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Article Review

RIVER CURRENT POWER GENERATION DEVICE MODEL (Case Study of Lagan River Current, East Tanajab Regency)

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Abstract

This research is motivated by the fact that the utilization of river currents for Hydroelectric Power Plants (PLTA) has a number of advantages in providing renewable energy in Indonesia, especially in Jambi province. The purpose of this study is to find a model for utilizing Lagan river currents as a river current power plant. The method used is engineering techniques or design of power generation equipment. The results obtained are that the vertical current turbine model can be used as a power generation tool for Lagan river currents in Lagan village, East Tanjungjabung district.

Keywords: *Model, Power Generation Equipment, River Current Power*

INTRODUCTION

In every river there are upstream and downstream parts. The flow of a river will move from upstream to downstream. The flow in a river has different speeds. This difference is determined by the steepness, shape of the river bank, shape of the river bed and others. Rivers in the upstream area will have a higher flow speed compared to the downstream area. This is because the position of the upstream area of the river is always in a higher area. However, the speed of the river flow in the downstream area, although small, tends to still be able to produce energy. The Lagan River is a tributary of the Batanghari River located in Lagan Village, Tanjung Jabung Timur Regency, Jambi Province. The Lagan River was formed due to a depression that extends towards the Batanghari River basin. During the rainy season, the Lagan River will have a lot of water that will flow towards its main river, the Batanghari River. However, the upstream of the Lagan River is not in a high area, so the Lagan River is more appropriately called a tidal river. The characteristics of tidal rivers are not the same as rivers whose upstream is at a height (hill or mountain). The tidal river has two opposing current directions. When the sea water is high, the current direction will move from downstream to upstream. And when the sea water is lower or recedes, the flow direction will move from upstream to downstream.

In previous studies, data has been obtained that the current speed of the Lagan River at the Lagan Tengah Village catchment point with the position of the measuring buoy in a straight river flow is 0.269 m / s. When measuring the wind speed ranges from 3 m / s with a direction angle of 1500. However, this data has not been included in calculating the actual river flow speed. Thus, it is found that the measured river flow speed is still below the threshold of effectiveness for power generation. For this reason, efforts are needed to

increase the current speed, considering that the cross-sectional area of the Lagan River at the catchment point in Lagan Tengah Village is quite large.

River flow is included in the group of new renewable energy. The energy possessed by river currents will continue to be renewed, meaning that this energy will never run out unless the river dries up. The greater the discharge of a river flow, the greater the potential energy it has, and the faster the flow speed of a river, the greater the mechanical energy that can be produced. This means that these two main components are very important in producing mechanical energy from a river.

LITERATURE REVIEW

Microhydro power generation is the generation of electricity generated by a DC or AC electric generator. Microhydro comes from the word micro which means small and hydro means water, the overall meaning is the generation of small power electricity driven by water power. Large water power from small rivers or dammed lakes and then from a certain height and having the appropriate discharge will drive the turbine connected to the electric generator.

The generator used for microhydro is designed to be easy to operate and maintain, designed to support safety, but electrical equipment will be dangerous if not used properly. Several points from this guideline, the instructions show things that must be considered and must be followed as shown below.

Microhydro power plants in principle utilize the difference in height and the amount of water discharge per second in the irrigation water flow, river or waterfall. This water flow will rotate the turbine shaft so as to produce mechanical energy. This energy then drives the generator and produces electrical energy.

RESEARCH METHOD

Methods used Engineering techniques or design of power generation equipment. The method used in this writing is descriptive qualitative. This method is used to describe the facts in the field. The purpose of the method is to: 1) Collect actual information in detail that describes existing symptoms, 2) Identify problems and examine applicable conditions and practices, 3) Make comparisons and evaluations, 4) Determine what others do in dealing with the same problem and learn from others to determine and establish decision plans in the future.

