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Portable Pico Hydro Power Plant for Power Station Charger

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ABSTRACT

The increasing need for energy will cause the depletion of energy reserves on earth and require energy reserves that can be renewed. Water flowing energy is the right choice to replace it by using it to generate electricity. And electrical energy can be stored in batteries that can be used at any time. In this study, converting the energy of the water into electricity is stored in batteries in the form of portable generators that can be taken anywhere. By requiring a component such as a turbine, generator, charger controller, auto buck bost converter, battery and other supporting components that are assembled into one in a portable form. With out a 12V battery that can increase and decrease the voltage as a charger for cellphones, laptops and other electronic equipment. By taking the results obtained, do a comparison by comparing the difference in the discharge of flowing water with the charging time on the power charger. The results obtained were river discharge 73.621 l/s charging time 42 hours, river discharge 73.621 l/s charging time 42 hours, pipe discharge 6.41 l/s charging time 84 hours, pipe discharge 8.064 l/s pipe charging time 38 hours, pipe discharge 9.868 l/s charging time 32 hours, pipe discharge 14.42 l/s pipe 27 hour. The greater the discharge, the faster the charging of the battery.

1. INTRODUCTION

The need for energy continues to grow and the dwindling resources urge people to look for other energy sources [1]-[5] Therefore, other renewable energy sources are needed [6]-[10]. In the search for renewable energy sources, it should be one that has and produces a sufficient amount of energy, does not cost much and has a positive impact on the environment [11]-[14]. One such energy source is water flow energy [15]-[18]. Electricity is an important need as the community's need for electronic devices is increasing [19]-[24]. Hydropower plants are plants that are widely found and used in areas where there are many small and large rivers that can all be used [25]-[31]. For low discharge water flow conditions can use Archimedes screw turbines [32]-[36]. Screw turbines have ease of manufacture, so the use of this turbine will facilitate its assembly and maintenance [37]-[41].

At this time, electronic technology such as communication and information is developing very quickly, such as cell phones and laptops [42][43]. It turns out that the use of smartphones today is not only for interpersonal communication. But nowadays, smartphones are generally used as a tool to take pictures, watch movies, study, play videos and even see the world directly through the search function on the Internet, and smartphones also have many uses [44]-[46]. Smartphones and laptops require electrical energy so that they can turn on which is stored in the battery. If the battery is used continuously, the battery will run out quickly or what is commonly called non-continuous [47]-[49]. This causes the performance of smartphones and laptops to decrease, so the need to recharge the cellphone and laptop batteries [50]-[52]. Previously, a cellphone and

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laptop battery charging system was made by making a charger station as a charger for electronic devices such as smartphones and laptops [53]-[55]. However, the station charger if the stored energy runs out, it requires recharging by using low voltage electricity, namely 220V, which is not available in all places such as forests or natural places [56]-[58].

So, this research makes a smartphone and laptop battery charging tool using a Portable Pico Hydro Power Plant (PLTPH) to generate electricity stored in smartphone and laptop batteries. This system is made with several electronic components, namely the Solar Charger Controller, battery capacity display, Boost Converter module and others. Therefore, in this study the title "Portable Pico Hydro Power Plant for Power Station Charger" was made.

2. METHODS

Pico Hydro Power Plant (PLTPH) is a hydroelectric power plant applied in rivers or waterfalls, utilizing the difference in height between upstream and downstream, the amount of water flow and water. Pico hydro plants can be used in several applications, one of which is the Archimedes screw turbine application. The Archimedes screw turbine, often called a screw turbine, is a technology invented and used since ancient times as a pump, which in its structure consists of one or more helical blades mounted on a shaft and acts as a moving blade to carry water upwards [59]-[61].

With an increasingly advanced and rapid era, researchers are making new breakthroughs in this research that are useful as technological needs. By making portable pico hydro power plant tools for power station chargers can facilitate human work, especially in energy storage. By combining portable pico hydro power plants with energy storage, namely power stations, humans can store energy as battery chargers for electronic goods. Besides being able to be carried anywhere, the energy storage can also be recharged because it has been combined with a portable pico hydro power plant that uses an Archimedes screw turbine so that it can be placed in the river flow [62]-[65].

