Methods of Using Cross Flow Model Fins on Water Wheels on The Rotating Power of The Shaft at Low Flow Discharges With Variations in The Number of Wheels As Electric Generator Drives Pico Hydro Power Plant Testing

Suliono Suliono[1], Delffika Canra [1], Muhamad Ghozali [1], Dori Yuvenda [2], Wanda Afnison [2]

[1] Politeknik Negeri Indramayu, Indonesia
[2] Universitas Negeri Padang, Indonesia
suliono@polindra.ac.id, delffika.canra@polindra.ac.id, muhamadghozali@polindra.ac.id, doriyuvenda@ft.unp.ac.id, wandaafnison@ft.unp.ac.id

Abstract. Pico Hydro Power Plant (PLTPH) is the smallest scale power plant among other power plants with power generated with a capacity of less than 5 kW. Pico Hydro is one of the renewable energy sources that is environmentally friendly and also considered safe. In this study aims to; Making energy-efficient and environmentally friendly Pico Hydro hydropower plants ; The application of Pico Hydro power plants on rivers in Indramayu; Help illuminate the roads around the river flow. In the process of making this Pico Hydro power plant tool is made by using galvanized hollows as tool frames, sheet plates and pipes as turbine materials and alternators as the main source of electrical energy. This research was conducted on the Sindupraja River precisely at the Sondol sluice gate, where the current at this sluice gate is fairly strong. The load in this study used a variety of lamps, namely 10 watts, 18 watts, 24 watts, 34 watts, 42 watts and 52 watts.

Keywords: PLTPH Manufacturing, Lamp Loading, Pico Hydro.

1 Introduction

Please Indramayu has many rivers that have low water discharge, so there is rarely utilization of energy sources from these streams. Currently, very widely used sources of electrical energy come from fossil fuel energy and renewable energy sources such as water energy, wind energy and solar thermal energy [1]. However, as the population increases and technological advances, the need for energy sources today and in the future has increased uncontrollably. Water is an energy source that is easily obtained and relatively economical, in addition to environmentally friendly utilization, this Pico Hydro Power Plant (PLTPH) can also be used to help support the needs of energy sources needed by the community because it can be applied to low flows or small discharges. In

M. U. H. Al Rasyid and M. R. Mufid (eds.), *Proceedings of the International Conference on Applied Science and Technology on Engineering Science 2023 (iCAST-ES 2023)*, Advances in Engineering Research 230,
https://doi.org/10.2991/978-94-6463-364-1_68

order to meet the electricity needs in an area, the region must have an additional source of electrical energy from a power plant. This can directly or indirectly boost the economy and community welfare [2].

In the results of a survey conducted by the author in several villages around Indramayu, it is rare to find a Pico Hydro Power Plant (PLTPH) therefore a simple Pico Hydro Power Plant (PLTPH) tool is needed in terms of design and technology, this power plant utilizes a sufficient flow of water to run turbines in every dry season and rainy season [3]. Therefore, irrigation in the Indramayu area can be used for Pico Hydro Power Plant (PLTPH), irrigation in this area rarely recedes because this irrigation comes from the Cimanuk River in the mountains of Garut regency through Sumedang Regency to Indramayu. The Cimanuk River that passes through Majalengka Regency is made a large teak reservoir. So that the reservoir.

Fig 1. Village sluice gate Keliwed Blok Sondo

This can be for irrigation purposes in the Majalengka, Kuningan, Cirebon and Indramayu areas as well as relatively stable discharge. The manufacture of Pico Hydro Power Plant (PLTPH) equipment is carried out to determine the flow rate of water in the Indramayu area to be used as a Pico Hydro Power Plant (PLTPH) which will be applied to the river flow in the Indramayu area . Pico Hydro technologically has a very high efficiency so that it can increase public knowledge about energy management, besides that Pico Hydro is also considered safe [4], while irrigation in the Indramayu area is only for irrigation purposes and is not used for other purposes. The input of the tool is a stream of water that rotates the turbine then transmitted to the generator. The output is a source of electrical energy that can be used by the community around irrigation to meet the lighting needs of houses and village roads and for other business purposes. The main reason for this research is to utilize a low-flow river to drive a pico hydro electric generator that produces electrical energy to meet rural street lighting.

