Numerical Simulation of a Wave-Powered Autonomous Underwater Vehicle Charging System

Awais Ahmed, Ocean and Mechanical Engineering, Florida Atlantic University
James VanZwieten, Ocean and Mechanical Engineering, Florida Atlantic University
Yufei Tang, Electrical Engineering and Computer Science, Florida Atlantic University
Mark Supal, Engineering Technologies, LLC

The Platypus Prowler WEC effectively converts wave energy into electrical power.

INTRODUCTION

Wave Energy Converters (WECs) harness the energy found in waves to create electricity through methods. There are three types of WECs;

1. Overtopping WECs; These devices capture water above the water level. Convert it into electrical power by utilizing its potential energy.

2. Oscillating Water Column WECs; By utilizing the movement of waves to drive air through directional wind turbines these WECs generate electricity.

3. Oscillating Body WECs; These devices use wave movements to generate power with their motions serving as the basis, for electricity production.

This study focuses on modeling and Simulation process of an oscillating body WEC using WECSim software providing insights, into simulation results.

Hydrodynamic coefficients are calculated using Capytaine.

Platypus WEC Design

- The AUV is positioned vertically, three paddles emerge from its side.
- The paddles' motion induces fluctuating torque and angular speed relative to the AUV body.
- The Platypus Prowler WEC features a 48-inch cylinder with specific buoyancy and mass characteristics for upright flotation.

- The paddle assembly includes a half-sphere bladder that inflates during the recharge phase for efficient power harvesting and energy conversion.
- The Paddle length is 48 inches from the hinge point.
- To increase the buoyancy inflated ballon are placed at the of each paddle

