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MODELLING AND WORKING OF POINT ABSORBER USING WAVE ENERGY CONVERTOR

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Abstract— The need for electrical energy is indispensable in today's world. The energy source like coal, oil, natural gas used to generate electricity cause massive damage to the ecosystem as they can leave large hole while extracting energy from them and are causing various ill effects to mankind a well as nature. While the alternative "Wave Energy" derived from oceans do not cause any damage to earth and has the potential to produce electricity. It is safe and genuine method to extract energy from ocean .Wave energy is a sustainable source of power that comes from the boundless, harmless and endless march of waves as they roll into the shore then back. Wave energy is harnessed along the coastal regions of United States, Scotland and Australia. India has yet to mine energy from waves having a coastline of 7,517Km from kutch in the west to Sundarbans in the east. Point Absorber is a type of Wave Energy Convertor (WEC) machine which proves to be an easy and cost effective device for harnessing wave energy. A Point Absorber is a floating structure that absorbs energy from all direction through its movement at or near the water surface. It converts the motion of the buoyant top relative to the base electrical power. Energy output produced by wave energy convertor (WEC) machines is determined by the height, wave speed wavelength and water density. Aquabuoy 2.0 consists of a large round buoy measuring 15 feet across, 3meters wide buoy tied to a70 foot long shaft. By bobbing up and down, the water is pushed into an acceleration tube, which in turn causes a piston to move. This moving of the piston causes a steel reinforced rubber to stretch making it act as a pump. The water is then pumped into a turbine which in turn powers a generator. We have generated a working model based on the above large scale device considering workable conditions and factors.This model will prove to be a sustainable device for harnessing wave energy along years to come.

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I. INTRODUCTION

It is familiar that wave energy technologies vary widely in mechanical and electrical conversion modes, mainly depending on relevant working principle. In current analysis, the point absorber is assumed as a reference WEC device, as proved by the variety of concept designs and full scale prototypes, developed in the last decade by several research administrations and private companies. It is pointed out that even if the working principle of point absorbers is always the same and mainly consists of harnessing the heave motion of a floating buoy in a seaway, the overall layout may substantially differ. The first device with a nominal power equal to 3 kW, was developed by the Company "Ocean Power Technologies" and recently deployed off the New Jersey coastline, under the US Navy "Littoral Expeditionary Autonomous Power Buoy (LEAP) Program". It consists of a floating buoy with spar-type configuration and a damping heave plate on the bottom, connected to the seabed by means of mooring lines .The plate maintains the spar in a stationary position, while the relative motion of the floating buoy drives a mechanical system that converts the linear motion into a rotary one, moving a turbine or motor and producing electricity. The second device, with a nominal power of 10 kW, was developed by the Uppsala University and widely tested in open sea conditions at the Lysekil research site on the Swedish west coast.It mainly consists of a floating buoy connected, by means of a gravity-based foundation, lying on the seabed and equipped with a permanent magnet linear generator, converting the heave motion into electricity mainly consists of a floating buoy connected, by means of a tensioned line, The conversion of wave energy into electrical power can be performed by means of commonly applied technologies, such as linear or rotary electrical generators, the latter in conjunction with oil-hydraulic transformer units .In this respect, in the last decade several research activities have been also

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performed to optimize the PTO layout and maximize the power production, by means of active control techniques, such as latching or unlatching.

II. METHODOLOGY

Abstract

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Introduction

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Wave energy introduction

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Wave energy characteristics (Fig 1)

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Buoyancy consideration (Fig 2, 3)

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Water piston Fig (4, 5)

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Pelton wheel turbine Fig (6-a,b,c,d,e,f)

⇩

Conclusion

III. WAVE ENERGY INTRODUCTION

1. Sea waves offer the highest energy density among renewable energy sources. Waves are generated by winds, which in turn are generated by solar energy. Solar energy intensity of typically 0.1– 0.3 kW/m2 horizontal surface is converted to an average power flow intensity of 2–3 kW/m2 of a vertical plane perpendicular to the direction of wave propagation just below the water surface.
2. Limited negative environmental impact in use.
3. Natural seasonal variability of wave energy, which follows the electricity demand in temperate climates.
4. Waves can travel large distances with little energy loss. Storms on the western side of the Atlantic Ocean will travel to the western coast of Europe, supported by prevailing westerly winds.
5. It is reported that wave power devices can generate power up to 90 per cent of the time, compared to ~20–30 per cent for wind and solar power devices.

