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POWER GENERATION BY HARNESSING TIDAL ENERGY WITH PUSH PLATE

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Abstract- *In this paper, a summary on the ongoing design practices in the field of tidal energy is presented. Here also the background and methodology of the power generation using the kinetic energy of tidal streams are included. Although various tidal stream devices for extracting the energy from the tides are available, this study focuses only on harnessing tidal wave with push plate. With the mechanism, using the height and speed of the tide, electric power with minimum effort is produced compared to the existing devices that are generally used to produce renewable energy. Height of the tide was measured by the measuring tape before the installation of the structure. The voltage and current, converted from the tide, measured with a multimeter.*
Keywords: Power generation, Tidal streams, Kinetic energy.

1.INTRODUCTION

Energy crisis is a common phenomenon in Bangladesh. And due to this reason the capacity of generating power is also limited. Hence search of the sources of Renewable Energy is the call of the new decade. There are lots of sources of Renewable Energy such as wind, water etc. Among them tidal energy is best as it can be predicted and continuous.

The oceans has a vast and largely untapped source of energy in the form of fluid flow (current, waves and tides known as hydrokinetic) thermal and salinity gradients. Numbers of ways are devised for extracting energy from these sources [1]. These are: Ocean Thermal Energy Conversions (OTEC), Tidal power (barrage or dam) and Wave power (Kinetic hydropower).OTEC operation relies on the basic relationship between pressure *P*, temperature *T* and volume *V* of a fluid and can be expressed in equation form:

$$\frac{PV}{T} = a(constant) \qquad (1)$$

OTEC works sound when the temperature difference between the warmer, top layer of the ocean and the colder, deep ocean water is about 20°C [2].

Four large-scale tidal power plants currently exist. They are the La Rance Plant (France, 1967), the Kislaya Guba Plant (Russia, 1968), the Annapolis Plant (Canada,1984) and the Jiangxia Plant (China, 1985; Gorlov, 2001). The main characteristics of these tidal power plants are given in Table 1.

Table 1: Large tidal power plants in the world [1]

Country	Site	Power (MW)	Basin Area (km^2)	Mean tide (m)
France	La Rance	240	22	8.55
Russia	Kislaya Guba	.4	1.1	2.30
Canada	Annapolis	18	15	6.40
China	Jiangxia	3.9	1.4	5.08

All existing tidal power plants use dam or barrage, the construction cost of which is high and it requires long payback period. As a result, the cost per kilowatt-hour is not competitive with conventional fossil fuel powered system. The wave energy due to tides (rise and fall of sea level relative to the land) has been challenging the engineers & scientist for several decades. The growth in demand for sources makes a shift and re-starts in the late 1990s after 70s. Renewable energy like tidal power accounts for only 2.5% of the world consumption, but with new technology techniques, tidal power can be a useful source of energy [3].

Tidal power, also called tidal energy, is a form of hydropower that converts the energy of tides into electricity or other useful forms of power. Although not yet widely used, tidal power has potential for future electricity generation. Tides are more predictable than wind energy and solar power. Among sources of renewable energy, tidal power has traditionally suffered from relatively high cost and limited

availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability. However, many recent technological developments and improvements, both in design (e.g. dynamic tidal power, tidal lagoons) and turbine technology (e.g. new axial turbines, cross flow turbines), indicate that the total availability of tidal power may be much higher than previously assumed, and that economic and environmental costs may be brought down to competitive. Use of tidal energy could decrease the need for nuclear power, with its associated radiation risks. The few studies that have been undertaken to date to identify the environmental impacts of a tidal power scheme have determined that each specific site is different and the impacts depend greatly upon local geography. If fossil fuel resources decline during the 21st century, as predicted by Hubbert peak theory, tidal power is one of the alternative sources of energy that will need to be developed to satisfy the human demand for energy. Chart report of the world energy consumption (Fig 1), World net electricity generation by fuel (Fig 2) also suggest that developing alternative sources for energy is the call of the time.

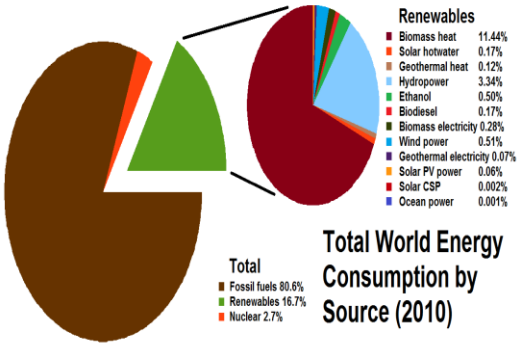

Figure 1: 2010 chart report of the world energy consumption [4].