RESULTS AND DISCUSSION

Electrical energy is energy produced from the movement of electric charge or energy stored in electric current with units of amperes and electric voltage with units (V) has provisions for the need for electric power consumption with units of watts to be used for various purposes. Ardiansyah, 2024). Electrical energy. Electrical energy has a very important role in everyday life, for example to turn on lights in homes, streets, and offices so that humans can carry out activities at any time, day or night. Hydroelectric power plants convert water kinetic energy into electrical energy. Here's how a hydroelectric power plant works: Water from the river is collected in a dam, then the water is channeled through pipes to the turbine, the water turns the turbine, then the turbine will turn the generator, and the generator will produce electricity.

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Indonesia as an archipelagic country has abundant sources of sustainable and renewable water-based alternative energy (energy from ocean currents, rivers, waves, tidal energy, and energy from the difference in temperature between the sea surface and the seabed (OTEC). Of the alternative energy sources that are abundantly available, one of them has not been optimally utilized, namely energy sources from ocean/river currents. This source is found in almost all regions of Indonesia.

This technology is most suitable for application in places that have strong river currents and stable seasonal water, one example of which is the Citarum River in West Bandung Regency, West Java. The greater the river current and the higher the water level, the more electricity will be generated from the hydroelectric power plant. Challenges that will be faced in utilizing river currents for hydroelectric power plants in Indonesia.

Lack of public awareness of renewable energy based on river currents is evidenced by the fact that many people still throw garbage in rivers. Climate change Climate change in Indonesia can affect the water cycle, such as reduced rainfall to drought. This condition can have an impact on the performance of hydroelectric power plants. Licensing and regulation Licensing and regulation process for hydroelectric power plant construction in Indonesia is still quite complicated and takes a long time.

Utilization of river currents for Hydroelectric Power Plants (PLTA) has a number of advantages in providing renewable energy in Indonesia. PLTA utilizes river currents that are continuously available, so that this renewable energy source can be renewed and sustainable. As long as the air flows, energy can continue to be produced without fear of running out of resources. The advantage of using ocean/river current energy is that in addition to being environmentally friendly, ocean/river current energy has a much higher density compared to wind energy (830 times) so that with the same capacity, the dimensions of the current turbine will be much smaller than the wind turbine (more efficient).

Electricity is the main source of life. Without electricity, other aspects, such as economic, social, security and education aspects will not run well. In fact, there are still many areas that have a fairly large current speed source but the area has not been fully served by PLN electricity so that aspects such as those mentioned above do not run well. This condition causes a region to be underdeveloped in terms of development compared to other areas that have been served by electricity. To overcome this, it is necessary to carry out river current engineering with a certain model. The Turbine Model of river current power generation can be applied in rivers that have a current speed of around 2.5 m/s. The advantages of this model include:

1. As a source of electrical energy for residents in the interior (Kalimantan, Papua, Sumatra or River Basins (DAS) on the island of Java). Helping
2. The government in the program of developing and utilizing renewable energy sources for power generation.
3. So that it can reduce pollution and environmental damage. can be used as a means of education and technology tourism (if installed in a tourist area or river in the city (city park)

There are several theories in planning this river current power plant. Among them is if in an area that has a low difference in river water level, the design of the power plant is made with a Dam (dam) system. In this system, river water is dammed so that it has a significant difference in water level to produce pressure on the prime mover/water turbine.

As a result of a pressure head (pressure difference) between the top and bottom, the dammed flow is then channeled to the turbine rotor at a higher flow rate so that it will rotate the turbine rotor. Unfortunately, construction like this requires very expensive costs and is not appropriate if the river is still used as a means of transportation.

In addition, there is another design that can be said to be right for rivers that are still used for transportation. In this design, not all of the width of the river is utilized, but only a small part. In certain parts of the river, a kind of flow trap is made so that the current entering the trap will have a higher speed. This system only uses a small part of the river width. Design This will require different turbine planning compared to the complex turbines in general. This is also different for turbine designs for flat river flows such as those generally found in a number of large rivers in Sumatra, Kalimantan or Papua. No dam is needed to hold back the water pressure, but it is sufficient to be equipped with a duct as a flow accelerator.

