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The Superhydrophobic Boat

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MECHANICAL AND NUCLEAR

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CAPSTONE DESIGN EXPO 2015

Introduction

- The purpose of this project to construct a faster boat by reducing the drag force using a superhydrophobic coating.
- A superhydrophobic coating repels water from the surface it is applied to.
- A boat constructed from a superhydrophobic mesh reduces the boats wetted area all while preventing water from permeating through its open spaces.

Experimental Procedure

- The contact angles of several commercial superhydrophobic coatings were measured to find the best coating as well as the best method for its application.

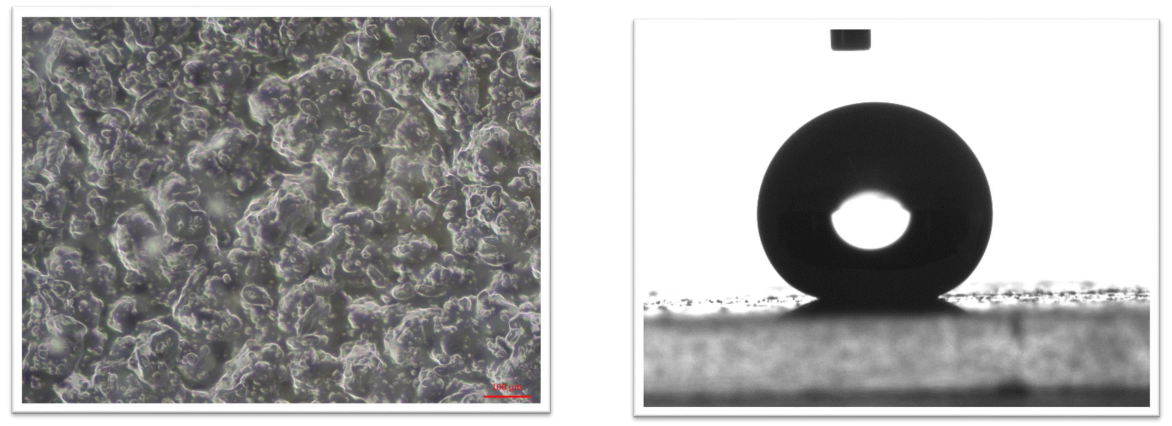

Figure 1: Left: Superhydrophobic coating under a microscope.
Right: Contact angle measured by goniometry.

- Sample meshes with different wire spacings and diameters were coated using the application method previously identified and the contact angle was again measured via goniometry.
- The breakthrough pressure of the meshes were tested by adhering them to the bottom of a hollow tube, lowering said apparatus into water, and measuring the weight of the water displaced at the moment water permeated the mesh.

