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Tidal Power Generation Using Vertical Axis Turbine

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ABSTRACT

This paper delineates the background to the development of unique and novel techniques for power generation using the kinetic energy of tidal streams and other marine currents. Also this study focuses only on vertical axis tidal turbine. Tidal stream devices have been developed as an alternative method of extracting the energy from the tides. This form of tidal power technology poses less threat to the environment and does not face the same limiting factors associated with tidal barrage schemes, therefore making it a more feasible method of electricity production. Large companies are taking interest in this new source of power. There is a rush to research and work with this new energy source. Marine scientists are looking into how much these will affect the environment, while engineers are developing turbines that are harmless for the environment. In addition, the progression of technological advancements tracing several decades of R & D efforts on vertical axis turbines is highlighted.

Keywords - Renewable energy, tidal current turbine, tidal energy, Vertical Axis Tidal Turbine (VATT).

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I. INTRODUCTION

Electricity is most needed for our day to day life. There are two ways of electricity generation either by conventional energy resources or by non-conventional energy resources. Electrical energy demand increases in word so to fulfill demand we have to generate electrical energy. Now a day's electrical energy is generated by the conventional energy resources like coal, diesel, and nuclear etc. The main drawback of these sources is that it produces waste like ash in coal power plant, nuclear waste in nuclear power plant and taking care of this wastage is very costly. And it also damages the nature.

The nuclear waste is very harmful to human being also. The conventional energy resources are depleting day by day. Soon it will be completely vanishes from the earth so we have to find another way to generate electricity. The new source should be reliable, pollution free and economical. The non-conventional energy resources should be good alternative energy resources for the conventional energy resources. There are many non-conventional energy resources like geothermal, tidal, water, solar etc. the tidal energy has drawbacks like it can only implemented on sea shores. While geothermal energy needs very lager step to extract heat from earth. Solar and water are easily available in all condition. The non-conventional energy resources like solar, water can be good alternative source. Solar energy has drawback that it could not produce electrical energy in rainy and cloudy season.

Free flow water turbines are considered as one of the best known renewable energy sources among the other renewable sources like solar and water energy due to more predictability of flowing water in river or canal. Free flow hydrokinetic turbine electricity generation is mainly aimed for rural use at sites remote from existing electricity grids. It is a useful tool for improving the quality of life of people in these locations and for stimulating local economies. These turbines also can be considered for the wide variety of applications like tides, marine currents, channel flows, and water flows from industrial processes. These turbines generate electricity using the kinetic energy of natural water resources using different types of rotors. These rotors are fixed to a structure on the riverside or on floating pontoons. These devices are easy to transport and relocate. Water current turbines are of horizontal axis and vertical-axis type based on their alignment of the rotation axis with respect to water flow. Vertical-axis water turbines are also called as cross flow turbines. Horizontal-axis turbines are mainly used for extraction of the ocean energy.

These turbines look like old water mills and are expensive for small-scale power applications. Horizontal-axis turbines require additional mechanism to orient itself in the direction of the flow. However, vertical-axis turbines can accept flow from any direction. Vertical-axis turbines are generally used for small scale power generation and for off-grid applications at remote locations. Vertical-axis turbines are less efficient compared to horizontal-axis turbines. Savonius turbine, helical turbine, Darrieus turbine, and H-shaped Darrieus are commonly used vertical-axis turbines. The Savonius water turbine was invented by the Finnish engineer Sigurd Johannes Savonius in 1922.

Savonius water turbines are a type of vertical-axis water turbine (VAWT), used for converting the force of the water into torque on a rotating shaft. The turbine consists of a number of aerofoils, usually but not always vertically mounted on a rotating shaft or framework, either ground stationed or tethered in airborne systems. But Water flow has about one thousand times higher density than the air flow, which brings a greater energy per unit area. This attracted the researchers to work with water turbines. Different kinds of water current turbines are being installed and tested worldwide for various ranges of powers.

II. NEED OF TIDAL ENERGY GENERATION

As increasing demand and supply gap we have to use alternative resources to full fill demand. For achieving this target we have extend the use of conventional sources. But the availability of conventional resources is not going to full fill our future demand due to inadequate amount of resources. Thus we have to switch to renewable sources for meeting the demand.

Renewable resources are available in various form :

1]Solar
2] Wind
3]Geothermal
4]Tidal

Among all these tidal is more efficient. i.e. around 80% . Solar having drawback of power to area ratio is high and depend on weather condition. Wind generate less amount of energy due dependency on flow of wind. Geothermal needs special geographic area.