Electrical energy is generated by converting the kinetic energy of the ocean current which is channeled to the turbine rotor and then through the generator converted into electricity. In a turbine structure without a Duct, the energy generated by the rotor is relatively small because the pressure drop in the flow area around the rotor is very small so that the flow is also small. By using a duct, the current can be accelerated almost twice because there is a decrease in pressure (quite a large pressure drop) which causes an increase in the flow speed towards the rotor. This increase in speed affects the increasing power generated to generate electricity, or in other words, to produce the same power, the dimensions of the rotor can be reduced by almost half so that it will save production costs.
In addition to these functions, some of the advantages of a turbine that uses a Duct are:

1. The efficiency of the turbine becomes greater so that with the same power requirements, it does not require a large size oversized supporting equipment.
2. Can protect the turbine from objects in the river that can interfere with turbine operations.
3. Protects the turbine from waves that can cause a decrease in efficiency.
4. Protects the turbine from direct sunlight so that it will inhibit the growth of marine animals/plants that stick to the turbine blades.
5. On the duct funnel, a grid can be installed to prevent dirt or other items from entering the turbine.
6. The flow in the accelerated duct will accelerate the rotation of the turbine so that it can reduce the cost of making the gear box.

There have been several studies conducted to design the shape of the duct to produce the most optimum operational efficiency, including testing the duct model that was conducted by UPT-BPPH, BPPT in the Hydrodynamics Laboratory's Towing Tank. The result is that the use of Duct can increase the flow rate around the rotor and the flow becomes steadier (does not depend on changes in flow rate outside the duct).

In a paper written by Ponta and Dutt (1999), 'An Improved vertical axis water current turbine incorporating a channeling device', a duct has been designed to be placed in the river so that the river current passing through the rotor work area will be accelerated. This type of duct is open on top. This design is very suitable for rivers without static head or flat rivers without rapids as shown in the picture below:

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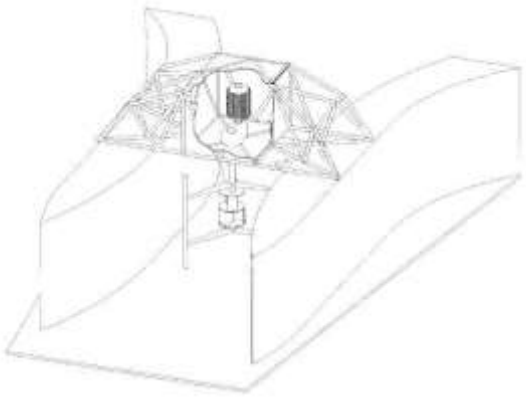


Figure 1. River current turbine designed by Ponta and Dutt

The advantage of this turbine is that it does not require a dam so that production costs are much cheaper and it does not hinder boat traffic passing through the river channel. Other literature written by Kirke, B.K (2005)."Developments in ducted water current turbines" reported the results of a duct design from a combination of foil pieces so that the foil forms the neck and funnel of the duct. The results of the study proved to be able to increase the efficiency of turbine power.



Figure .2 Duct designed by Brian Kirkie



Figure 3. Duct Prototype in UPT-BPPH Workshop

Since 2006, research has been conducted on the development of ocean current potential in several locations throughout Indonesia, starting from Numerical Mapping, Turbine Design, Duct (sheath) design, model making and testing in the Hydrodynamics Laboratory to the scale of prototype making where in early 2010 it was successfully tested in the Flores Strait-NTT.

For river current turbine technology, basically there is no principal difference between turbine design at sea and in rivers, even river turbine technology is relatively easier. UPT-BPPH, BPPT are pioneering cooperation in the design and installation of River Current Turbines in Nunukan Regency, Kalimantan.

It is a fact that there are still many of our brothers and sisters who until now still cannot enjoy PLN electricity services due to limited fuel supply for power plants or locations that are difficult to reach for transmission and distribution purposes so that economically PLN feels unprofitable (electricity rates are lower than operational costs). The installation of river current turbines is expected to be able to overcome the above problems, especially for areas that have rivers with fairly fast currents to lower currents and are still suitable for installing current turbines. The cost of manufacturing and maintenance is designed to be as economical as possible so that local residents can operate it.

