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Experimental studies of interaction forces that affect the position of vertical plates on oscillating heave plates with cylindrical bodies in regular waves

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Abstract

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Abstract

This paper discusses an experimental study of a wave energy converter (WEC) without using reaction from the seabed. The WEC uses buoys and heave plates, which can react to their self-reacting. The interaction force between heave plates and buoys can absorb energy from ocean waves better. The heave plate model affects the output of energy produced. It is presented in this study with variations in the position of upright plates. The research aims to measure the influence of the place of the addition

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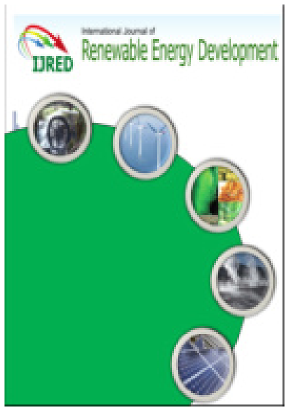

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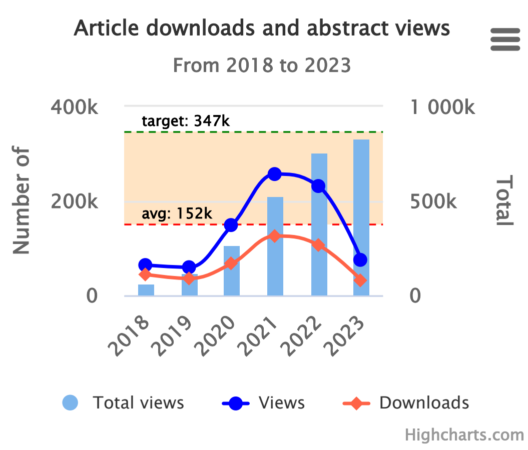

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Research Article

Experimental Studies of Interaction Forces that Affect the Position of Vertical Plates on Oscillating Heave Plates with Cylindrical Bodies in Regular Waves

Eko Sasmito Hadi[a,*], Muhammad Iqbal[a], Ari Wibawa[a], Ojo Kurdi[b], Karnoto[c]

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ABSTRACT. This paper discusses an experimental study of a wave energy converter (WEC) without using reaction from the seabed. The WEC uses buoys and heave plates, which can react to their self-reacting. The interaction force between heave plates and buoys can absorb energy from ocean waves better. The heave plate model affects the output of energy produced. It is presented in this study with variations in the position of upright plates. The research aims to measure the influence of the place of the addition of vertical plates into heave plates on the WEC on the hydrodynamic performance (coefficient of mass increase, drag coefficient, and KC value) and the interaction of the force it produces with the buoy on regular waves. The conclusion is the vertical plate position makes the coefficient of mass added Ca increase with an increasing amount of KC, and an almost linear relationship was observed between them. As the frequency increases, the value of C increases slightly, but it is not clear. Thus, the oscillating frequency has little effect on the mass coefficient of added heave plates with vertical plates. Thus, the change in the vertical plate position has only a powerful effect on KC < 0.75. ©2020. CBIORE-IJRED. All rights reserved

Keywords: Wave energy converter, heave plate, coefficient of mass, drag coefficient, buoy

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1. Introduction

Wave energy converters (WECs) that use non-seabed reaction sources, such as heaving plates, which are referred to in the wave energy literature as self-reacting WECs and because the buoy dimensions are relatively small compared with incident wavelengths, can be referred as the point of reaction at the absorber itself. The use of submerged bodies that act as reference actions of floating objects is not a new concept but will have a promising future.

Heave plates are used to transfer the PTO reaction force to the water, which is relatively stationary under WECs. Apart from the critical role played by heave plates in determining the dynamics of WECs and the efficiency of PTO, heave plates have little published research in the context of wave energy.

