CFD SIMULATION OF A MOORED WAVE ENERGY DEVICE

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State-of-the-art and implementation of design tools for floating structures

• **Scope of work**
  
  - To date there has been no widely available and well validated tool for numerically testing of **moored floater** designs in more **extreme sea conditions** involving steep-sided and breaking waves or strong currents.
  
  - Aim is to develop and validate a CFD tool for assessing floating WECs
    
    • **Flexibility** of the structure ignored so 6 DOF representation of body state.
    
    • Focus on **2-way coupling** between structure and water including
State-of-the-art and implementation of design tools for floating structures

• Contribution

In this study OpenFOAM® has been employed,
- incompressible Navier-Stokes equations
- Testing of key components
  - two-way coupling between the body motion and fluid dynamics
    - Interface: body boundary position and boundary condition
  1) 6 DOF body motion
  2) fluid-structure boundary surface is displaced in accordance with the total hydrodynamic plus external forces → dynamic mesh algorithm → redistribute mesh internal mesh points governed by mesh quality algorithm.
  3) moving wall BC is applied for the fluid velocity field in order to ensure the no-slip condition.
  4) With the updated boundary position + condition, the surrounding flow for the new time is computed

• Surface capturing algorithm
  - VOF: volume fraction scalar and solving the corresponding phase fraction equation
Proof of concept

• A TLP concept is applied, which envisages a combined wind and wave energy extraction design.

Body
• $h = 1.5$ m,
• diameter top: 0.16 m and bottom 0.45 m
• draft $T = 1.2$ m,
• roll moment of inertia $5.45 \, \text{kgm}^2$

Comp. domain
• $10 \times 10 \times 6 \, \text{m}^3$
• still water level being at $z = 5.0$ m

Mooring lines
• Springs including damping
• Attached at bottom

Turbulence model

BCs
• Active absorption
• JONSWAP spectrum $H_s = 0.15 \, \text{m}, T_p = 1.6 \, \text{s}$
• Regular waves: $H = 0.2 \, \text{m}, T = 1.8 \, \text{s}$
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hydralab IV measurement at DHI

- TLP (MIT/NREL) model 1:40
  - simple geometry and mooring lines
  - Regular waves and real sea state measurements
  - spring mooring lines
hydralab IV measurement at DHI

- Motion of the floater
  - Drift motion
Numerical results

- Results in irregular waves
Numerical results

- Results in irregular waves

Snap shot of the solution state
Numerical results

• Simulation example

Time: 0.00 s

Hs = 3.6 m and Tp = 5.4 s
Motion of the floater

- Results of CFD simulation
hydralab IV measurement at DHI

- Mooring forces

Regular waves

Irregular waves

Irregular waves (OpenFOAM)
Thank you for your attention

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