IV. WAVE CHARACTERISTICS

The variations of wave characteristics on a yearly basis are also important. The ocean wave characteristics and thus the wave energy have regional and seasonal variations (fig 1)Shows a 10-year power estimate in kW/m. It can be seen that regions between 40° and 60° latitude have higher average yearly wave energy compared to other regions.

The wave energy is also different for different seasons (shown for January and July) Another important aspect in selecting prospective farm sites is wave refraction due to the concentration of wave energy in certain inshore areas as a result of the irregular bathymetry, Higher energy is generally available in deeper water compared to shallow water where the waves get affected by the seabed, leading to refraction, shoaling, and sdiffraction.

Waves are a regular source of power and can be predicted in advance. It has the highest energy density among all other renewable energy sources. The swell, which has a high relative energy, has a relatively great length and a small wave height and is the most frequently observed wave and, as such, is of primary interest in wave energy conversion .Higher energy is generally available in deep water waves compared to shallow water where the waves begin to feel the bottom .

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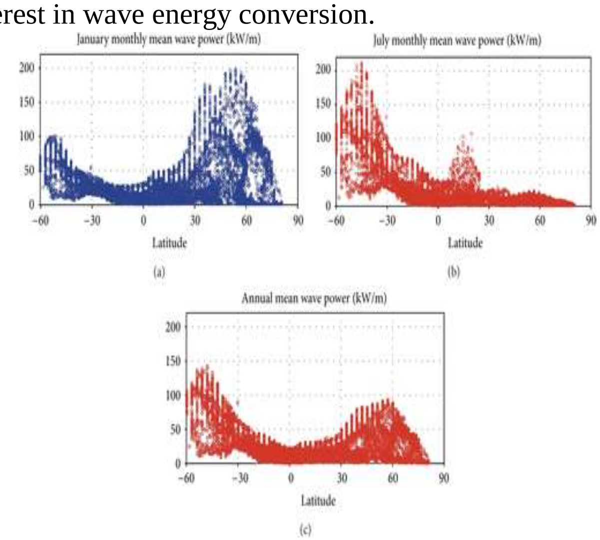

Figure 1: Variation in mean monthly and annual wave power against latitude

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V. BUOYANCY CONIDERATION

Consider a symmetric device floating at rest as shown in .The center of gravity, G, is positioned on a vertical line through the center of buoyancy, B, because of rotational equilibrium. If the device faces an external heeling moment M_H, it will incline with an angle ϕ. The floating device heels about the centre of floatation, which is an imaginary pivot point located at the point of intersection of the two water planes created by the immersed and emerged volumes. As a result of heeling, the shape of the underwater part of the device will change and the center of buoyancy shifts from B to B'' on a line parallel to the line through the centers of the emerged and immersed wedges $z_e z_i$ [5, 9, 10, 72]. For equilibrium to be achieved, the righting stability moment M_R should equal M_H:

$$MH=MR=\rho g\nabla\cdot GZ, \quad (1)$$

where ρ is seawater density, g is gravity, and ∇ is displaced volume. The righting stability lever arm, GZ, can be calculated as

$$GZ=GM\cdot\sin\phi, \quad (2)$$

where M is the metacenter and ϕ is the angle of inclination. The stability lever arm GZ is determined by the hydrostatic properties of the submerged portion and the position of the center of gravity [9, 10]. The metacenter, M, which is the point of intersection of the lines through the vertical buoyant forces at a zero angle and at an angle of ϕ, is defined by the angle of inclination and the shape of the emerged and immersed wedges. For a stable equilibrium, the metacenter positions must both lie above the centre of gravity, although the centre of buoyancy need not do so.