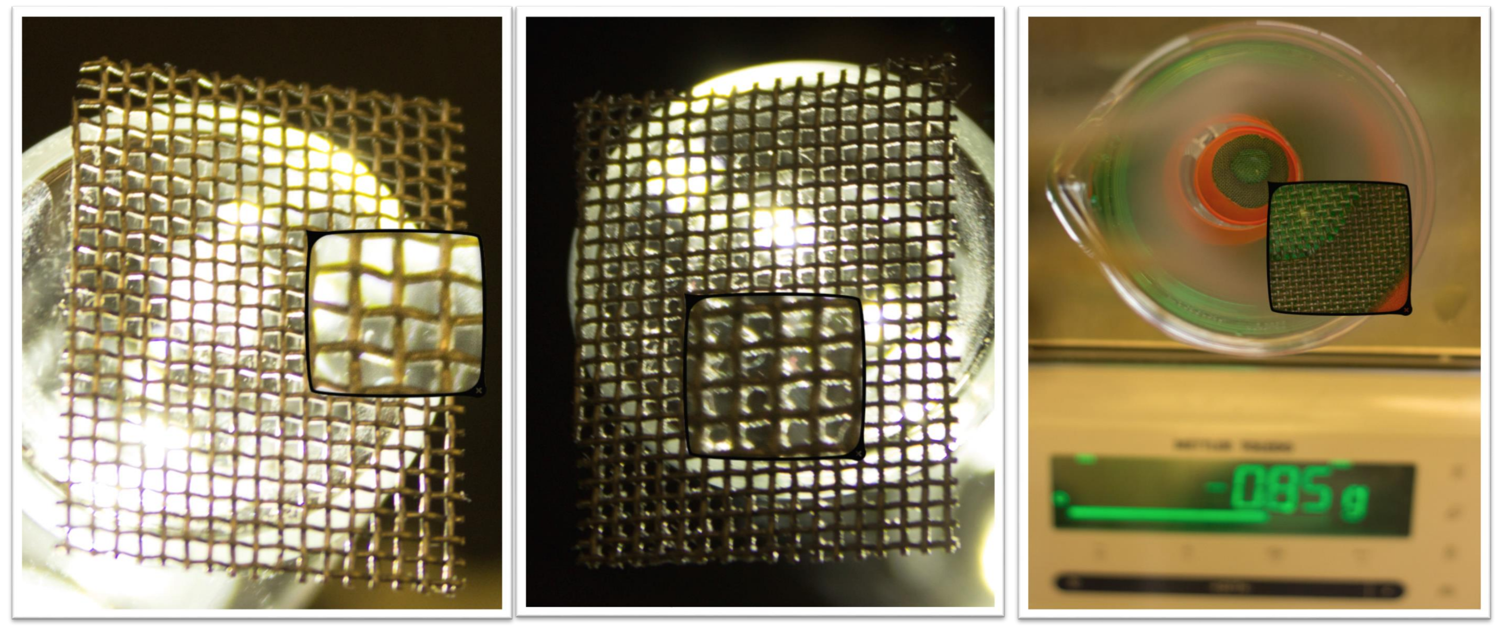

Figure 2: Left: Uncoated Mesh. Center: Coated mesh.
Right: Mesh at breakthrough pressure

