
Contribution ID: **93**

Type: **Oral Presentation**

# Sharp-front models for wicking into porous media under non-isothermal conditions

*Wednesday, 21 May 2025 09:05 (15 minutes)*

Wicking, the spontaneous movement of liquid into a dry porous medium, is a critical phenomenon with wide-ranging industrial applications. Though wicking under isothermal conditions have been studied/modeled for more than a century, wicking under non-isothermal conditions remains relatively unexplored.

In an earlier study, we proposed, using the sharp-front approximation, three different models for wicking height as a function of time for the non-isothermal wicking phenomenon. Three temperature models are: the Liquid Temperature Model, the Average Temperature Model, and the Dynamic Temperature Model. The first two models use the Darcy's law based analytical solution for wicking height as a function of liquid properties including viscosity, surface tension and density and where these properties are varied with an estimation of liquid temperature. The Liquid Temperature Model (with the liquid temperature set at the constant temperature of the incoming liquid) incorporates some temperature effects but tends to underestimate the wicking height due to its simplified assumption. The Average Temperature Model improves accuracy by evaluating properties at the average of the liquid and wick temperatures but still falls short, due to its failure in capturing the dynamic nature of energy redistribution during wicking. The Dynamic Temperature Model calculates liquid temperatures along the wick using a 1-D finite difference-based simulation and dynamically computes fluid properties at these varying temperatures along the wick. This model achieves superior predictions of wicking height and successfully captures temperature transitions observed in experiments.

We will be predicting the wicking height of hexadecane at room temperature in a beaker with a polypropylene wick at elevated temperatures (which is the opposite of the situation considered by us earlier with the liquid set at higher temperatures). Similar conditions are commonly encountered in industrial applications, for example, in heat pipes where wicking materials are at higher temperatures compared to the working fluids. This work will provide novel insights into non-isothermal wicking by demonstrating how temperatures influence liquid transport in porous media. The findings hold significant implications for applications in textiles, heat pipes, and advanced cooling systems, where thermal effects are critical for liquid management.

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## References

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**Session Classification:** MS17

**Track Classification:** (MS17) Complex fluid and Fluid-Solid-Thermal coupled process in porous media: Modeling and Experiment