THE CHOICE OF GEOMETRIC CONSTRAINTS VALUE APPLIED IN THE CONSTRUCTAL DESIGN FOR OSCILLATING WATER COLUMN DEVICE

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Abstract. *The present paper presents a two-dimensional numerical investigation about the fluid dynamic behavior of an Oscillating Water Column (OWC) Wave Energy Converter (WEC) into electrical energy. Constructal design is employed with the aim to perform a geometric evaluation of an OWC WEC. The objective function is to maximize the energy conversion. The hydropneumatic chamber volume* (V_E) *and the total OWC volume* (V_T) *are*

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adopted as geometric constraints, having constant values during the optimization process. The goal is to analyze the influence of the choice of this geometric constraints value on the OWC performance. For this purpose, the Constraint Variation (C_V) is considered. For this, different values defined from the volume formed by the height and the incident wavelength will be tested. To do so the degrees of freedom H_1/L (ratio between height and length of the hydropneumatic chamber), H_2/l (ratio between height and length of the chimney) and H_3 (OWC submergence) are kept constant. For the numerical solution it was used the Computational Fluid Dynamic (CFD) commercial code FLUENT®, based on the Finite Volume Method (FVM). The multiphasic Volume of Fluid (VOF) model was applied to tackle with the water-air interaction. The computational domain is represented by the OWC WEC coupled with the wave tank. Preliminarily, it is intended to obtain a theoretical recommendation about the constant value for the application of constructal design, aiming the maximization of the energy conversion from the incident waves. The results showed that when C_V = 1.75 the RMS hidropneumatic power available is maximum.

Keywords: *Wave Energy, Oscillating Water Column, Constructal Design, Volume Of Fluid, Geometric Constraint.*

1 INTRODUCTION

Fossil fuels supply a large percentage of the world's energy needs through a variety of technologies. Because they have been plentiful and are usually less expensive than other energy sources, fossil fuels supply nearly all of the world's energy. Fossil fuel technology has changed. Scientists are constantly looking for technology that makes fossil fuels work more efficiently and reduces pollution. Fossil fuels are so common and considered so necessary that there is great incentive for engineers to improve methods of acquiring and using fossil fuels (Schlager and Weisblatt, 2006).

In the international context, the word 'development' refers to improvement in quality of life, and, especially, standard of living in the less developed countries of the world. The aim of sustainable development is for the improvement to be achieved whilst maintaining the ecological processes on which life depends. Energy resources exemplify these issues. Reliable energy supply is essential in all economies for lighting, heating, communications, computers, industrial equipment, transport, etc (Twidell and Weir, 2006).

Based on these aspects, recently the countries have been invested in the explanation of new energy sources, especially in so-called renewable energy sources. Among them, the conversion of ocean wave energy into electrical energy has been highlighted. The energy contained in oceans can have different origins, generating different classifications. One possibility is the use of the kinetic energy available in the ocean waves through devices whose operating principle is the Oscillating Water Column (OWC) (Cruz and Sarmento, 2004).

One of the ways to develop technologies and/or devices to transform the energy of ocean waves into electrical energy is through numerical simulations. Several studies have been carried out employing numerical simulations about the operating principle of ocean wave energy converters in electrical energy. The multiphase Volume of Fluid (VOF) model was employed for the treatment of water-air interaction, proposed by, Hirt e Nichols (1981). The computational domain (OWC coupled to a wave tank with a numerical beach) was created and discretized in GAMBIT® software, while the numerical simulations were carried out by means a computational modeling implemented in the Computational Fluid Dynamic (CFD) commercial software FLUENT®, which is based on the Finite Volume Method (FVM) (ANSYS, 2016; Versteeg and Malalasekera, 2007).

It is possible to check that researchers have been apply the VOF model to numerical simulations of wave energy converters devices, as well as in the works of: Horko (2007), Conde and Gato (2008), Marjani et al. (2006), Liu et al. (2008a), Liu et al. (2008b), Gomes et al. (2009), Gomes (2010), Iahnke (2010), Conde et al. (2010), Conde et al (2011), Liu et al. (2011), Ramalhais (2011), Teixeira (2013), Gomes (2014), Gomes et al. (2015) e Lisboa et al. (2016). In the literature, there are some works about the geometrical optimization of the OWC device, as example:Tseng e Huang (2000), Dizadji and Sajadian (2011), Zhang et al. (2012), Senturk and Ozdamar (2012) and Bouali and Larbi (2013).

The OWC geometric optimization performed in Gomes et al. (2013) and Gomes (2014) was conducted employing the Constructal Design method, which is based on the Constructal Theory developed by Adrian Bejan (Bejan, 2000; Bejan and Lorente, 2008; Bejan and Zane, 2012; Bejan and Lorente, 2013). The Constructal theory explain deterministically how the generation of shape in flow structures of nature (river basins, lungs, atmospheric circulation, animal shapes, vascularized tissues, etc) is based on an evolutionary principle of flow access in time. That principle is the Constructal law: for a flow system to persist in time (to survive), it must evolve in such way that it provides easier and easier access to the currents that flow through it (Bejan and Lorente, 2008).

As it is possible to observe in the work of Gomes (2014) was considered simultaneously the VOF model and significant wave climate characteristics for development the OWC device. In this approach a CAO type device is sized so as to obtain maximum performance considering a regular wave characteristic.

