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Oscillating Water Column Wave Energy Converter with Deep Water Reactance

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Abstract : The oscillating water column (OSC) wave energy converter (WEC) with deep water reactance (DWR) consists of a large hollow sphere filled with seawater at the base, referred to as the 'stabilizer', a hollow cylinder at the top of the device, with a said cylinder having a bottom open to the sea and a sealed top save for an orifice which leads to an air turbine, and a long, narrow rod connecting said stabilizer with said cylinder. A small amount of ballast at the bottom of the stabilizer and a small amount of floatation in the cylinder keeps the device upright in the sea. The floatation is set such that the mean water level is nominally halfway up the cylinder. The entire device is loosely moored to the seabed to keep it from drifting away. In the presence of ocean waves, seawater will move up and down within the cylinder, producing the 'oscillating water column'. This gives rise to air pressure within the cylinder alternating between positive and negative gauge pressure, which in turn causes air to alternately leave and enter the cylinder through said top-cover situated orifice. An air turbine situated within or immediately adjacent to said orifice converts the oscillating airflow into electric power for transport to shore or elsewhere by electric power cable. Said oscillating air pressure produces large up and down forces on the cylinder. Said large forces are opposed through the rod to the large mass of water retained within the stabilizer, which is located deep enough to be mostly free of any wave influence and which provides the deepwater reactance. The cylinder and stabilizer form a spring-mass system which has a vertical (heave) resonant frequency. The diameter of the cylinder largely determines the power rating of the device, while the size (and water mass within) of the stabilizer determines said resonant frequency. Said frequency is chosen to be on the lower end of the wave frequency spectrum to maximize the average power output of the device over a large span of time (such as a year). The upper portion of the device (the cylinder) moves laterally (surge) with the waves. This motion is accommodated with minimal loading on the said rod by having the stabilizer shaped like a sphere, allowing the entire device to rotate about the center of the stabilizer without rotating the seawater within the stabilizer. A full-scale device of this type may have the following dimensions. The cylinder may be 16 meters in diameter and 30 meters high, the stabilizer 25 meters in diameter, and the rod 55 meters long. Simulations predict that this will produce 1,400 kW in waves of 3.5-meter height and 12 second period, with a relatively flat power curve between 5 and 16 second wave periods, as will be suitable for an open-ocean location. This is nominally 10 times higher power than similar-sized WEC spar buoys as reported in the literature, and the device is projected to have only 5% of the mass per unit power of other OWC converters.

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