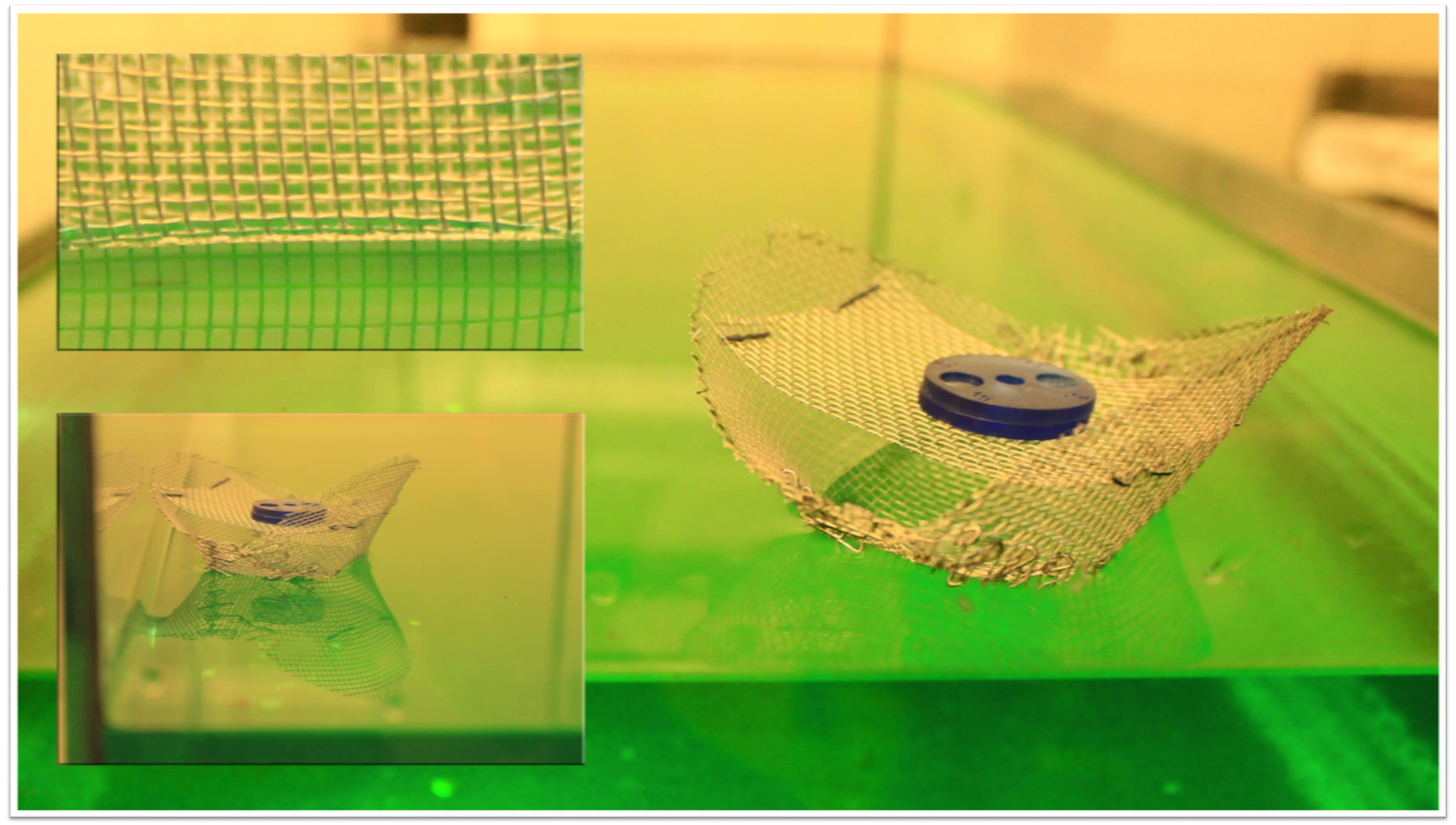

Figure 3: Superhydrophobic boat model holding weights.

Mathematical Modeling

- The modeling of water permeating the pores in the material composing the boat is done by equating the pressure and the capillary forces acting on the meniscus.
- To make the calculation of the breakthrough pressure less computationally expensive, the porous material composing the boat is assumed to be composed of a single set of parallel wires of infinite length and a given hydrophobicity, wire spacing and diameter.

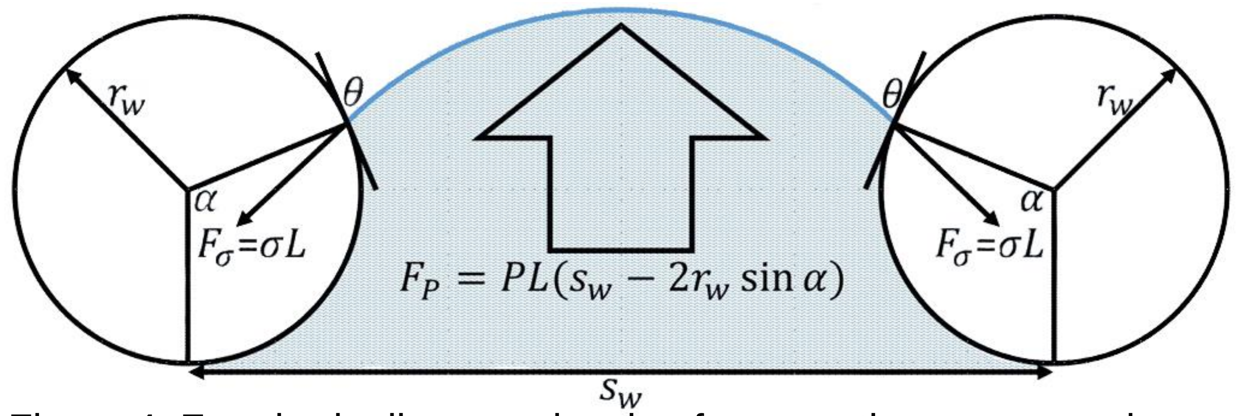

Figure 4: Free body diagram showing forces acting on an meniscus.

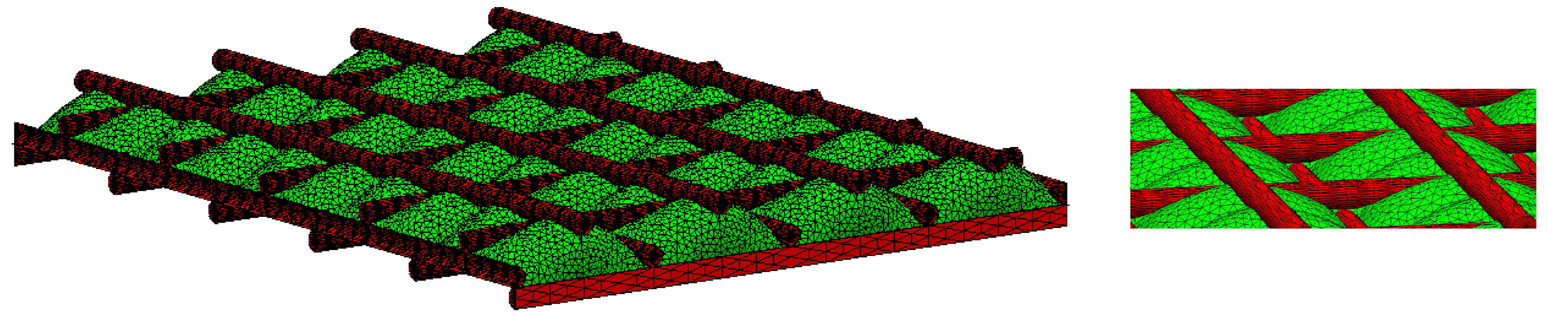

Figure 5: Calculation of breakthrough pressure via finite element method.