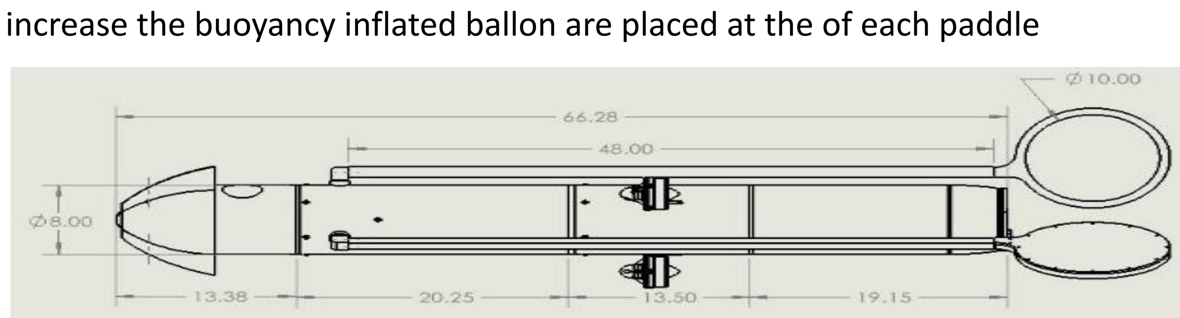


Figure 2: Geometrical Parameters of platypus Prowler WEC

RESULTS

Figure 1: Dual modes of the Platypus Prowler WEC

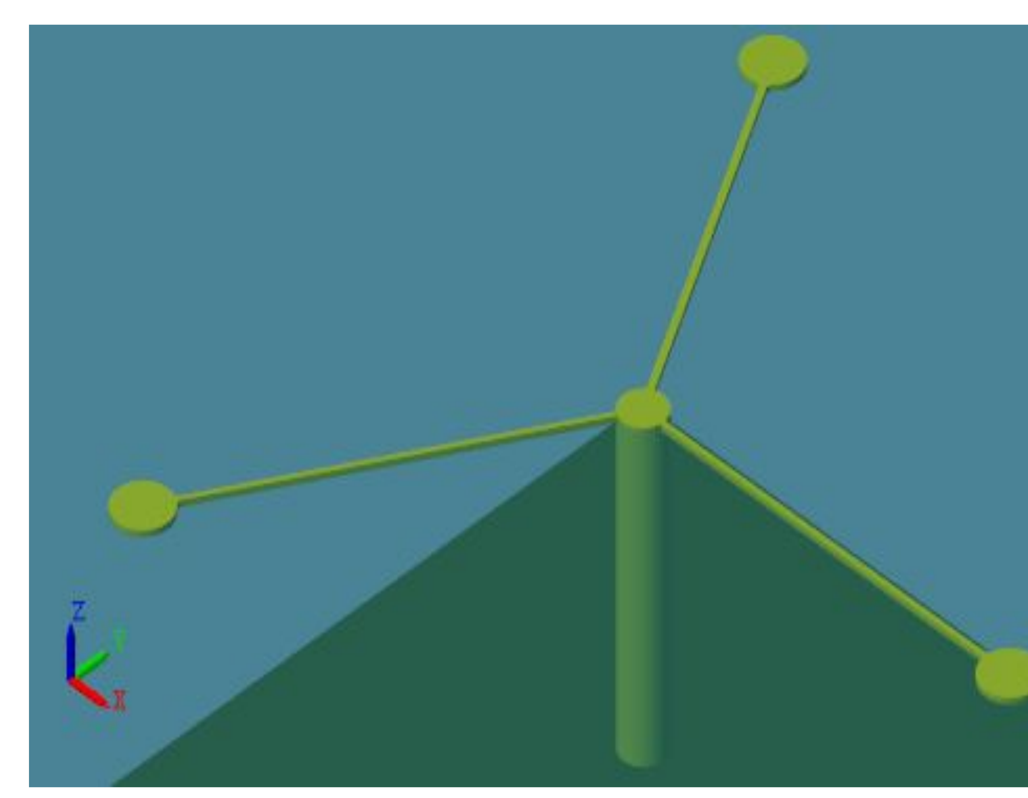


Figure 4: Numerically simulation of platypus Prowler WEC

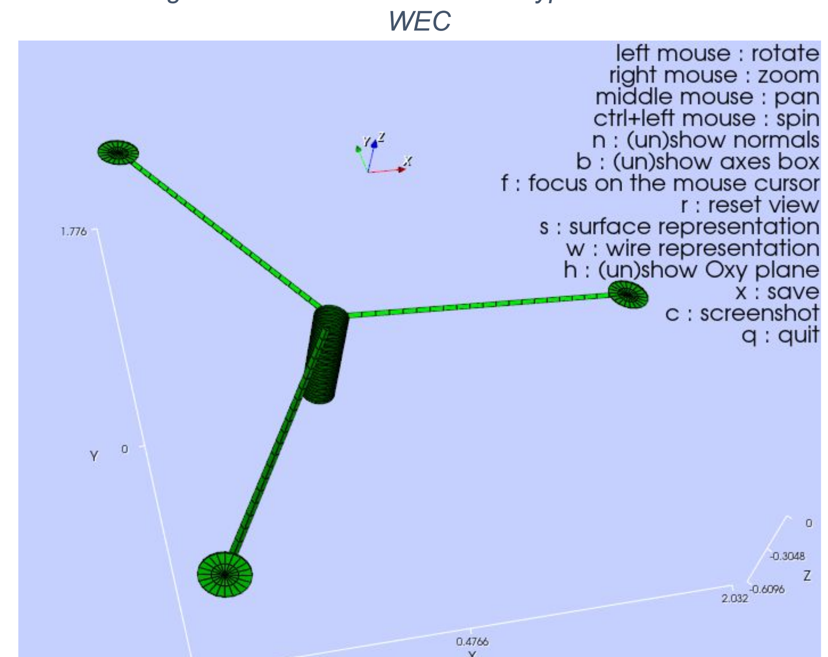


Figure 3: Mesh analysis of Platypus WEC in Capytaine.