In the present work, the goal is to analyze the influence of the choice of this geometric constraints value on the OWC performance. Therefore the Constraint Variation (C_V) is varied. The present study account the degree of freedom H_1/L (ratio between height and length of the hydropneumatic chamber), H_2/l (ratio between height and length of the chimney) and H_3 (OWC submergence) are considered to be equal to, respectively, 0.13 , 3.0 and 9.50 m. As geometric constraints for the optimization process, the hydropneumatic chamber volume (V_{HC}) and the total OWC volume (V_T) are varied according the Constraint Variation (C_V).

2 WAVE ENERGY CONVERTERS (WEC) – OSCILLATING WATER COLUMN DEVICE (OWC)

The energy contained in oceans can have different origins, generating different classifications. No doubt, the most relevant are the ocean tidal energy (caused by interaction between the gravitational fields of sun and moon), the ocean thermal energy (direct consequence of solar radiation incidence), the ocean currents energy (originated in the gradients of temperature and salinity and tidal action) and, finally, the ocean wave energy (which is result of the wind effect over the ocean surface) (Cruz e Sarmento, 2004).

The criterion usually adopted to classify the Wave Energy Converter (WEC) devices is related with its installation distance from the coast. In accordance with this classification, the WECs are grouped in: onshore (integrated with coastal structures, facilitating the access), near-shore (devices located in depths of 8 to 20 m) and offshore (installation depths upper than 25 m) (Cruz e Sarmento, 2004).

Another possible classification is associated with the principle adopted to transform the wave energy into electricity, existing three principal groups: Oscillating Water Column (OWC), Wave Activated Bodies (WAB) and Overtopping Devices (OTD). This classification does not end the possibility of other operating principle to be able for convert the ocean wave energy, being an example the submerged plate device (Carter, 2005).

The OWC devices are, basically, hollow structures partially submerged, with an opening to the sea below the water free surface, as can be seen in Fig. 1. In accordance with Cruz and Sarmento (2004), the electricity generation process has two stages: when the wave reaches the structure, its internal air is forced to pass through a turbine placed in its chimney, as a direct consequence of the augmentation of pressure inside the hydropneumatic chamber; and when the wave returns to the ocean, the air again passes by the turbine, but now being sucked from the external atmosphere, due to the chamber internal pressure decreasing. So, to use these opposite air movements usually the Wells turbine is employed, which has the property of maintaining the rotation direction irrespective of the flow direction. The set turbine/generator is the responsible for the electrical energy production.

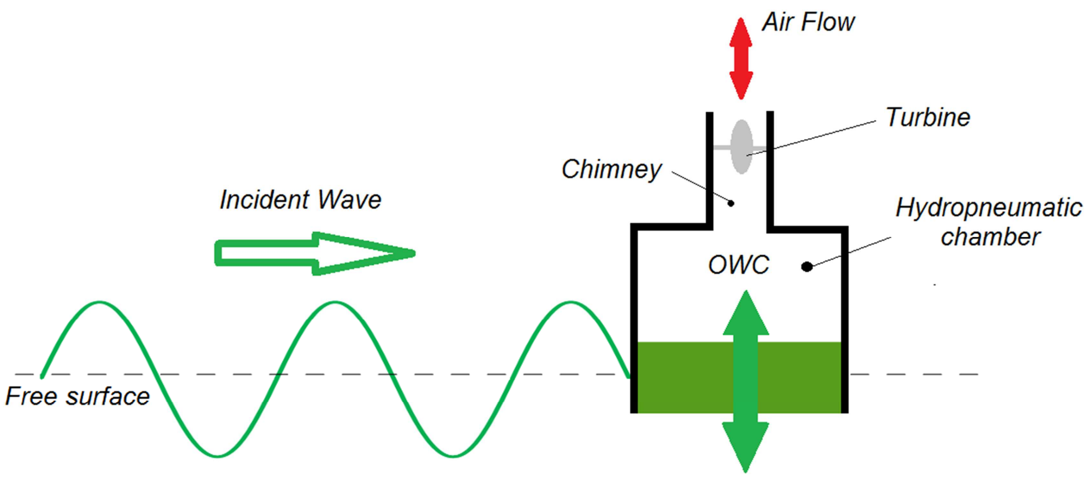

Figure 1. Illustration of physical main operational principle of Oscillation Water Column.

3 MODELING THE PROBLEM

3.1. Computational domain

One way to reproduce the interation among incident ocean waves and OWC's structure is by means a wave tank where the OWC device is placed (Horko, 2007; Liu et al., 2008, Gomes, 2009). In order to represent the problem on a appropriate scale in the computational domain is necessary know the wave parameters. Based on the of the period (*T*), height (*H*) and propagation depth (*h*) of the wave, it is possible to define the length (L_T) and height (H_T) of the wave tank (Fig. 2). The following characteristics were adopted: T = 5 s; H = 1 m; λ = 37,5 m e h = 10 m, H_T = 13 m e H_3 = 9,5 m.

