Testing Superhydrophobic Surfaces
Introduction

What is a Superhydrophobic Surface?
Introduction

Superhydrophobic Surface
Contact Angle > 150°

Hydrophilic Surface
Contact Angle < 90°

Hydrophobic Surface
Contact Angle > 90°
Fluid Mechanics

- Laminar Flow appears to follow a smooth and predictable pattern
- Turbulent Flow looks unpredictable and sporadic.
Quotes on Turbulent Flow

Werner Heisenberg

"When I meet God, I am going to ask him two questions: Why relativity? And why turbulence? I really believe he will have an answer for the first."

Horace Lamb

"I am an old man now, and when I die and go to heaven there are two matters on which I hope for enlightenment. One is quantum electrodynamics, and the other is the turbulent motion of fluids. And about the former I am rather optimistic."
Introduction

Drag

- When a solid object moves through a fluid, the drag is the force or forces that act opposite the object’s direction of movement.

- There are many types of drag: parasitic drag, lift-inducing drag, wave drag.

- The drag my experiment is related to is a type of parasitic drag called skin friction.
Introduction

Skin Friction

- Theoretically, one way to reduce skin friction drag is to use a superhydrophobic surface to make the boundary layer stay laminar. In the front of the body, this boundary layer is laminar and becomes turbulent based on the Reynolds number.
Introduction

Cassie-Baxter State to Wenzel State

Cassie-Baxter State

Wenzel State
Hypothesis

“Establish the presence of an air layer on the Superhydrophobic surface by measuring the light reflected off the surface at different pressure levels. As the pressure increases the reflection decreases. This decrease demonstrates the transition from a Cassie-Baxter state to the Wenzel state. Also the geometry of cuts will effect the rate of the transition.”
Methods & Materials

How the Superhydrophobic surfaces were made.

• Cuts were made on metal plates by a laser.
• Two types of cuts were made, continuous and 1mm.
• The distance between the cuts varied from 37.5μm to 62.5 μm.
• This was followed by silica coating from 30-100.
• After this, they were coated with Silane.
Methods & Materials

My Experiment

1. Tile was put into a pressurized tank filled with water.
2. A laser was shot at the tile and digital images were taken at angles ranging from 25°-75°.
3. These same sets of images at different pressure levels from 0psi to 100psi.
4. The images were downloaded on the computer and run through a Matlab program to measure the reflectance of each image.
Methods & Materials

Reflection at Angles 25-75

Angle = 25°
Angle = 30°
Angle = 35°
Angle = 40°
Angle = 45°
Angle = 50°
Angle = 55°
Angle = 60°
Angle = 65°
Angle = 70°
Angle = 75°
The Theory

Superhydrophobic Surface
Results

My Data

Reflectance Theory

Pressure [psig]

Angle

Reflectance

0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

0 20 40 60 80 100
# Results

## My Data

### 1mm Samples

<table>
<thead>
<tr>
<th>1mm Samples</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>50pwr/37.5p</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5Wenzel transition 1/30psi 2/60psi 3/50psi 4/40psi</td>
<td></td>
</tr>
<tr>
<td>Reflectance Range</td>
<td>0.1 0.5 0.1 0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Continuous Samples

| 50pwr/37.5p | 4      | 4      | 4      | 3Wenzel transition 1/10psi 2/10psi 3/10psi 4/20psi |
| Reflectance Range | 0.7 0.7 0.7 0.5 |

| 100pwr/50p | 4      | 4      | 4      | 4Wenzel transition 2/30psi 3/30psi 4/40psi |
| Reflectance Range | 0.3 0.4 0.6 |

| 100pwr/62.5p | 4      | 4      | 4      | 4Wenzel transition 1/30psi 2/30psi 3/40psi 4/40psi |
| Reflectance Range | 0.4 0.5 0.7 0.6 |

| 100pwr/50p | 2      | 4      | 4      | 4Wenzel transition 1/10psi? 2/20psi 3/30psi 40/50psi |
| Reflectance Range | 0.4 0.7 0 0 |

| 100pwr/62.5p | 4      | 5      | 5      | 4Wenzel transition 1/40psi 2/40psi 3/40psi 4/40psi |
| Reflectance Range | 0.5 0.3 0.6 0.6 |
Data Observations

• Wenzel state transition pressure was inconsistent but generally from 30-40 psi.
• The reflectance level at the Wenzel state was very inconsistent from trial to trial.
Next Steps

• Continue trials with the six selected tiles.
• Note the room lighting during tests, because it may be the cause of overall difference in reflectance levels between trials.
• Consider the erosion of the silane surface overtime.
• Considered the Wenzel state transition may be localized.
• Considered human error.