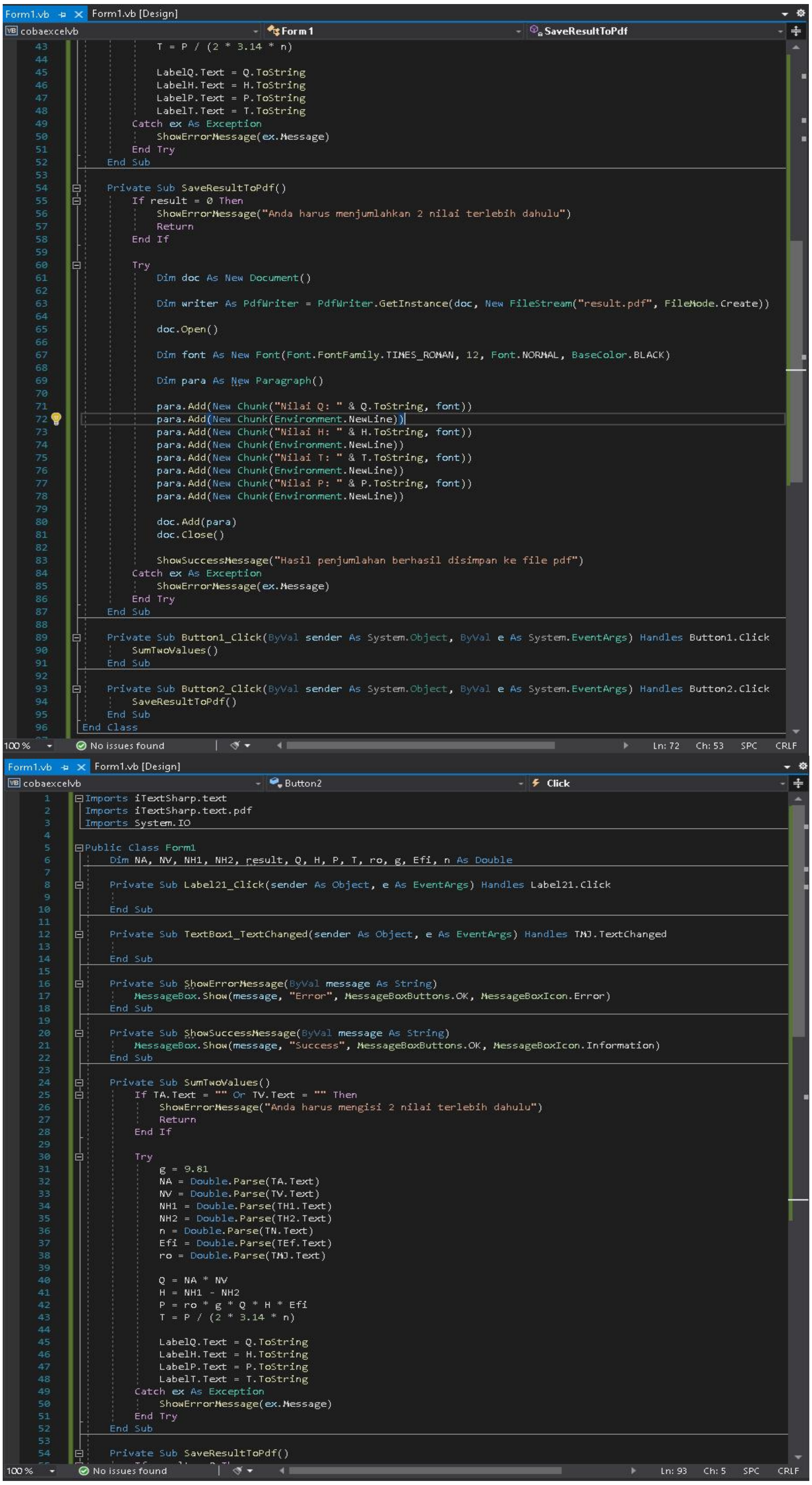

Figure 9. Program

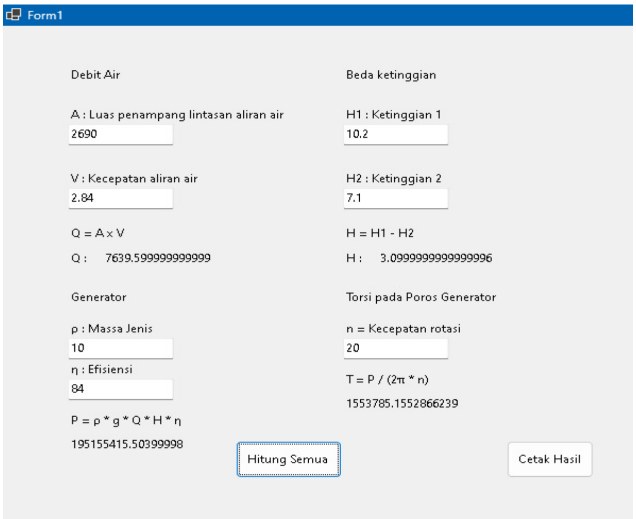

Figure 10. Output Programe

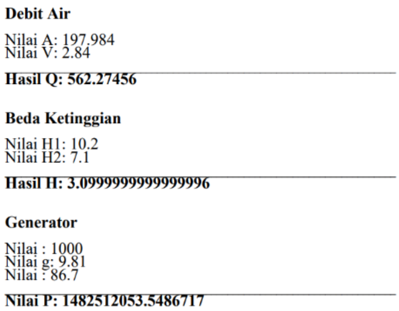

Figure 11. Result

Data values obtained during research or field surveys on irrigation canals are input into the program which has input parameters and formulas, after running the calculation of these values will be output. In this program, two survey data were input, namely, data taken from irrigation in the Mount Kawa area during the rainy season and dry season. It was obtained that the calculation results and output power were different, namely that in the rainy season, where the water flow was quite heavy, the output power was greater than during the dry season. This program can also include several data, not just two, but this research chose 2 conditions as representative of the seasons in Indonesia.

CONCLUSION

The conclusions from this research are:

1. A pico hydro power plant is one that is included in the classification of hydro power plants based on power capacity. Where the Piko Hydro Power Plant is a small-scale power plant producing less than 5 kW of power.
2. The application of genetic algorithms to manage the efficiency and haversing of picohydro really makes it easier to create hydroelectric power plants in this case picohydro
3. Obtain parameters, namely in the form of input parameters (water discharge, height difference); process parameters in the form of generators and turbines and output parameters are obtained from the input
4. Haversting and energy efficiency influence the value of the input parameters

5. Picohydro development is good if the water flow and height difference are appropriate
6. Two tests were carried out, namely on irrigation samples during the rainy season and dry season as comparative data. The results obtained were that during the rainy season the water discharge was greater so that the pico hydro system would also be more optimal.

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