2 Theoretical

2.1 Pico Hydro Power Plant

Please This hydroelectric power plant is a power plant that relies on kinetic energy from water discharge to produce electrical energy. The electrical energy generated is commonly referred to as hydroelectric. The main form of this type of power plant is a generator connected to a turbine driven by kinetic power from water. This study discusses the process of testing pico hydro power plants as a converter of water energy into electrical energy and the effect of loading on the variations of lights connected to the electrical panel on pico hydro power plants. [5]. In this test, the alternator is used to charger the electric charge on the battery so that during the loading process the power lamp taken from the battery can be recharged so that the power supplying to the lamp is stable [6].

Table 1. Power Classification

No	Power classification	Power generated
1	Large-hydro	more than 100 MW
2	Medium-hydro	between 15 – 100 MW
3	small-hydro	between 1- 15 MW
4	Mini-hydro	power above 100 kW, but below 1 MW
5	Micro-hydro	between 5 kW – 100 kW
6	Pico-hydro	the power output is less than 5 kW

Pico Hydro Power Plant is a plant that can produce electrical energy less than 5 kW and can be classified as a small-scale power plant. Pico Hydro Power Plant has several advantages including:

1. The manufacturing cost is relatively cheap.
2. The manufacturing materials are easy to find on the market.
3. Environmentally friendly because it does not use fossil fuels.
4. Its construction can be combined with the construction of irrigation networks.
5. The technological development is still relatively small, so it is suitable for long-term use.
6. It does not require complicated maintenance and can be used for quite a long time.
7. Small size, suitable for rural areas that have not been reached by PLN's electricity network.

Principle of hydroelectric power plants

Hydropower generation is a form of energy change from water energy with a certain height and discharge into electrical energy, using water turbines and generators. The principle of hydroelectric power generation is to convert the kinetic energy of water into mechanical energy, which is then converted into electrical energy. This process involves several main components, namely:

a) Water collection: Water is collected from water sources such as rivers, lakes, or dams.

b) Penstock: Water is flowed through a carrier channel called Penstock. This penstock directs the flow of water to the turbine.

c) Turbine: Water flowing through the Penstock rotates the turbine. This turbine has blades mounted on a shaft and rotates as water flows through it. The rotational motion of this turbine converts the kinetic energy of water into mechanical energy.

d) Generator: The mechanical energy produced by the turbine is used to drive the generator. These generators convert mechanical energy into electrical energy. The working principle of the generator is to utilize the principle of electromagnetic induction, where the movement of magnets around the wire coil produces an electric current.

e) Transformer: The electric current generated by the generator has a low voltage. To transmit it through the power grid, this voltage needs to be increased using a transformer. Transformers convert low voltage into high voltage so that it can be transmitted over the power grid with better efficiency.

f) Power grid: Electrical energy generated by hydropower plants is flowed through the power grid to be distributed to homes, buildings, or industries. This electrical energy can be used for various purposes, such as lighting, the use of electronic devices, and other electrical needs.

2.2 Water Turbine

Turbines in general can be interpreted as initial driving machines where the working fluid energy used directly rotates the turbine wheels, the working fluid is in the form of water, water vapor and gas. Thus a water turbine can be interpreted as an initial driving machine whose working fluid is water [7]. In the working principle of the water turbine, the construction of the turbine wheel has a blade, which is a slab with a certain shape and cross section, water as a working fluid flows through the space between the blades, thus the turbine wheel / runner will be able to rotate and on the blade there will be a force that works. This force will occur because there is a change in the momentum of the working fluid of water flowing between the blades. The spoon should be formed in such a way that there can be a change in momentum in the working fluid of the water [7].

2.3 Water turbine classification

Based on the working principle of turbines in converting the potential energy of water into kinetic energy, water turbines are divided into 2 groups, namely turbines impulse as well as reaction turbines.

1) Impulse turbine: Impulse turbine is a turbine that converts all energy from water (potential, speed and pressure) into kinetic energy to rotate the turbine. The potential energy of water will be converted into kinetic energy in the nozzles. The water coming out of the nozzle has a very high pressure then hits the spoon. The collision of water and spoon will change the direction of flow speed so that there is a change in momentum (impluse).

