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Layered wicks enable passive transport of condensation out of cooling systems

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Presenter Information

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Layered wicks enable passive transport of condensation out of cooling systems

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Motivation

- The cooling process that occurs in systems like condensers or the cooling towers of a power plant often occurs through the condensation of water, which forms a liquid film
- This liquid film reduces heat transfer, making the cooling system less efficient
- In this work, we use the capillary/surface tension forces to passively transport water. This is applicable for removing liquid films from condensers

https://pixabay.com/photos/power-plant-industry-chimney-2411932/

Hypothesis

- Wicks can be used to passively transport condensation out of condensers (i.e., power plant cooling systems)

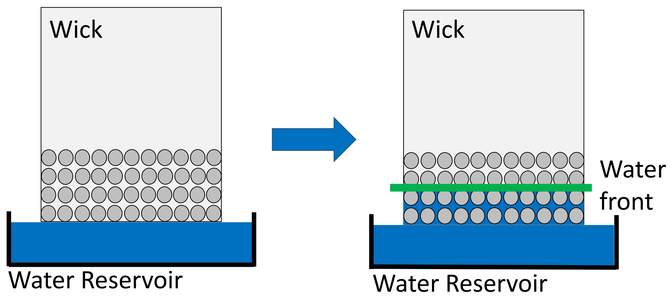
Methodology

- SOLIDWORKS was used to design wicking structures which were then sent to WSU to be 3-D printed
- The wicks used in these experiments are an array of layered spheres bridged by cylindrical columns
- Porosity was calculated using the following equation

$$\varepsilon = \frac{V_{total} - V_{solid}}{V_{total}}$$

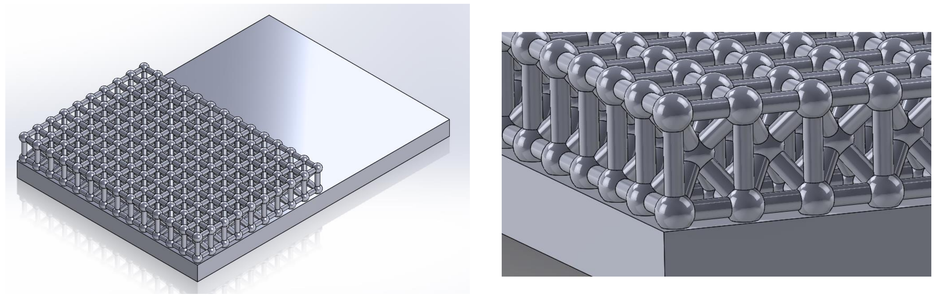
- The interactions between the wick and the water are observed under a high speed camera

Rate-of-rise Test

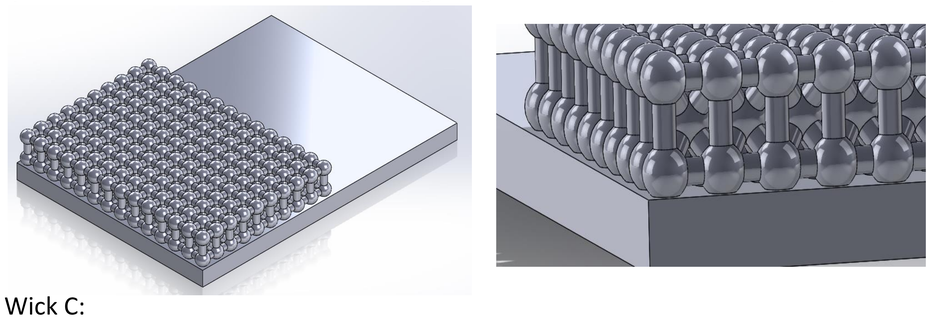


Wick Designs

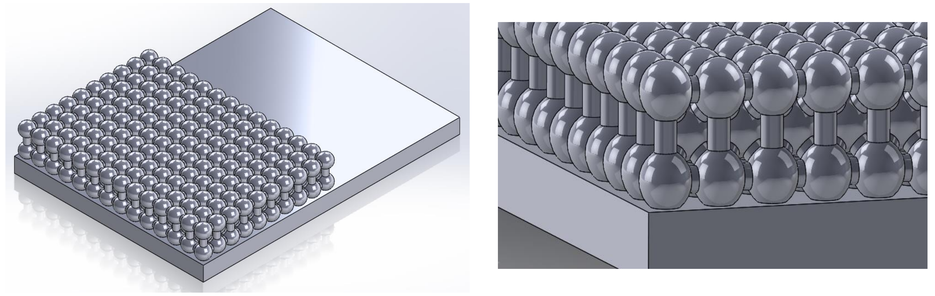
Wick A:
Sphere Diameter: 1.00 mm Bridge Diameter: 0.5 mm Porosity: 0.66



Wick B:
Sphere Diameter: 1.50 mm Bridge Diameter 0.75 mm Porosity: 0.42

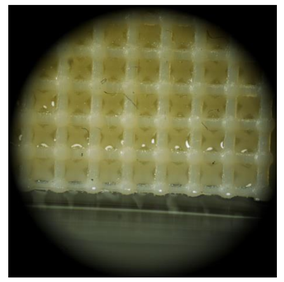


Wick C:
Sphere Diameter: 1.75 mm Bridge Diameter: 0.75 mm Porosity: 0.35

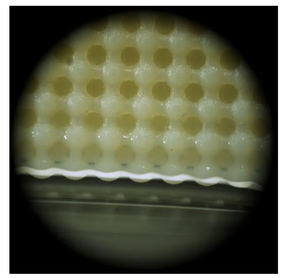


3-D Printed Wicks

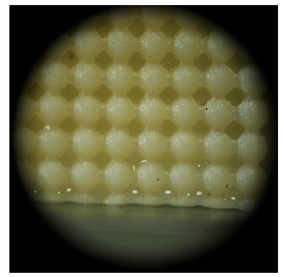
- When the wicks were printed, due to the small pore volume of the wicks, the support material left debris between the layers of the wick



- Wick A after further cleaning; debris left inside will make it difficult to quantify any measurements



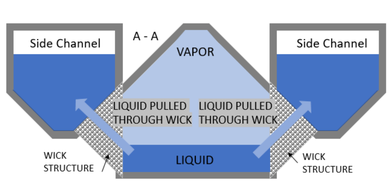
- Wick B after further cleaning; due to low porosity, debris remains within structure

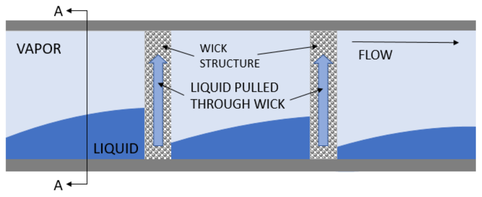


- Wick C after further cleaning; due to low porosity, support material remains attached to structure – unusable for testing
- Future wicks will be designed with a greater pore volume than wick C

Conclusions

- The design process for these wicks outlined various factors to be accounted for as this project moves forward. Wick A will serve as a point of reference for future wicks
- The success of this project could improve space cooling systems and power plants
- Below is a conceptual sketch of the application of this project





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- J. Morrow, N. Aponte, R. Huber, P. Chakraborty, G. Riley, M. Derby."Permeability and Rate-of-Rise of Additively-Manufactured Wicking Structures," 2019 ASHRAE Annual Conference, Kansas City, MO.