In addition, for urban river areas, the installation of river current turbines can be used as an educational facility and can also be used as a tourist facility (technology park) to introduce residents (especially students) to the importance of utilizing environmentally friendly renewable energy sources that will never run out until the end of time.

The flow speed in the river is not the same along the body of the river channel, this depends on the shape, roughness of the river channel and river patterns. The greatest speed is located in the middle of the channel and the upper part of the deepest part of the channel which is far from frictional drag on the walls and bottom of the channel. From the research data that has been carried out in the first stage, it turns out that the flow speed of the Lagan River at the Lagan Tengah village point is still low, namely 0.296 m / sec. This has an impact on the effectiveness of the system in producing mechanical energy. For this reason, it is necessary to increase the speed of river flow in the catchment area of Lagan Tengah village. A higher river flow speed will produce greater mechanical energy, thus producing greater electrical energy.

In a meandering river, the maximum velocity zone is on the outside of the bend and the minimum velocity zone is on the inside of the bend. This pattern is an important cause of lateral erosion in river channels and river pattern migration. The speed of water flowing is proportional to the slope of the river channel. A large slope produces a faster flow which is common in rivers in mountainous areas. Very steep slopes encourage the development of waterfalls where water moves freely. On gentle slopes, it produces slow speeds even approaching zero. Flow also depends on the volume of water. The larger the volume, the faster the flow.

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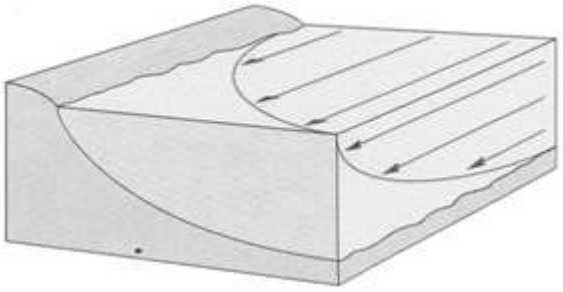


Figure 4. River basin section

Variations in flow velocity in natural river channels occur in vertical and horizontal positions. Friction reduces velocity along the channel bed and channel walls. The maximum velocity in a straight channel is at the top and middle of the river channel (Hamblin & Christiansen, 1995).

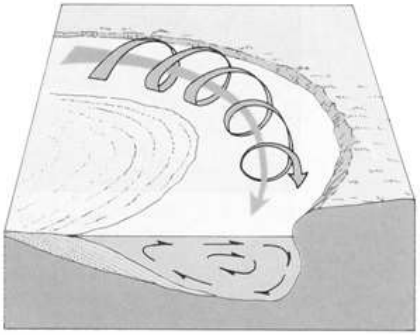


Figure 5. Flow in a meandering channel follows a screw pattern

The water on the outside of the bend is pushed faster than the water on the inside of the bend. This difference in speed together with the normal friction drag on the canal walls produces the screw pattern. As a result, erosion occurs on the outside of the bend and sedimentation occurs on the inside of the bend. This results in an asymmetrical channel (Hamblin & Christiansen, 1995). Stream gradient A steeper river gradient is usually found in the upstream area, while a gentler river gradient is usually found in the downstream area. The longitudinal cross-section of a river can show a smooth, concave, convex appearance which then becomes very flat at the end of the river. For example, a river in the Rocky Mountains has a slope of 50m/km while in the downstream part of the Mississippi River the slope is only 1 or 2 cm/km.

a) Sediment load

Flowing water naturally carries material towards the ocean. The capacity of river flow to transport sediment increases 3 to 4 times from the original flow velocity. Flowing water is the main cause of erosion, not only capable of abrading and eroding channels but also has a great ability to carry decomposed sediment from weathering. In the river system, sediment is transported in three ways, namely:

1. Fine particles are carried in suspension.
2. Coarse particles are carried through traction such as rolling, sliding and saltation.