2) Reaction Turbine: Reaction turbine is the most widely used type of turbine, this turbine has a specially shaped blade that causes water pressure to decrease when passing through the blade. This pressure difference is what will drive the runner (the rotating part of the turbine) to rotate.

2.4 Test equipment

Test equipment is a measuring and test tool used to analyze, validate, and verify measurements of electronic and mechanical systems.

1)*Digital Watt Meter :* This tool serves to measure the voltage on the dc current generated from the generator, this is done to determine the voltage of the load consumed on a circuit [8].

2)Tachometer : Tachometer is a sensor device to measure the speed of a rotation of an engine shaft such as a pulley. The tachometer is designed based on centrifugal force [9].

3)Current Meter : Current meter is a device used to measure the speed of water in an irrigation or river flow. The use of current meters in river flow is used because current meters have high accuracy for measurements of river flow speed besides that current meters are also equipped with electronic counters that show the rotation of the propeller [10].

3 Implementation Method

3.1 Pico Hydro Testing

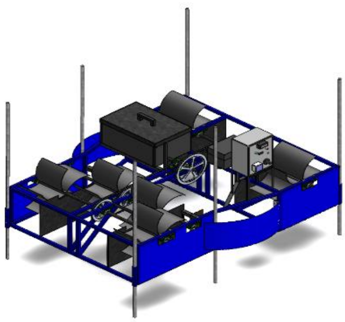

Fig 2. Design of pico hydro power generator

The process of making components of the PLTPH manufacturing and testing process is carried out through 4 stages. The first stage is to find data, namely surveying the water flow to be used for testing, then processing the data is then carried out, then continued the stage of making PLTPH until it is completed at the assembly stage, when all manufacturing is complete, the last stage is where the manufacturing process has been completed, then the testing process is carried out with variations on the turbine used, this aims to find out the largest rotation in the tool being tested.

4 Result and Discussion

4.1 Manufacture of PLTPH tools

In the process of making this PLTPH tool is carried out using galvanized hollow iron on the frame and naja plate on the turbine then cutting is carried out according to the working drawings that have been made, then the connection process is carried out using the welding method then continued with sanding and checking to provide strength to the tool against corrosion. The components of the Pico Hydro Power Plant with a propeller turbine can be seen in the following table :

Tabel 2. Turbine Components

No	Component	Sum	Information
1	Main Frame	1	Made
2	Shaft 1	2	Made
3	Shaft 2	1	Made
4	Blade 1	4	Made
5	Blade 2	2	Made
6	*Bearing* UCP 206	14	Purchased
7	Shaft Pully	1	Made
8	Pully 10 inch	4	Purchased
9	Pully 3 inch	2	Purchased
14	Pully 14 inch	1	Purchased
15	*Alternator*	1	Purchased
16	Electric panel	1	Purchased
17	Kaki frame	6	Made
18	Inverter	1	Purchased

4.2 Flow Discharge Data

WATER DISCHARGE DATA ON THE SINDUPRAJA MAIN CANAL								
No	Date & Month	Secondary Channel						
		Sukareja	Dutamati	Sipelem	Tirta Upaya	Darung	Sondol	Tertiary channel
1	16-Jul	5.046	4532	370	1475	4.959	3.679	326
2	17-Jul	5.046	4532	370	1475	4.959	3.679	326
3	18-Jul	4.847	3847	146	1283	3.748	2.163	318
4	19-Jul	4.326	3847	146	1283	3.748	2.163	318
5	20-Jul	4.226	3097	288	1410	3.464	2.163	259
6	21-Jul	5.598	4415	370	1541	4.646	3.487	447
7	22-Jul	5.335	3737	250	1162	4.040	3.487	259
8	23-Jul	5.335	3737	250	1162	4.040	3.487	259
9	24-Jul	3.242	3627	370	1743	3.187	3.974	459
10	25-Jul	4.326	3097	288	1410	3.464	3.487	503
11	26-Jul	3.541	3097	308	1410	3.893	3.023	359
12	17-Jul	4.991	4071	349	1607	3.748	2.662	506
13	28-Jul	5.687	4532	349	1607	4.040	2.755	506
14	29-Jul	5.687	4432	349	1607	4.189	2.755	445
15	30-Jul	3.694	2893	196	1084	3.787	3.695	350

Fig 3. Water Discharge Data On The Main Canal

Before conducting the test, a suitable river flow was selected to be used as a testing site by selecting the existing river flow discharge from the PUPR ministry as shown above.

