Operation optimization of vacuum membrane distillation using the shipboard waste heat

Jaewuk Koo\textsuperscript{ab}, Sook-Hyun Nam\textsuperscript{a}, Eunjoo Kim\textsuperscript{a}, Tae-Mun Hwang\textsuperscript{a,*}, Sangho Lee\textsuperscript{b}

\textsuperscript{a}Korea Institute of Civil Engineering and Building Technology, 283 Dachwa-Ro, Ilasan-Seogu, Goyang-Si, Gyeonggi-Do 411-712, Republic of Korea, Tel. 82-31-910-0741; Fax: 82-31-910-0291; email: taemun@kict.re.kr

\textsuperscript{b}School of Civil and Environmental Engineering, Kookmin University, Jeongneung-Dong, Seongbuk-Gu, Seoul 136-702, Republic of Korea

Received 6 October 2016; Accepted 21 November 2016

**Abstract**

Membrane distillation (MD) is investigated as an alternative to solve the high power costs and environmental pollution caused by reverse osmosis, which is a widely used water purification technology today. MD is driven by the difference in vapor pressure that occurs between the surfaces of hydrophobic porous membranes. It is operated at a relatively low temperature compared with the existing evaporation process, and theoretically, most of the inorganic ions can be removed, and it is not affected by feed water. MD is broadly classified into four types; among them, vacuum membrane distillation (VMD) has the lowest heat loss as well as the highest performance. Therefore, VMD is considered a process optimized when using engine waste heat generated from marine vessels and in the environment of low directness. Nevertheless, the performance of the VMD process varies according to the characteristics and forms of membrane modules used in the process, and membrane performance degrades when operated for a long time due to the direct vacuum pressure on a membrane. Therefore, this study aimed to find ways to maximize the performance of VMD system by identifying the optimum operating conditions through experiments under various operating conditions, and to reflect the findings in the design of the VMD plant process to secure its safety. The experiments of this study were carried out in a lab scale. Also, the types of membranes, feed water temperature, flow rate of feed water and vacuum pressure were set as the parameters of operating conditions, and the effect of each of them on VMD performance was analyzed. Water flux increased along with an increase in the temperature of the feed water. In case of the types of membranes, the membrane module of Capillary type showed the highest water flux. Three types of membrane modules displayed >99% salt rejection. Changes in performance according to flow rate and vacuum pressure were also investigated. It was judged that VMD performance can be maximized if optimum operating conditions determined through this experiment are applied to the design of freshwater plant for marine vessels.

**Keywords:** Membrane distillation; Vacuum membrane distillation; Capillary membrane; Desalination; Water treatment

* Corresponding author.

1944-3994/1944-3986 © 2017 Desalination Publications. All rights reserved.