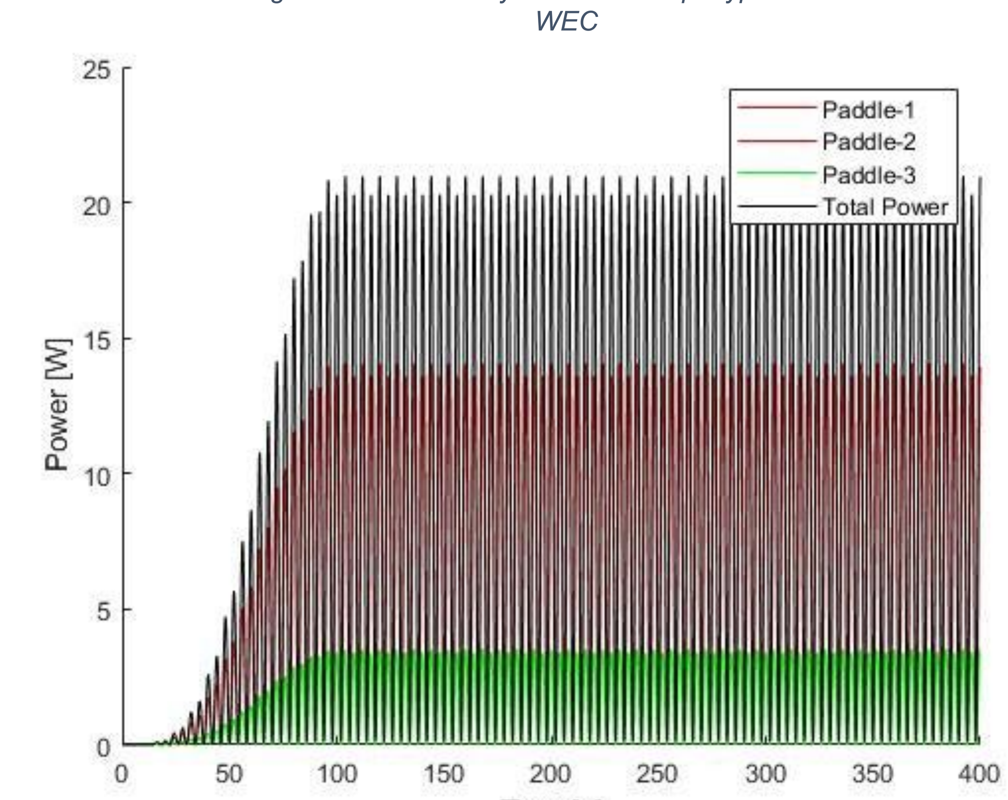
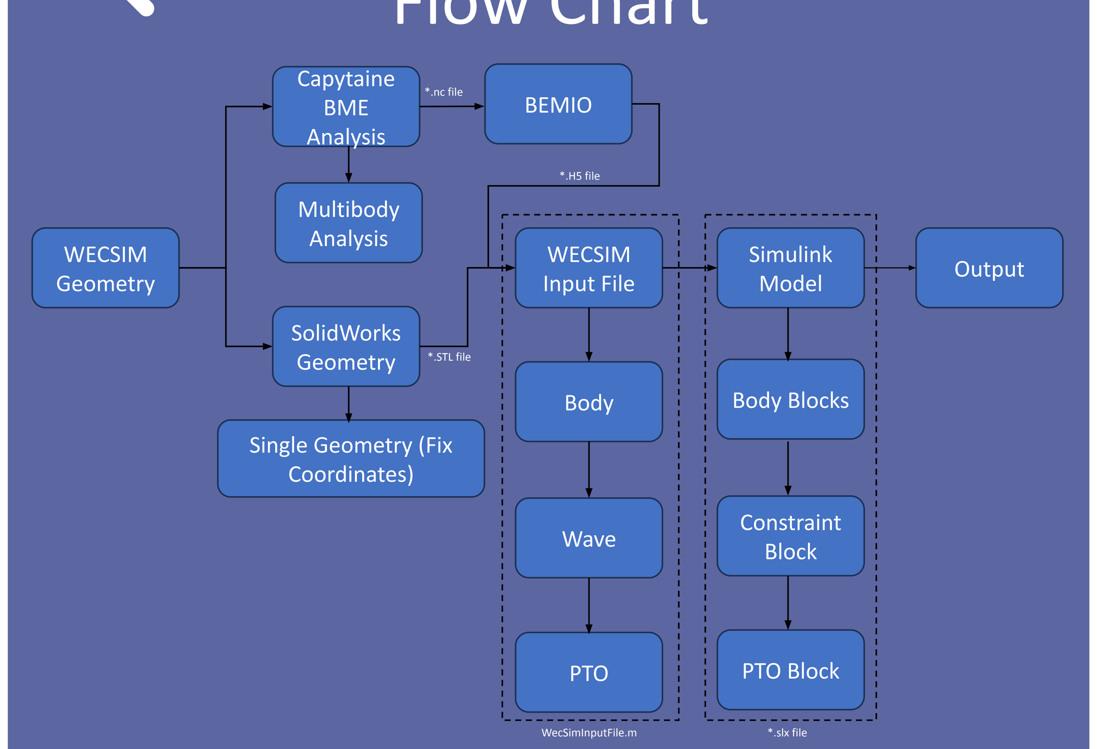


Figure 5: Power Produced by Paddles and Total Power.

Numeric Simulation Development

- The WEC was accurately replicated in SolidWorks, featuring a primary hull and three identical paddles positioned at regular 120-degree intervals.
- The design ensures precise calculations with the origin set at [0, 0, 0].
- Hydrodynamic coefficients were obtained using Capytaine, a commercial boundary element method software.
- A high-resolution mesh with 152,640 elements was used to capture diffraction and wave reflection effects.
- The model was integrated into a Simulink simulation, assigning each paddle and hull component relevant mass and inertia parameters.
- Rotational PTO systems were implemented at the paddle pivot points to efficiently convert mechanical energy into electrical energy.
- Each PTO was configured with precise damping coefficients and positioned at specific coordinates to optimize energy conversion and maintain balanced forces across the system.

Flow Chart



Results & Future Work

- Simulation runs from 0 to 400 sec with a wave ramp time of 100 sec.
- Regular wave conditions with a height of 0.5 meters and a period of 8 sec.
- Total system power reaches around 22 watts as all paddles generate power.
- WEC averages 9 watts of power output.

FUTURE WORK

- Evaluate design variants with different significant wave height and Time period.
- Performance evaluation will be done by changed number of arms 3 to 6, buoyancy ±25% and length of the paddles ±25%.
- Analyze the one-way (rising only) torque transfer approach for power production.

CONTACT

Awais Ahmed
Email: awaisahmed2022@fau.edu