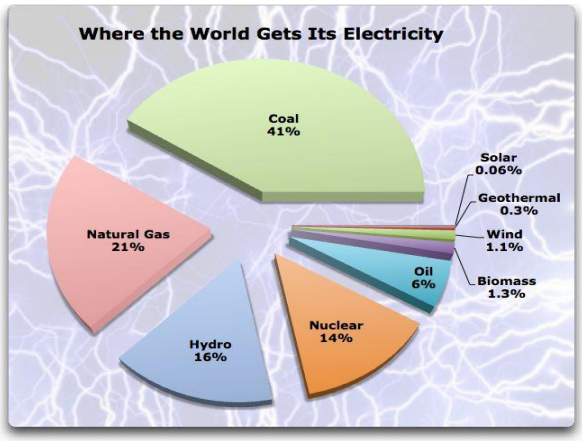

Figure 2: World net electricity generation by fuel [5]

1.2 Scope and Limitation of the Study

Tidal power or tidal energy is a form of hydropower that converts the energy of tides into electrical power. As tides are more predictable than wind and sunlight, tidal energy can easily be generated from the changing sea levels. The coastal area of Bangladesh has a tidal rise and fall of between 2 to 5 meters [6]. Among these coastal areas, with 5 meter tides experienced, Sandwip has the best prospect to generate tidal energy [6]. Moreover, according to Reference [6], Bangladesh can generate tidal power from these coastal tidal resources by applying Low head tidal movements and Medium head tidal movements, low head tidal movements which uses tides of height within 2m to 5m can be used in areas like Khulna, Barisal, Bagerhat, Satkhira and Cox's Bazar regions and the height tidal movements which use more than 5m of tides can be mainly used in Sandwip. So we can say that with suitable tidal height available, this can be a great source of energy for Bangladesh.

1.3 Methodology of The Research

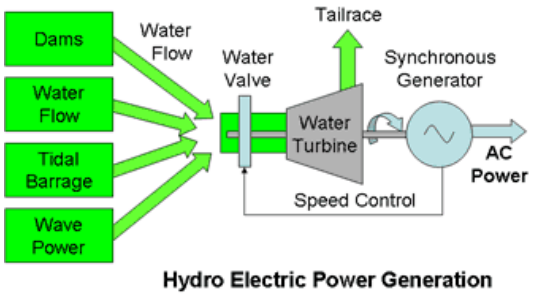

Figure 3: Methods of producing electric energy from tidal energy [7].

To generate electricity, large amounts of energy within the oceans tides is utilized (fig 3). Tidal Energy is an “alternative energy” that can also be classed as a “renewable energy source", as the Earth uses the gravitational forces of both the moon and the sun every day to move vast quantities of water around the oceans and seas producing tides [8]. As the Earth, its Moon and the Sun rotate around each other in space, the gravitational movement of the moon and the sun with respect to the earth causes millions of gallons of water to flow around the earth’s oceans creating periodic shifts in these moving bodies of water. These vertical shifts of water are called "tides"[8].

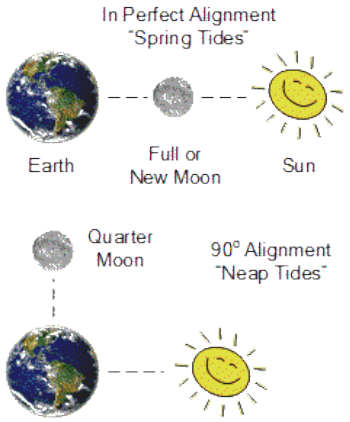

Figure 4: Alignment of the Moon and Sun on Tides [8].

When the earth and the moons gravity lines up with each other(fig 4), the influences of these two gravitational forces becomes very strong and causes millions of gallons of water to move or flow towards the shore creating a "high tide" condition. Likewise when the earth and the moons gravity are at 90^{o} to each other, the influences of these two gravitational forces is weaker and the water flows away from the shore as the mass of water moves to another location on the earth, creating a "low tide" condition[8]. This ebbing and flowing of the tides happens twice during each period of rotation of the earth with stronger weekly and annual lunar cycles superimposed onto these tides.

The main big advantage of this is that the tides are therefore perfectly predictable and regular unlike wind energy or solar energy, allowing miles of coastline to be used for tidal energy exploitation and the larger the tidal influence, the greater the movement of the tidal water and therefore the more potential energy that can be harvested for power generation. Therefore tidal energy can be considered as a renewable energy source as the oceans energy is replenished by the sun as well as through tidal influences of the moon and suns gravitational forces [8].