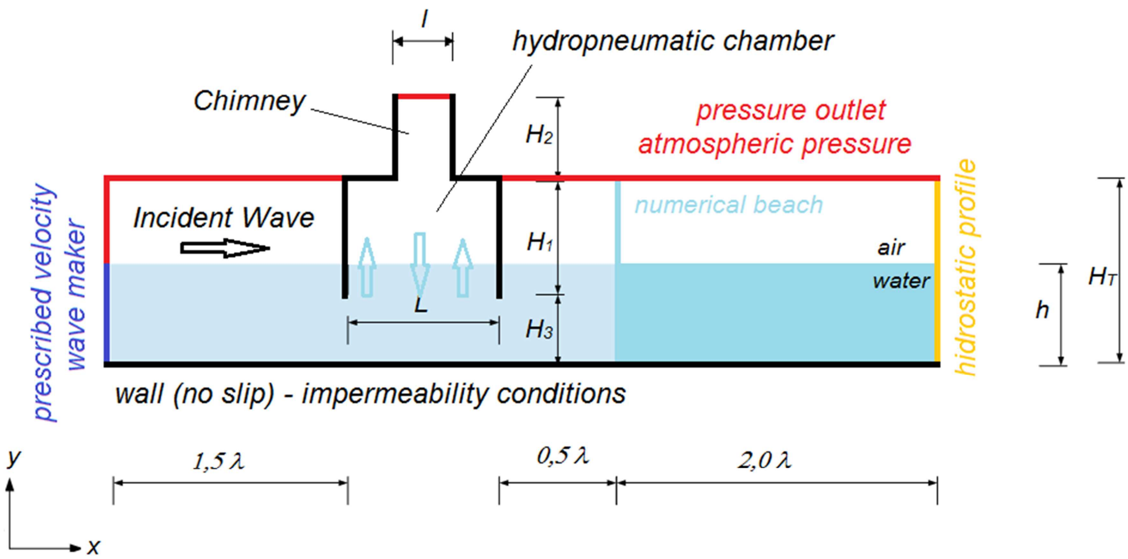

Figure 2. Computational domain schematic representation.

3.2. Boundary Conditions

As can be observed in Fig. 2, the wave maker is placed in the left side of the wave tank. For the regular wave generation it was employed the called Function Methodology (Gomes *et al*., 2009). This methodology consists of applying the horizontal (u) and vertical (w) components of wave velocity as boundary conditions (prescribed velocity inlet) of the computational model, by means an User Defined Function (UDF) in the FLUENT® software. These velocity components vary as functions of space and time and are based on the Stokes 2nd order theory. So these wave velocity components are given by (Dean and Dalrymple, 1991):

$$u = Agk\frac{\cosh(kz+kh)}{\omega\cosh(kh)}\cos(kx-\omega t) + A^2\omega k\frac{\cosh 2k(k+z)}{sen^4(kh)}\cos 2(kx-\omega t) \quad (1)$$

$$w = Agk\frac{senh\,(kz+kh)}{\omega senh\,(kh)}sen(kx-\omega t) + A^2\omega k\frac{senh\,2k(k+z)}{\cos^4(kh)}sen\,2(kx-\omega t) \quad (2)$$

where: H is the wave height (m); g is the gravitational acceleration (m/s^2); λ is the wave length (m); k is the wave number, given by $k = 2\,\pi/\lambda$ (m^{-1}); h is the depth (m); T is the wave period (s); ω is the frequency, given by $\omega = 2\pi/T$ (rad/s); x is the streamwise coordinate (m); t is the time (s); and z is the normal coordinate (m).

For the free surface elevation the following equation it is considered (Dean e Dalrymple, 1991):

$$\eta = A\cos(kx-\omega t) + \frac{A^2k\cosh(kh)}{4\,senh^3(kh)}\left[2+\cosh(2kh)\right]\cos 2(kx-\omega t) \quad (3)$$

Concerning the other boundary conditions, in the upper surfaces of wave tank and chimney and above the wave maker (dashed line in Fig. 2) it was considered the atmospheric pressure (pressure outlet). In the bottom of computational domain a no slip and impermeability conditions (wall) were adopted.

Initially it was considered the static fluid with depth (h) = 10.0 m. For this, the flat method, available in ANSYS (2016), was used to initialize the computational domain through Eq. 3 at time t = 0 s.

In the region of the right end of the tank, after the OWC device, see Fig. 2, it is considered a numerical beach. At the end of the tank is adopted a hydrostatic profile. Thus the effects of wave reflection are eliminated, and a totally numerical approach. The numerical beach method consists of adding sink terms in the momentum equations in a given region of the domain.These terms are represented by (Lisboa et al.,2016; ANSYS,2016):

$$S = -\left[C_1\rho V + \frac{1}{2}C_2\rho|V|V\right]\left(1 - \frac{z - z_{fs}}{z_b - z_{fs}}\right)\left(\frac{x - x_s}{x_e - x_s}\right)^2 \quad (4)$$

where C_1 and C_2 are linear and quadratic damping coefficients, respectively, ρ is the specific mass, V is the velocity, z is the normal position, z_{fs} and z_b are the vertical positions of the free surface and the bottom, x is the horizontal position, x_s and x_e are the horizontal position at the beginning and end of the numerical beach and S is a momentum sink term. According Lisboa et al., (2016), $C_1 = 20$ e $C_2 = 0$, as recommended.

