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DEVISING A MECHANISM TOWARDS PRODUCING ENERGY FROM THE TIDES

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ABSTRACT

Tidal Energy is one of the many forms of Renewable Energy like Solar, Wind and Geothermal Energy. Tidal Energy is a form of Gravitational Energy which can be used to do Work or be converted in other forms of Energy. Tidal Energy is still an immature technology with advancements in Tidal Energy not as rapid as other forms of Renewable Energy. While esoteric and path breaking approaches are being developed to harness the freely available renewable wave and tidally energy, the full commercial development is still some way away. On the other hand, Tidal Barrages is a mature technology though its development too has been slow because of high investment and long building time. Here are the uses of Tidal Energy. In our project one directional generator has been used. When the rack moves upward direction the current gets produced. During high tides the pinion rotates 3 revolutions which allows the generator to produce 3V current. During high tides the pinion rotates 3 revolutions which allow the generator to produce 3V current.

1 INTRODUCTION

Tides are the periodic motion of the waters of the sea due to the inter-attractive forces between the celestial bodies. Tides are very long-period waves that move through the oceans in response to the forces exerted by the moon and sun. Tide and current are not the same. Tide is the vertical rise and fall of the water and tidal current is the horizontal flow. In simple words, the tide rises and falls, the tidal current floods and ebbs. The principal of tidal forces are generated by the Moon and Sun. The Moon is the main tide-generating body. Due to its greater distance, the Sun's effect is only 46 per cent of the Moon's.

1.1 DEMONSTRATION PROJECT AT SUNDERBANS

A report was submitted by West Bengal Renewable Energy Development Agency (WBREDA) in 2001 for setting up a 3.65 megawatt capacity tidal power station at Durgaduani Creek in Sundarbans Island of West Bengal. These details were submitted to the Ministryon June 2006. Also, WBREDA entered into a MoU with the National Hydroelectric Power Corporation Limited (NHPC), Faridabad for updating of the Project Report and its execution. The updated Report prepared by NHPC was received by the Ministry in November, 2007. The NHPC Limited was given responsibility to complete the project. However, the project has been discontinued due to very high tender cost.

1.2 TIDAL POWER PROJECTS IN GULF OF KUTCH, GUJARAT

A committee was established under the Central Electricity Authority (CEA) on the 900MW Kutch Tidal Power Project for estimating the cost of the project. The project was not found to be commercially viable due to high capital cost as well as high cost of generation of electricity.

In January 2011, Gujarat signed a MoU with Gujarat Power Corporation Ltd. (GPCL) for establishing a 250 MW tidal power project at Mandavi district in Gulf of Kutch. GPCL has initially started a 50MW tidal power project in Kutch. GPCL has made a request for grant for the tidal power plant to Ministry of New and Renewable Energy (MNRE).

The experience gained in the above project will decide the future course of action for the advancement of tidal energy in India.

1.3 TIDAL ENERGY AROUND THE WORLD

The necessity to reduce CO2 emissions and gradual increase in cost of fossil fuel has resulted in a significantly increased use of tidal energy (Nicholls and Turnock, 2008). Today, tidal energy around the world is increasingly being considered as a potential source of renewable energy (Bryden and Scott, 2007). Extreme tides are found in many locations across the globe. Some of them are: the Pentland Firth, Scotland; the Severn estuary; the Aleutians; the fjords of Norway; the Philippines; the Straits of Messina, Italy; the Bosporus, Turkey; the English Channel; Indonesia, and the straits of Alaska and British Columbia.

The first major hydroelectric plant was put to operation in 1967 that used the energy of the tides to generate electricity. It produced about 540,000 kW of electricity. Studies have shown that the European territorial waters have 106 locations for extracting tidal energy that would provide electricity of 48 TW per year. It is estimated around 50,000 MW of installed capacity being achievable along the coasts of British Columbia alone. There are greater predictions of extracting energy of about 90,000 MW off the North West coast of Russia and about 20,000 MW at the inlet or Mezen River and White Sea. There are also estimations along the West coast of India having potential to generate 8,000MW.

2 METHODS OF TIDAL ENERGY EXTRACTION

Different methods have been suggested by authors for the extraction of tidal energy. However the basic principle behind the methods remains same. However, there are two primary methods to extract energy from the tides.

a. Estuaries into which large amounts of ocean water flows in due to high tidal range, are captured behind barrages and the turbines are rotated by utilizing the potential energy of the stored water.

b. The kinetic energy of moving water can be used to extract energy similar to the principle of extraction of wind energy.

