

Tidal Wave Energy Large Scale Conversion Technology.

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ABSTRACT

The objective of this paper is to describe how we can get maximum amount of working force from tidal wave energy. The paper starts with defining various forces acting on a floating object. Then describe the theory of how unnecessary forces can be opposed except the force which is useful and how this useful force can be increased hugely, how we can use the force safely. Afterward, method then calculation for a 21.5MW hydropower from tidal wave. Using some freehand drawings. Finally conclusion states the advantages.

KEYWORDS

Anchor, Electricity, Floating object, Pump, Ship city. Tidal wave energy.

BACKGROUND

The unlimited source of energy ocean tide has the potential to generate unlimited amount of electricity and to provide unlimited water demand. Since 1799 till now energy companies are not able to harness sufficient amount of energy from this constant source of energy. Existing projects are small, critical technology and so are not economic.

Tidal energy basically is a physical water movement, so compare to solar and wind, harnessing energy from tide should not so difficult.

INTRODUCTION

Tidal force on a floating object has two elements: 1) Horizontal force (H_F): Is a one directional force creates by tidal flow/current. 2) Vertical force (V_F): Is a bidirectional force create by tidal wave (with gravity). Fig: 1.

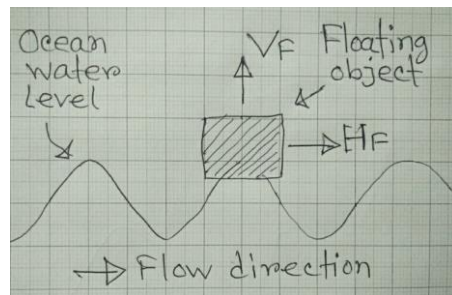


Fig: 1 Tidal force on a floating object.

Application of Vertical force (V_F) and Horizontal force (H_F): Fig 2a & 2b shows some examples of existing various projects.

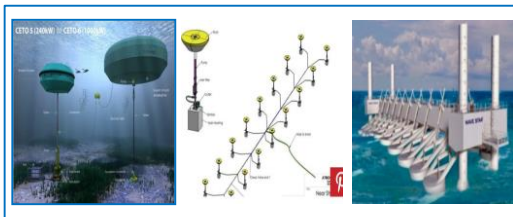


Figure 2a: Application of Vertical force (V_F)

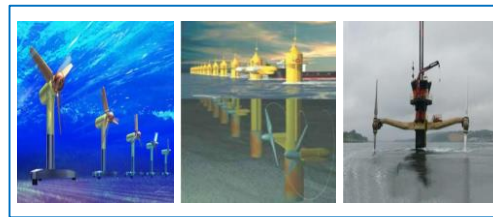


Figure 2b: Application of Horizontal force (H_F)

DESCRIPTION

Tidal horizontal force (H_F) (and with others external any kind of wind forces) on a floating object can be opposed by anchor it properly (by using minimum four long-distance anchors) so that the vertical force (V_F) remain almost same. This vertical force (V_F) is useful and it can be very much useful as easily increase this vertical force (V_F) by increasing the size of the object. This bidirectional vertical force (V_F) is very much suitable for pumping purpose (Figure 3)[1].

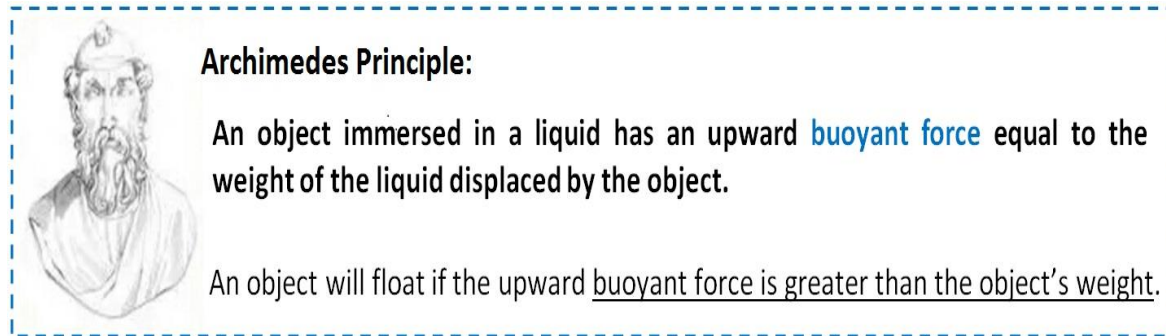


Figure 3: Archimedes Principle.