3.3. Discretization of Computational Domain

For mesh generation, a methodology based on the stretched mesh technique was adopted (Mavripilis, 1997).In all numerical simulations the mesh follows a pattern where a special refinement is employed in some specific regions of the computational domain. As can be observed in Fig. 3, in the vertical direction the wave tank is divided in three regions nominated A, B and C. In the water free surface region (B region) it is adopted a refinement with 40 volumes in y direction (interval size equivalent to $H/20$) and with 50 volumes per wavelength in the x direction. Furthermore 10 and 90 volumes are used in y direction for the spatial discretization of A and C regions, respectively, in accordance with Barreiro (2009) and Gomes *et al*. (2012). To complete the computational domain mesh, squares with 0.1 m were used in the OWC discretization (region E). In the numerical beach region a stretch is applied to the mesh and 25 volumes per wavelength are considered.

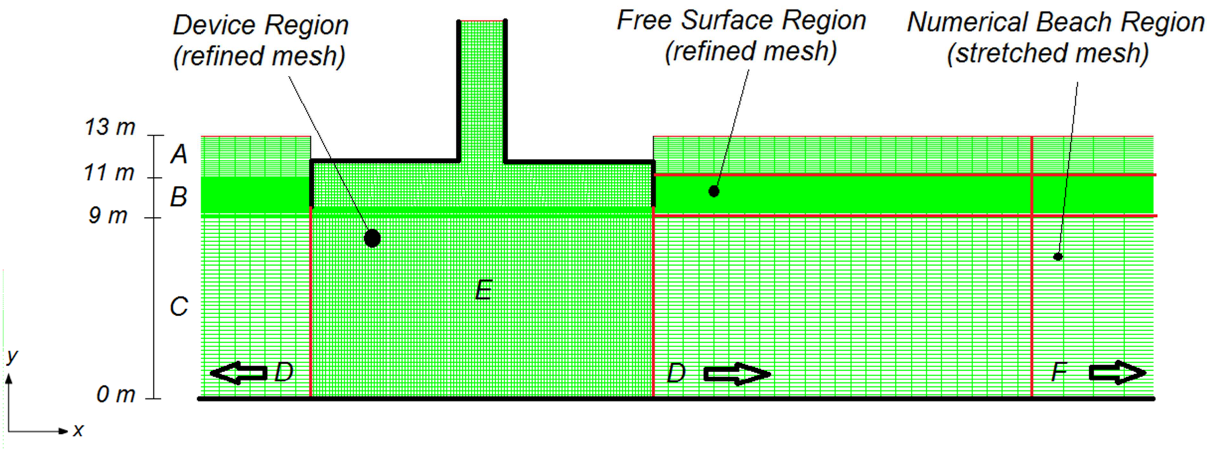

Figure 3. Detail about the regions defined for the mesh generation in the computational domain.

4 MATHEMATICAL AND NUMERICAL MODELS

The analysis consists in finding the solution of a water-air mixture flow. For this, the conservation equations of mass, momentum and one equation for the transport of volumetric fraction are solved with the Finite Volume Method (FVM) (Patankar, 1980; Versteeg *et al*., 2007).

The conservation equation of mass for an isothermal, laminar and incompressible flow with two phases (air and water) is the following:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{v}) = 0 \quad (5)$$

where ρ is the mixture density (kg/m³) and $\vec{v}$ is the velocity vector of the flow (m/s).

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The conservation equation of momentum is:

$$\frac{\partial}{\partial t}(\rho\vec{v})+\nabla(\rho\vec{v}\vec{v})=-\nabla p+\nabla\left(\overline{\overline{\tau}}\right)+\rho\vec{g} \tag{6}$$

where p is the pressure (N/m²), $\rho\vec{g}$ and $\vec{F}$ are buoyancy and external body forces (N/m³), respectively, and $\overline{\overline{\tau}}$ is the deformation rate tensor (N/m²), which, for a Newtonian fluid, is given by:

$$\overline{\overline{\tau}}=\mu\left[\left(\nabla\vec{v}+\nabla\vec{v}^{T}\right)-\frac{2}{3}\nabla\cdot\vec{v}I\right] \tag{7}$$

where μ is the dynamic viscosity (kg/m·s), I is a unitary tensor and second right-hand-side term is concerned with the deviatoric tension (N/m²).

In order to deal with the air and water mixture flow and to evaluate its interaction with the device, the Volume of Fluid (VOF) method is employed. The VOF is a multiphase model used for fluid flows with two or more phases. In this model, the phases are immiscible, that is, the volume of one phase cannot be occupied by another phase (Hirt and Nichols, 1981; LV *et al*., 2011).

In the simulations of this study, two different phases are considered: air and water. Therefore, the volume fraction concept (α_q) is used to represent both phases inside one control volume. In this model, the volume fractions are assumed to be continuous in space and time and the sum of volume fractions, inside a control volume, is always unitary, i.e., $0 \le \alpha_q \le 1$. Consequently, if $\alpha_{water} = 0$ the cell is empty of water and full of air ($\alpha_{air} = 1$) and if the fluid has a mixture of air and water, one phase is the complement of the other, that is $\alpha_{air} = 1 - \alpha_{water}$. Thus, an additional transport equation for one of the volume fractions is required:

$$\frac{\partial\left(\rho\alpha_q\right)}{\partial t}+\nabla\cdot\left(\rho\alpha_q\vec{v}\right)=0 \tag{8}$$

It is worth mentioning that the conservation equations of mass and momentum are solved for the mixture. Therefore, it is necessary to obtain values of density and viscosity for the mixture, which can be written by:

$$\rho=\alpha_{water}\rho_{water}+\alpha_{air}\rho_{air} \tag{9}$$

$$\mu=\alpha_{water}\mu_{water}+\alpha_{air}\mu_{air} \tag{10}$$

In the present work, the solver is pressure-based and all simulations were performed by upwind and PRESTO for spatial discretizations of momentum and pressure, respectively. The velocity-pressure coupling is performed by the PISO method, while the GEO-RECONSTRUCTION method is employed to tackle with the volumetric fraction. Moreover, under-relaxation factors of 0.3 and 0.7 are imposed for the conservation equations of continuity and momentum, respectively.

