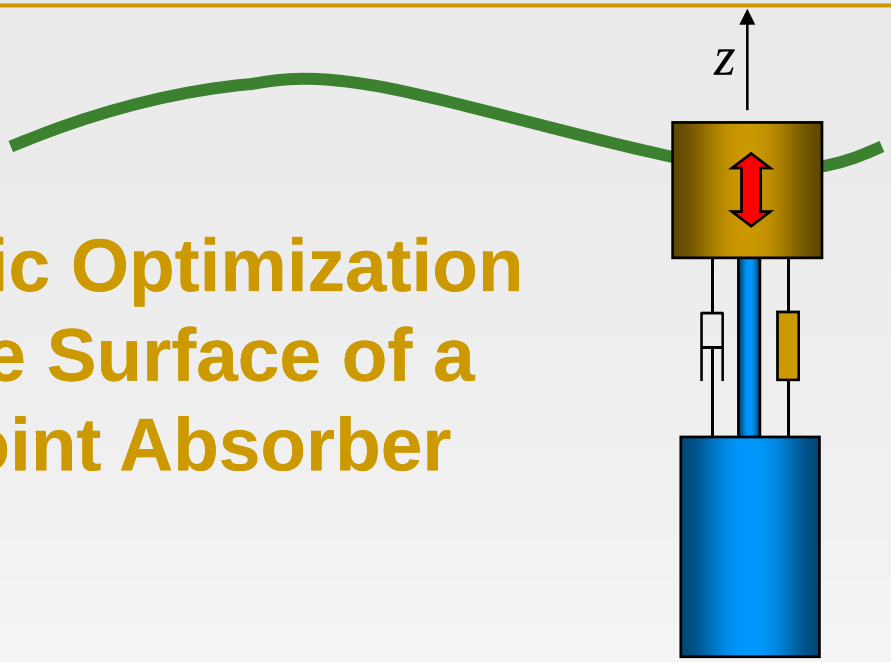

Hydrodynamic Optimization of the Active Surface of a Heaving Point Absorber

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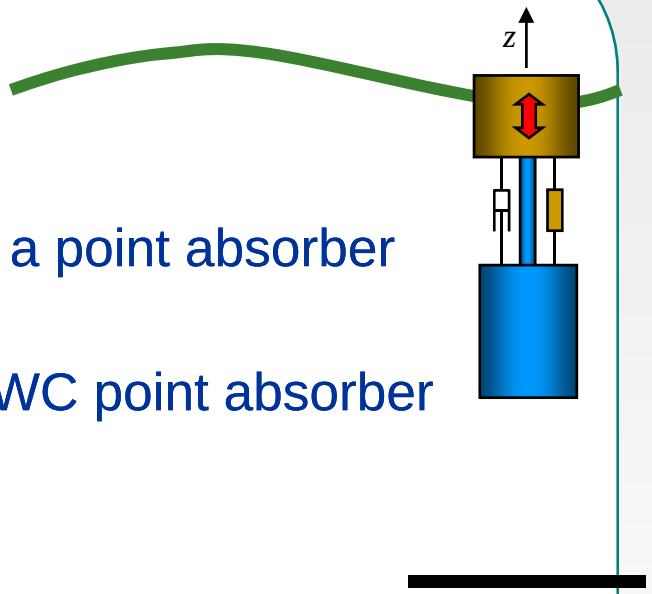
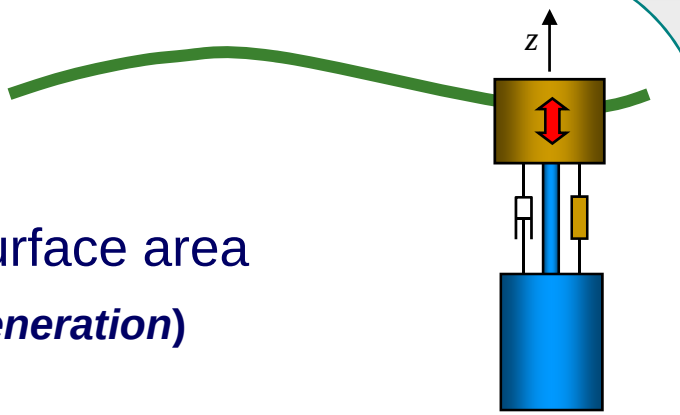
Summary

