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Power Generation from Sea Wave: An Approach to Create Renewable Energy

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Abstract - This paper presents a brief overview about the design, benefits, risk, and environmental impact of a sea wave power plant. The intention of this accomplishment is to serve society without hampering environmental ecology. This task is based on the renewable sea wave energy. Burning fossil fuel causes global warming. Again wastes of nuclear power plant are very hazardous. Accident of this plant yields great turn of human lives. The power generation from sea wave has growth a huge potentiality. The price of fossil fuel is rising day by day because of its scarcity in nature. As the operating cost of sea wave power plant is low and uses a renewable source of energy, it is possible to produce power at low price. Existing hydrostatic power plant needs dam. This is very harmful for environmental ecology and lives diversity. But this proposed plant does not require any dam or any other hazardous construction and this also reduces the installation cost. However it is reliable, sustainable, environmentally friendly power extraction procedure from sea wave.

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Power Generation from Sea Wave: An Approach to Create Renewable Energy

Md. Mahbubur Rahman [α], Nirupom Paul [σ], Shahrior Ahmed [ρ], Md. Safi Rashed [ω] & Md. Saiful Islam [¥]

Abstract - This paper presents a brief overview about the design, benefits, risk, and environmental impact of a sea wave power plant. The intention of this accomplishment is to serve society without hampering environmental ecology. This task is based on the renewable sea wave energy. Burning fossil fuel causes global warming. Again wastes of nuclear power plant are very hazardous. Accident of this plant yields great turn of human lives. The power generation from sea wave has growth a huge potentiality. The price of fossil fuel is rising day by day because of its scarcity in nature. As the operating cost of sea wave power plant is low and uses a renewable source of energy, it is possible to produce power at low price. Existing hydrostatic power plant needs dam. This is very harmful for environmental ecology and lives diversity. But this proposed plant does not require any dam or any other hazardous construction and this also reduces the installation cost. However it is reliable, sustainable, environmentally friendly power extraction procedure from sea wave.

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I. Introduction

Nowadays the humanity has an energy resources lacking and it try to face it with new renewable energies instead of the old ones which are unsustainable and produce emission of CO2 and threaten to finish in few years. In this way, we have to consider the oceans like a good source which can provide us an amount of clean and inexhaustible energy. Three fourth of the world's surface is covered by the ocean. Most of the energy that arrives from the sun to the earth is retained by the water of the seas. The oceans are like a very great solar collector. Along this century, several technologies have been researched to get the energy from the sea.

Today there are four types of renewable ocean's energy that are becoming interesting for their good future perspectives.

Wave power refers to the energy of ocean surface waves and the capture of that energy to do useful work. Sea waves are a very promising energy carrier among renewable power sources, since they are able to manifest an enormous amount of energy able to manifest an enormous amount of energy Resources in almost all geographical regions. The global theoretical energy from waves corresponds to 8x106TWh per year, which are about 100 times the total hydroelectricity generation of the whole planet. To produce this energy using fossil fuels it would result an emission of 2 million tons of CO2.This means that wave energy could contribute heavily for the attenuation of pollutant gases in the atmosphere, as defended by the Kyoto Protocol [1].

The global wave resource due to wave energy is roughly TW and Europe represents about 320 GW, which is about 16% of the total resource. However, for various reasons, it is estimated that only 10 to 15% can be converted into electrical energy, which is a vast source of energy, able to feed the present all world. Eventually, wave energy could make a major contribution by yielding as much as 120 TWH per year for Europe and perhaps three times that level worldwide. The ocean is a true store of renewable energy. It is believed by some that only about 0.2 percent of the energy in ocean waves could power the entire planet [1].

The main reasons of figuring waves are propel of wind as well as the fluctuation of pressure below the water surface level. Though generating power from wave is not a recently introduced subject at all, very few works have been done using the surface wave of ocean compared to the system of energy generation from storing a huge amount of water and releasing it suddenly. Ocean Trader is a kind of floating object which is partially submerged in the water. This research is also about generating energy by using some submerged objects that are connected to a generator [2].

Ocean waves have two forms of energy (shown in figure 1): the kinetic energy of the water particles (in general follows circular paths) and the potential energy of elevated water particles. The combination of forces due to the gravity, sea surface tension and wind intensity are the main factors of origin of sea waves. Figure 1 illustrates the formation of sea waves by a storm. Wave size is determined by wind speed and fetch (the distance over which the wind excites the waves) and by the depth and topography of the seabed (which can focus or disperse the energy of the waves) [3].