The dynamics of heave coupling in WECs have been taken into consideration by several authors (Davis, Thomson, Mundon, & Fabien, 2014; Olaya, Bourgeot, & Benbouzid, 2013; Rhinefrank et al., 2013; Ruehl, Michelen, Kanner, Lawson, & Yu, 2014). The dynamics of heave coupling in WECs are taken into consideration by several authors (Davis, Thomson, Mundon, & Fabien, 2014; Olaya, Bourgeot, & Benbouzid, 2013; Rhinefrank et al., 2013; Ruehl, Michelen, Kanner, Lawson, & Yu, 2014). A literature review reveals two patents and no technical papers that specifically focus on heave plates (Bull, Gerber, & Powers, 2011; US patent no. 20140232116A1, 2014). Heave plates are generally widely used in offshore structures because they can provide additional damping and mass increase to enhance the hydrodynamic response of the system (Zhu & Lim, 2017). The application of the use of an additional damper plate in the design of a WEC can increase the average annual energy production by 41% in the case of the point absorber WEC that self-reacts to heave movements in irregular waves (Beatty, Bocking, Bubbar, Buckham, & Wild, 2019).

Several articles about heave plates and their use have been found. Heave plates have been widely used for the spar platform to suppress heave movements, and then efficient top tensioned risers with dry trees can be used (Tao & Cai, 2004). Chakrabarti (Chakrabarti, Barnett, Kanchi, Mehta, & Yim, 2007) designed a truss-pontoon

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Research Article

On The Eddy Current Losses in Metallic Towers

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ABSTRACT. The existence of magnetic field around high-voltage overhead transmission lines or low-voltage distribution lines is a known fact and well-studied in the literature. However, the interaction of this magnetic field either with transmission or distribution towers has not been investigated. Noteworthy it is to remember that this field is time-varying with a frequency of 50 Hz or 60 Hz depending on the country. In this paper, we studied for the first time the eddy currents in towers which are made of metals. As the geometrical structures of towers are extremely complex to model, we provide a simple approach based on principles of electromagnetism in order to verify the existence of power loss in the form of eddy currents. The frequency-domain finite difference method is adapted in the current study for simulating the proposed model. The importance of such a study is the addition of a new type of power loss to the power network due to the fact that some towers are made of relatively conductive materials. ©2020. CBIORE-IJRED. All rights reserved

Keywords: Eddy current, finite difference method, metallic towers, power systems

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1. Introduction

It is a well-known fact that some of electrical energy generated and supplied to a distribution utility does not reach to the end consumer. Power generated in power stations passes through large and complex networks like transformers, overhead lines, cables and other equipment, which cause energy losses in the system. Losses in the transmission and distribution system are defined as technical and non-technical losses (Gustafson *et al.* 1989, Davidson *et al.* 2002). Some of the energy is lost as heat in the conductors, some are absorbed in insulating materials, and some of energy is dissipated into a magnetic field. So, different types of losses are present regardless of how carefully the system is modeled and designed.

Focusing on the magnetic losses, some literatures were dedicated to focus on the magnetic and electric fields around the overhead transmission lines (Grigsby 2007, Pettersson 1996, Ippolito *et al.* 2015, Liu *et al.* 1996, Pathak *et al.* 2003, Budnik *et al.* 2006). The environmental effect of the electromagnetic fields emitted from transmission lines on electrical and electronic instruments near it, the probability of affecting its operation and the effect of these fields on human's health have been one of the important concerns for many researches. Different methods was presented for minimising the magnetic field according to the place of the conductor in space (Pettersson 1996), or using passive circuits for the reduction of the harmful magnetic field for instance but not limited to Ippolito *et al.* (2015). The magnetic field around the conductors of the transmission lines reduces as the distance from the tower increases (Pathak *et al.* 2003) that is why high voltage transmission towers should not be located near residential areas as much as possible.