The movement of the sea water is harnessed in a similar way using waterwheels and turbines to that used to generate hydroelectricity [8]. But because the sea water can flow in both directions in a tidal energy system, it can generate power when the water is flowing in and also when it is ebbing out [8]. Therefore, tidal generators are designed to produce power when the rotor blades are turning in either direction. However, the cost of reversible electrical generators is more expensive than single direction generators [8].

2 PREVIOUS STUDIES

2.1 The European Marine Energy Centre

There are four main types of TECs as defined by EMEC (The European Marine Energy Centre Ltd., 2010). This refers to a wider range of designs.

2.1.1 Horizontal Axis Turbine

A horizontal axis turbine is similar to a wind turbine and is the most common type of tidal stream turbine. The moving currents spin the turbine's blades as fig: 4(A) illustrates. Devices can be housed within ducts to create secondary flow effects by concentrating the flow and producing a pressure difference. The blades drive a generator, which converts energy harnessed from the ocean currents into power.

2.1.2 Vertical Axis Turbine

A vertical axis turbine looks like a large eggbeater. The turbine has large blades that rotate like a washing machine as currents move past as fig: 4(B) illustrates. It is similar to Figure 2.1(A), however the turbine is mounted on a vertical axis.

2.1.3 Venturi Effect

Fig: 4(C) illustrates a bi-symmetrical horizontal axis turbine in a symmetrical venturi duct. The shroud increases the water flow through the turbine, and as it is bi-directional yawing is now required for ebb and flow.

2.1.4 Oscillating Hydrofoil

By attaching a hydrofoil to an oscillating arm it is possible to harness the motion caused by the tidal current flow on either side of a wing, which results in lift. This motion can then drive fluid in a hydraulic system to be converted into electricity, as figure 4(D) illustrates.

2.1.5 Other Designs

This section covers devices with a unique and very different design to the more well-established types of technology or if information on the device's characteristics could not be determined.

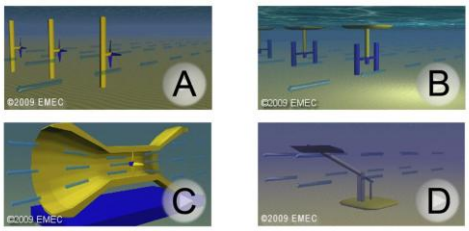

Figure 4: Tidal Energy Convertors definition from EMEC [9].

3 RESEARCH MODEL

3.1 Introduction

Theme of concept is to harness the kinetic energy within the flow of water without using the conventional

methods like water wheel or other types of turbines, as these conventional methods have negative impact on the environment. With some changes this can be a source of producing clean energy from tidal current.

3.2 Components of System

1. 1/8 "Thick M/S plate for body

Mild steel is the most common form of steel. Mild steel is a carbon steel typically with a maximum of .25% carbon and .4%- .7% manganese, .1%-.5%silicon and some traces of other elements such as phosphorous, it may also contain lead (free cutting mild steel)

Reason for using mild steel

- ✓ Mild steel is ductile and can be easily machined.
- ✓ Cost factor is of prime importance as other steel are more costly than Mild steel.
- ✓ Mild steel is easily available. One will find it in his scrape yard.
- ✓ Cutting speed and feed does not required special skills.
- ✓ Generation of heat is less than that of steel machining.
- ✓ No need to change the tool repeatedly and no special tools are required for machining.

2. 18 BWG sheet (Fan Blade)

3. $1\frac{1}{4}$" diameter M/S shaft

This shaft is 18" in length. The plates are being welded on this shaft. As the water flow hit the push plates, the shaft rotates. As it rotates, the motor shaft also rotates as it is attached with the shaft through a belt and pulley.

4. Bearing 2" diameter

5. Bearing Cup

The bearing cups are shown in figure 5.

Figure 5: Bearing cup

6. 3/8 " diameter bolt (Both end threaded with nut)

7. Electrode (10 no size)

Electrodes are required to weld the various parts in the structure. As the push plates are being welded on the shaft, there requires electrodes. There also various welding in the structure to ensure the stability and strength of the structure as it has to face strong flow of current

8. Enamel paint

Enamel paint is paint that air dries to a hard, usually glossy, finish, used for coating surfaces that are outdoors or otherwise subject to hard wear or variations in temperature.

9. Paint Thinner

Paint thinner is a solvent used to thin oil-based paints or clean up after their use. Commercially, solvents labeled "Paint Thinner" are usually mineral spirits having a point at about 40 °C (104 °F), the same as some popular brands of charcoal starter.

