Oscillating Water Column With Projecting Walls

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*Abstract*—Oscillating-water-column (OWC) devices, of fixed structure or floating, are an important class of wave energy devices. A large part of wave energy converter prototypes deployed so far into the sea is of OWC type. Among the numerous wave energy converters (WECs), the oscillating water column (OWC), which runs on the concept of capturing energy from the rise and fall of the water column in a closed chamber resulting from wave motion, has become quite popular. The compressed water column in the chamber advances an air stream that can drive a turbine coupled to electric generators. Many experimental and numerical investigations are performed on the OWC till date. The change in efficiency of OWC with respect to parameters like shape, size, damping etc. are studied. Also, the performance of OWC under different conditions, the concept of multi-resonant OWC and the recent development in OWC research, the concept of integration of OWC with projecting walls, its advantages and disadvantages, are also discussed. The present study aims to investigate the influence of the projecting sidewalls, or so-called harbour walls, of an OWC on its energy-efficiency characteristics. The design and optimization of the harbour wall’s projecting length and its inclination are as important as the hydrodynamics of waves inside the chamber, apart from the characteristics of the air vent and the turbine parameters, which play a critical part in the performance of these devices. Different numerical modelling and study are being carried out on the same. An open source hydrodynamics program REEF3D is used for the modelling of the oscillating water column with projecting walls numerically. The results are compared with published journal papers, designed to run on many processors. High-order spatial and temporal discretization schemes result in accurate and stable numerical behaviour. With a focus on coastal, marine and hydraulic engineering flows, REEF3D solves the governing equations at all relevant scales. Finding the percentage efficiency of such a system when installed in real sea conditions.

Keywords— Wave energy, Oscillating water column, Projecting sidewalls, Harbour walls, Energy efficiency.

Introduction

Wave energy is a huge energy source which is renewable. The Wave energy will be very much high in offshore area so that we can install wave energy converter devices in those area for generation of electricity efficiently. Energy converter devices that have only been installed on land till then, have gained much importance with the development of wave power technology and resulted in more offshore devices. Wave energy converter devices like Oscillating water column wave energy converter at sea are a benefited because they will not indulge with flora and fauna on land. Moreover, in steadier wave better energy efficiency is achieved at sea than on land.

Oscillating water column (OWC) wave energy converter (WEC) is an ecofriendly option for generating electricity with least harm to the nature. Oscillating Water Columns convert the wave energy in to mechanical energy and then to electrical energy. It works in such a way that it harnesses energy from the oscillation of the seawater inside a chamber caused by wave action. OWCs cause much lower environmental impact and therefore, multiple companies have been working to design innovative and efficient OWC models. These devices have a semi submerged chamber opened to the sea beneath, trapping an air pocket above a water column. Due to wave action, this water column acts like a piston, moving up and down, and forces the air out of the chamber and back into it. A bidirectional stream of high-velocity air is created by this continuous movement force, which is channeled through a Power-Take-Off (PTO) system. Airflow is converted into energy by PTO system. The PTO system mainly consists of a bidirectional turbine which converts airflow energy to electrical energy. That is, for continuous energy generation the turbine always spins in the same direction regardless of the direction of airflow

In the past two decades, the continuously increasing energy demand, the significant fossil fuel depletion and the need of a more sustainable future with reduced pollution have triggered worldwide interest in green power generation. The first interest in renewable energy was stimulated during the oil shortage crisis in 1973. Thus, people began to reconsider ocean energy as an alternative energy resource. All the studies for the energy consumption states that the energy need and demand will be tremendously increasing in the coming years despite of the declining energy resources. It is in this context the study about OWC associated with breakwater becomes relevant. The OWC concept which incorporates an air turbine is simple to understand. The concept is adaptable and can be used on a range of collector forms situated on the coastline, in the nearshore region or floating offshore. The use of an air turbine eliminates the need for gearboxes. It is easy to maintain. It uses sea space efficiently. There are very few moving parts so that there is less chance for wear and tear.

The hydrodynamic efficiency of the OWC device is very much influenced by the introduction of projecting walls to it. The main problem with the OWCs is lower primary wave energy conversion efficiency i.e. the power take-off system. To improve effective primary conversion of wave power take-off introduction of harbour walls plays a great role. It also depends on the incident wave height, incident wave lengths. The researchers performed experimental and theoretical investigations on the response of OWC device like dynamic pressures, force 20 components of OWC and hydrodynamic efficiency with the help of linear waves and non-linear waves by changing the dimensions and configurations of both the harbour walls and the device. Apart from the addition of Projecting walls to OWC’s some parameters like PTO damping, proper sloping sections and shapes (triangular, circular and rectangular) and optimum dimensions of the OWC was also suggested for higher efficiency.

Objective Of The Present Study

This study focuses on the improvement of hydrodynamic efficiency of the oscillating water column with projecting walls introducing the concept of damping. Oscillating water columns are the reliable wave energyconverters to absorb the maximum incident wave energy from the ocean waves. These devices make use of the air column under pressure inside the device which oscillates in response to the wave condition for the conversion of ocean energy to electrical energy. As the installation and maintenance of the device as a single, isolated unit is costly, they are integrated with coastal structures to bring down installation and maintenance cost. The damping concept used in the present study is the desirable damping which increases the energy absorption rate of OWC from wave energy. Improvement in the hydrodynamic efficiency with respect to the bottom slope of the structure is also checked in the present study.

The major objectives of the present study are:

• Numerical study on the integrated oscillating water column with projecting wall (PW) using Computational Fluids Dynamics (CFD) tool REEF3D.

• To find the improved efficiency of oscillating water column wave energy converter when attached with projecting walls. • To find the influence of damping on hydrodynamic performance of OWC.

• To analyze the efficiency of an oscillating water column for regular waves having zero damping coefficient for a constant wave heights and wave lengths and study the wave energy absorption concept for OWC with projecting wall and change in bottom slopes

*Effect of Harbour Walls On The Efficiency Of An OWC*

In recent decades, studies on the conversion of wave energy to clean electricity have evoked keen interest among researchers worldwide. The Oscillating Water Column (OWC) which falls under the category of terminator devices is a partially submerged structure opening below the water line. The amount of power captured by the OWC from the ocean waves is controlled by the amplitude and the wave oscillation phase. The absorption can therefore be optimized by controlling amplitude when not in or near resonance. The stage between the wave oscillations outside and inside the OWC should be improved. The Oscillating water column concept developed by Yoshio Masuda in 1947 was adopted at the next level in real plants, for example the LIMPET Shoreline OWC installed in Scotland. The OWC power plant in Mutriku, Spain, which was installed in 2011, is currently operating systems. Typically, the OWC chamber dimensions have a single resonant frequency that captures wave energy over a narrow range of frequencies, while the rest is reflected. The provision of a pair of additional harbour walls in front of the device creates an additional resonance, thereby capturing significant wave energy over a wider range of frequencies. However, there is a significant loss of energy due to wave deformation as the wave approaches shallow waters, in which case the harbour walls prevent any further dissipation. Although there were a few pilot OWC plants, much remains to be investigated, especially in terms of improving OWC efficiency