When talking about environment subjects that are affected by the magnetic field of transmission lines, it is worthy to shed light on the tower holding it too. Most of electrical transmission towers in most of countries are made of steel as for its high mechanical strength withstanding under bad climatic conditions. In addition, steel needs less maintenance compared to other material types. These towers are interacting with the magnetic field produced by the current carrying conductors of the three-phase transmission line (Ryan 2001). The transmission tower has a complex design characterized in a way to meet the special needs from structural/mechanical and electrical points of view.

The effect of the magnetic field on the maintenance personnel and how different type of towers have different susceptible to electromagnetic field is discussed in (Zemljaric 2011), where the author illustrates that the geometry of the one-circuit Y shaped tower is less favorable than the barrel two-circuit tower. Also, climbing routes which used for maintenance purposes were analyzed and the electric and magnetic fields are

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Research Article

Mathematical Modelling of Solar Photovoltaic Cell/Panel/Array Based on the Physical Parameters from the Manufacturer's Datasheet

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ABSTRACT. This paper discusses a modified V-I relationship for the solar photovoltaic (PV) single diode based equivalent model. The model is derived from an equivalent circuit of the PV cell. A PV cell is used to convert the solar incident light to electrical energy. The PV module is derived from the group of series connected PV cells and PV array, or PV string is formed by connecting the group of series and parallel connected PV panels. The model proposed in this paper is applicable for both series and parallel connected PV string/array systems. Initially, the V-I characteristics are derived for a single PV cell, and finally, it is extended to the PV panel and, to string/array. The solar PV cell model is derived based on five parameters model which requires the data's from the manufacturer's data sheet. The derived PV model is precisely forecasting the P-V characteristics, V-I characteristics, open circuit voltage, short circuit current and maximum power point (MPP) for the various temperature and solar irradiation conditions. The model in this paper forecasts the required data for both polycrystalline silicon and monocrystalline silicon panels. This PV model is suitable for the PV system of any capacity. The proposed model is simulated using Matlab/Simulink for various PV array configurations, and finally, the derived model is examined in partial shading condition under the various environmental conditions to find the optimal configuration. The PV model proposed in this paper can achieve 99.5% accuracy in producing maximum output power as similar to manufacturers datasheet.

Keywords: Forecasting, I-V characteristics, MPP, Partial shading, P-V characteristics, PV cell

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1. Introduction

Due to the rapid growth in renewable energy sources, the PV power market is rapidly expanded, especially in distributed generation field. So, the PV designers are in need of a reliable and flexible tool to predict the power generation by the PV systems of various sizes. The solar PV modeling is being updated endlessly to help the researchers for a better understanding of the operation. Depends on the various simulation software's such as Matlab, Simulink, C-program, Sci-lab, LTSpice, etc., the developed PV model differs from each other. However, most of the mathematical models are developed based on the voltage (V) – current (I) relations that result from simplifications to two-diode PV model presented by Chan & Phang 1987. The V-I relations for the one-diode model takes responsibility that one diode is sufficient to define the PV cell characteristics. This V-I relation is the basis for all the PV cell modeling. The simplification to V-I relation is done by considering infinite shunt resistance, and this is the basis for four parameter PV cell model. A simplified explicit model was developed by Chenni *et al.* (2007) by considering the short-circuit current of the cell is equal to the photocurrent. To solve the problem of deriving the maximum power output from the PV cell, Zhou *et al.* (2007) proposed the concept of fill factor.

The researchers such as Walker (2001); Premkumar *et al.* (2019); Ahmadi *et al.* (2018); Premkumar *et al.* (2018a); Longatt (2005); and Nguyen & Nguyen (2015) have developed the PV model using Matlab software to find the output PV current from the voltage, cell temperature, and solar irradiation, and discussed the effect on the PV cell due to the change in operating conditions such as cell temperature, diode quality factor, series resistance, and the solar irradiation. However, the readers require a programming skill to understand the overall concepts. Gow and Manning (1999) have developed a model using Matlab and C-programming and it is much difficult to understand the concepts. Among the various

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