2.1. Design concept

In Figure 1 the flow of turbine design flowing water will drive the turbines which later the turbine drives the generator. For the generator voltage can be monitored using a DC voltmeter, then the voltage from the generator will enter the auto buck boost converter to stabilize the voltage of 13.6V and then enter the SCC (Solar Controller Charger) where the SCC functions as a battery charger and will regulate the voltage entering the battery. For 12V lights as for emergency lights whose voltage can be taken from the SCC that has been installed on the battery. Furthermore, the voltage from the battery will be lowered using an auto buck boost of 5V as a Handphone charger and from the battery there is another auto buck boost which increases the voltage by 20V as a Charger.

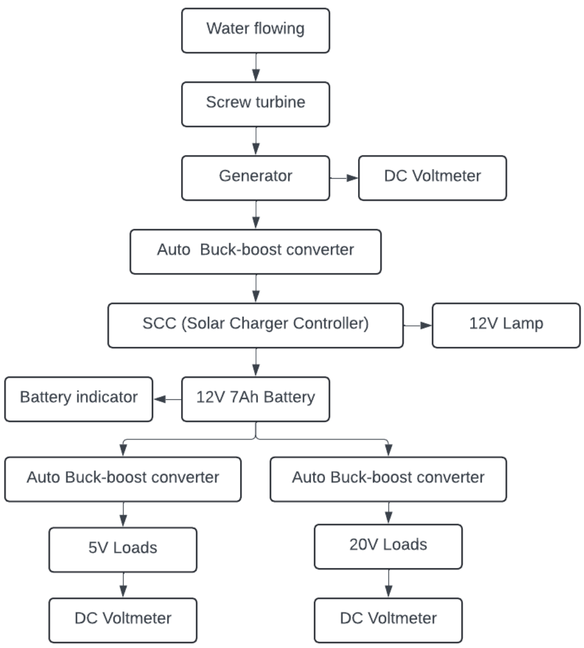

Figure 1. Tool planning flow

Table 1. Tools and materials

Component Name	Quantity
Archimedes turbine	2
DC12/24V generator	1
SCC (Solar Controller Charge)	1
Auto Buck Boost Converter XL6009	3
Battery indicator	1
12V 7AH battery	1
DC voltmeter	3
Generator pulley	2
Connecting cable	10
12V lamp	1

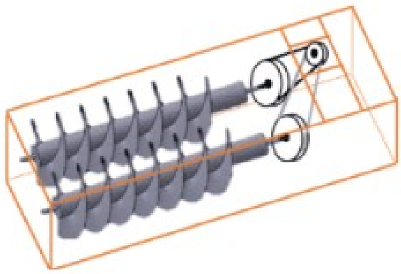

Figure 2. Archimedes turbine design

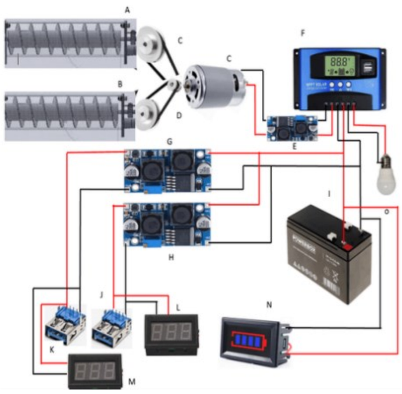

Figure 3. Block diagram of design flow

A. Archimedes turbines 1
B. Archimedes turbines 2
C. Pulley 1
D. Pulley 2
E. Buck – Boost converter 13,6V
F. SCC (Solar Controller Charger)
G. Buck – Boost converter 5V
H. Buck – Boost converter 20V
I. Battery 12V 7Ah
J. Extend USB 20V
K. Extend USB 5V
L. DC voltmeter
M. DC voltmeter
N. Battery capacity display
O. 12V Lamp