Results

- While the model accurately predicted inverse relationships between wire spacing, wire diameter and breakthrough pressure, breakthrough pressure was underestimated by a factor of two with any dramatic deviations from the trend in experimental data coming from the quality with which the sample meshes were adhered to the hollow tube.

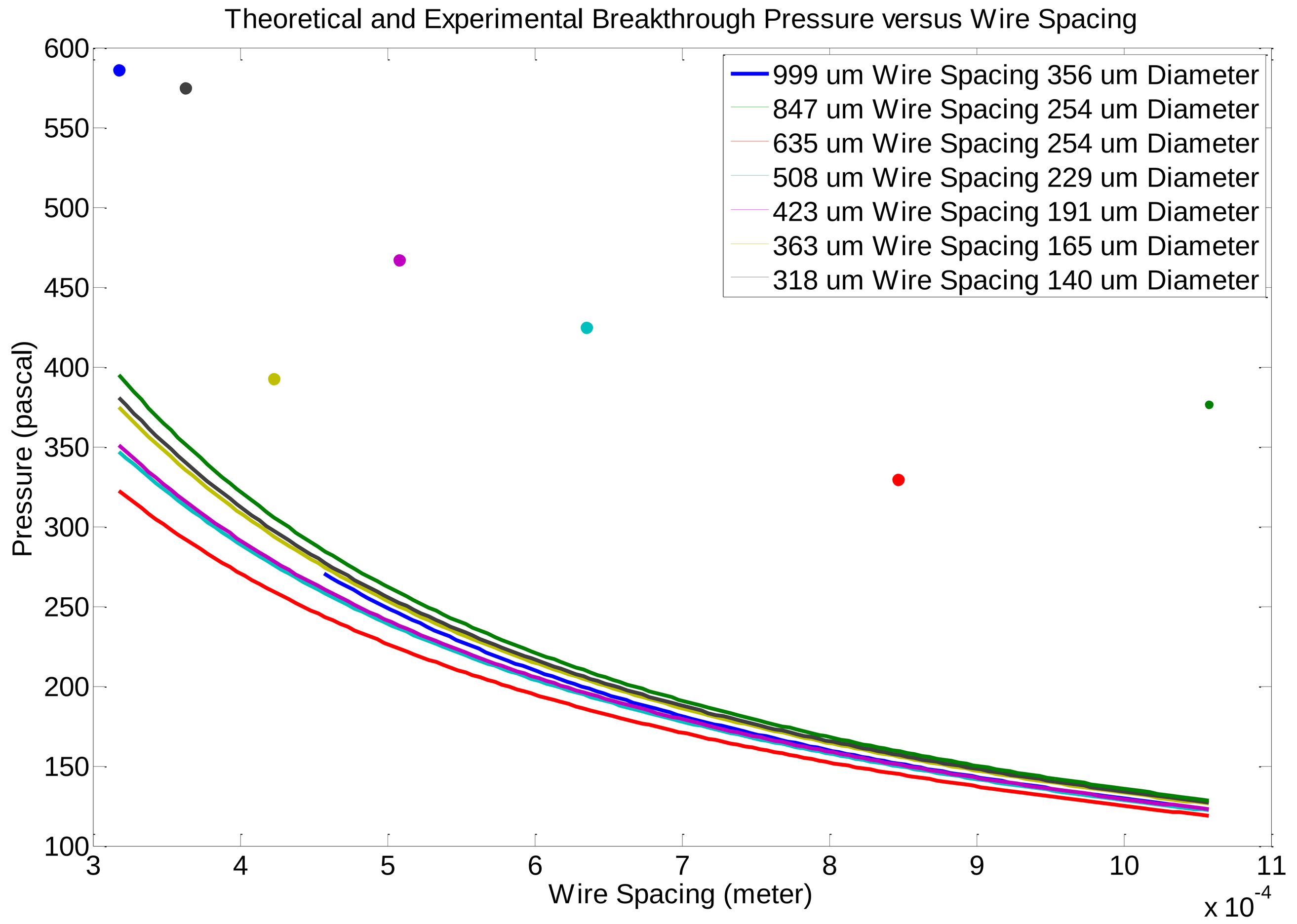

Figure 6: Theoretical & experimental breakthrough pressure.

Conclusion & Future Work

- The boat was made from the coarsest mesh which would hold its weight and a modest load and was constructed by cutting out a series of pointed petals and stapling their edges into a hemispherical pattern.
- The next logical step would be to calculate the boat's slip length and physically measure the drag force acting upon it.

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