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## Measurement of capillary pressure and relativity permeability relations for two-phase air-water cross flow in thin sintered metal wicks

Monday, 30 May 2022 12:05 (15 minutes)

Thin capillary wicks provide an integral function serving as evaporators in vapor chamber thermal management devices [1]. The application of high heat fluxes at the evaporator causes boiling to occur in the wick; the resulting two-phase flow dynamics dictates the thermal performance and critical dryout limits. These wicks are commonly composed of high thermal conductivity copper powders sintered into thin layers. While the physiochemical properties and single-phase flow characteristics in such wicks are widely known, the two-phase flow properties, namely, capillary pressure and relative permeability as a function of the liquid saturation, have been scarcely explored. We propose a novel experimental technique for characterizing the air-water capillary pressure and relative permeability curves of sintered copper wicks using two complementary facilities that together yield both properties. For measuring the capillary pressure as a function of liquid water saturation during both drainage and imbibition, a facility inspired by a previous microfluidic method of Fairweather et al. [2], is developed. The sintered sample is sandwiched between a hydrophilic membrane and a hydrophobic membrane prior to performing sequential liquid and gas (air) intrusion experiments in opposite directions based on the membrane configurations. The capillary pressure difference across the sample is measured as a function of the liquid saturation based on active weighing of the liquid in the sample. Next, the liquid relative permeability is measured from a core flooding experiment [3], a modified version of the earlier stationary liquid method proposed by Leas and co-workers [4]. In this method, the porous sample is continuously flooded with water at a constant flow rate from a reservoir at high pressure, which flows through the length of the sample. Subsequently the non-wetting phase (air) is injected at different flow rates through the sample thickness in a cross-flow manner using a syringe pump. The injection flow rates of air are varied in a wide range (2-15 ml/min) to alter the local two-phase flow saturation and subsequently, relative permeability as a function of saturation, using sintered samples of three different particle sizes (45–53  $\mu\text{m}$ , 90–106  $\mu\text{m}$  and 180–212  $\mu\text{m}$ ). The sintered porous samples are treated with a controlled oxidation process so that they are stably wetting with water throughout the experiments. We first validate the proposed two-step measurement technique by characterizing the properties of carbon paper and comparing to the results reported by Koido et al. [5]. Post-validation, the single-phase liquid permeability, capillary pressure, two-phase pressure drop, and water saturation are sequentially collected for each different sintered copper sample. Using the appropriate data reduction techniques and Darcy's equation for two-phase flow, we obtain capillary pressure and relative permeability as a function of saturation. The experimental results highlight the sensitivity of these properties to the two-phase flow orientation and nature of the porous media configuration. The developed method can be used as a tool for characterizing the two-phase flow behavior of a variety of salient porous media types including sintered mesh wicks or sintered fiber wicks.

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### MDPI Energies Student Poster Award

No, do not submit my presentation for the student posters award.

## Country

United States

## References

- [1] Sudhakar, S., Weibel, J. A., & Garimella, S. V. (2018). Design of an area-scalable two-layer evaporator wick for high-heat-flux vapor chambers. *IEEE Transactions on Components, Packaging and Manufacturing Technology*, 9(3), 458-472.
- [2] Fairweather, J. D., Cheung, P., St-Pierre, J., & Schwartz, D. T. (2007). A microfluidic approach for measuring capillary pressure in PEMFC gas diffusion layers. *Electrochemistry communications*, 9(9), 2340-2345.
- [3] Pini, R., & Benson, S. M. (2013). Simultaneous determination of capillary pressure and relative permeability curves from core-flooding experiments with various fluid pairs. *Water Resources Research*, 49(6), 3516-3530.
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- [5] Koido, T., Furusawa, T., & Moriyama, K. (2008). An approach to modeling two-phase transport in the gas diffusion layer of a proton exchange membrane fuel cell. *Journal of Power Sources*, 175(1), 127-136.

## Time Block Preference

Time Block B (14:00-17:00 CET)

## Participation

Unsure

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