Table 3. Row Measurement

Measurement	Turbine variations		
	1 row	2 row	3 row
Water velocity	0,502	0,558	0,558
Alternator rotation	1021	990	720
Current (A)	2,18	2,11	2,01
Voltage	11,53	8,99	8,78
Power	25,15	18,87	18,43

In the table above, a graph is then made in order to find out the variations obtained in each test of each row.

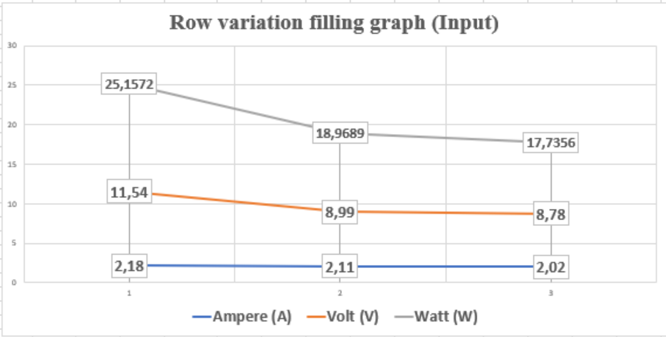

Fig 4. Row Measurement Graph

After testing the loading on each lamp, data collection was carried out which was summarized in a table, in this process the row variation used was 1 row because in this variation the largest round was obtained. The following is a table of output voltages obtained in the loading testing process within 30 minutes on each lamp.

Table 4. Voltage Measurement

No.	Time	10W	18W	24W
1.	0-5	11,70	11,44	11,77
2.	5-10	11,46	11,49	11,46
3.	10-15	11,51	11,33	11,0
4.	15-20	11,61	11,54	10,86
5.	20-25	11,49	11,44	10,55
6.	25-30	11,6	10,95	9,17

The table above shows the results of measuring the output voltage with loads varying in volts (V). For the value of the installed load with a relative voltage decreases. The greater the load power installed, the smaller the voltage generated. From the data produced above, the following is a table of loading testing graphs on each lamp.

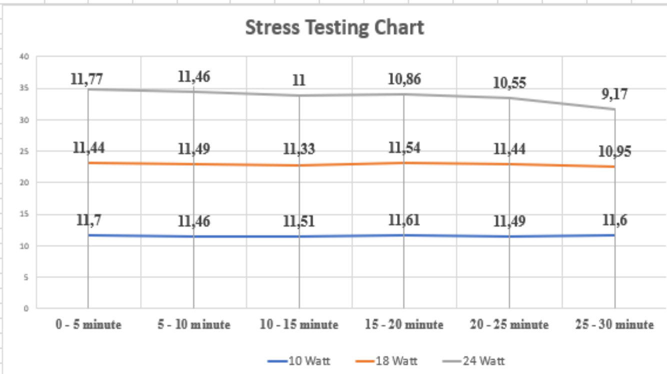

Fig 5. Voltage Measurement Graph

Graphs of voltage on the process of loading 10 watt, 18 watt, 24 watt lamps within 30 minutes calculated every 5 minutes, on this graph. Then next is the table of the results of the current output testing process (A) on each lamp load connected directly to the panel box terminal.

Table 5. Current Measurement

No.	Time	10W	18W	24W
1.	0-5	0,331	0,372	0,431
2.	5-10	0,331	0,372	0,431
3.	10-15	0,331	0,372	0,431
4.	15-20	0,331	0,372	0,431
5.	20-25	0,331	0,372	0,431
6.	25-30	0,331	0,372	0,431

The table above shows the results of current output in each lamp. In general, the current output number produced in each lamp is stable / constant in each lamp variation.