Both methods that are mentioned above have been suggested and followed and each has its own advantages and disadvantages (Bryden and Melville, 2004). It may also be possible to employ pumping strategies for barrages to obtain better efficiency and to match electricity demand better (MacKay, 2007).

The devices that are used in the energy generation vary in size, shape and specifications. ISSC (2006) has classified the devices into three types:

a. Tidal barrages that store tidal flow and generate power through discharge.

b. Tidal fences which block a passage and extract energy in either or both directions of tidal flow.

c. Tidal current devices which are fixed or moored within a tidal stream.

A. TIDAL BARRAGE

Tidal barriage is a structure generally built across the mouth of the estuary through which the water flows in and out of the basin. The tidal barriage has sluice gates that allows the flow of water in and out of the basin. The water flows into the bay during high tide and the water is retained by closing the sluice gates at the beginning of low tide. The barrage gates are controlled by knowing the tidal range of the location and operating it at right times of the tidal cycle. There are turbines located at the sluice gates which produce electricity when the gates are opened during the low tide. Using this principle, authors have mentioned different ways of extraction of energy like ebb generation, flood generation, ebb and flood generation, pumping, two basin schemes etc. Figure 1 shows the Plan view of a hypothetical tidal barrage. Even though the barrage method has high theoretical efficiency, only one large scale tidal barriage has been constructed at La Rance, France.

The advantage of using barrage to method to generate electricity in comparision with fossil fuels is that it reduces the greenhouse effects, to provide a better environment. La Rance tidal power plant, France is an example for barrage method. On the top of the barrage there is a four-lane highway that cuts 35 km of distance between the towns of Saint Malo and Dinard representing.

B. TIDAL STREAM ENERGY

In the early 1990s, tidal power was mainly focused on harnessing the tidal flow and generating the energy by means of potential storage rather than through tidal stream. Tidal stream technologies have made massive progress towards commercialisation in the last decade. Extensive research is being carried out in UK waters related to tidal stream energy. UK has a target at achieve 20% of its electricity requirement through ocean resources by 2020. About 40 energy converting machines are being developed and prorotypes are being tested in the labs and in waters of UK (Irena, 2014). Since the tidal stream energy is still a emerging technology, it has no standardizations, but variety of devices are being developed to make use of the water flow to extract electricity. However, the efficiency of each of the devices has to be flawlessly examined by extensive testing to choose the appropriate device for a particular location

3 WORKING METHODOLOGY

The ocean tides rise and fall and water can be stored during the rise period and it can be discharged during fall. Our project is constructed allowing the tides from the sea to rise the floating object and then lower down the float to its original position. During high tide period, water flows from the sea into the structure allowing the float to rise. When the tides allow the float to rise which is attached to the rack moves up. The movement of the rack allows the pinion to rotate. This rotational of pinion is then converted into current by connecting it with the generator. Now the float lowers down and the rack comes to its original position. The generation of power stops when the tides are low. For the generation of power economically using this source of energy requires some minimum tide height and suitable site.

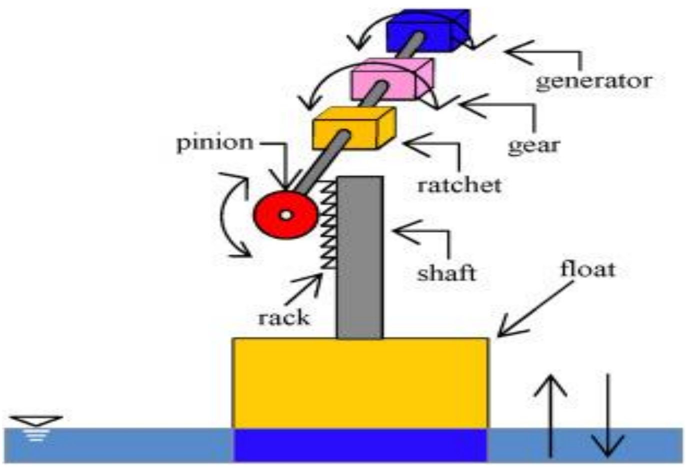

Fig 3.1 Block Diagram

Some preliminary standards to identify sites that are suitable for the development of a tidal energy extraction. The most important variables generally considered are:

1. The local water depth: Existing device technology concepts are generally limited to operational water depths of 25–45 metres.
2. The location of the nearest exploitable grid connection: For an immature industry, the economics of tidal energy extraction require easy access to a nearby grid connection with spare capacity; otherwise the capital cost cannot be viably recouped across the life of the project.
3. An energetic and persistent resource: Large mean spring and neap tide velocities are highly desirable. Some sites have the added advantage of minimizing the low velocity periods of the tidal cycle as the local dynamics ensure that the tidal flow reverses through the slack period at an accelerated rate. The sites that the developers are interested to extract energy tend to have peak spring tidal velocities of 3+ m/s.