4.1. Verification of the Numerical Model

The computational model verification was performed comparing the transient water free surface elevation numerically obtained, in a specific position, x = 37,5 m, with the respective analytical solution, calculed by Eq. (3), vide Fig. 4.

For the error analysis are considered: Mean Absolute Error (MAE), Root Mean Square Error (RMSE), norm l_∞ and the phase difference between the numerical and analytical solutions. In order to compare the free surface elevation of the analytical and numerical solutions, the MAE was employed, given by:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|x_{num,i} - x_{ana,i}\right| \tag{11}$$

where: n is the number of samples analyzed, i is the sample number analyzed, $x_{num,i}$ represents the elevation instantaneous free surface obtained numerically and $x_{ana,i}$ represents the elevation instantaneous free surface obtained analytically. Also, the Root Mean Square Error (RMSE) was used to analyze the deviation, given by:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_{num,i} - X_{ana,i})^2}{n}} \tag{12}$$

In order to compare the peaks heights, of the analytical and numerical solution, one can use the norm l_∞, given by:

$$\left\|x\right\|_\infty = \underset{j}{máx}\left|x_j\right| \tag{13}$$

where x_j represents the variable in consideration at a given instant.

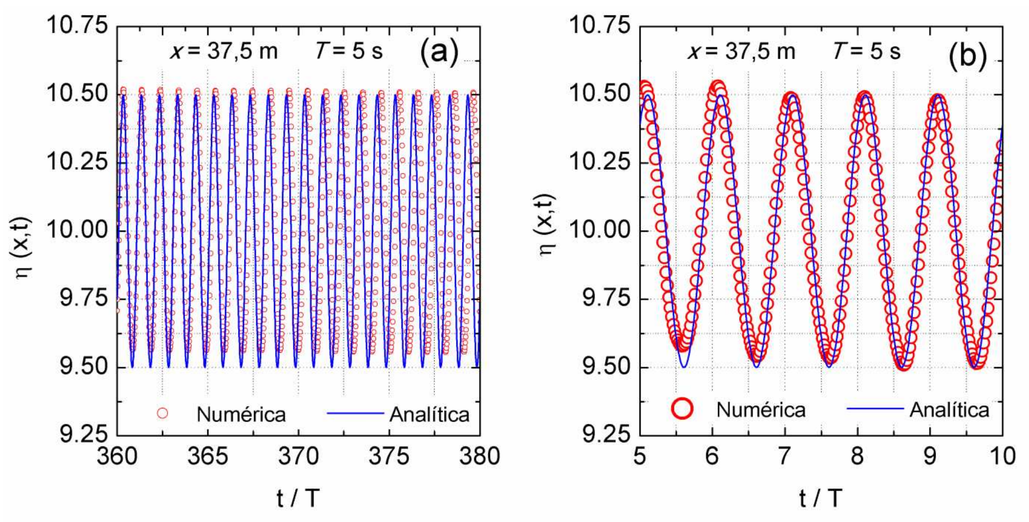

Figure 4. Water free surface elevation in x = 37.5 m for time range: (a) 360 < t/T < 380 e (b) 5 < t/T <10.

As can be seen in Fig. 4, the ocean wave generation with an MAE below 4% and with RMSE of less than 6%. In addition, as difference between the peaks ($\|x\|_\infty$ - norm) is less than 0.03 m. It should be noted, as can be seen in Fig. 4a, that there is a maximum phase difference between a numerical solution and an analytical value of -0.07.

Computational modeling using the VOF method has been largely employed to numerically simulate the WECs. Validations and verifications of these methodologies can be found in Horko (2007), Liu *et al*. (2008a), Liu *et al*. (2008b), Gomes *et al*. (2009), Gomes (2010), Ramalhais (2011), Liu *et al*. (2011) and Gomes *et al*. (2012).

5 CASE STUDY

5.1. Constructal Design

Constructal Design is a method employed to achieve geometric optimal shapes in flow systems. According this method the flow is malleable and the geometry is obtained from a principle of global performance maximization. In addition, geometry must be subject to global constraints and varied according to its degrees of freedom (Bejan, 2000). To apply the Constructal Design for the geometric optimization of a physical system it is required an objective function (a quantity that will be optimized), degrees of freedom (geometric parameters which may vary during the optimization process) and geometric constraints (parameters that are kept constant during the optimization process).

The aim this work is to analyze numerically the effect of choice the geometric constraint on performance of the OWC device. To do so the degrees of freedom H_1/L (ratio between height and length of the hydropneumatic chamber), H_2/l (ratio between height and length of the chimney) and H_3 (OWC submergence) are kept constant and, respectively, equal to: 0.13, 3.0 and 9.50 m, according proposed by Gomes(2014).