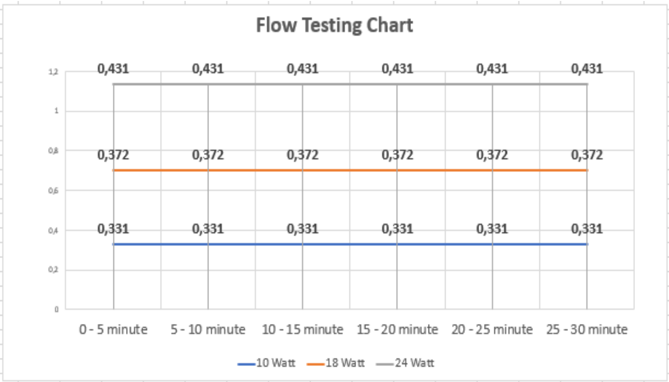

Fig 6. Current Measurement Graph

The amperee graph on the loading process of 10 watt, 18 watt and 24watt lamps is carried out using led and halogen lamps commonly used for street lighting, measuring lamp currents used with multimeters and carried out one by one on each lamp.

4.3 Second Test

The test continued to find the maximum value in the river flow in Indramayu using different river flows, in this test the method used is still the same as the previous method, namely with the initial step of measuring the speed of water flow in the river using a Current meter measuring instrument.

Fig. 7. Water velocity measurement results

Selection (H The picture above shows the results of the water velocity obtained from the river which will be continued as a test method, based on the data obtained the water velocity in the river is obtained at 0.841 m / s, in this river flow the water speed is greater than the previous river but the river used for testing the tool has a very deep depth. In this river flow, RPM testing was carried out again on the alternator to find out the amount of RPM obtained to be used as a power plant, in this river flow the RPM obtained was 1449 RPM, after testing rpm then carried out the process of testing charging from the alternator rotation to charge the battery, here is a picture of the RPM rotation on the alternator

Fig 8. Pully speed measurement

Then after the RPM testing process on the alternator continued with charging testing on the battery which is used as a power storage in the form of a battery, in this process the voltage on the battery shows 9.48V and also the power capacity stored in the battery is very low.

Fig 9. Power Measurement

In this process charging the battery is used with an alternator with a rotation of approximately 1449 RPM, then charging is done within 1 hour, in this process the results obtained during charging are 9.65 Ah, with the resulting voltage of 13.57V. as in the picture.

Fig 10. 2nd Power Measurement

In this process, the battery battery used for power storage has a capacity of 40 Ah, meaning that if in 1 hour of charging obtained by 9.65 Ah, the time needed to charge the battery battery from the storage power that runs out to have a full power capacity is about 4 hours 30 minutes, this is very normal for charging the battery battery.

After the process of measuring rotation on the alternator and the charging process on the battery battery, then loading again using lamp media, in this loading test the lamp media used are lamps with LED types and hologen lamps with different power variations in each lamp.

No.	Time (minute)	Voltage Lamp Load Variations(V)					
		52 watt	42 watt	34 watt	10 watt	18 watt	24 watt
1	0 - 5 minute	13,55	13,92	14,13	13,5	13,62	13,62
2	5 - 10 minute	13.55	13,9	14,11	13,52	13,73	13,78
3	10 - 15 minute	13,57	13,9	14,16	13,55	13,8	13,81
4	15 - 20 minute	13,59	13,9	14,11	13,5	13,81	13,83
5	20 - 25 minute	13,73	13,95	14,13	13,85	13,78	13,85
6	25 - 30 minute	13,74	13,94	14,16	13,76	13,78	13,88

Fig.11. Voltage Lamp Load Variation

In the table above can be seen the voltage on each lamp after data collection, each lamp has a different voltage but in each lamp the voltage produced is relatively stable at 1449 RPM rotation on the alternator.

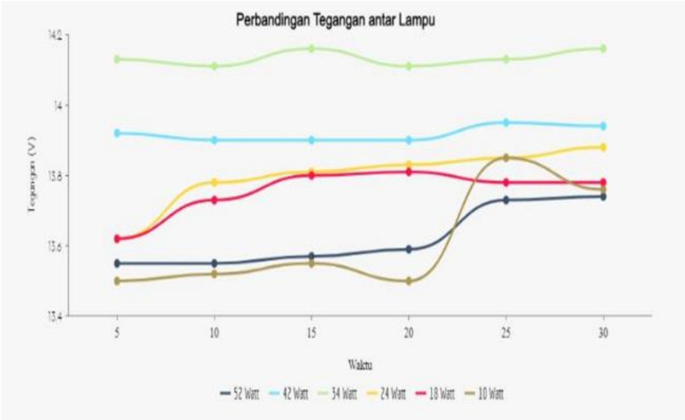

Fig 12. Graph of Voltage Measurement Results

Next is the data collection of amperes per hour (Ah) at each loading time produced and then summarized in a table.

