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Ocean Wave Energy- A Step Towards Recharging Batteries

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Abstract:
In the earth's ecology the bulk energy resources are renewable energy. Some of them are solar, wind and ocean energies. Ocean energy contains merely of oceanic thermal energy, tidal and wave energies. Wave energy is mainly focused due to immense energy densities, colossal potentials and anticipations. Existing technologies cannot exploit wave energy efficiently on commercial scale. Our paper explains the experimental work over exploitation of wave energy throughout the world's coastline. The global estimation of practical prospective is approximately 500GW based on a conversion efficiency of at least 35-40%. Wave power means the energy capture of waves on ocean surface. The device that is able to convert any wave energy into power through its capability, then it is called a Ocean Wave Energy Converter (OWEC). The principal of operation of this device is to convert vertical heave dispersion into a rotational action which generates electricity. This electrical power can be stored in batteries and also to recharge them. As the wave energy is pollution free, reliable, and incessant which reduces our dependence on fossil fuels.

Keywords: *Ocean Wave Energy, Power Storage, Rechargeable batteries, Renewable energy, Wave Energy Converter.*

I. INTRODUCTION

The waves produced on top of oceans are formed by the act of flowing air called winds. This causes a disturbance over the sea. By the action of earth's gravity this interruption in sea gets to normal position that results in waves. These waves have a specific nature of forming crests and troughs. The crest is vertical distance to top from equilibrium and trough is a vertical distance towards down from equilibrium. The distance between crest and trough vertically is called height of wave. The distance between any two successive points of a crest or trough is called its wave length.

There is a continuous change in temperature which leads to change of atmospheric pressures [1]. This results in blowing of winds with different energies at different pressure gradients. The higher energy that is relative to wind is transferred to the still water by pressure acting normal to surface of sea. There is a shear formed which is peripheral to it.

The world's coastline is about 620,000 kilometres (372,000 miles). The place where ships, boats, and barges can be docked is called a harbour. There are

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approximately 1100 ports and harbours around the globe which has a capacity of average berths of 25 as minimum and terminals of 10 as per world's ports data.

Renewable energy is a natural reserve which can restock by means of time through organic reproduction and other naturally persistent processes. These reserves are a part of atmosphere and the major components of earth's ecosphere. The transfer of energy from waves and is captured to do work is called wave power which includes generation of electricity, desalination of water, and water pumping into reservoirs [2]. The Equipment that is able to capture and exploit wave power is called a Ocean Wave Energy Converter (OWEC).

Most of wave energy is nearer to the ocean surface. There are separate designs for each range that are used in capturing the energy of waves. These energy capturing devices are designed in such a way that they are set in bottom of water and some are set like floating devices on ocean surface which are used for capturing of kinetic energy of waves in which each range of energy is converted into electric power through the usage of a generator.

There are many capture methods. Some of them are:

1)Oscillating Water Column: These are one of the capturing methods which may involve in cavity set directly on the shoreline that is submerged. These types of devices can capture and convert wave energy into air pressure. There is a generator of wind turbine fixed in top of surface of ocean which generates electric power using the arrangement that is built upright to waves which traps the wave motion into the cavity and makes to oscillate up and down seems to be a piston [3].

2)Point absorbers: This is one of the basic methods of energy capture in which a undersized straight up device is fixed on ocean floor directly. This device can generate electric power by the motion (bobbing) caused through usage of rafts or bags floating over ocean surface. These types of devices can be deploying in deep water when the wave has a greater height and high energy.

3)Over Topping devices: This is a low power output device which contains of floating ramps that which waves of more than 2 metres height are reserved on ramp that is set upright to wave's direction. These devices cannot be set at wave height of less than 2 metres. The reservoir set is used in capturing the potential energy of waves. There is a generator of low head Kaplan turbine which generates electric power. These devices convert the potentials of energy present in water into mechanical energy that rotates turbine.

4)Wave Attenuators: These are another method of capture which contains stretched flat semi-submerged zigzag devices. These are set into the direction parallel to waves. These types of attenuators possess a chain link of cylindrical sections by stretchy hinged joints which allows rotating relative to each other [4]. This motion produced by attenuator is utilized that a hydraulic piston is to be pressurized.

This high pressure then turns the generator of hydraulic turbine which is used in generating electric power. These wave attenuators are used in converting the oscillating action into hydraulic pressure.

II. Objective

To provide eco-friendly and pollution free power generation using renewable energy.