Two global constraints were considered: the OWC hidropneumatic chamber volume (V_E) and the OWC total volume (V_T), which are defined as:

$$V_E = H_1 L L_1 \tag{14}$$

$$V_T = V_E + H_2 l L_1 \tag{15}$$

where L_1 is the out-of-plane dimension which is constant and unitary, so that a bidimensional analysis can be assumed.

In general, the proposal is to apply Constructal Design associate with exhaustive search to optimize the two-dimensional geometry of a OWC converter device for maximum converting of wave energy. According Gomes (2014), using as reference the wave climate, it were considered that $L = \lambda$ and $H_1 = H$, allowing to define the value of the constraint V_E, see

Fig. 5. In turn, to determine the value of the constraint V_T, it was assumed that V_E has a value which is equal to 70% of V_T.

Thus, to analyze the effect of this choice, a Constraint Variation (C_V) was defined. This constant C_V is arbitrarily defined and causes variations in the volume V_E, as can be observed in Fig 5. The variation constant C_V is applied to Eq. (14) in order to analyze the effect of choice the geometric constraint V_E on performance of the OWC device.

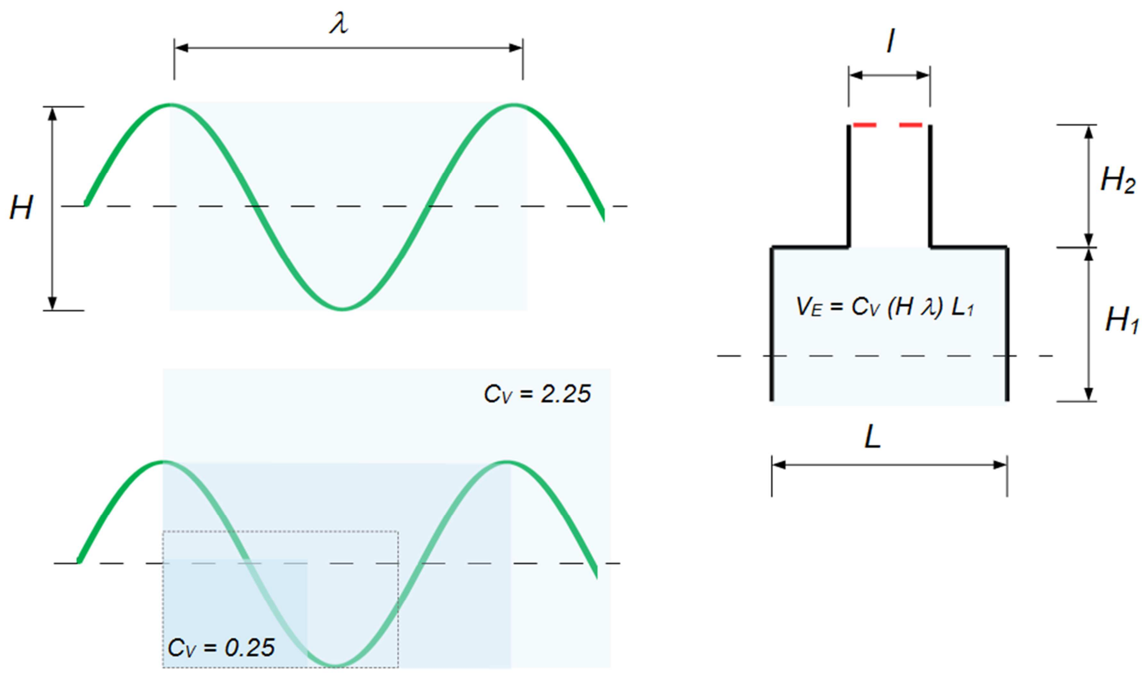

Figure 5. Definition and variation of the OWC device volume.

As showed in the Tab. 1, it is possible checked the geometrical configurations considered in this study. Besides that, the Constraint Variation (C_V) tested is presented in the Tab. 1. In general, the objective function considered is: mass flow rate, pressure and hydropneumatic power.

Table 1. OWC-WEC geometry variations

C_V	V_E [m^3]	V_T [m^3]	l [m]	H_2 [m]	L [m]	H_1 [m]
0.25	9.38	13.39	1.16	3.47	8.49	1.10
0.50	18.75	26.79	1.64	4.91	12.01	1.56
0.75	28.13	40.18	2.00	6.01	14.71	1.91
1.00	37.50	53.57	2.31	6.94	16.98	2.21
1.25	46.88	66.96	2.59	7.76	18.99	2.47
1.50	56.25	80.36	2.83	8.50	20.80	2.70
1.75	65.63	93.75	3.06	9.19	22.47	2.92
2.00	75.00	107.14	3.27	9.82	24.02	3.12
2.25	84.38	120.54	3.47	10.42	25.48	3.31

5.2. Results and discussion

The amplification factor (*Hm*/*H*) is defined by the ratio between the average height of the water free surface inside the OWC hydropneumatic chamber (*Hm*) and the height of the incident wave (*H*). In a practical point of view, the amplification factor allows to quantify the piston effect caused by the incidence of the waves over the OWC WEC (Ramalhais, 2011).

The behavior of the amplification factor in relation to the Restriction Constraint (C_V) is showed in Fig. 6.The results indicated in Fig. 6 show that, in general, the greater the Restriction Variation (C_V) (consequently, larger length (L) and Height (H_1) of the hydropneumatic chamber) the piston effect tends to decrease. Except when C_V = 2.25 where the amplification factor increases slightly.

