Wave Climate Study for Ocean Power Extraction

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Abstract

To harness the Wave power it is needed to study the wave climates. In order to assess an area for wave energy development, the wave climate must be defined. The wave climate describes an Area's wave height (H) distribution, Wavelength (L) distribution, and Total mean water depth (d). From these parameters, one can compute wave power levels. A significant piece of data to gather from study is that the waves present on the western edge of the continents contain more energy because of the west-to-east winds. An important fact not shown in study is that average wave power is cyclical with winter bringing energy levels up to six times greater than summer.

Keywords: *Wave Climate, Wave Height, Wave Height, Wave length, Depth of the Water.*

I. Introduction

II. Methods and Materials

II.A. Wave Energy Calculations

"The utilization factor for wave power – the ratio of yearly energy production to the installed power of the equipment – is typically 2 times higher than that of wind power. That is whereas for example a wind power plant only delivers energy corresponding to full power during 25% of the time (i.e. 2,190 h out of the 8,760 h per year) a wave power plant is expected to deliver 50% (4,380 h/year)." [1-14]

While we know that wave power is more energy dense than wind power and produces power for a larger percentage of the year, we still do not know how to calculate the power available from a wave. This is important for the design process of a wave energy converter. First, the power and forces acting on the device should be assessed, and then the device may be sized for the desired energy output [15-33].

II.B. Wave Energy and Power

The following analysis describes a wave's energy and power characteristics.

Symbols	**Variables**
Edensity:	wave energy density [J/m^2]
SWL:	mean seawater level (surface)
Ewavefront	energy per meter wave front [J/m]
Pdensity:	wave power density [W/m^2]
Pwavefrot:	power per meter wave front [W/m]
H:	depth below SWL [m]
ω:	wave frequency [rad/sec]
λ (or L):	wavelength [m] = $gT^2/(2\pi)$
ρ:	water seawater density [1000 kg/m3]
g:	gravitational constant [9.81 m/s^2]
A :	wave amplitude [m]
H:	wave height [m]
T:	wave period [s]
C:	Elerity Cell (wave front velocity) [m/s]

II.B. Reason for Ocean Waves

Ocean waves may develop for various reasons-

1. The wind,
2. The passage of a ship,
3. The attractive forces of moon and sun,
4. Earthquakes or volcanic explosions beneath the oceans etc. The most common reason for the development of waves is wind. Wave motions in water is roughly divided into two groups: (1) Tidal Waves (L>> d) and(2) Surface Waves (L << d). Where, L=Wave length, d=Water depth

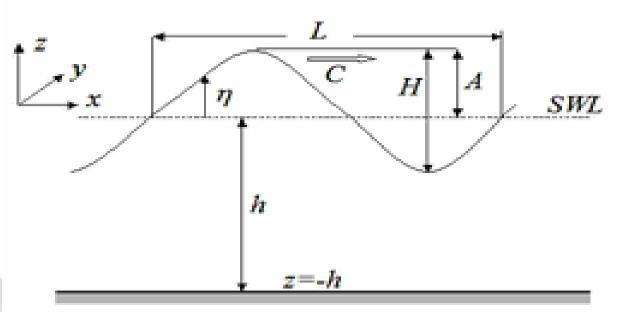


Fig.1 Wave Nomenclature

Relationship among Velocity, Wave Length and Time Period-

According to the classical wave theory, these various characteristics are related by the following equations:

$$V = \frac{L}{T} = \sqrt{\frac{gL}{2\pi}} = \frac{gT}{2\pi}$$

$$L = \frac{2\pi V^2}{g} = \frac{gT^2}{2\pi}$$

$$T = \sqrt{\frac{2\pi L}{g}} = \frac{2\pi V}{g}$$

If one characteristic is known, the others can be computed. When the foot-pound-second system of units is employed, the following expressions are obtained:

$$V = 2.26\sqrt{L} = 5.12T$$

$$L = 0.195V^2 = 5.12T^2$$

$$T = 0.442\sqrt{L} = 0.195V$$

Where, V = Speed of the Wave, L = Wave Length and T = Time Period.