If these three primary criteria are met, a site is considered to have solid potential for future development. The majority of coastal locations can be rejected out of hand by consideration of just these three variables. The English Channel, the Arctic Ocean, The Gulf of Mexico, The Amazon, The Straits of Magellan and Taiwan are some of the possible locations for locationg tidal devices. Table 6 shows some potential sites for tidal power installations. There are estimates that the energy that can be globally extracted is around 1800 TWh/year (Nicholls and Turnock, 2008). But, it has to be taken care that the effect on environment, economic and social constraints have to ve addressed. It is suggested that 10% of the extraction of energy can be considered as guideline for harnessing renewable energy resources.

4 TIDAL ENERGY CALCULATIONS

Total tidal energy is the energy due to the tidal stream (kinetic energy) and the energy due to release of the stored water in the basin (potential energy). It is also a fact that the increase in tidal variation or the tidal stream energy results in increase of energy extraction to a large extent (Shaikh and Shaikh, 2011).

4.1 Kinetic energy

The kinetic energy of the stream flow flowing across the cross section with a velocity is given by, P = 1/2 ρ A CpV3 (4.1)

ρ is the density of sea water (kg/m^3); C_p is the power coefficient; A is the area of cross section of the channel (m^2); V is current velocity (m/s)

The power output or the efficiency of the turbine " η " depends on the design of the turbine. The power output for a turbine from these kinetic systems can be obtained by the following equation

$$P = (\eta \rho V^3)/2 \tag{4.2}$$

η is turbine efficiency; P is power generated (watts); ρ is density of the water (seawater is 1025 kg/m³); A is sweep area of the turbine (m²), V is velocity of the flow

4.2 Potential energy

The potential energy is mainly dependent on the tidal prism of the basin. Potential energy obtained due to the stored water can be calculated as (Gorlov, 2001; Shaikh and Shaikh, 2011).

$$E = 1/2\ \rho\ A\ gh2 \tag{4.3}$$

h is the vertical tidal range; A is the horizontal area of the barrage basin; ρ is the density of water = 1025 kg per cubic meter (seawater varies between 1021 and 1030 kg/m^3); g is the acceleration due to the Earth's gravity = 9.81 m/s^2

From equation 3, it can be seen that the potential energy varies with square of tidal range. So, a barriage should be placed in such a location where it is possible to achieve maximum storage head. Black and Veatch (2003) suggest that the ideal water depths to achieve the best possible power output at few potential sites around the UK range between 25 and 40 m and the recommend diameter of the rotor to range between 10 m and 20 m. (Frost et. al, 2015). The inlets that are between islands having large basin area are considered to have a greater amplification effect because of the reduction in the throat area and the water depth relative to the surroundings, producing a venturi effect. This accelerates the water as it is forced through a channel with a smaller cross-sectional area.

In this approach, one directional generator has been used. When the rack moves upward direction the current gets produced. high tides the pinion rotates 3 revolution which allows the generator to produce 3V current.

1 Tide = 3Revolution = 2V

Time gap between the consecutive tides is assumed as 5seconds.

5sec = 2V; 1 min = 2 x 12tides which equals 24V/min. So according to our project and calculations we have noted down that

During high tides the pinion rotates 3 revolution which allows the generator to produce 3V current.

In 1hr we can generate approximately 1,440V

4.3 ADVANTAGES

- Tidal power is a renewable and sustainable energy resource. It reduces dependence upon fossil fuels.

- It produces no liquid or solid pollution. It has little visual impact.
- Tidal power exists on a worldwide scale from deep ocean waters.
- Tidally driven coastal currents provide an energy density four times greater than air.
- Tidal currents are both predictable and reliable, a feature which gives them an advantage over both wind and solar systems. Power outputs can be accurately calculated far in advance, allowing for easy integration with existing electricity grids.

5 CONCLUSION

The tidal energy industry has to develop a new generation of efficient, low cost and environmentally friendly apparatus for power extraction from free or ultra-low head water flow. The negative environmental impacts of tidal barrages are probably much smaller than those of other sources of electricity, but are not well understood at this time. It is important to consider the influence of energy extraction while estimating the available energy from a potential tidal energy site. The future costs of other sources of electricity, and concern over their environmental impacts, will ultimately determine whether humankind extensively harnesses the gravitational power of the moon. As yet the majority of this tidal energy resource is under-utilised; however, if effectively captured using suitably engineered systems, it could be capable of making a major contribution to our future energy needs.

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