III. Motivation

Using Multidisciplinary Techniques from mechanical and electrical fields in power generation inspiring from previous projects and power generation techniques from all parts of world.

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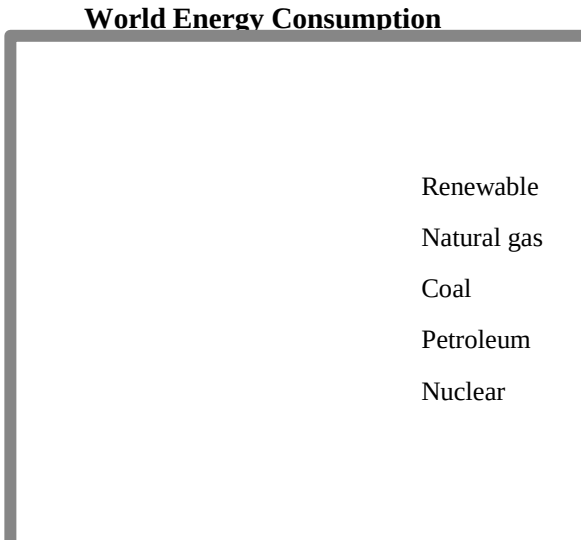
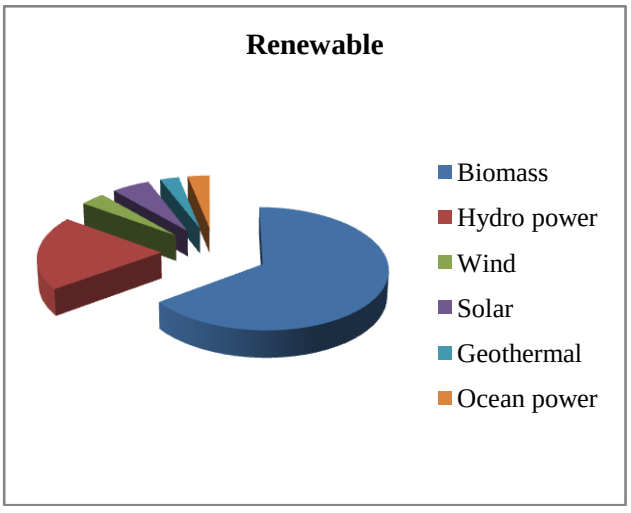
The wave energy is pollution-free which doesn't require even a little bit of non-renewable energy fuels to work. The main advantage of wave energy is it can be predictable and can be used for many purposes endlessly with low cost, less maintenance and more efficient [5]-[6].

From the Graph 1: Fossil fuels are of 78.4% and nuclear takes the least value of 2.6%.



Graph 1: World Energy Consumption



Graph 2: Renewable Energy Consumption

In the world, energy consumption from renewable source is estimated to be 19% in which the biomass takes the major part and ocean power takes the minor role.

Our paper is discussed over this ocean power which is estimated to be 0.60% that it can comprises of nearly 15% of domestic power (full consumption) usage all over the globe shown in Graph 2.

IV. Methodology

Present approach comprises of basic structure of our Wave Energy Converter (WEC), operation/ mechanism, power generation setup along with energy transfer from wave to electrical through mechanical energy and its storage in rechargeable batteries

a) Basic Design of Structure:

This Wave Energy Converter (WEC) consists of entrenched vertical member, a float, sprocket with a long chain linkage, shaft, hooks, and spur gears of desired diameter, roller bearings, generator and electricity storage device. And specifications of each part are tabulated in Table 1.

	COMPONENT	SPECIFICATION
1	Vertical Member	960X660X910 mm
2	Float	990X460X90 mm
3	Sprocket	Ø12.7PitchDiaX3.17WidthX18 mm
4	Chain	60inches(1inch per link)
5	Spur Gear(Driven)	Ø6(ID)XØ2.5(PitchDia)mm
6	Spur Gear(Driver)	Ø12(ID)XØ5(PitchDia)mm
7	Shaft	Ø12X800mm
8	Generator	12VoltsX10Amps
9	Rectifier	Bridge wave rectifier
10	Capacitor	22microFaraday, 25V
11	Rechargeable Battery(sample)	9V(Charge 2hrs, Discharge 2hrs)

Table 1: Specifications of prototype.

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Fig 1: Prototype of Wave Energy Converter

a) Operation/Mechanism:

Fig 1: Experimental setup of prototype

This converter which contains the entrenched vertical member is fixed to the harbour wharf which holds the float member which is nudged by the ocean waves. From Fig1 Assume the float member has a bow end in its front portion and stern end as its back portion. There is a shaft supported by the vertical member so that it can rotate freely. Bearings are used to reduce the friction.