For in this case, large movements of water take place inside the hydropneumatic chamber. Under these conditions, the length (L) of the hydropneumatic chamber approaches the length (λ) of the incident ocean wave. The movement of the free surface is large, but this growth isn't translated into an increase in the mass flow rate in the turbine region, as will be shown in Fig. 7.

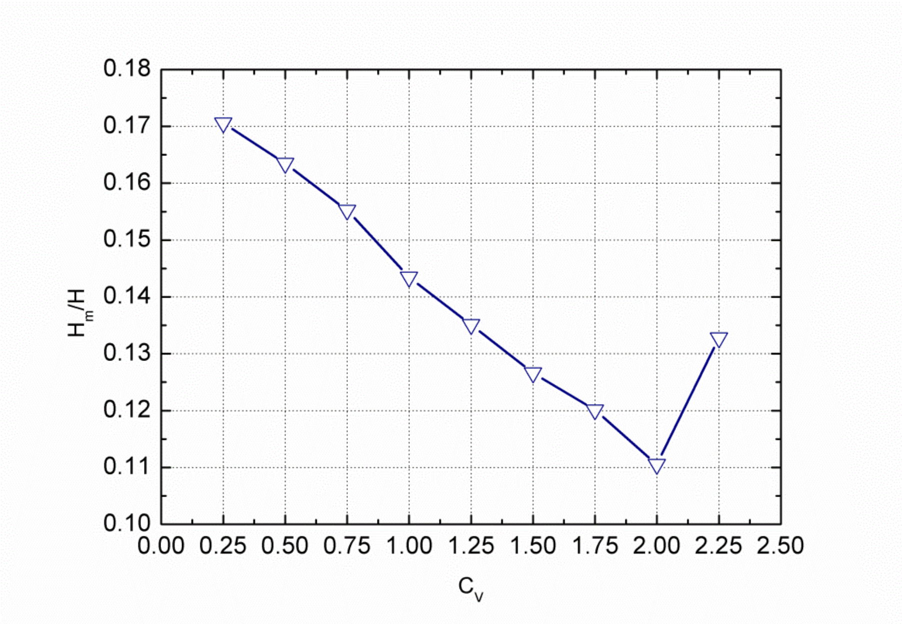

Figure 6. Behavior of the amplification factor.

In Fig. 7 it is possible to observe the behavior Root Mean Square (RMS) of the mass flow, as indicated by Marjani et al (2006) and Gomes (2014). The behavior shown in Fig. 7 indicates that when C_V = 1.0 a higher average mass flow rate is obtained in the turbine region. It should be noted that C_V = 1.0 was used by Gomes (2014). Table 1 shows the values of the length (L) of the hydropneumatic chamber for each constraint variation (C_V). By relating the length (L) of the hydropneumatic chamber with the length (λ) of the incident wave (λ = 37.5 m) it is possible to conclude that as the C_V increases the L / λ ratio increases. When C_V = 1.0 , best case, it has to be $L/\lambda \cong 0.5$.

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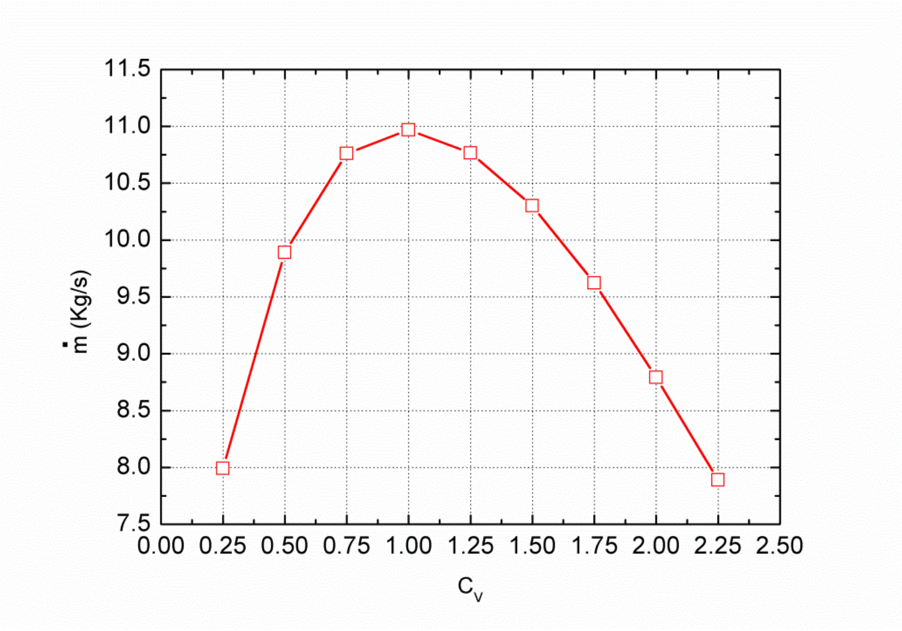

Figure 7. RMS behavior of the mass flow.

The pressure inside the hydropneumatic chamber is strongly related to the piston effect in the device, as indicated in Fig. 6 and Fig. 8. Figure 8 shows RMS the behavior for pressure similar to amplification factor.