2.2. Water discharge

Water discharge can be calculated with this equation below

$$Q = V \times A' \tag{1}$$

$$V = \frac{D}{t} \tag{2}$$

$$A' = \frac{l}{d} \tag{3}$$

where V is average flow velocity (m/s), Q is the water discharge (I/s), v is the volume (m^3), A' is the wet cross-sectional area (m^2), t is the time (s), D is the distance (m), l is the river width (m), and d is the river depth (m)

2.3. River discharge

To find the water discharge is taken from Eq. 1 and carried out 3 times the experiment whose results will be calculated on average with the following equation

$$Average\ Q = \frac{Q\ total}{Number\ of\ Trials} \tag{4}$$

2.4. Hydrolysis power

In this case, the hydraulic power is obtained from the water power generated by the river.

$$Ph = p\ .g\ .Q\ .h \tag{5}$$

where Ph is Hydraulic power (Watt), p is the fluid/water density (kg/m^3), Q is the water discharge (m^3 /s), g is the gravity force (m/s^2), and h is the head or height of falling water (m)

2.5. Output power of turbine and generator

To calculate generator power and turbine power at constant head:

$$Pg = V_L\, x\, I_L \tag{6}$$

where V_L is the load voltage (V), and I_L is the Load current (A). From the data analysis, the turbine output power is obtained with the equation:

$$NTA = \frac{Pg}{\eta G} \tag{7}$$

where Pg is turbine output power, and ηG is the generator efficiency (80%). To find the efficiency of the turbine, is derived as follows

$$\eta TA = (Pg)/\ (Ph)\ x\ \ 100\% \tag{8}$$

where Pg is the Generator power, and ηTA is the generator efficiency

2.6. Battery Charging

2.6.1. Slow charging method

The slow charging method is charging with 10% of the incoming current from the total current of the battery. The total current owned by the battery is 7 Ah, so the minimum current used for the slow charging method is 0.7A. Charging a 7 Ah battery requires a current for slow charging is 10%, which is 0.7 A.

2.6.2. Fast charging method

The fast-charging method is charging with 40% of the incoming current from the total current of the battery. The total current owned by the battery is 7 Ah, so the maximum current used for the fast-charging method is 2.8A. Charging a 7 Ah battery requires a current for fast charging is 40%, which is 2.8A and can be calculated charging time charging time with the equation:

$$Charging\ time\ (hour) = \frac{Battery\ capacity\ (Ah)}{Current\ (Ah)} + \left(\frac{20}{100}\right) x\, \frac{Battery\ capacity\ (Ah)}{Charging\ current\ (Ah)} \tag{9}$$

3. RESULTS AND DISCUSSION

3.1. Knowing the power comparison using 1 turbine and 2 turbines with a 10Watt lamp load

With a constant discharge = 12.5 l/s = 0.0125m3 /s. In accordance with equation (3), the hydrolysis power of 12.206 Watt is obtained.

Figure 4. Comparison of voltage, current of test 1 turbine and comparison of voltage, current of test 2 turbines

In Figure 4 is the result of a trial to determine the comparison of power generated using 1 turbine and using 2 turbines. Conducted by testing the first using 1 turbine and the second using 2 turbines. Both comparisons of the results will be obtained current and voltage which will result in differences in turbine efficiency, which is more efficient using 1 turbine or 2 turbines.

Table 2. Comparison results with the same load of 10 watt

Using 1 Turbine	Using 2 Turbine
In accordance with Eq. 4 *NG*= 0.754 watt	In accordance with Eq. 4 *NG*= 1,12 watt
In accordance with Eq. 5 NTA= 0.9425 watt	In accordance with Eq. 5 NTA= 0.9425 watt
In accordance with eq. 6 ηTA= 7,7%	In accordance with eq. 6 ηTA= 7,7%

From the data in Table 2, measurements and calculations found that using 2 turbines the power generated is greater and for greater efficiency. In the first design when testing was carried out on a small river with a discharge of 73.6 l/s. In accordance with Figure 5, the tool is done by directly placed in the river.