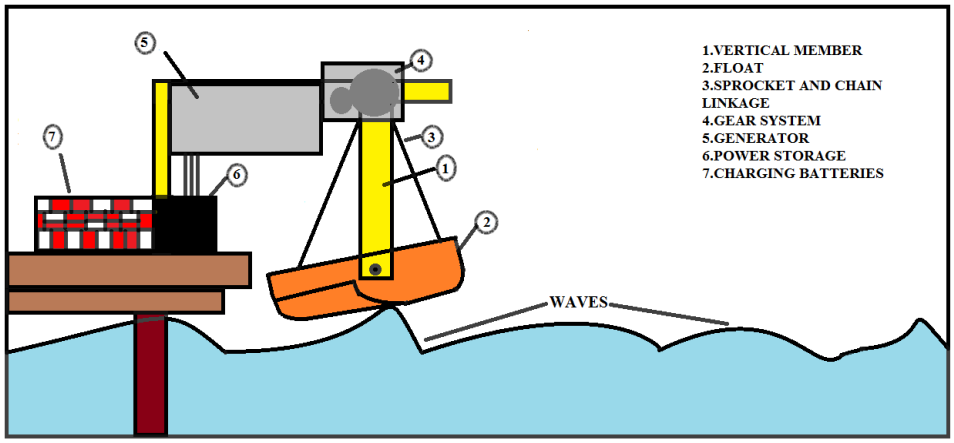

Fig 2: Installation setup

The driver gear is fixed to one end of the shaft and the driven gear is fixed to the shaft of generator.

Sprocket system is fixed to the shaft and the chain linkage is hooked to float on both ends shown. The pitch movement of float is created by waves formed in the ocean which makes the float to move up and down (pitch motion).

This motion captures the wave energy and transfers it to the sprocket through chain linkage which is hooked to the float. The shaft which is coupled to sprocket tends to rotate the driver gear allied to it. The rotating driver gear engaged to driven gear of generator shaft also gets rotated which converts energy from mechanical to electrical.

Generator is the device that is used in converting mechanical action into electric power [7]. There are coils present inside which produces an induced emf in the armature conductor.

The electrical energy generated in generator is stored in the power storage devices. Installation is shown in Fig 2.

a)Power storage:
The devices that are used in storing power are called power storage devices. Some of them are capacitors, rechargeable batteries, double layer or ultra-capacitors, portable power banks.

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Rechargeable batteries are secondary batteries which are both charged and discharged. These batteries are comprised of a special circuit which is set in a special case of battery that is able to control the power flow.

This makes it capable of storing electric power in it and can be used further to charge other electronic devices.The most commonly used rechargeable battery is lead-acid battery. These are having a recharging capacity that can be used in cars. It involves in both charging and discharging [8].

A capacitor is used in the circuit shown in Fig 3 which stores electrical energy in a limited capacity. A resistor is used in the power storage process into the rechargeable battery that resists the circuit not to get damaged by over flow of electrical energy. A rectifier is used which converts the alternating current generated in the power generation process into direct current which is used for storage purpose.

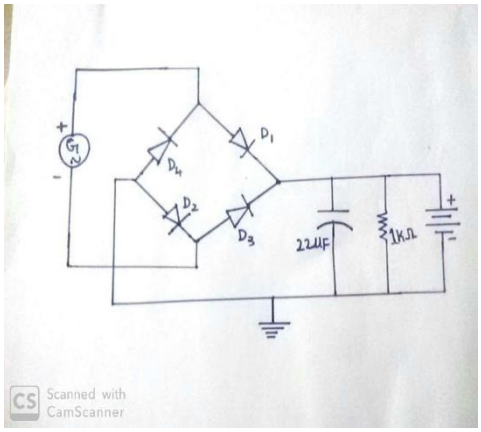

Fig 3: Circuit Diagram for Power storage into Rechargeable batteries

V. Results and Discussions

Present discussion is on the results gathered from the calculations of the prototype in which the amount of power generated is approximately 120Watts by using the following equations. The generator used for this device is of 45rpm.

Due to some losses including frictional losses, thermal losses the power generated is reduced than the expected.