- Introduction
- Methodology to optimize the active surface of a point absorber
- Optimization of the overall dimension of an OWC point absorber
- Conclusions



Introduction

- Objectives:
  - Determination of the active surface area
    (*area responsible for the waves generation*)
  - Entire Volume of the WEC



- Assumptions:
  - Linear wave theory
  - Axissimetric point absorbers
  - Sinusoidal waves
  - Deep waters
  - 1 DoF (heaving)

Optimization of the Point Absorber Active Surface

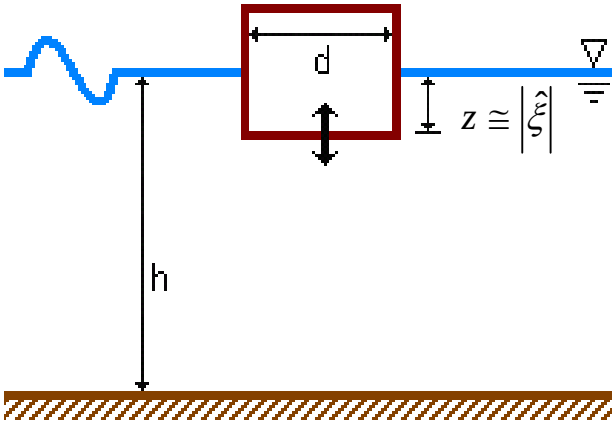
ACTIVE SURFACE DRAFT

- **Constant Hydrostatic Coefficient (*avoid slamming*)**
- **Velocity and Excitation Force in Phase**

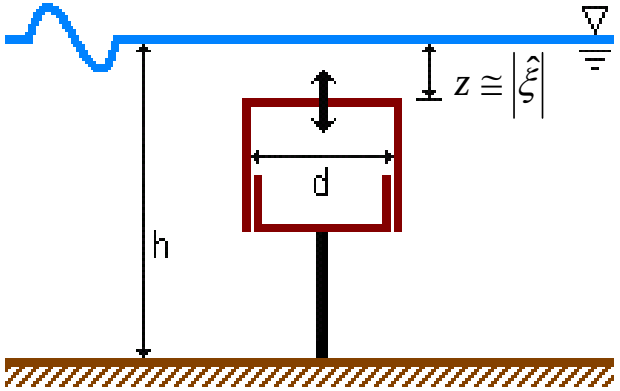
Heave Amplitude = Active Surface Draft

MAXIMIZATION of the WEC RADIATION CAPABILITIES

Partially submerged heave *WEC*



Totally submerged heave *WEC*



Optimization of the Point Absorber Active Surface

DECOMPOSITION of the EXCITATION FORCE

FROUD KRILOV

Totally submerged heave *WEC*

$$\hat{F}_{ext} = \hat{F}_{FK} + \hat{F}_d = \left(A\rho gS - A\omega^2 m e^{-k|z|} \right) \pm A\left(\omega^2 M - i\omega D\right)e^{-k|z|}$$

Partially submerged heave *WEC*

DIFFRACTION

SIMPLIFIED EXCITATION FORCE

$$\hat{F}_{ext}{}^{*} \cong \left(1 \mp k|z|M^{*}\right)e^{-k|z|}$$

Dimensionless Excitation Force as a function of the added mass *M* and the active surface draft *z*

ASSUMPTION:

Impedance dominated by the reactive term

iωM>>D

Optimization of the Point Absorber Active Surface

RESULTANT EXCITATION FORCE

$\hat{F}_{ext}^{\ *}$ → **Haskind** → D^{*} → **Kramers-Kronig** → $M(\omega)^{*}$