Figure 5. River testing

Table 3. In-river test data

	n t	n G	I in SCC	V G	Q 1/s	Vabb
Before SCC load	74	170,2	0	5,5	73,6	13,5
At SCC load	46,5	107	0,2	2,7	73,6	12,6

In Table 3, the data is obtained, and the charging time is in accordance with equation number (7). With a river water discharge of 73.6 l/s and a 7 Ah battery, it takes 42 hours of charging time until the battery is fully charged.

In the next test will be carried out in rivers with different discharge, but there are obstacles to finding rivers because some rivers in the surrounding area the water discharge is very small and cannot be used for testing. To overcome this problem, a modification was made to the turbine by adding a PVC pipe. The pipe is placed to cover both turbines, so that water can hit both turbines. In Figure 6 the PVC pipe covers the entire turbine with the aim that all water flow can hit the turbine. Further testing is carried out with the help of a diesel water pump and can be set the discharge as the difference produced.

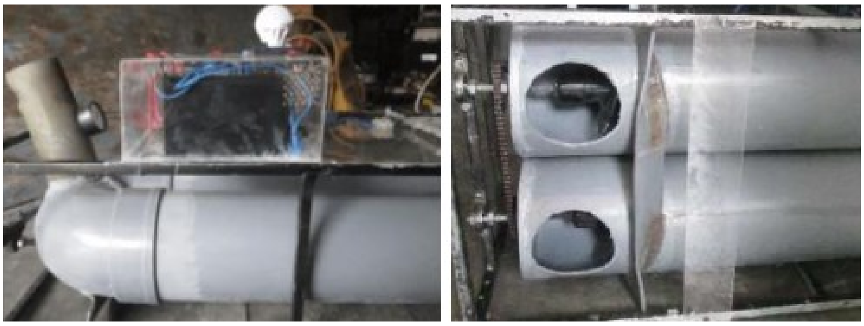

Figure 6. Turbine modification using pipes

3.2. Testing with turbines through the pipe at the first discharge with Q = 6.41 l/s

In Table 4 the data is obtained, and the charging time is in accordance with equation number (7). With a river water discharge of 6.41 l/s and a 7 Ah battery, it takes 84 hours of charging time until the battery is fully charged.

Table 4. First pipe discharge test result data

	n t	n G	I in SCC	Pa	V G	Vabb
Before SCC load	62,17	143	0	0	7,1	13,5
At SCC load	52,17	120	0,1	0	2,9	12,5

where nt is the turbine speed (Rpm), nG is the Generator speed (Rpm), I in SCC is the Electric current into SCC (A), Pa is the water pressure (bar), VG is the Generator voltage (V), Vabb is the Auto buck boost exit voltage (V)

3.3. Testing with turbines through the pipe at the second discharge with Q = 8,064 l/s

In Table 5 the data is obtained, and the charging time is in accordance with equation number (7). With a water discharge of 8.064 l/s and a 7 Ah battery, it takes 38 hours of charging time until the battery is fully charged.

Table 5. Second pipe discharge test result data

	n t	n G	I in SCC	Pa	V G	Vabb
Before SCC load	98,69	227	0	0	8,2	13,5
At SCC load	58.26	134	0,22	0	3	12,5

3.4. Testing with turbines through the pipe at the third discharge with Q = 9,868 l/s

In Table 6 the data is obtained, and the charging time is in accordance with equation number (7). With a water discharge of 9.868 l/s and a battery capacity of 7 Ah, it takes 32.3 hours of charging time until the battery is fully charged.

Table 6. Third pipe discharge test result data

	n t	n G	I in SCC	Pa	V G	Vabb
Before SCC load	124,7	287	0	0	9,31	13,5
At SCC load	63,9	147	0,26	0	3	12,5

3.5. Testing with turbines through the pipe at the fourth discharge with Q = 14,42 l/s

In Table 7, the data is obtained, and the charging time is in accordance with equation number (7). With a water discharge of 14.42 l/s and a battery capacity of 7 Ah, it takes 27 hours of charging time until the battery is fully charged.