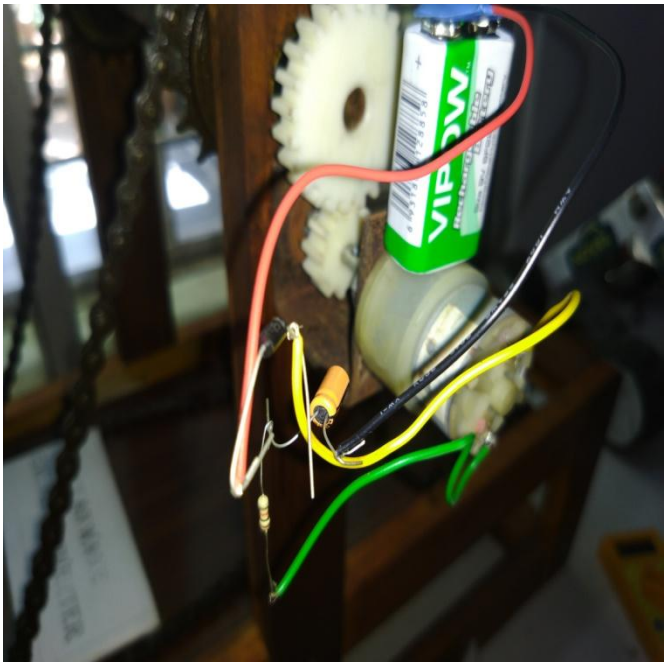

Fig 4: Circuit setup for the prototype

In the Fig 4, the circuit setup is shown which involves in connection of rechargeable batteries to the resistor, capacitor, rectifier that are directly connected to generator system. This helps in storing power in a rechargeable battery.

Theoretical calculations

$$(P)= (2 \pi n T)\div 60 \quad \text{------(1)}$$

Where n= Number of rotations of shaft
T= Torque (Nm)
P= Power (Watts)

Torque is the turning moment of force of a rotating object about its axis.

$$(P)=\text{Volt}\times\text{Ampere} \quad \text{-------(2)}$$

From the Equations (1) and (2), calculating the torque produced by the shaft and Power generated from the whole system.

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Fig 5: Initial Battery Voltmeter reading

From Fig 5, the rechargeable is drained completely with nearly 1.16 volts of power is present in it as shown in voltmeter. This battery is getting charged using the prototype Wave Energy Converter for nearly 2 hours.

Fig 6: Voltmeter reading of battery after charging for some time.

From Fig 6, the battery is getting charged up to 7.42 volts according to the voltmeter reading after some time. The final reading is taken for the battery.

Fig 7: Voltmeter reading of battery after 2 hours

From Fig 7, the battery is charged up to 7.51 volts according to the voltmeter reading after 2 hours. This final reading indicates the power storage after 2 hours charging of battery.

From Fig 8: the 9volt capacity battery gets charged approximately 7.5volts that have a capacity of 2hours continuously. This shows that the prototype is able to generate power that can be stored in rechargeable batteries. This power generation is non-polluting and eco-friendly.

Fig 8: Rechargeable Battery final power storage

This prototype system only can charge up 8 batteries at a time which has a capacity of 9volts each. It can light up 36 LED bulbs at a time in both directions which are of capacity 1.8-2.2 volts each.

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As the values of N and τ are directly proportional to the Power generated. The amount of power generation may get increased by increase in the generator capacity and decrease in rpm of shaft which depends on gear arrangements.

The power can be generated in both directions i.e., float position on clock wise as well as anti-clock wise directions by setting up the generator in desired position of positive and negative terminals accordingly using a Rectifier.

VI. Scope of Future Work

There is a lot of scope for future development result in generating Mega Watts of power in which it can be sold for cheaper rates. Series of these systems setting up on harbours and ports can generate an amount of 20MW using the generators of (assumption) 2000KW capacity with required quantities. This also can provide a lot of domestic power supply for ports and harbours as well as charging up the ship batteries. As some surveys reveals that 1MW of power can light up to 160 homes at a time. This saves a lot of money investing on buying power from fossil fuel power plants. This power can be used up to charge a huge bulk of batteries for storing and reusing purpose.

VII. Conclusion

The power generation form the ocean wave is still in the developing stage, much advancement in the technology leading to many innovations in this field.

- This system is of simple design and easy in operation
- Requires low maintenance cost and have a capability of making least priced power. Being it uses Renewable energy this is an eternal power.
- There is power generation through crest and troughs of ocean wave. That is the power generation is in two directions.
- The efficiency is predictable and no need of skilled labour.
- As there is >25% rate of increase in power usage by 2050 revealed by some surveys and Ocean Wave Energy could be a focused way for simple power generation source.

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