No.	Time (minute)	Charging the battery when given a load of amperes/hour (Ah)					
		52 watt	42 watt	34 watt	10 watt	18 watt	24 watt
1	0 - 5 minute	0,29	2,95	6,27	11,94	16,32	19,47
2	5 - 10 minute	0,78	3,52	6,57	12,16	16,87	19,89
3	10 - 15 minute	1,38	4,13	7,03	12,67	17,67	20,69
4	15 - 20 minute	1,84	4,64	7,47	13,36	18,11	20,92
5	20 - 25 minute	2,31	5,18	7,93	15,55	18,77	21,57
6	25 - 30 minute	2,63	5,92	8,36	15,99	19,21	21,97

Fig 13. Charging Battery

The table above shows the charging that fills the battery battery when it is loaded, in each charging lamp is still running normally, it can be seen that the loading of each ampere lamp per hour (Ah) continues to increase.

The ampere per hour graph in the process of loading lamps 10 watts, 18 watts, 34 watts, 42 watts, 52 watts is done using led and hologen lamps commonly used for street lighting, current measurements are carried out on data on digital watt meters and carried out one by one on each lamp.

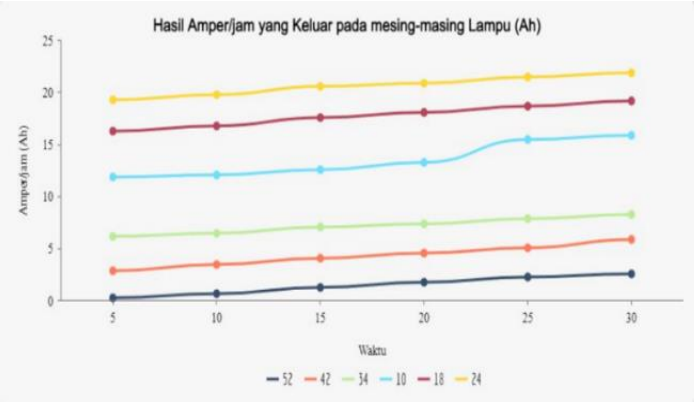

Fig. 14. Battrey Capacity Measurement Graph

Next is the wattage per hour data collection, in this data collection where the power generated from the voltage that appears on the alternator is then multiplied by amperes per hour (Ah) so that wat per hour results are obtained.

No.	Time (minute)	Results of the power that comes out of each lamp (Wh)					
		52 watt	42 watt	34 watt	10 watt	18 watt	24 watt
1	0 - 5 minute	3,9295	41,064	88,5951	161,19	222,278	265,181
2	5 - 10 minute	10,569	48,928	92,7027	164,403	231,625	274,084
3	10 - 15 minute	18,7266	57,407	99,5448	171,679	243,846	285,729
4	15 - 20 minute	25,0056	64,496	105,402	180,36	250,099	289,324
5	20 - 25 minute	31,7163	72,261	112,051	215,368	258,651	298,745
6	25 - 30 minute	36,1362	82,5248	118,378	220,022	264,714	304,944

Fig. 15. Result of The Power That Comes Out of Each Lamp

Based on the data above, the hourly wat obtained varies on each lamp, this happens because each lamp tested, charging on the battery battery continues to increase so that the results obtained increase. On the wattage per hour graph obtained from the calculation Wh = V x Ah then obtained the results in the table made on the graph.