Table 7. Fourth pipe discharge test result data

	n t	n G	I in SCC	Pa	V G	Vabb
Before SCC load	139,1	320	0	0	11, 4	13,5
At SCC load	64,7	149	0,31	0	3,2	12,5

3.6. Difference in discharge and charging time

From the results of the trials that have been carried out, according to Table 8 and Figure 7, the value obtained is at a pipe water discharge of 6.41 l / s obtained battery charging results for 84 hours, pipe water discharge of 8.064 l / s obtained battery charging results for 38 hours, pipe water discharge of 9.868 l / s obtained battery charging results for 32 hours, pipe water discharge of 14.42 l / s obtained battery charging results for 27 hours.

Table 8. Hour charging length difference

	River discharge 73,6 1/s	Pipeline discharge 6,41 1/s	Pipeline discharge 8,064 1/s	Pipeline discharge 9,868 1/s	Pipeline discharge 14,42 1/s
Charging time (hour)	42	84	38	32,3	27

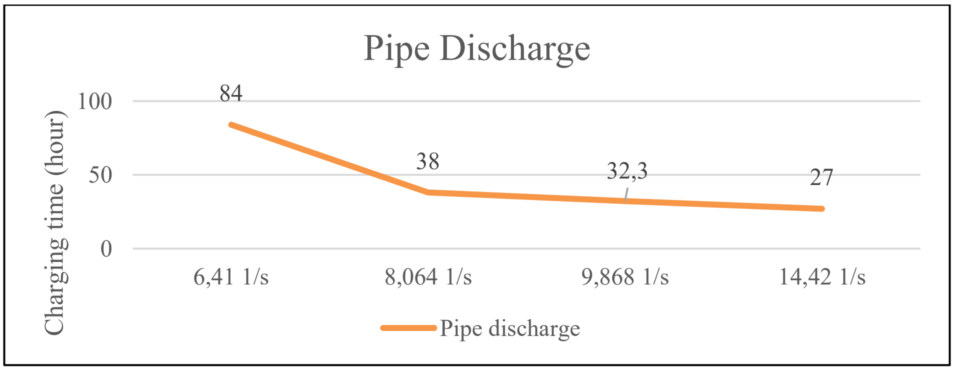

Figure 7. Hour charging length difference

4. CONCLUSION AND LIMITATION

In this design using 2 turbines that function to drive a 550watt generator which will distribute the voltage to the Solar Charger controller by stabilizing it first through an auto buck boost converter with a voltage setting of 13.6V which functions to increase and decrease the voltage either the voltage from the generator is 7-8 or greater than the volt setting. So that it can charge into a 12V 7Ah battery. And also functions as a 5volt voltage drop from the battery to the cellphone charger load and for a voltage increase of 20volt as a laptop charger. With the existing equation according to the calculation, the results obtained in the water discharge that most quickly fills the battery, namely water of 14.42 l / s, the results of battery charging for 27 hours. The greater the discharge that drives the turbine, the greater the power generated by the generator and the faster it is to store energy into a 12V 7Ah battery. With the results of the calculation of the maximum river water discharge of 73.61 l / s, the hydrolysis power of 71.869 watts and the turbine output power of 34.5 with a turbine efficiency of 48%, obtained charging on the battery for 42 hours with a load of 0.2A generated according to the amount of river water discharge.

Researchers hope that further research can continue and optimize this tool so that the results can be even better, whether in terms of mechanics or in terms of electronic components. In making turbines, it is recommended to use thicker and stronger materials, namely iron plates. And make a difference using 1 turbine and using 2 turbines, according to the calculation. In order to find out which is more efficient using 1 turbine or 2 turbines Test the components that have been assembled by running the electrical system first in order to find out if there are components that are not running properly so that they can prevent damage to the tool.

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