3. Dissolved material is carried in solution (dissolved load)

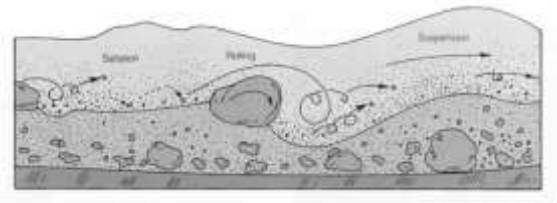


Figure 6. Sediment load movement in the river.

Clay and shale are carried in suspension. Larger particles are carried by rolling, sliding and saltation (Hamblin & Christiansen, 1995). River current energy is kinetic energy that can be easily converted into electrical energy with fairly high efficiency. Although the basic principle of ocean current energy conversion technology is the same as the energy conversion technology in wind turbines, in practical use and how much the economic cost of ocean current energy conversion technology has not been widely developed and known. Through research activities and the design of ocean current power plants, it is hoped that a technological solution will emerge for electricity supply on islands that are quite far from electricity sources, so that these islands become independent in the energy sector, which also means encouraging national independence in the energy sector.

DISCUSSION

In the provisions in force in Indonesia, the minimum electricity for one family is 450 VA. Assuming that the need for lighting is 3 lamp points of 60 watts, and the rest is used for television, refrigerator or electric motor whether it is for water pump, blender, mixer, washing machine, or for carpentry purposes. This need is a realistic need for rural communities. After determining the minimum power requirement based on government regulations, which is 450 VA, then by dividing it by a DC voltage of 12 V, a DC generator with a minimum power of 37.5 A is needed. The size of the planned channel by assuming the river flow speed is increased to 3 times, which is 3 x 0.296 m / sec. So the engineering speed is 0.89 m / sec. By determining the flow speed in the channel, using the formula below, the cross-sectional area of the channel to be engineered can be found.

$$P = 1/2\rho * A2 * V23$$

Previously by entering the Betz electrical efficiency factor then 450 W/0.593 = 0.5 * 1000 kg/m3 * A * (0.89 m/s)3
So that the channel area A = 2.15 m2 is obtained
So that the inlet channel area on this current velocity engineering tool is:

$$A1 * V1 = A2 * V2$$

Where A1 = Inlet channel area
V1 = Inlet flow velocity
A2 = Outlet channel area
V2 = Outlet flow velocity
then
0.269 m/s * A1 = 2.15 m2 * 0.89 m/s
So that A1 = 7.11 m2

The selected turbine is a turbine with a vertical axis. To get the turbine rotation that will be generated by the river current, it is necessary to know the radius of the turbine first.

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It is known above that the area of the outlet channel is 2.15 m2, with the selected height of the turbine being 1 meter based on the minimum water height from the riverbed at the selected point, then the width of the turbine blade is 2.15 m. The width of the turbine blade is the same as the radius of the turbine. So the circumference of the turbine is

Kell = 2π r
= 2 π 2.15 m
= 13.5 m
The turbine rotation is = Flow speed / Kell
= 0.89 m / s / 13.5 m
= 0.065 rotation / second
= 3.95 rpm

While the DC generator rotation is expected to be 1500 rpm so that the generator can produce electric current that will be supplied to the battery as a storage device for electrical energy. So the rotation ratio between the turbine and the generator is 380.

CONCLUSION

From the calculation results above, it can be concluded that the dimensions of the Model of the River Current Power Plant based on the engineering of the current speed are as follows: P = 450 VA, A1 = 7.11 m2 V1 = 0.269 m / s, A2 = 2.15 m2 V2 = 0.89 m / s, Rotation ratio = 380, DC Generator = 37.5 A, Generator Rotation = 1500 rpm. With these results, the tool model can be used as one of the models of the Lagan River Current Power Plant. This needs attention because the speed of the Lagan River flow in the catchment area in Lagan Tengah Village will change according to climate conditions and the height of the moon.

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