

Estimating the length of a leading-edge cavity

The goal of this exercise is to compute the length of a leading-edge cavity developing on the suction side of a 2D hydrofoil for various flow conditions (i.e. inlet velocity: C_{ref} , inlet pressure: p_{ref} and foil incidence angle: α).

To this end, we will assume that the cavity shape can be approached by the envelope formed by the successive states of a nucleus, whose evolution in still liquid is governed by the pressure distribution over the hydrofoil, as shown in the figure below.



We will consider a NACA0009 hydrofoil with a thickness distribution y_b given by the equation below, using $c_0=110$ mm for the chord length.

$$0 \leq \frac{x}{c_0} \leq 0.5 \quad \frac{y_b}{c_0} = a_0 \left(\frac{x}{c_0}\right)^{1/2} + a_1 \left(\frac{x}{c_0}\right) + a_2 \left(\frac{x}{c_0}\right)^2 + a_3 \left(\frac{x}{c_0}\right)^3$$

$$0.5 < \frac{x}{c_0} \leq 1.0 \quad \frac{y_b}{c_0} = b_0 + b_1 \left(1 - \frac{x}{c_0}\right) + b_2 \left(1 - \frac{x}{c_0}\right)^2 + b_3 \left(1 - \frac{x}{c_0}\right)^3$$

$$\begin{cases} a_0 = +0.1737 \\ a_1 = -0.2422 \\ a_2 = +0.3046 \\ a_3 = -0.2657 \end{cases} \quad \begin{cases} b_0 = +0.0004 \\ b_1 = +0.1737 \\ b_2 = -0.1898 \\ b_3 = +0.0387 \end{cases}$$

- Using the applet Xfoil or JavaFoil (open software), compute the pressure distribution on the hydrofoil for an upstream velocity of 20 m/s and incidence angles of 0° , 2° and 4° .
- Compute the pressure distributions for an upstream velocity of 40 m/s (same incidence angles).
- With the computed C_p distribution, find the pressure $p(t)$ experienced by a nuclei travelling on the foil suction side for 20 m/s and 40 m/s upstream velocity and incidence angles of 0° , 2° and 4° . The cavitation number is $\sigma = 0.8$ for all these cases.
- Using the code that you have developed in the part 3 on bubble dynamics, compute the radius evolution of a nucleus evolving under the transient pressure computed above.
- Finally, estimate the shape of the cavity by assuming that its thickness corresponds to the radius of the nucleus at a particular time.