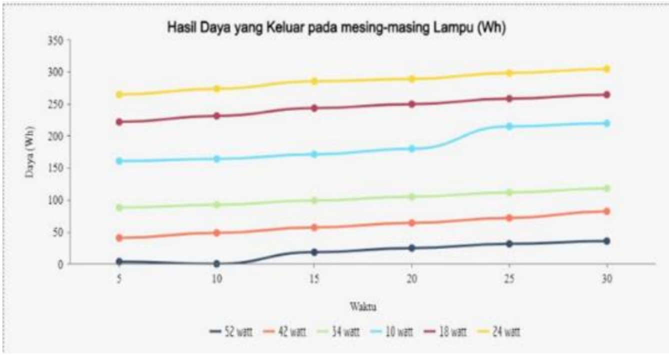

Fig. 16. Graph of Results Measurement of Power Produced

5 Conclusion

After making and testing the Pico Hydro Power Plant tool, several conclusions were obtained:

1. The manufacture of Pico Hydro Power Plant equipment is carried out in several stages, namely the determination of a predetermined design, then the purchase of materials, manufacturing, finishing and the last stage, namely the assembly process . In this tool the material used as a frame is a galvanized hollow 40 x 40 x 1.2 mm, alternator, 12v battery, 1200W DC to AC inverter and as the main mover of the turbine which is transmitted to the alternator through pulleys and van belts.
2. Testing of the P ico Hydro Power Plant tool is carried out on the river flow in Indramayu, which is carried out on the flow of sluices, with the expected test targets in the form of Volts, Amperes, Watts, RPM on the alternator and water speed, in this test the row variation used for loading is 1 row.
3. The Pico Hydro Power Plant tool can function on the river flow in Indramayu because several targets have been met.

References

1. D. Devianti, R. Bulan, P. Satriyo, and D. Sartika T, "Kajian kapasitas daya pembangkit listrik tenaga air melalui pendekatan debit rencana metode rasional di sub-DAS Lawe Sempali, Provinsi Aceh," J. Pengelolaan Sumberd. Alam dan Lingkung. (Journal Nat. Resour. Environ. Manag., vol. 10, no. 2, pp. 307–319, 2020, doi: 10.29244/jpsl.10.2.307-319.
2. H. E. Mantiri, M. Rumbayan, and G. M. C. Mangindaan, "Perencanaan Pembangkit Listrik Tenaga Listrik Minihidro Sungai Moayat Desa Kobo Kecil Kota Kotamobagu," J. Tek. Elektro dan Komput., vol. 7, no. 3, pp. 227–238, 2018.
3. L. A. G. Sinaga, "MIKRO HIDRO DENGAN TURBIN CROSSFLOW," PROSES PERAKITAN DAN Penguji. PEMBANGKIT List. TENAGA MIKRO HIDRO DENGAN TURBIN CROSSFLOW, vol. 10, no. 2, pp. 2–7, 2022.

4. S. Anwar, M. T. Tamam, and I. H. Kurniawan, "Rancang Bangun Sistem Pembangkit Listrik Tenaga Air Menggunakan Konsep Hydrocat," Resist. (Elektronika Kendali Telekomun. Tenaga List. Komputer), vol. 4, no. 1, p. 7, 2021, doi: 10.24853/resistor.4.1.7-10.
5. Margana, Wahyono, B. M. H, and N. F. A, "Pengujian Piezoelektrik Tipe PZT Sebagai Pembangkit Listrik Tenaga Air," Pros. NCIET, vol. 2, pp. 55–65, 2021.
6. Sofiah and M. Hurairah, "Jse-11," Ranc. Bangun Pembangkit List. Altern. dengan Bantu. Pully dan Belt Mot. DC sebagai Penggerak Altern., pp. 10–17, 2020.
7. Arismunandar, "No Title," Penggerak mula turbin, Ed. ketiga. Bandung ITB., 2004.
8. D. Liestyowati, I. Rachman, E. Firmansyah, and Mujiburrohman, "Rancangan Sistem Pembangkit Listrik Tenaga Surya (PLTS) Berkapasitas 100 WP dengan Inverter 1000 Watt," INSOLOGI J. Sains dan Teknol., vol. 1, no. 5, pp. 623–634, 2022, doi: 10.55123/insologi.v1i5.1027.
9. A. Darmawi and B. Yulianto, "Penggunaan Alat Ukur pada Mesin-mesin Industri Tekstil Sebagai Standar Parameter Kinerja Mesin," vol. 5, no. 1, pp. 8–18, 2022.
10. Hanny Tangkudung, "Gbr 1. Kecepatan aliran pada pelampung 28," Pengukuran Kecepatan Aliran Dengan Menggunakan Pelampung Dan Curr. M., pp. 28–31, 2011.