While tidal overcomes all these drawback. Availability of tidal energy is highly predictable and not subject to the impact of weather condition. The energy density of tides is also higher than solar and wind energy.

Among all this India having a coast line of 7500km. The avg. potential to generate energy along Indian coast is 5 to 10 kw/m. So total potential of India is 40,000 MW. Even a 15% utilization would mean the availability of approximately 6000 MW .Gulf of Cambay and Gulf of Kutch on west coast where the maximum tidal range is 11 m and 8 m with average tidal range of 6.77 m and 5.23 m respectively.

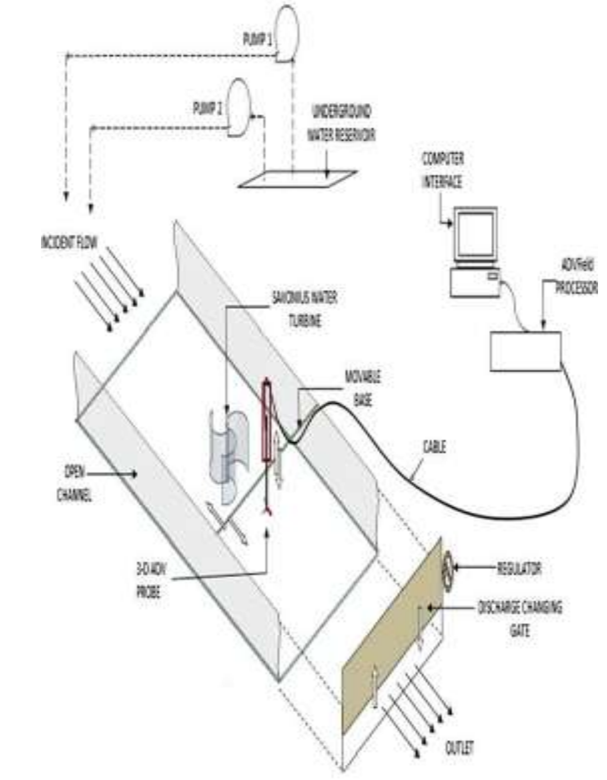

Figure 1.Schemetic diagram of tidal power generation.

Component

A] Generator
B] Gear Box
C] Duct Structure
C] Rotor Shaft
D] Hydro Foils Blade

A] Generator

In electricity generation a generator is a device that converts mechanical energy to electrical energy for use in an external circuit. Sources of mechanical energy include steam turbines, gas turbines, water turbines, internal combustion engines and even hand cranks. The reverse conversion of electrical energy into mechanical energy is done by an electric motor, and motors and generators have many similarities. Many motors can be mechanically driven to generate electricity and frequently make acceptable manual generators.

B] Gear Box

A gearbox is typically used in a wind turbine to increase rotational speed from a low-speed rotor to a higher speed electrical generator. Some multi megawatt wind turbines have dispensed with a gearbox. In these so-called direct-drive machines, the generator rotor turns at the same speed as the turbine rotor. This requires a large and expensive generator. There is a trade-off between the reliability of gearboxes and gear stages and the cost of slower, higher torque generators.

C] Duct Structure

It is closed structure which is fitted on turbine for proper flow of an water. It has two part upper & lower which is fitted on top & bottom side of an tidal turbine. The blade of turbine which is closed in these duct structure. Also Passage to water flow & turbines are fitted inside of it. It supports turbine.

D] Rotor Shaft

Held's Hydro Foils Blade & rotates in current direction along with blades. Next coupled with the generator to produce electricity. A Rotor Shaft is a vital piece of a Multi block Turbine. It serves as an attachment point for rotor blades, and also allows turbine coils to convert rotational energy into Redstone Flux. While a turbine may be assembled without a shaft, it will not be functional. Rotor shafts must be placed in the turbine's interior.

E] Hydro Foils Blade

Blades rotates along with current & revolves the shaft coupled to generator. The term "foil" is used to describe the shape of the blade cross-section at a given point, with no distinction for the type of fluid, (thus referring to either an "airfoil" or "hydrofoil"). In the helical design, the blades curve around the axis, which has the effect of evenly distributing the foil sections throughout the rotation cycle, so there is always a foil section at every possible angle of attack. In this way, the sum of the lift and drag forces on each blade do not change abruptly with rotation angle. The turbine generates a smoother torque curve, so there is much less vibration and noise than in the Darrieus design. It also minimizes peak stresses in the structure and materials, and facilitates self-starting of the turbine. In testing environments the GHT has been observed to have up to 35% efficiency in energy capture reported by several groups.[4] "Among the other vertical-axis turbine systems, the Davis Hydro turbine, the En Current turbine, and the Gorlov Helical turbine have all undergone scale testing at laboratory or sea. Overall, these technologies represent the current norm of tidal current development.

