A Low-cost Wave Energy Harvesting Device

Mechanical Engineering

Student Team: : Matthew Moniz, Sanjay Sivakolundu, Bilal Anwar, Kharma Garcia, Vincent Yang, Mahmoud Qaddoura, Ezequiel Trujillo, Maria Badas, Jelizaveta Chern, Jose Sandoval, Aleksey Bodur.

Advisor: Dr. Yuanyuan Xie **Industrial Advisor/Mentor:** Mr. Joseph Santos

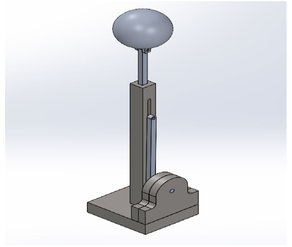
FRESNO STATE

Lyles College of Engineering

Abstract

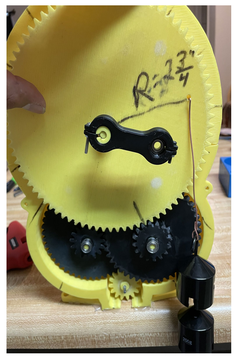
Marine energy has great potential to help reduce greenhouse gas emissions and mitigate climate change, which also can help improve national energy security by diversifying the sources of energy used to generate electricity. In this project, a marine energy system is designed and tested, which leverages an innovative electro-mechanical drivetrain to efficiently harness the oscillating power of ocean waves for renewable electricity generation. The design uniquely incorporates adjustable geometry allowing operation across a wide range of wave heights and tidal conditions.

Design Concept



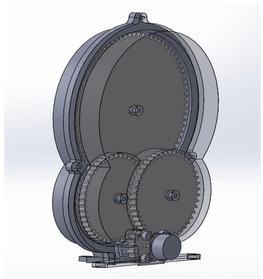
A buoyant surface component couples the wave motion via a sliding piston to an underwater four-bar crank mechanism driving a generator's rotating shaft. Critical features include a dual-crank, a flywheel providing inertial energy storage for consistent generator operation, and a gearbox boosting the input speed to the optimal generator rpm.

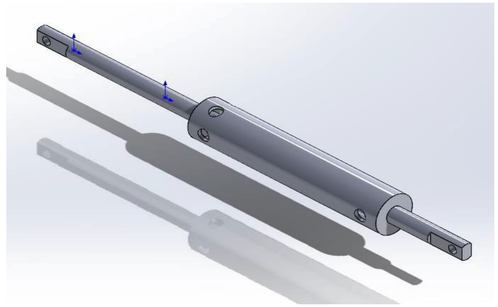
Prototyping and Test



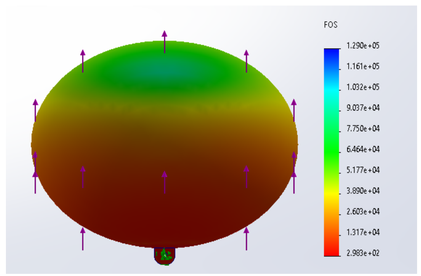
Gear Train and Piston Arm

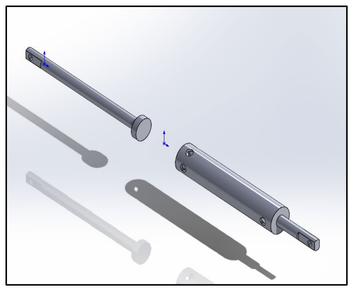
A gear box and a four-bar mechanism were designed to provide consistent power to generator:

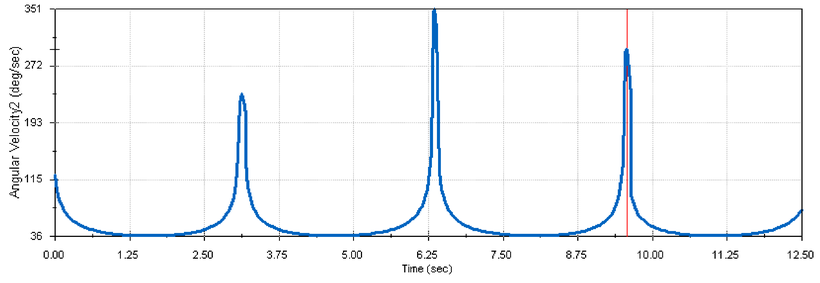


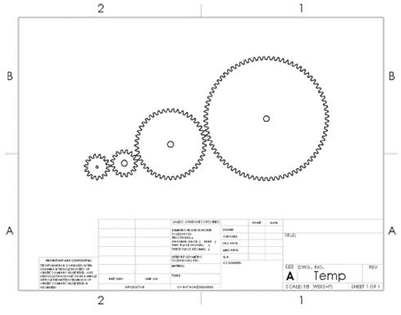


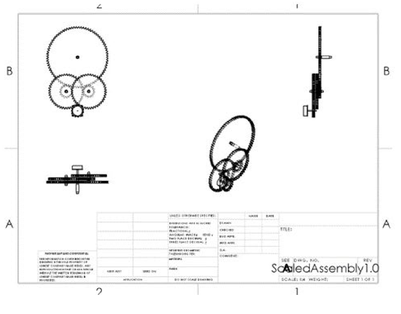
SW Drawings & Simulation











Mechanical Loading and Power

The wave energy harvesting system is designed to operate at 30 ft depth, 2 ft wave height every 14 seconds:

1) Buoy diameter of 6 ft with maximum buoyancy force of 3,000 lbs, which is applied vertically upwards on the piston and results in a factor of safety of 4.6 on the driving arm (max stress of 4.6 MPa);

2) Torque on input gearbox shaft calculated as 3,407 W assuming max buoyancy force, and after 95% efficient gearbox, 3,237 W power can be transmitted to generator, which likely operates most efficiently around 3,000 W output.

Summary

- We developed an energy harvesting device to convert ocean wave motion into electricity through an innovative design of a sliding piston and four-bar mechanism connected to a buoyant surface buoy.
- As waves raise and lower the buoy, the adjustable geometry can accommodate varying wave heights by allowing controlled water flow into/out of the piston cylinder. This oscillating motion drives a dual-arm crank mechanism that spins a flywheel coupled to an electrical generator. A gear train with a ratio of 1:45 steps up the crank rpm to the generator's optimal speed.
- The overall electro-mechanical drivetrain is designed with appropriate factors of safety per offshore codes, while the buoy and mooring provide hydrostatic stability. The design allows broad operation across varying wave conditions while decoupling for storm survivability.

Acknowledgement

We gratefully acknowledge the support from MECC24 (NREL & DOE), and the support from LCOE, our faculty advisor and industrial mentor.

2024