Offshore & Dredging Engineering

Technische Universiteit Delft

Analysis of a Wind Driven Reverse Osmosis Desalination System: Experimental Study Using a Pressure Exchanger Energy Recovery Device

With a fast growing world population, the lack of fresh water is one of the world's biggest future concerns. Water stress can lead to conflicts, holds back economic growth and has a major impact on human health. Nowadays, more and more countries that lack fresh water sources are using the saline water from the oceans and desalinate it to produce fresh water. The most common way to do this is by the means of Reverse Osmosis (RO). However, one of the biggest negative aspects of desalination is its high energy consumption, mostly provided by fossil fuels. Therefore, a more sustainable solution using renewable energy sources to power a RO system is necessary

Delft Offshore Turbine (DOT) is currently developing a hydraulic drive train wind turbine that converts the aerodynamic power captured from the wind into hydraulic power. With a positive displacement pump, a high pressure water stream is created for centralised electricity production using a spear valve and a Pelton wheel. Using this hydraulic turbine for the purpose of fresh water production with RO can be a well fitted combination. Using wind as an energy source for desalination purposes, however, creates some major challenges, one of which is dealing with the inconsistency of wind. For varying wind speeds, a hydraulic wind turbine is controlled by regulating system pressure hence the pump torque with the spear valve. With a Seawater Reverse Osmosis (SWRO) system with ERD, it is researched how to regulate the flows and pressures for a stable operation.

In this thesis, the combination of the hydraulic wind turbine with a Reverse Osmosis system with an Pressure Exchanger Energy Recovery Device (ERD) is being analysed in more detail. For this, a numerical model is used to determine the systems' behaviour and an experimental test setup is designed and constructed to validate the model results. The aim of this thesis is to compare the desalination system performance with a stand-alone system without an ERD, to determine the influence of varying ERD settings on the systems' pressure for potential system pressure and torque controllability, and to investigate how the RO system with an ERD affects the wind turbines stability.

The analysis shows a large positive influence on the amount of produced permeate when using an ERD in the RO system. In addition, the power consumption of the RO process can be reduced by up to 80%. A varying input provided by the high pressure pump, for example as a results of varying wind speeds, does not seem to (negatively) affect the efficiency of permeate production. By varying the ERDs' rotational speed, the feed pressure at the membranes inlet hence the pressure at the high pressure pump can be slightly influenced. However, this limited influence is not enough to effectively affect and control the high pressure pumps' torque.
On top of that, for the wind turbine to operate in a stable operating region, it seems that the use of an ERD affects the system in such a way that water production can only be realised at fairly high wind speeds. To optimally make use of the hydraulic wind turbine and operate at the highest possible aerodynamic efficiency, a combination of electricity production at low wind speeds and water production with an ERD when wind speeds are sufficient, can be interesting. For this, future research is required.

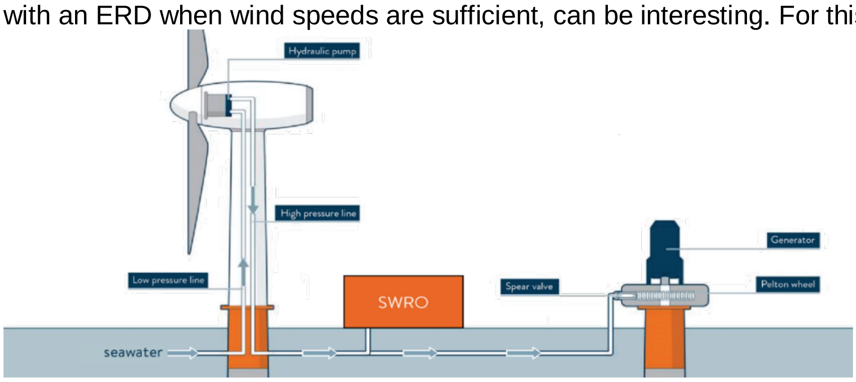

Figure 1: Visualisation of the DOT hydraulic wind turbine with a SWRO system.

Student	Sponsor	Thesis committee
Roy Smits	DOT B.V.	Prof.dr. A. Metrikine
April 17th, 2019		Dr.ir. A. Jarquin Laguna
		Dr.ir. F. Pisanó
		Ir. R. Jorritsma