Therefore, the vertical force (V_F) of tidal wave on a floating object can be huge.

METHOD

Movement of this anchored ship (Figure 4) due to the tidal wave is only vertical and the amount of energy it carries is big. The vertical upward force of this ship can be useful (Figure 5).

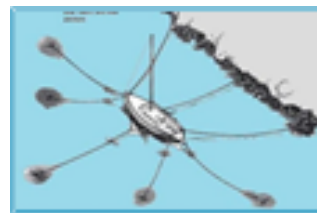


Fig. 4 Anchored ship.



Figure 5: Useful energy that is out of our sight.

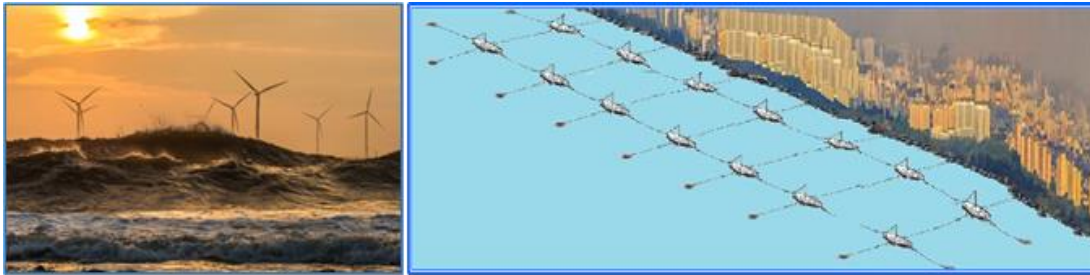


Figure 6: Some anchored big ships can provide electricity and water demand of a big city.

By installing pump protected by RCC structure, using the vertical upward force of the wave on an anchored floating object continuously sufficient water pumping possible for hydro power station as shown in Figure: 7.

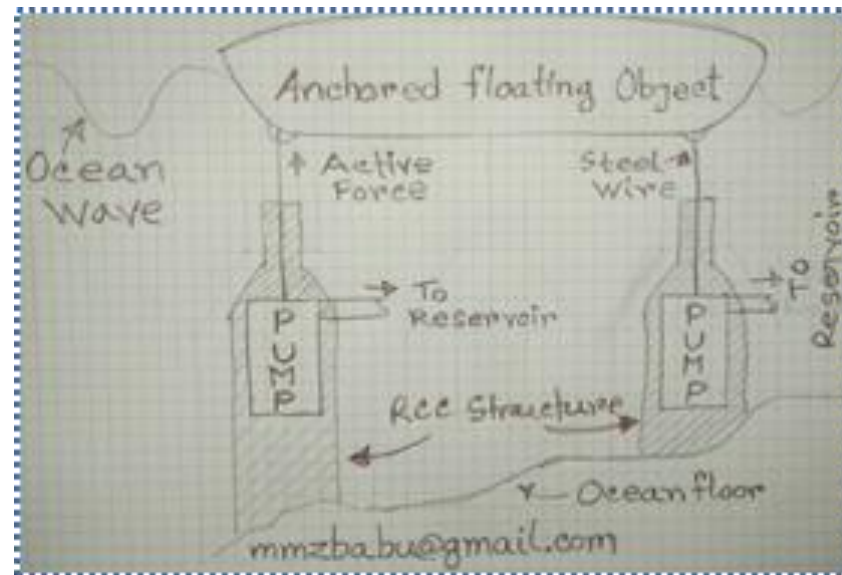


Figure 7: Vertical force of Tidal waves are pumping water to hydropower station reservoir.

CALCULATION

Consider a piston cylinder diameter $D_c = 10$ m. and cylinder height \geq maximum wave height.

So the cross section area of cylinder $A_c = \pi(D_c)^2/4 = \pi(10)^2/4 \text{ m}^2 = 78.54 \text{ m}^2$ (1)

Let, wave height is 3 m. So the piston can move 3 m. i.e. active length of cylinder $H_c = 3$ m.

If the piston is connected with a floating object then due to a tidal wave the amount of water will pump is

$Q = A_c \cdot H_c$ per wave $= 78.54 \times 3 \text{ m}^3/\text{wave} = 235.62 \text{ m}^3/\text{wave}$

If the wave period is 10 seconds,^[2]

Then $Q = 235.62 \text{ m}^3/10 \text{ sec} = 23.56 \text{ m}^3/\text{sec}$ (2)

Consider a floating ship of displacement tonnage 10,000. (i.e. total weight of the ship is 10,000 ton).