Figure2: Kickboard as buoy

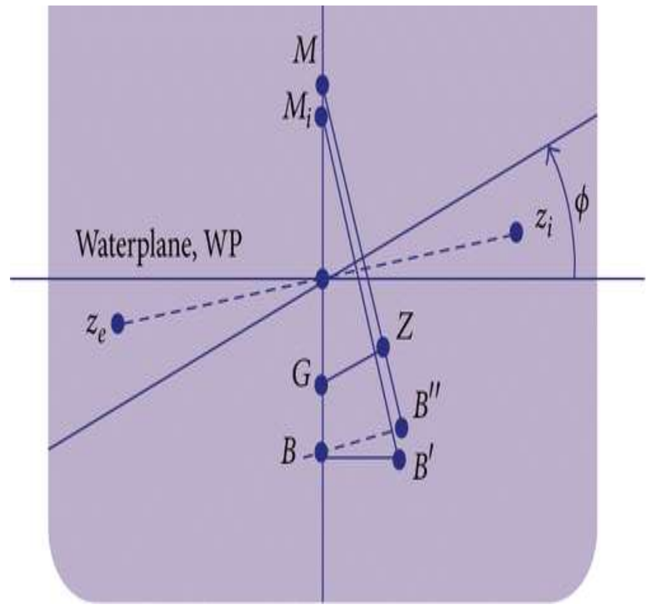

Figure 3: a floating device at an angle of inclination

The shift of z_e of the emerged wedge to z_i of the immersed wedge can be split into a horizontal and a vertical shift. The horizontal shift causes a horizontal displacement of the center of buoyancy from B to B' calculated as

$$BB'=BMi\cdot\tan\phi. \quad (3)$$

The horizontal shift describes the initial metacenter, M_i, as shown in the figure. The distance BM_i can be calculated in terms of the moment of inertia of the water plane, I, and the displacement volume ∇:

$$BMi=I/\nabla. \quad (4)$$

The vertical shift causes a vertical displacement of the center of buoyancy from B' to B'' which is calculated as

$$B'B''=Mi\ .M. \quad (5)$$

The vertical shift describes the metacenter, M, as shown in the figure. The distance M_iM can be calculated in terms of the moment of inertia of the water plane, I, the displacement volume ∇ and the angle of heel ϕ:

$$MiM=I/\nabla\cdot 1/2\tan 2\phi. \quad (6)$$

The distance BM can be calculated from superposition of (6) and (8):

$$BM=BMi\cdot(1+1/2\tan 2\phi).$$

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VI. WATER PISTON

Water rushes to fill the vacuum which occurs(Fig. 3 B); this applies of course only up to a certain limit of the height water can be pulled by a vacuum,. In the first case water is displaced by the piston, but in the second case, the piston serves to create a vacuum and the water is actually displaced by atmospheric pressure pressing on its external Water is for most practical purposes incompressible. Consequently, if a close fitting piston is drawn through a pipe full of water, it will displace water along the pipe. Similarly, raising a piston in a submerged pipe will draw water up behind surface, as indicated in the figure. So water car. be displaced either by "pushing" or by "pulling", but it can also be "displaced" by a solid object being pushed into water so that the level around it rises when there is no where else for the water to go, as indicated in(Fig. 5 C).

n a lift pump, the upstroke of the piston draws water, through a valve, into the lower part of the cylinder. On the downstroke, water passes through valves set in the piston into the upper part of the cylinder. On the next upstroke, water is discharged from the upper part of the cylinder via a spout.

The material(s) of a pump should be considered based on type of application. The base (casing) and housing (cylinder) materials should be of adequate strength and also be able to hold up against the conditions of its operating environment. Materials in contact with the pumped media (the plunger, discharge valves, and suction valves) need to be resistant to any corrosion induced by the fluid. Some materials used are listed below.

Cast iron provides high tensile strength, durability, and abrasion resistance corresponding to high pressure ratings. **Plastics** are inexpensive and provide extensive resistance to corrosion and chemical attack

Figure4: Piston of water pump

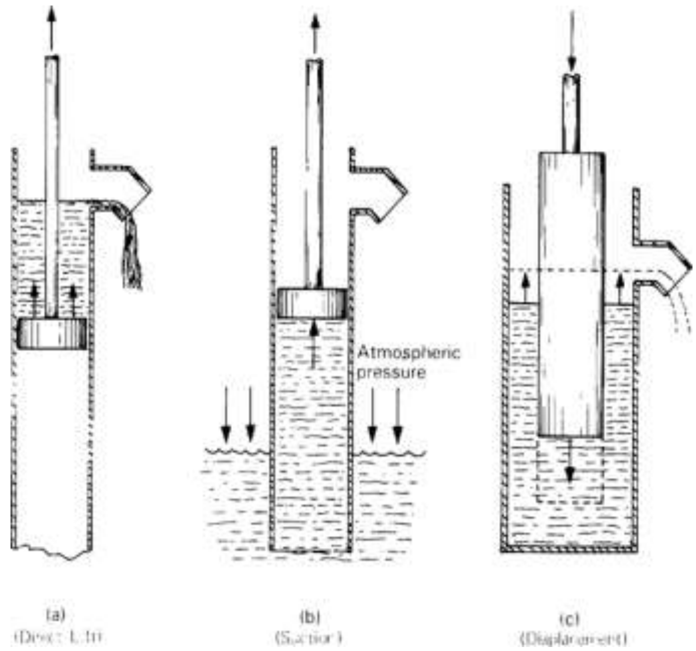

Figure5: Working of water piston pump

Piston pumps and plunger pumps use a mechanism (typically rotational) to create a reciprocating motion along an axis, which then builds pressure in a cylinder or working barrel to force gas or fluid through the pump. The pressure in the chamber actuates the valves at both the suction and discharge points.

