Smart Temperature Monitoring System for Parabolic Solar Thermal Collector Integrated with Membrane Distillation System

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***Abstract* — In this work, a smart temperature monitoring system was developed for a Parabolic Solar Thermal Collector (PSTC) integrated with Membrane Distillation (MD) system. The objectives of this work were to monitor and record the temperature data of salt solution in the PSTC system and to control the circulating water pump flow based on the targeted temperature. The PSTC system was used as a supporting system to pre-heat the salt solution until the it reaches the desired temperature. This was monitored by a DS18B20 waterproof temperature sensor. The real-time data was then be displayed on an LCD, saved in a microSD card and via smart phone. An Internet of Thing (IoT) of Blynk Applications and data logging systems were utilized. The energy and the separation performance of the integrated system was also investigated. The highest temperature attained by the PSTC system based on the conducted experiments was above 60°C. Based on the results, a fluctuation of energy consumption by the integrated system was observed. This was due to the supplementary energy supplied by the solar collector system. The integrated system also exhibited a moderate separation efficiency with maximum permeate flux of 3.5083 kg/m^2.h and salt rejection of 93.96%. As a conclusion, the PSTC system integrated with MD system can surely bring a lot of benefits for the desalination industry. Additionally, IoT can be employed in the future as means to accurately monitor solution temperature for such integrated systems.**

Keywords—temperature monitoring; IoT; solar thermal collector; membrane distillation; desalination

I. INTRODUCTION

Membrane distillation (MD) is an emerging hybrid membrane-evaporative separation process whereby a non-wetting, microporous membrane is used to separate different liquid phases. This system has generated great interest among researchers for water purification purposes. The difference of liquid temperatures allows the water vapor to pass through the hydrophobic membrane in order to extract pure water from saline water. In the field of desalination, MD exhibits greater advantage compared to other conventional treatment system like reverse osmosis as MD can treat feed solution of high salinity where the ions, macromolecule and colloids present can be removed to produce distillate of high purity [1].

Nowadays, the attractive features exhibited by MD system has attracted the interest of researchers to design various integrated systems. The demand for both energy and water has been intense in the industry, and is somewhat related to one another. Furthermore, in remote areas where water and electricity infrastructures are mediocre, renewable energy systems such as a small scale solar thermal collector and MD units can be very beneficial to satisfy clean water needs without worrying about energy source [2]. Integration of solar energy with MD system for desalination can solve both the need for clean, sustainable energy and clean water needs simultaneously. This hybrid system utilizes renewable energy to drive seawater to the desalination system to produce clean water for human consumption.

Such desalination systems can be classified into two types; stand-alone and hybrid system. Stand-alone desalination systems utilize solar energy to produce freshwater directly from solar collector itself which is also knows as a solar still. The basic idea of a solar still is that the saline water is preheated directly by solar energy or electricity and causes it to evaporate. Then, vapor condenses on the inclined glass covering the surface in order to collect the fresh water into a collection unit. On the other hand, the main idea of a hybrid solar desalination system is the salt solution is preheated by solar radiation. Then, it flows alongside the nanostructured membrane where vapor from the heated salt solution passes through the hydrophobic membrane. The water vapor then condenses on the other side of the membrane while non-volatile contents cannot enter the membrane. There are three types of solar thermal collector that can be incorporated into a hybrid desalination system. This includes flat plate solar thermal collector, evacuated tube solar thermal collector and parabolic solar thermal collector (PSTC) [3]. In this work, a PSTC was fabricated and integrated with the MD system. This is because the parabolic troughs generate very high temperatures which is suitable for heating [4-5].

Although previous works have proven the feasibility of a solar powered membrane distillation (SPMD) system, there is no study focused on the techniques to develop a solar thermal collector integrated with MD system for desalination with smart temperature monitoring system. As temperature difference is the main driving force of MD, this study employed an Internet of Things (IoT) solution for real-time temperature supervision. The solution is composed of a hardware prototype for temperature data collection and Web compatibility for data access.

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