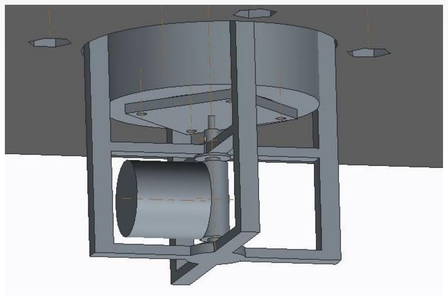

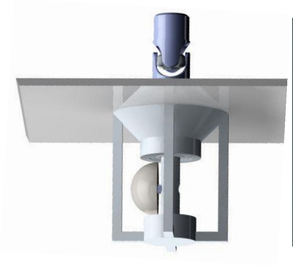

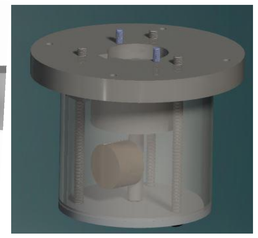

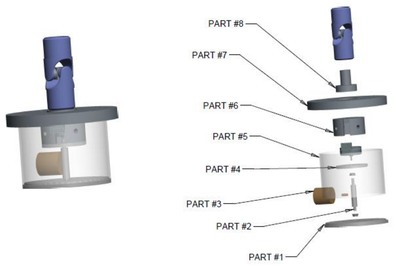

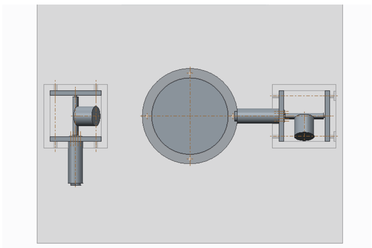

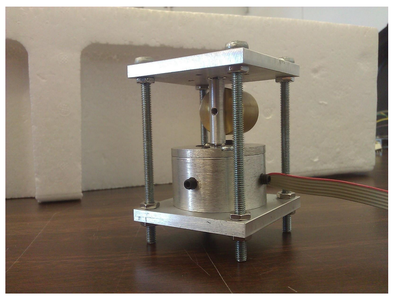

Experimental Modeling and Simulation of a Ship Wave Energy Harvester and Wave Generator

Abstract

An experimental sea-wave ship energy harvester model is presented. Oceans and other large bodies of water have naturally occurring consistant waves, holding large amounts of untapped energy. In contrast to typical hydroelectric power generation (mills, pumps, etc.) which relies on the flow of water, wave energy harvesting has gained significant attention due to its availability around the world. The motivation for this work came from the interesting nonlinear relationships between roll and pitch frequencies experienced by seagoing ships when excited by low-frequency traveling waves of the ocean. By stationing a sea-wave ship energy harvester out to sea, energy can be collected from the ocean waves and provide power to remote locations or if placed near a shore, provide power to the grid. The test setup that is presented herein consists of the following: a scaled ship-like design that houses a pendulum-based energy harvesting device, a wave generator system, and various data acquisition systems. The initial ship designs were of very simple geometry, a trapezoidal cross-section made up of polycarbonate plastic. The last trapezoidal ship design housed three pendulum energy harvesters, each with a different configuration so comparisons could be easily made between the three. The pendulum energy harvester consists of a brass cylinder that acts as the pendulum, coupled to a DC generator. As the ship experiences roll and pitch motion the pendulums rotate, turning the DC generator in order to produce electricity. To simulate the ocean conditions, a large water flume is pumped with water and a wave generator was designed and built to produce similar waves to force the ship into roll and pitch motions. Data was collected using a range of sensors to accurately capture the motion of the ship, the wave height and frequency, the motion of the pendulums, and the power produced by the DC generators. After subsequent analysis, several iterations of the ship and energy harvester module have been made to optimize the amount of energy collected.

Design Progression

The design process, as was stated, consists of three parts: the wave generator, the ship, and the energy harvester module. The wave generator was designed and fabricated early on in the course of this project. The challenge for us was getting it to function properly. After much investigation we managed to have it produce smooth rolling waves. This was done by changing the voltage and current supplied to the motor, the arm length of the paddle, and a method to dissipate the waves at the opposite end of the flume.

The next challenge was in the design of a ship model. Early modeling of the possible characteristics of the ship design proved overly complex and thus a design was chosen to be tested and later improved upon. The first trapezoidal ship model had only the vertical axis pendulum based energy harvester which can be seen on the left. This was the configuration we have focused on most as it is driven by the coupled pitch and roll motions. Due to the ship design however we could not acquire desirable results. The second ship design can be seen below on the right. This new design also featured a trapezoid and incorporated another two pendulum energy harvesters, one to capture pitch and the other to capture the roll motions. From this model we found the essential issue of our ship design lay in the center of mass. At present we are fabricating a new ship that will allow much more configuration of weight distribution and sensor location. A new energy harvester module was fabricated using parts from previous iterations. This new module is much smaller and lighter while still having the same generator and pendulum as the previous vertical axis energy harvester, bottom left.

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