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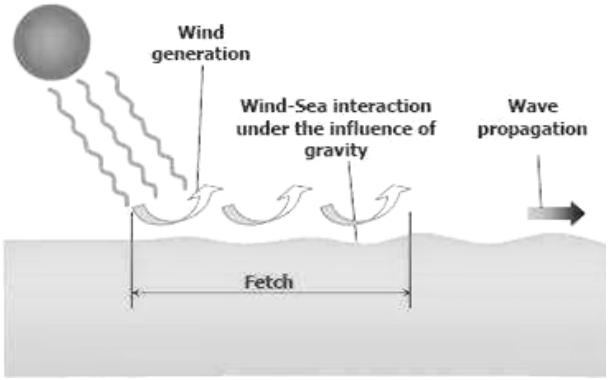

Figure 1 : Typical Sea Wave [3]

The water particles excited by the wind have in each location of the ocean circular trajectories with highest diameter at the surface and diminishing exponentially with depth. The conjugation of this circular motion is responsible for the wave formation and respective propagation, as shown in figure 1. The energy produced by wave depends highly on the following things-

Crest: the uppermost part of the wave

Trough: the lowest point on a wave

Wave length: the horizontal distance between one crest and the next crest (or trough and trough)

Wave height: the vertical distance between a wave's trough and its crest

Frequency: a measure of how many waves pass in a certain amount of time

The frequency of the waves is proportional to the power engendered. On the other hand, the more the waves are generated in a cyclic order the more is the chance of getting sufficient energy [3].

The Ocean can produce two different types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves. Ocean Thermal Energy Conversion (OTEC) systems are thought to be very versatile because they have a lot of applications, such as, electricity generation, water desalination, hydrogen production or refrigeration and air-conditioning. On the other hand, both tidal and wave energy can only be used to generate electricity by driving a turbine or generator. Mechanisms of producing ocean mechanical energy are very different from ocean thermal energy. Tidal and waves energy don't need sun heat to be produced, tides are driven by the gravitational pull of the moon, and waves are driven by the winds. That's why, tides and waves energy are intermittent sources of energy, while Ocean Thermal energy is fairly constant. Besides, unlike thermal energy, the electricity conversion of both tidal and wave energy usually involves mechanical devices [4].

Tidal energy is an intermittent source of energy because it only provides power for around ten hours each day, when the tide is actually moving in or out, in spite of it, tides are totally predictable and it produces electricity reliably. But there are not many places in the world where this technology is efficient. Offshore turbines and vertical-axis turbines are not too expensive to build and neither to maintain because it needs no fuel. Once it is built, tidal power is free. Besides, tidal installations don't produce a large environmental impact and it produces neither greenhouse gases nor other waste. Tidal power turbines provide a higher average power than either wind or wave devices for a given maximum capacity.

Tidal power turbines also have higher duty cycle (50%) than wave turbines (25%). But there is one type of turbine (Shrouded turbine) which may be dangerous to marine life, because fish or marine mammals might get into the turbine blades, through the Venture. Waves generate a clean energy because no fuel is needed and they don't produce any waste. Shore based wave generating equipment is already attracting opposition due to the massive concrete constructions on coastlines which are thought to destroy visual landscape. So appropriate spacing of plants throughout the tropical oceans can nearly eliminate any potential negative impacts of OTEC processes on ocean temperatures and on marine life. Besides, some waves systems can be noisy when waves cross the installation but this can be justified with power generation.

In summary, offshore wind and wave power farms are unpredictable and unreliable energy sources which are subject to extreme weather conditions requiring expensive engineered facilities which have to withstand highly corrosive air/salt-water conditions [5].

For a given area: solar produces kW, wind produces MW and ocean currents produce GW. The oceans cover 71% of the earth's surface with tidal flows and currents on all coastlines as opposed to the limited sites for conventional hydro dams. Based on preliminary surveys the global ocean energy resource is estimated at over 800,000 MW [6].

II. Methodology

The methodology of sea wave power generation includes Basic design and operation and Output Analysis. Some figures are also included to explain the methodology more clearly.

a) Basic design and operation

The proposed power generation system is not a highly sophisticated process. It includes a number of empty vessels. The empty vessels get up and down randomly due to the upward wave thrust. Each empty vessel is connected to a crank. Cranks are attached with a single shaft. Empty vessel moves up and down. Crank facilitates this linear motion of empty vessel into the rotation of shaft.