Dimensionless Excitation Force as a function of the infinite added mass m_{∞}.

$$\left|\hat{F}_{ext}^{*}\right| = \frac{\left(1-k|z|m_{\infty}^{*}\right)}{e^{3k|z|} - \frac{k^{2}SA}{2|z|}\left(k|z|m_{\infty}^{*} \pm 1\right)} e^{2k|z|}$$

Kramers Kronig Relation

$$M(\omega) - m_{\infty}^{*} = \int_{0}^{\infty} \frac{D(y)}{\omega^{2}-y^{2}}\,dy = \int_{0}^{a} \frac{D(y)}{\omega^{2}-y^{2}}\,dy + \underbrace{\int_{a}^{\infty} \frac{D(y)}{\omega^{2}-y^{2}}\,dy}_{=0}$$

ASSUMPTION:

Neglected **D(y)** for ***y>>a*** *and* ***z(a²/g)<1***

Optimization of the Point Absorber Active Surface

RADIATION POTENTIAL

$$\hat{\phi}_r = \underbrace{\hat{\phi}_{r_{nf}}}_{=0} + \hat{\phi}_{r_{ff}}$$

$$\hat{\phi}_r \approx C(\theta)e(kz)(kr)^{-1/2}e^{-ikr}$$

ASSUMPTION:

Neglected near body radiated potential for long distances from the wave source.

+

FAR FIELD COEFFICIENT

$$C = \frac{|A_r|g}{\omega}(kr)^{1/2} = \left(\frac{\omega k D}{\rho\pi}\right)^{1/2}|z|$$

ASSUMPTION:

For deep waters and long distances from the wave source the far field coefficient, C, can be described as for a plan wave.

+

EXCITATION FORCE for the DESIGN FREQUENCY

$$\left|\hat{F}^*_{ext}\right| = \frac{A}{|z|}\frac{1}{\pi(ka)^2}$$

ASSUMPTION:

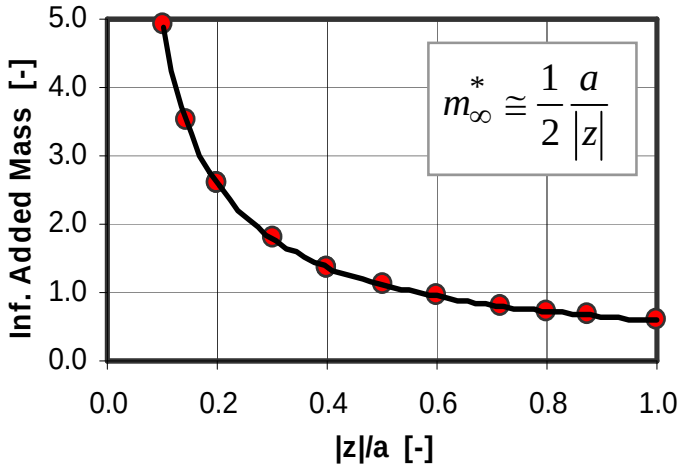
Optimal absorption condition, i.e, radiated power equal to the absorbed power

Optimization of the Point Absorber Active Surface

Equalizing Both Excitation Force Expressions Results:

$$\frac{A}{|z|}\frac{1}{Sk^2} = \frac{\left(1-k|z|m_\infty^*\right)}{e^{3k|z|} - \frac{k^2 SA}{2|z|}\left(k|z|m_\infty^* \pm 1\right)} e^{2k|z|}$$