II.C Classification of the Categories of the Ocean Wave Energy:

There are three main categories that wave power can be split into, these are:

1) Near Shore
2) At Shore
3) Off Shore

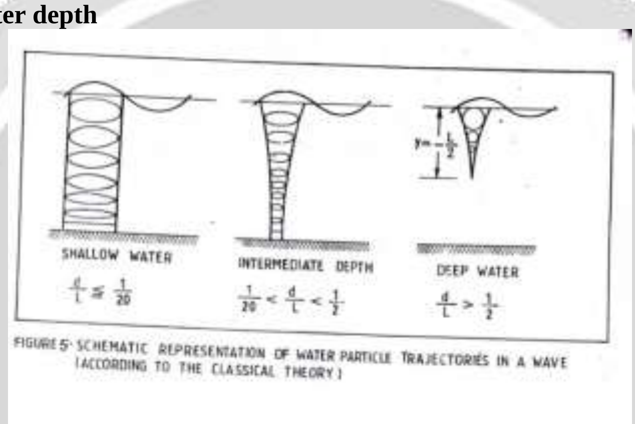
II.D Wave Braking in the Ocean

Fig.2 Wave Breaking

Causes of Wave Braking:
1.H/L=Slope of the wave=1/7
2.d/H=1.3
3.Angle of wave=120 degree.
For Deep water waves: $d>L/2$
For Shallow waves: $d/L<1/20$
For Shallow waves: $V=3Ld^{1/2}$

II.E Types of Wave Breaking
There are three types of Wave Breakings: (1)Spilling breaker wave (2)Plunging breaker wave (3)Surging breaker wave.
(1)Spilling breaker wave: Plunge line, H=d Surf zone: distance between plunge line and coast line
(2)Plunging breaker wave: $V_{wb} = V_{wc}$, Where V_{wb} = Velocity of Wave body and V_{wc} = Velocity of Wave crest. For this case
$V_{wb} < V_{wc}$
(3)Surging breaker wave: For this case
$V_{wb} = V_{wc}$

II.J Classification of Water depth



II.G Current Wave Energy Technology
According to the DTI, there are three types of wave energy collector[34]. These are:
1. Buoyant Moored Device
2. Hinged Contour Device
3. Oscillating Water Column

II.L Different Types of Wave Energy Converters:

1. Pelamis Wave Energy Converter (PWEC)/Sea Snake

Fig.4 Pelamis/Sea Snake

2. Land Installed Marine Power Energy Transformer (LIMPET)

Fig.5 LIMPET

3. Floating Wave Power Vessel (FWPV)

Fig.6 FWPV

4. Stingray Tidal Stream Generator (STSG)

Fig.7 **STSG**

II.M Social Implications of Tidal Power

Tidal Streams are common in remote areas. This means that careful consideration of the wishes of the local community is required to ensure the scheme can work to its potential[52-80]. Being under water avoids aesthetic problems and shipping and navigation should not be affected provided it is taken into consideration when planning. The scheme can provide employment during construction and operation, which will add to the local economic prosperity [81-89].

II.N America's Premiere Wave Power Farm Sets Sail

Wave energy is among the impressive list of renewable energy resources that is being developed in the United States.New Jersey-based developer, Ocean Power Technologies has launched a project that features the nation's first commercial wave power farm off the coast of Reedsport, Oregon. Once the project is completed, wave energy will generate power for several hundred homes in Oregon.The wave power farm operates on the wave energy that is created[34-51].

Fig.8 Tidal Power Extraction Device

II.O: How much power can you get from a wave?

Linear wave theory assumes that the motion of the water past a point is sinusoidal. The period (T) for one wave to pass this point can be expressed by:

$$T = \sqrt{\frac{2.\pi.\lambda}{g}}$$

Where, λ = wavelength (m) and g = gravity = 9.81 ms^{-2}

The power contained in the wave can be expressed in terms of the length of the wave (kW/m). This is given by the following equation[90-100]:

$$P = \frac{\rho . g^2 . a^2 . T}{8\pi}$$

Where, a = Wave Amplitude (m)

II.P Wave power formula

In deep water where the water depth is larger than half the wavelength, the wave energy flux is[60] :

$$P = \frac{\rho g^2}{64\pi} H_{m0}^2 T \approx \left(0.5 \frac{\text{kW}}{\text{m}^3 \cdot \text{s}}\right) H_{m0}^2 \, T,$$

with P the wave energy flux per unit of wave-crest length, H_{m0} the significant wave height, T the wave period, ρ the water density and g the acceleration due to gravity. The above formula states that wave power is proportional to the wave period and to the square of the wave height. When the significant wave height is given in meters, and the wave period in seconds, the result is the wave power in kilowatts (kW) per meter of wave front length [100-120]

III. Conclusion

There are a lot of wave energy converters now a days. Among them 4 types of converters Pelamis, Flowting Wave Power Vessel and Sting Ray Tidal Stream Generator are remarkable[82-99]. These wave power converters can help the people those who are living in the coastal belt of the world[100-120].

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