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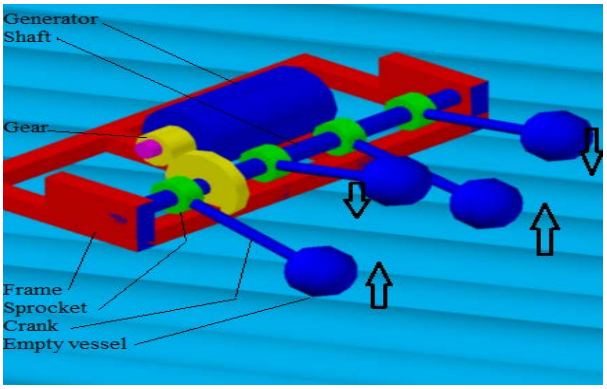

Figure 2 : Schematic view of the power extractive mechanism

There are sprocket system between crank and shaft. The sprocket system promotes only one way rotation of the shaft. At the time of upward movement of empty vessel shaft is engaged with crank, but at the downward movement of empty vessel sprocket system set crank free from shaft. Therefore shaft rotates when an empty vessel rises but the shaft doesn't respond to the downward movement of the vessel. Actually there is the random movement of empty vessel so shaft movement is not uniform. To remove this difficulty a fly wheel is connected to the shaft. Fly wheel give the opportunity to the shaft to rotate uniformly. Vibration may hamper the total structure, but total structure will be made considering vibration. It will be considered the resonance due to sea wave, empty vessel movement, air flow earth quack and what not.

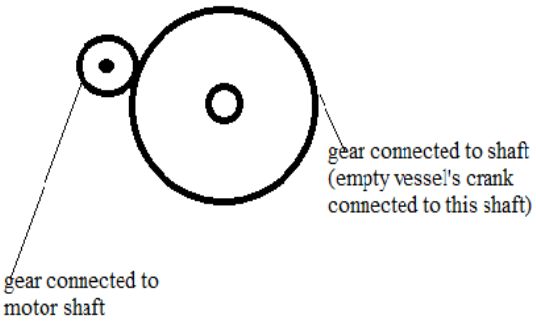

Figure 3 : Gear Train

Gear system is placed between generator and rotating shaft to drive the generator. Another function of this gear system is speed expedition. Main structure is hanged to the sea bed by rope. This structure makes it easy to move vertically to the response of water level variation. This system facilitates horizontal movement of main structure a little bit to the response of tide.

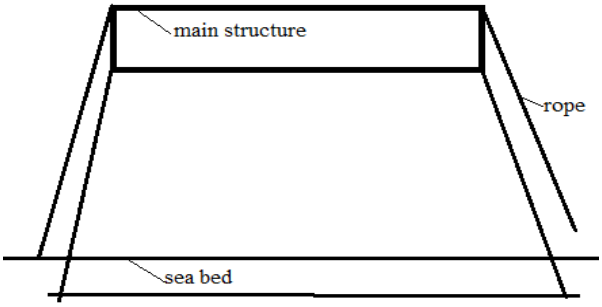

Figure 4 : Total system fixing to the sea bed

Precisely Power transmission from wave to shaft is the conversion of wave energy to mechanical energy. From the shaft power is again transmitted to the generator. At last generator transform mechanical energy to electrical energy. Generator is connected with the bus i.e. the transmission line by submerged cable.

b) Output Analysis

Empty vessels feel upward force which can resist weight of mass,

$$m_f=(v_v*\rho-m_v \quad (1)$$

Empty vessel get rise due to upward thrust of water. Then single vessel can make a thrust force,

$$F_th=m_f\ gh \quad (2)$$

The torque on shaft produced by an empty vessel,

$$T=F_th\times l_c \quad (3)$$

The shaft gains Energy from the toque produced by empty vessel. This energy for a single empty vessel,

$$E=2\pi N \quad (4)$$

Therefore due to n vessels, total energy,

$$P=n\times E \quad (5)$$

Energy is transferred from shaft to generator by gear mechanism. If gear efficiency is E_g,
Then energy transmitted to generator,

$$P_g=E_g\ P \quad (6)$$

Generator accepts energy from shaft. Generator is not able to all mechanical energy into electric energy. If generator efficiency is E_m, electrical energy,

$$P_m=\ E_m\ P_g \quad (7)$$

Thus the electric energy generation capacity can be calculated using Eq.(7). A hypothetical calculation can be carried out with the following assumption:

A sea wave power plant has 1000 empty vessels which are attached with the main shaft with cranks of length 5 meter. The volume and mass of the vessels are 1 m3 and 200 kg respectively. These empty

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vessels make the main shaft rotate at 2 RPM averagely. The gear mechanism has 95% efficiency and the generator has 70% efficiency. With these facilities this plant will be able to produce 325 MW.

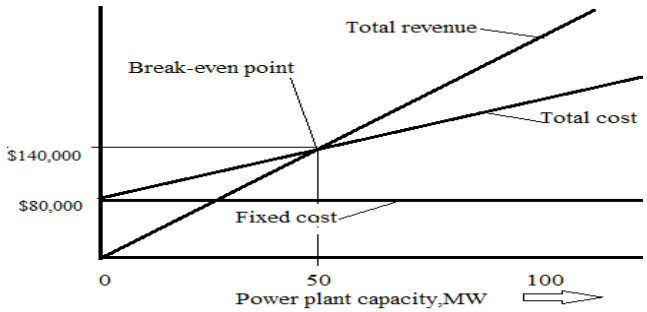

Figure 5 : Estimated Cost-volume analyses

It needs to be realized that what amount of power production will be profitable. For this purpose cost volume analysis has been done. The Fig.5 has shown the relationship among power plant capacity and total revenue, total cost. It has been manifested that when power plant capacity will be more than 50MW, total revenue will surplus the total cost. It is the break-even point. For the purpose of making profit it need to run the power plant at the capacity of more than 50MW.

III. Environmental Impact

The whole world is under the threat of pollution. It includes water pollution, air pollution, soil pollution etc. The existing power plants are largely responsible for these threats. Nuclear power plant has radiation hazardousness. Dam or other structure may cause ecological imbalances. It also causes river pollution and salt pollution to the tropical area. Diesel or coal power plant emit huge amount of CO2, SO2 and NO2.

These causes acid rain and harvest destruction. The emission from diesel and coal power plant is highly responsible for Green House effect i.e. global warming. Dams used in the production of tidal power can raise tide levels. Damages like reduced flushing, winter icing and erosion can change the vegetation of the area and disrupt the balance. Whereas, the sea wave power plant is free from any kind of environmental pollution.

Wave energy is renewable, clean and unpolluted. There is no carbon dioxide or any other by-products released. It doesn't produce greenhouse gases or other waste. As it is renewable, it will help reduce our reliance on the burning of fossil fuels. Wave is always available so it is reliable.

IV. Swot Analysis

It involves specifying the objective of the proposed power generation process and identifying the internal and external factors that are favorable and unfavorable to achieve that objective.

Strengths: characteristics of the business, or project team that give it an advantage over others

- It is renewable and simple in operation
- Low running cost
- Little maintenance
- Does not hamper water navigation
- Reputation in innovation

Weakness: are characteristics that place the team at a disadvantage relative to others

- New practice
- Funding problem
- Connection to electrical grid is tough

Opportunities: external chances to improve performance (e.g. make greater profits) in the environment are

- Profitable power business
- No emission of gasses
- Environmental friendly
- Favorable distribution and resources
- Support from media and government

Threats: external elements in the environment that could cause trouble for the business or project

- Tsunami, tornado etc. can destroy the power generation system
- Power generation is not constant

V. Conclusion

The technology of ocean wave is still juvenile. It has been fairly possible to demonstrate a power generation plan in this paper. It has been manifested that the proposed plan of power generating from wave has some favorable distinct features which makes it possible to be renewable and eco friendly process. Because of the simple design and easy operation it requires low maintenance cost. It requires very few operating cost that makes it the least priced power. Since it is renewable it can be an everlasting process. Its operating cost is incredibly low.

Once you have built it, the energy is free because it comes from the ocean's wave power. It is important to estimate what amount of power generation will make a company profitable. For this purpose cost-volume analysis has been shown (fig. 3).It will attain revenue which wills surplus total cost at 50Mw. Therefore, wave power plant can be constructed due to its sustainability, renewability, eco-friendly and friendly to the environment.

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