VII. PELTON WEEL TURBINE

Various well developed hydro turbines has been used that have been used are classified as either hydro reaction turbines or hydro impulse turbine. Pelton wheel is an example for reaction impulse turbine whereas Kaplan and francis are examples of hydro reaction turbine. Impulse turbine runs in air and is operated by driving high speed water jets that are developed by allowing low velocity water to pass through a nozzle; rotating blade of turbine deflect the jet to maximize the force on the blades. The high speed water jets emerging form the nozzles strike the buckets at splitters, placed at the middle of a bucket, from where jets are divided into two equal streams. These stream flow along the inner curve of the bucket and leave it in the direction opposite to that of incoming jet. The high speed water jets running the Pelton Wheel Turbine are obtained by expanding the high pressure water through nozzles to the atmospheric pressure. The high pressure water can be obtained from any water body situated at some height or streams of water flowing down the hills.

Figure6 (a): model of turbine-wood

The change in momentum (direction as well as speed) of water stream produces an impulse on the blades of the wheel of Pelton Turbine. This impulse generates the torque and rotation in the shaft of Pelton Turbine.

A model of pelton turbine was created using Wood and plastic spoon as bucket or guide vane, Aluminum runner was made using sheets, shast was made using plywood piece ,

Figure6(b): model of turbine-plastic

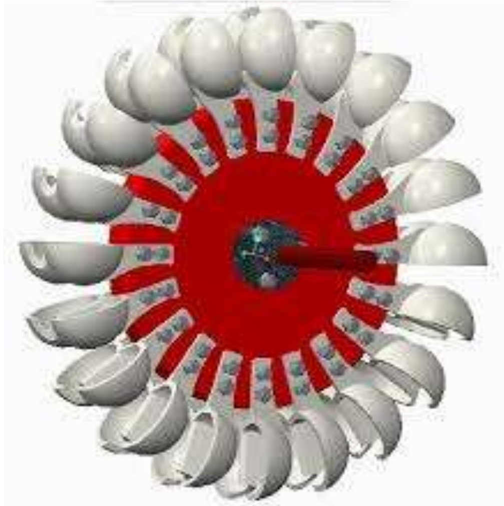

Figure 6(c): Pelton wheel turbine

Figure 6(d): DC motor fixed to turbine (500r.p.m)

To obtain the optimum output from the Pelton Turbine the impulse received by the blades should be maximum. For that, change in momentum of the water stream should be maximum possible. That is obtained when the water stream is deflected in the direction opposite to which it strikes the buckets and with the same speed relative to the buckets.

Thus for Power Take-off Systems (PTO) are used in number of WEC devices. A possible medium for such a system maybe seawater or any other fluid such as freshwater or oil n a sealed system .The heaving motion of the buoy produced by the surface waves drives a low speed piston or pump back and forth, pumping the hydraulic fluid through the power generation system. Electronically controlled valves in the control manifold the flow of fluid between the hydraulic pistons and the hydraulic circuit. The valves are controlled to facilitate the passage of oil between different combinations of chambers to provide optimum benefit.

Figure 6(e):Buoy and piston connection in shaft

Figure 6(f): Wave flume and turbine setup

VIII. CONCLUSION

Scaled modelling provides important information as to how the final device would behave under similar operating conditions. For a scaled model to correctly represent the prototype, all major factors should have similitude. However, similitude is not always achieved, such as similitude for Reynolds number and Froude number. major parameters carefully planned and executed operate in different wave environments due to different seasons.

- Wave energy is not expensive to operate since no fuel is needed and it solely relies on energy from waves.
- Point absorbers do not cause threat to sea animals and form artificial reefs.
- Point Absorber model PB500 developed by Ocean Power Technologies (OPT) ,in COOS BAY OREGON, produces 2,75,000MW annually.
- Combined electricity suppy for coastal and harbour design.
- Connecting series of point absorbers along mooring lines wave energy farms can be developed similar to wind farms.
- Implementing power take off systems,subsstation amplifies the current produced.

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