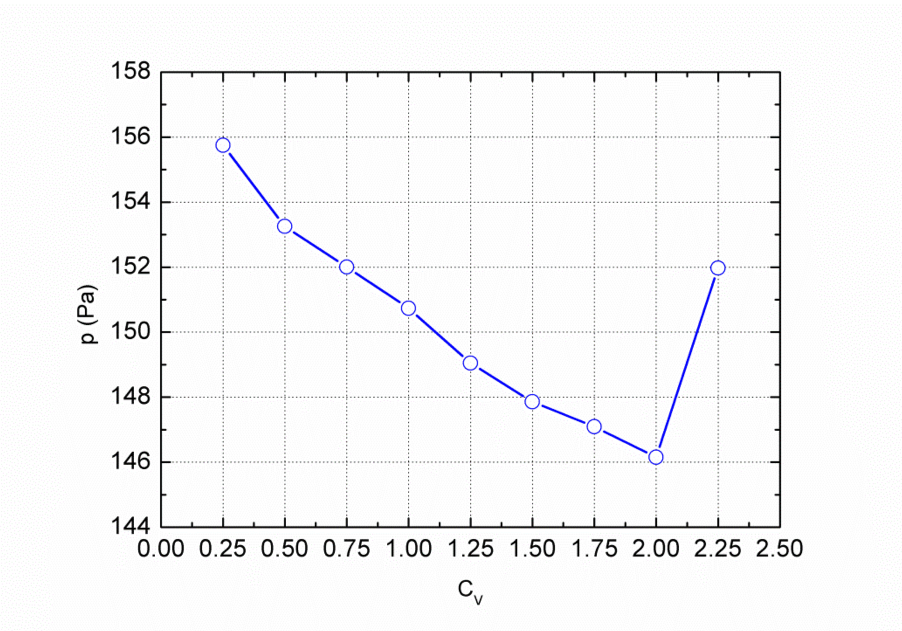

Figure 8. RMS pressure behavior.

So, the available hydro-pneumatic power was evaluated by (Dizadji and Sajadian, 2011):

$$P_{hyd} = \left(P_{air} + \frac{\rho_{air} v_{air}{}^{2}}{2} \right) \frac{\dot{m}}{\rho_{air}} \tag{16}$$

where: P_{air} is the static pressure in the OWC chimney (Pa), ρ_{air} is the air density (kg/m^3), $\dot{m}$ is the air mass flow rate crossing the chimney (kg/s), v_{air} is the air velocity in the chimney (m/s) given by:

$$v_{ar} = \frac{\dot{m}}{A\rho_{ar}} \tag{17}$$

being A the cross sectional area of the chimney (m^2).

Figure 9 shows the RMS hydro-pneumatic power for each C_V. It is important to emphasize that the hydro-pneumatic power is a composition of the mass flow and the pressure and the peaks of greater enjoy are different. When C_V = 1.75 the RMS hydro-pneumatic available reach the maximum peak. Comparing with C_V = 1.0, used in Gomes et. al (2013) and Gomes (2014) there was an increase of approximately 200 W in the average.

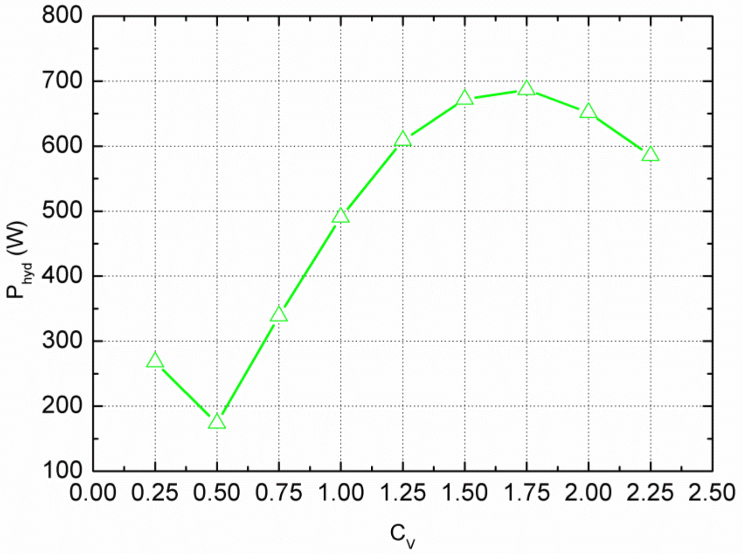

Figure 9. RMS hydropneumatic-power behavior.

Finally, for the case where C_V = 1.75 have that $L/\lambda \cong 0.59$, keeping the recommendations of Gomes (2014) which indicates that when $L / \lambda \cong 0.5$ has the maximum hydro-pneumatic power available.

6 CONCLUSION

In the present work a numerical study was carried out aiming to analyze numerically the effect of choice the geometric constraint, volume V_E, on performance of an Oscillating Water Column (OWC) Wave Energy Converter (WEC).

For this purpose, the Constraint Variation (C_V) was defined and considered. And different values defineded from the volume formed by the height and the incident wavelength was tested. To do so the degrees of freedom H_1/L (ratio between height and length of the hydropneumatic chamber), H_2/l (ratio between height and length of the chimney) and H_3 (OWC submergence) were kept constant. For the numerical solution it was used the Computational Fluid Dynamic (CFD) commercial code FLUENT®, based on the Finite Volume Method (FVM). The multiphasic Volume of Fluid (VOF) model was applied to tackle with the water-air interaction. The computational domain is represented by the OWC WEC coupled with the wave tank. The results show that when C_V = 1.75 the RMS hidropneumatic power available is maximum.

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