III. PRODUCTION OF TIDAL CURRENT FROM GRAVITATIONAL FORCE

Tidal currents are the effect of the longest oceanic waves which are characterized by the rhythmic rise (**flood**) and fall (**ebb**) of the sea level during a period of time of half a day or a day. This effect can be seen in Figure 2.1 where a 30-day tidal record from Tay estuary, Scotland shows the vertical movement of the sea level in approximately 12.5 hour periods (Evelyn Brown, 2005). The rise and fall of the sea level is caused by the resulting gravitational force of mainly the moon, but also the sun, acting on the oceans. The tidal currents are the horizontal water movements corresponding to the rise and fall in sea level. This is most obvious along the coast lines where the water is "coming in" or "going out" since the height difference often move the shoreline when it is covering larger or smaller areas of land with water. However, this is only the effect of the whole oceans water level rising/falling (Evelyn Brown, 2005).

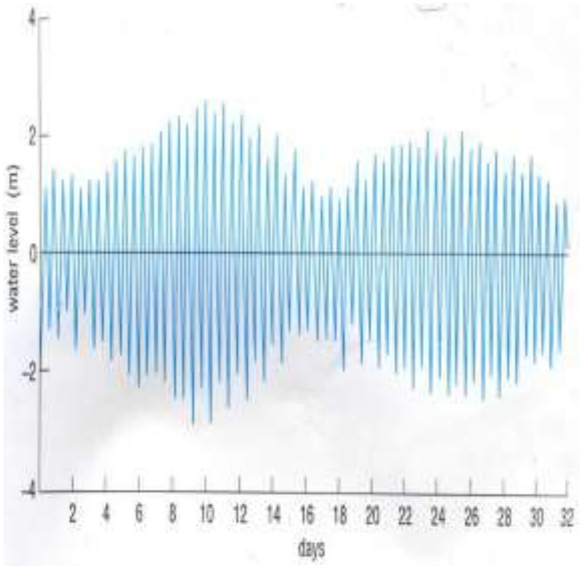

Figure 2.Flood and Ebb over a period of one month

Fig 2 clearly shows the daily oscillations and also that the days are different in another rhythmic pattern. The periods with higher sea levels around day 9 and 24 are called spring tides and have an amplitude of, relative to the mean level, nearly 3 meters with a range of nearly 6 meters. The lowest amplitude sections are called neap tides and in this case have a range of a little more than 2 meters (Evelyn Brown, 2005). These effects are very predictable and depend on the combination of the earth-moon (lunar tide) and earth-sun (solar tide) systems. Without being to theoretical Figure 2.2 shows the reason for these effects if one consider that the forces must be added up to a resultant acting force (Evelyn Brown, 2005).

IV. TIDAL ENERGY EXTRACTION TECHNIQUES

There are mainly two techniques to extract energy from tidal currents.

A] Tidal impoundment

A volume of water is impounded in order to create a height (head) difference when the sea level is rising/lowering. Then low-head hydro turbines are used when the water is released to flow through the outlets to generate electricity. This can be done using either barrages or lagoons. Figure illustrates the different technologies.

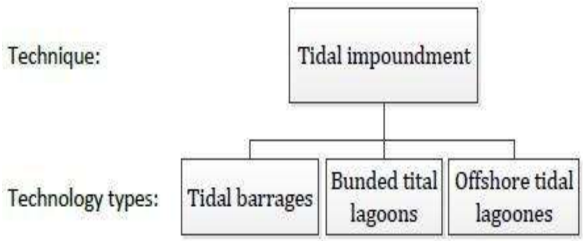

Figure 3.Tidal impoundment technologies

B] Tidal stream

This technique is based on kinetic energy and uses the energy from the currents occurring when the water levels are raising/ lowering. This type will be the main focus of this thesis.