Numerical Evaluation of the Infinity Added Mass



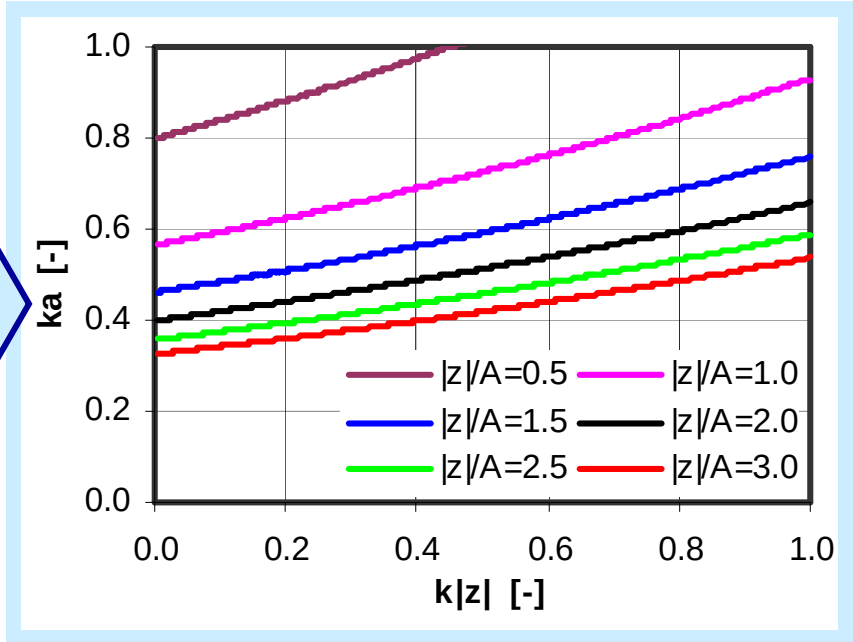
Non-dimensional relation between the optimal active surface radius, ***ka***, relative draft, ***k|z|***, and relative displacement amplitude, ***|z|/A***.

$$\frac{A}{|z|} \cong \pi(ka)^2 e^{-k|z|}$$

Optimization of the Point Absorber Active Surface

Non-dimensional relation between the optimal active surface radius, ***ka***, and relative depth, ***k|z|***, for several relative displacements, ***|z|/A***.

$$\frac{A}{|z|} \cong \pi (ka)^2 e^{-k|z|}$$

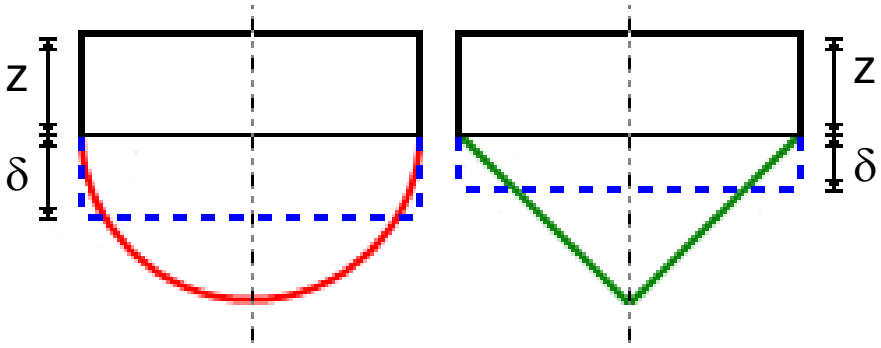


Optimization of the Point Absorber Active Surface

REDUCTION OF THE VISCOUS EFFECTS

Methodology:

Non-linear evaluation of several bottom shapes to identify the one which reduces the viscous dissipation and also minimizes the increment, ≙, of the dynamic pressure centre



Potential WEC bottom shapes for the reduction of viscous effects (red or green)

