Title: Low-Pressure Circuit Design for Hydraulic Power Take-Offs in Wave-Powered Reverse Osmosis

Abstract

Approaches to powering reverse osmosis (RO) desalination using wave energy include 1) a direct conversion to hydraulic power in the form of pressurized seawater (feed water) and 2) generation of electrical power using wave energy and using the electrical power to drive a conventional RO system. Converting the wave energy directly to pressurized feed water has the advantage of higher efficiency due to fewer energy conversion steps. This type of system uses seawater as the working fluid of a hydraulic power take-off (PTO) and includes a pump that is driven by the wave energy converter (WEC), an RO membrane module, and high-pressure accumulators used to manage pressure variation. Seawater taken in by the PTO requires filtering and should be passed through pre-treatment processes. Due to (1) the pressure loss across a filter and the inlet check valves of the WEC-driven pump and (2) the high peak to mean ratio of WEC velocity, cavitation in the WEC-driven pump is likely to occur without proper design. The pipeline dynamics, especially resistive and inertive effects, add to the risk of cavitation. A separate pressure-boosting charge pump is required, which is powered by an electric motor. Prior studies considering wave-powered RO systems that do not rely on a local grid have neglected charge pumps and other electrical power demands. A practical system requires co-generation of electric power along with the fresh, desalinated water. The added design complexity of this system and its potential design performance is studied in this paper. Strategies for powering the charge pump and specifying low-pressure accumulator sizes are considered. This study considers the Oyster 1 that was designed by Aquamarine Power as the WEC. A trade-off is found between the volume of low-pressure accumulators and energy losses due to operating the charge pump. This study finds that an accumulator volume of around 1000 liters is required in the low-pressure branch of the PTO and that driving the charge pump accounts for about 10% of the power captured by the WEC.