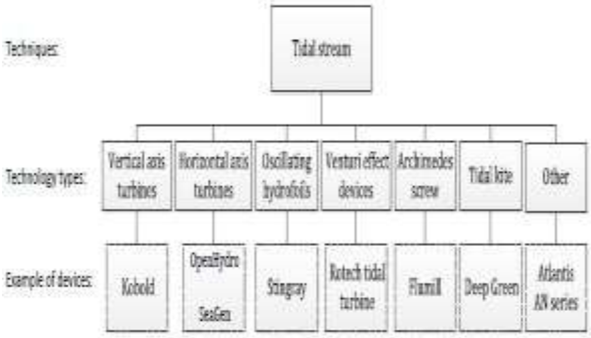

Figure 4. Tidal stream technologies

We are using 2nd technique because in 1st technique there are designing problem occur. We have to designing a dam at proper place where estuary present. In that estuary we have to fitted a turbine so that for that proper gap of estuary we have to design that size of turbine. These technique works by building Barrage to contain water after high tide, then water has to pass through a turbine to return to low tide.

POWER AVAILABLE FROM WATER

The operation of harvesting energy in free streaming water and currents is a field that is relatively poorly developed and explored when compared to other types of renewable energy. When utilizing the currents of the sea the procedure is much like wind energy conversion systems, which is a much more mature technology. When comparing the two, there are very little that separates the theory surrounding the energy within as well as the energy conversion of fluids in motion. It is therefore not surprising that many of the ideas employed in the wind energy sector are being reinvented in the marine current sector.

For a fluid in free stream the available kinetic energy (EK) for any given cross section is given by Eq. 1.

$$E_K = \frac{1}{2} m u^2$$

And the total power (P) can be expressed as Eq.2.

$$P = \dot{E}_K = \frac{1}{2}\dot{m}u^2 = \frac{1}{2}\rho A u^3$$

From Eq. 2 one can see the strength of applying similar technology in water. The density of water is roughly 833 times that of air which means that the same turbine could produce the same amount of power at considerably lower fluid velocities (almost at velocities a tenth of that of air). Another interpretation of this would be that since the fluid velocity is raised to the power of three, it is the single most important parameter when designing an energy conversion device utilizing free streaming fluids. For example, if the fluids velocity increases by 20% then the power in the fluid would increase by 72.8%.

In order to illustrate this, the parameters mentioned in section "1.2 Case" are used to get a sense of the power available in the current case.

Density [water at5°C]	999.965	kg/m^3
Radius	1	M
Height	4	M
Area	8	m^2
Velocity	0.1-3	m/s

By using Eq. 2 and in Table the available power in the water can be calculated. The result is shown in the figures.

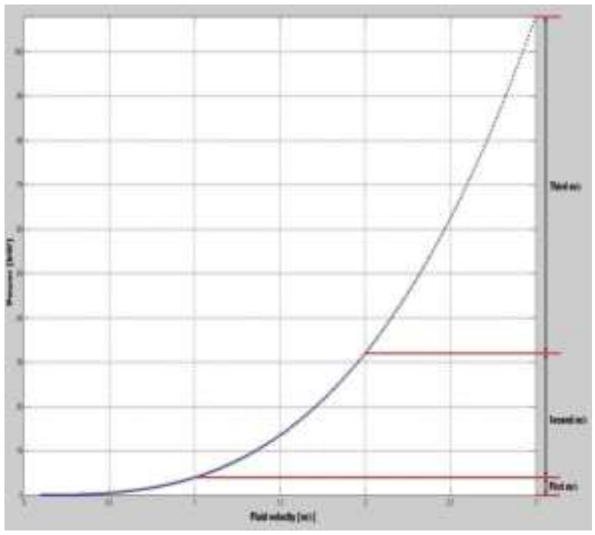

Figure 5.Total power available in the flowing water.

Figure clearly visualizes the effect of the fact that the power is dependent on the velocity cubed creating a parabolic curve. At 1 m/s the power is 4 kW, at 2 m/s it is 32 kW and at 3 m/s it is 108 kW. This means that a good site selection will be very vital for the possible power extraction and therefore also for the economical aspect.

One fundamental aspect about energy is that it cannot be either created or destroyed, it is only possible to convert it. In this case it is the kinetic energy of the fluid that is converted in to kinetic energy of the rotor i.e. movement which makes the rotor turn along its axis.

Through history there have been numerous different ways of achieving this and these can be divided in two general groups, technology based on utilization of the drag force and technology utilizing the lift force.

V. CONCLUSION

Tidal power is a proven technology and has the potential to generate significant amounts of electricity at certain sites around the world. Although, our entire electricity needs could never be met by tidal power alone, it can be invaluable source of renewable energy.

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