10. DC servo motor 24V, 6W

Figure 6: DC motor

A servomotor (fig 6) is a rotary actuator that allows for precise control of angular position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

More sophisticated servomotors measure both the position and also the speed of the output shaft. They may also control the speed of their motor, rather than always running at full speed. Both of these enhancements, usually in combination with a PID control algorithm, allow the servomotor to be brought to its commanded position more quickly and more precisely, with less overshooting.

11. DC motor clamp

Two motor clamps are used in the structure. These clamps (fig 7) are used to provide a steady and safe holding for DC motor. Mounting the DC motor over the structure becomes easier due to these clamps.

Figure 7: DC motor clamp

12. Bulb

The bulbs (fig 8) are of 24V and 2W.

Figure 8: Bulb

13. Bulb holder

The bulb holder (fig 9) is there to hold the bulb and keep the bulb away from water and other hazardous thing.

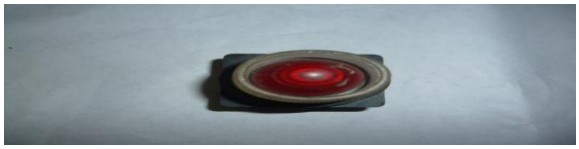

Figure 9: Bulb holder.

14. $1\frac{1}{2}$" M/S flat bar

This flat bar (fig 10) is welded on the very top of the structure. This bar is to provide a base to clamp the motor safely so that it stays dry.

Figure 10: M/S flat bar.

3.3 Working principle

The push plates are connected with a shaft, the shaft is gripped within two bearing cups. The water flow pushes one plate and when the plate reaches at a certain point ,another plate that is also connected with the same shaft happens to reach at the point of previous plate, so at this point the kinetic energy of the river flow works upon this plate to push it forward. Hence we expect to obtain a smooth run of system; the placement of appropriate gears can spin the shaft of a generator to produce clean energy. The principle is shown in fig 11.

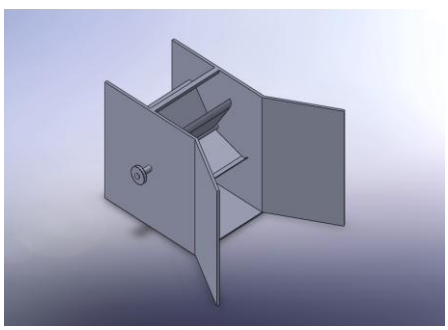

Figure 11: Working principle of producing energy by push plate

4. DATA COLLECTED

Data have been collected by choosing an open channel which is 4 feet in width. This channel is being chosen due to its availability and there is enough flow of water with sufficient speed.

Data are collected by dividing data collection period into several sessions with 10 minutes interval between each session. Duration of each session is 7 minutes.

5.RESULT AND DISCUSSION

The Fan blade revolution was measured to understand the rpm achieved. It also gave clear indication of the performance of the overall system.

The experiment was made in three different days to experiment the consistency of the performance of the system.

It was found that ,the fan blade gives 55 revolutions per minute. And it reduces as the height of water decreases further. It clearly indicates that , as the height decreases, the force on the plate decreases and we got less revolutions of the plate. Which ultimately reduced the output power.

Table 2: Test results at different sessions

Day	Height of water (feet)	Voltage (V)	Current (A)	Power (Watt)
Day 1	1	6	.03	.18
	.8	5.692	.02	.11384
Day 2	1	6	.03	.18
	.8	5.8	.01	.058
Day 3	1	7	.04	.28
	.8	6	.03	.18

From the result it is being observed that the power gain is very low. This is because there are some limitations in my structure.

- If push plates could be built by aluminum sheet, then it becomes very light. Revolution per minute will increase and thus my power gain would be great.
- Further increment of the smoothness of shaft revolution might increase the power gain.

6. CONCLUSION

Unlike other form of renewable energy, tidal energy can be prognosticated more easily Also it cause less impairment to the environment as little or no pollution of water by fine particulate terrestrial material, with a particle size dominated by silt or clay, less noise emission and produces no greenhouse gases or any solid waste[1]. The immense emission of carbon and other harmful gases due to burning of fossil fuels are one of the main agents of global warming, so environmentalist, scientist and researchers are in great favor of this verdant source of energy [1]. The purpose of this study is to acquaint oneself and to gather up to date about Harnessing Tidal Wave Energy with Push Plates for reviewers in one paper. From study it can be concluded that push plate has a simple structure with straight blades, so it can adapt easily with the change of direction of tidal flow

As the real problem issue in this design is huge friction and also heavy blade material [10], if some good technical and financial assistance would have been available, surely we can introduce the aluminum blade and give some extra support to hold the structure and increase the output.

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8. NOMENCLATURE

Symbol	Meaning	Unit
T	Temperature	(K)
P	Pressure	(Pa)