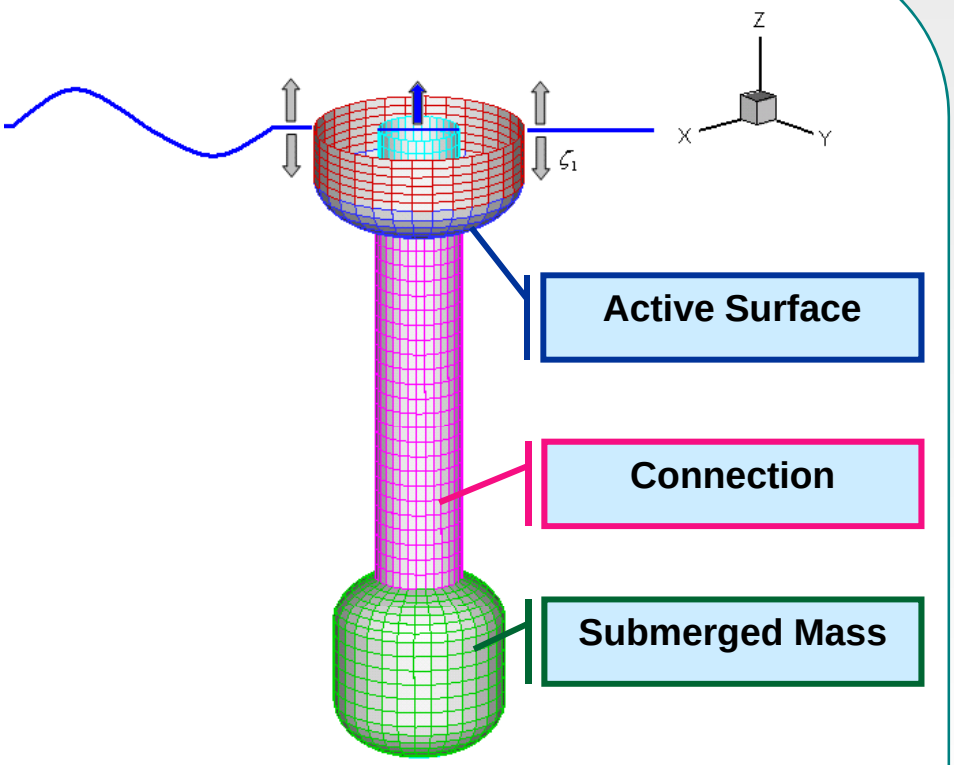
Respective flat bottoms at identical depth of the dynamic pressure centre (blue).

$$\frac{A}{|z|} \cong \pi(ka)^2 e^{-k|z+\delta|}$$

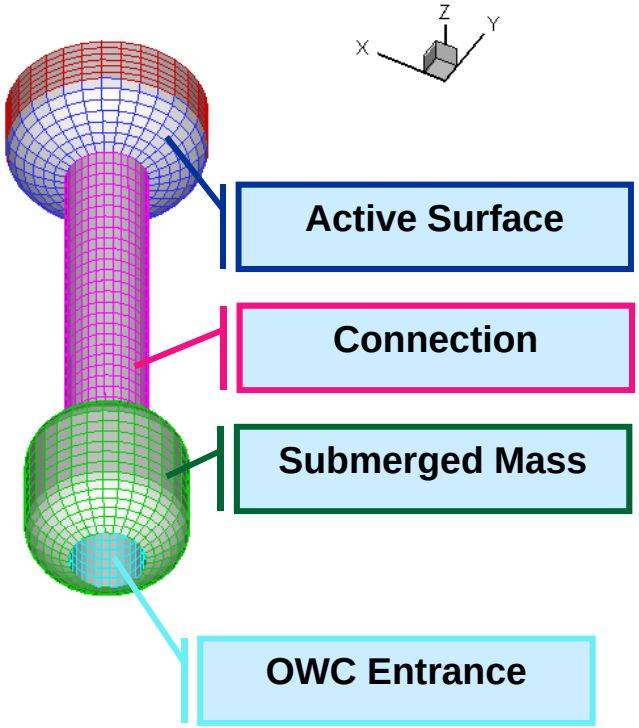
Non-dimensional relation slightly modified to take into account the additional depth of the dynamic pressure centre, ≙.

OWC WEC Under Evaluation

LATERAL VIEW



BOTTOM VIEW



Discretization of the OWC Wet Surface

Conclusions

Active Surface:

It seems to be possible to define the active surface of an heaving point absorber to maximize the energy absorption.

Entire Volume:

The entire volume of the device should be defined according to the area of the active surface adding a submerged mass located deep enough not to affect significantly the optimized radiation capabilities of the device.