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Hydraulic switch-mode power transformer for wave powered desalination plants

Efficient hydraulic power-take-off circuit for wave-powered reverse osmosis desalination plants that independently controls the load on the wave energy converter and the pressure at the reverse osmosis membrane through a switching valve

IP Status: US Patent Pending

Applications

- Wave-powered reverse osmosis (RO) desalination plants
- Optimization of RO systems in water and wastewater treatment plants
- Remote actuation in general fluid power applications

Key Benefits & Differentiators

- **Eliminates major design constraints:** Using a switch-mode power transformer decouples the operating pressures of the power source and RO process
- **Higher uptime and process control:** The electric generator can potentially operate as an electric motor to augment the performance of the transformer
- **Lower equipment costs:** New configuration reduces component size requirements related to the power source and uses fewer high cost components than other power transformers,which can result in significant cost savings

Technology Overview

Currently, 1% of the world's population consumes water from desalination, but the United Nations (UN) estimates that by 2025 this number will reach 14%. Desalination is mainly performed through reverse osmosis (RO) or distillation, which are both energy-intensive processes. Unfortunately, this high energy consumption makes desalination expensive and might result in high carbon emissions depending on the energy source. Wave-driven desalination plants, which use energy harvested from ocean waves to power RO systems, are a potential solution to this problem. However, significant design constraints and energy losses arising from coupling wave energy harvesting and RO processes need to be addressed, namely 1) that pressure pulsations generated by the wave energy harvesting process must not exceed levels appropriate for the RO system components and 2) that the operating pressure of the wave energy harvesting process is constrained to the limits of the RO process.

To overcome these challenges researchers at the University of Minnesota have developed a new fluid power circuit configuration that uses a hydraulic switch-mode power transformer (SMPT) with an electrical generator. In this new configuration, the SMPT uses the inertia of a hydraulic motor driven electric generator and switching of the hydraulic motor inlet between high and low-pressure sources to decrease the pressure at which power is transmitted to the RO process from the levels used in the wave energy harvesting process. This novel technology decouples the operating pressures of the wave energy harvesting and RO processes, allowing the wave energy harvesting process to operate at higher pressures, improving the power

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Category
Engineering & Physical Sciences/Design Specifications
Engineering & Physical Sciences/Energy
Engineering & Physical Sciences/Sustainable Technology

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density and enabling a significant reduction in component sizes (e.g. a 77% reduction in displacement of the wave energy converter-driven pump). This technology can potentially lead to more sustainable and cost efficient desalination plants. This novel technology is particularly relevant for establishing desalination plants in vulnerable coastal communities, which have experienced persistent water shortages and have limited power supply. Besides wave-driven desalination plants this technology can be used to improve power density, decrease power consumption, and improve controllability of RO systems in water and wastewater treatment plants, and general fluid power circuit applications such as off highway equipment.

Phase of Development

TRL: 2-3
Proof of concept using mathematical models has been performed

Desired Partnerships

This technology is now available for:

- License
- Sponsored research
- Co-development

Please contact our office to share your business' needs and learn more.

Researchers

- James Van de Ven Professor, Mechanical Engineering Department

Licensing Terms

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References

1. Simmons, Jeremy W., and James D. Van de Ven , https://doi.org/10.1115/FPMC2019-1647, Fluid Power Systems Technology