According to Archimedes' principle buoyant force (vertical upward force) on the floating ship due to the tidal wave is $\geq 10,000$ ton force, i.e. $V_F \geq 10,000$ ton force.

Let, $V_F = 10000$ ton force

$= 98067.1 \text{ kN}$(3)

If this force acting on the piston then, Pumping pressure

$P_{\text{pump}} = \text{Force/Area} = V_F/A_c = 98067.1/78.54 \text{ kN/m}^2$ [by eqⁿ (1) & (3)]

$= 1248.63 \text{ kN/m}^2$

As measured by a U-tube manometer, 1 kN/m^2 pressure can create a water head 0.102 m .^[3]

Then for Pumping pressure $P_{\text{pump}} = 1248.63 \text{ kN/m}^2$, water head $H_{\text{head}} = 1248.63 \times 0.102 \text{ m} = 127 \text{ m}$,

Consider head loss 13 m, then waterfall height

$$H = 127 - 13 = 114 \text{ m.} \dots\dots\dots(4)$$

From formula to calculate hydropower, Generating power (P_{gen}) ^[4]

$$P_{\text{gen}} = Q * \rho * g * H * \eta \text{ watt,} \dots\dots\dots(5)$$

Where, Q = flow rate in m^3/sec . [=23.56 m^3/sec eqⁿ (2)]

ρ = water density in kg/m^3 (sea water 1020 kg/m^3)^[5]

g = acceleration of gravity in m/sec^2 (9.81 m/sec^2)

H = water fall height in meter. [=127m eqⁿ (4)]

η = global efficiency ratio. {let here 0.8} (Usually between 0.7 and 0.9)

Then eqⁿ (5), Generating power

$$P_{\text{gen}} = 23.56 * 1020 * 9.81 * (114) * 0.8 \text{ watt,}$$

$$= 21,500,954 \text{ watt}$$

$$= \underline{21.5 \text{ MW}}$$

Reservoir size:

We have, $Q = 23.56 \text{ m}^3/\text{sec}$, For 30 min backup operation, Water required will be: $V_{oL} = 23.56 * 60 * 30 \text{ m}^3 = 42,408 \text{ m}^3$

If reservoir depth is 3 m then Reservoir area = $42,408 / 3 \text{ m}^2 = 14,136 \text{ m}^2$,

For square shape area, Reservoir length = width = $\sqrt{14,136 \text{ m}} = 119 \text{ m}$.

CONCLUSION

Hence, we can conclude that to generate 21.5 MW electricity from tidal wave we have to anchor a ship (total weight 10,000 ton) on the ocean wave height 3 m, need to be build a 119m*119m*3m size reservoir from $(127-3) = 120$ m above the sea level, have to be install a pump under the anchored ship of cylinder diameter 10 m, cylinder height \geq maximum wave height in the installation area and a 21.5 MW water turbine generator.

Considering the open space available in the ocean, we can install lots of ships. Anchored big ships on the big wave can take a big role for the solution of future energy.

This is a very easy technique to harness energy from ocean tidal energy as already running some small projects. Capacity can be increased as required by increasing the size of the object and pump very easily. Expensive waterproof devices are not required for this easy technique. Compare to the existing hydropower stations dam, big reservoir, big catchment area not required so cost effective.

Advantages:

#Zero emission, #Low cost renewable energy, #Very safe. #Reject ships can be used as a floating object so that form a ship city. #Very simple pumping operation so that pump can be design for any size of wave. #Continuous pumping so no need a big reservoir for hydro power station. #Economic. #Easy technology. #Reliable and #Unlimited.

***This anchored object method can be used in the river for irrigation purpose.

Acknowledgment:

Google Images, Marine energy/ship companies.

References

1. Archimedes Principle.
2. The European Marine Energy Centre Ltd (EMEC) (2019) Wave data. (<http://www.emec.org.uk/facilities/live-data/wave-data/>)
3. Conversion of Measurement Units. <https://www.convertunits.com/from/kn/m2/to/meter+of+head>.
4. Power Calculation (2019) Calculation of hydroelectric power and energy principle. (<https://power-calculation.com/hydroelectricity-energy-calculator.php>)
5. The Physics Factbook (2002) Density of Seawater. (<https://hypertextbook.com/facts/2002/EdwardLaValley.shtml>).