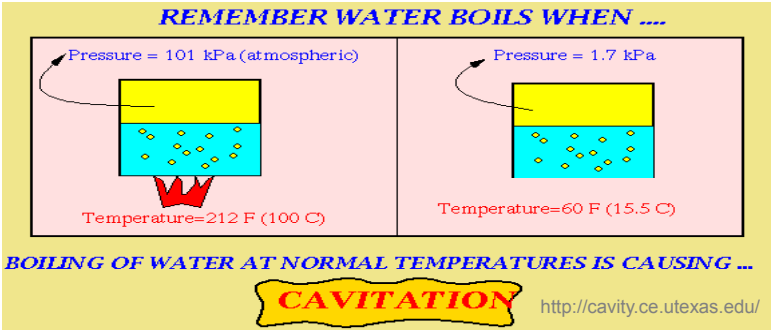
Cavitation and its Effects

(**A Case Study**)

What is Cavitation

"a general term used to describe the behavior of voids or bubbles in a liquid"

Cavitation occurs in liquids when the pressure is reduced to the vapor pressure at a given temperature of operation



Cavitation Number

$$\sigma = \frac{P_\infty - P_v}{\rho/2\, v_\infty^{\,2}}$$

$Where:\ \sigma = cavitation\ number$

$P_\infty; P_v = ambient\ and\ vapor\ pressure\ (Pa)$

$\rho = fluid\ density\ (kg/m^3)$

$v_\infty = velocity\ of\ uptream\ flow/trifoiler\ (m/s)$

NOTE:
- Velocity (v_∞) ↑ ➔ cavitation number (σ) ↓ ➔ CAVITATION occurs

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How it "works"

In local regions of low pressure:
Vapor bubbles start growing

In the regions of higher-pressure downstream:
Bubbles collapse

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Problems

- an increased noise
- damage to components
- vibrations
- loss of efficiency.

Benefit Uses

- Used in high power ultrasonics
- Used to homogenize, or mix and break down particles
- Used to cavitating water purification devices
- Used for destruction of kidney stones via shock waves

Case study

TRIFOILER

The World's Fastest Sailboat

50.1MPH

Common Questions:

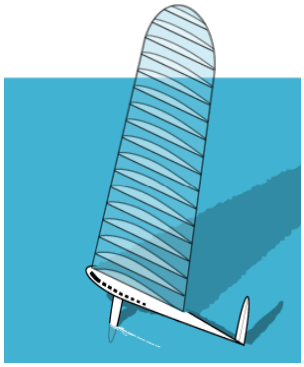
How we can overcome the resistance of water?

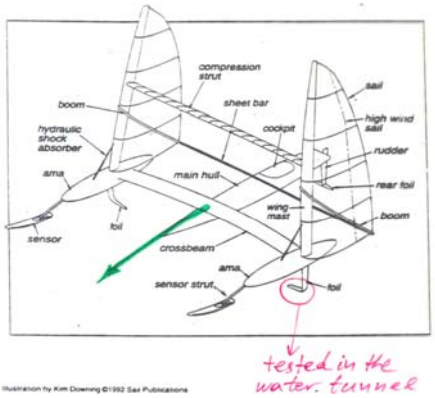
Why we can't make it go faster?

Hydrofoil =Lifting surface

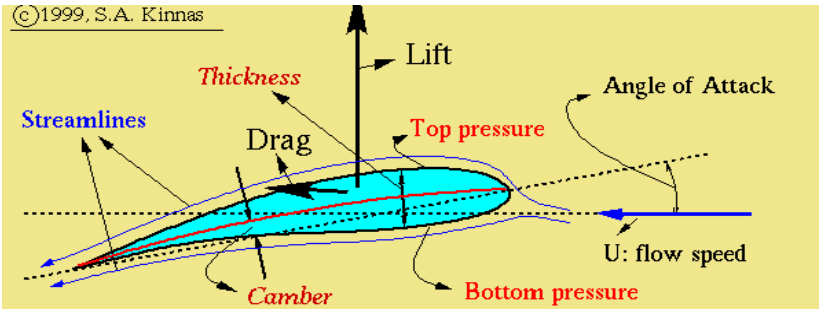
let a boat go faster by getting the hull out of the water

→ overcome the drag on the submerged hydrofoils instead of the drag on the hull





Hydrofoil



Top velocity HIGHER then bottom pressure ($v_{top}>v_{bottom}$)
Top pressure LOWER than bottom pressure (Bernoulli's equation) → **LIFT**
Lift increases with fluid velocity (U); Angle of Attack, Camber
INCREASE in U causes DROP in Top pressure

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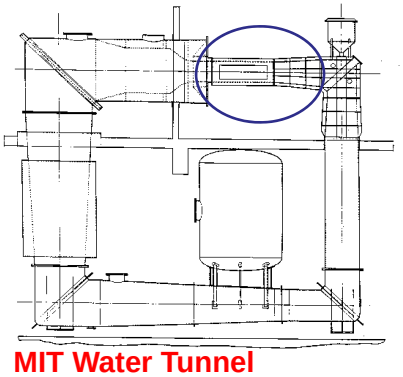
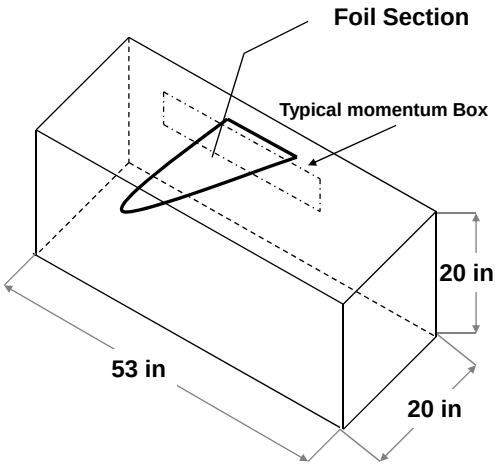
Cavitation Tunnel

Pressure is decreased in order to simulate the effects of high speed flow



MIT Water Tunnel

http://web.mit.edu/mhl/www/photos.html



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Super-Cavitation

Top pressure DROP → CAVITATION

Cavitation causes - loss of lift
- Increase of drag force

→ **Slowing down the sailboat**

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MOVIE on Cavitating Hydrofoil

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Take-home Messages

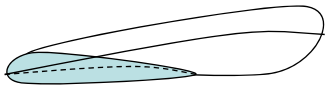
√ **Cavitation number** characterizes the mount of cavitation

$P_{ambient}$ INCREASES ➔ Cavitation DECREASES

√ **Forces** and **Foil Vibrations** become excessive as the cavity crosses the trailing edge of the foil

√ **Lift** is significantly decreased as the cavity becomes a super-cavity

Super-Cavitation causes the barrier in the speed of the TRIFOILER



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