VENTILATED CAVITY DYNAMICS BEHIND 2-D WEDGE IN INCOMPRESSIBLE FLOWS

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When an underwater vehicle is surrounded by a cavity, friction acting on the surface of the vehicle decreases considerably. Hence, the underwater vehicle has effects similar to those of the motion in the air. These effects can be applied to military underwater vehicles such as torpedoes. Supercavitation which encloses the whole vehicle with the cavity is generally generated by ventilating non-condensable gas into liquid. The objective of this study is to control the cavity effect related to non-condensable gas. This is performed by applying Kunz model which considered non-condensable gas to modify interphaseChangeFoam. The momentum equation for the flow field can be written as following:

$$\frac{\partial}{\partial t}(\rho_m \underline{u}) + \nabla \cdot (\rho_m \underline{u}\underline{u}) = -\nabla p + \nabla \cdot \left(\mu_{m,t} \nabla \underline{u}\right) + \rho_m \underline{g} \tag{1}$$

here, density is defined as a following equation.

$$\rho_m = \rho_l \alpha_l + \rho_v \alpha_v + \rho_{ng} \alpha_{ng} \tag{2}$$

The continuity equation considering the phase change can be written as following:

$$\nabla \cdot \underline{u} = (\dot{m}^+ + \dot{m}^-)\left(\frac{1}{\rho_l} - \frac{1}{\rho_v}\right) \tag{3}$$

The transport equation for the water as non-condensable gas can be written as following:

$$\frac{\partial \alpha_l}{\partial t} + \underline{u} \cdot \nabla \alpha_l = \left(\dot{m}^+ + \dot{m}^-\right)\frac{1}{\rho_l} \tag{4}$$

$$\frac{\partial \alpha_{ng}}{\partial t} + \underline{u} \cdot \nabla \alpha_{ng} = 0 \tag{5}$$

here, $\dot{m}^+$ and $\dot{m}^-$ are defined as following equations.

$$\dot{m}^+ = \frac{C_{prod}\, \rho_l (\alpha_l - \alpha_{ng})^2 (1 - \alpha_l - \alpha_{ng})}{t_\infty} \tag{6}$$

$$\dot{m}^- = \frac{C_{dest}\, \rho_l (\alpha_l - \alpha_{ng}) MIN[0, p - p_v]}{(1/2 \rho_l U_\infty^2) t_\infty} \tag{7}$$

To validate the modified solver, the numerical results for cavitation phenomenon were compared with experimental data.

The 2-D wedge geometry for the present study is shown in Figure 1. The wedge shapes were defined by angle (α), chord (c), and depth (d). The wedge angle of 20 degrees, chord of 35 mm, and depth of 12.34 mm were selected. The Reynolds number (Re) was based on the free-stream velocity (U_∞) and the wedge depth (d). The ventilation coefficient (C_Q) was defined as:

$$C_Q = \frac{\dot{Q}}{U_\infty d^2} \tag{8}$$

where, $\dot{Q}$ is volume flow rate.

The cavitation begins to form in the low-pressure region behind the wedge as in the backward facing step flow and propagates downstream as shown in Figure 1.

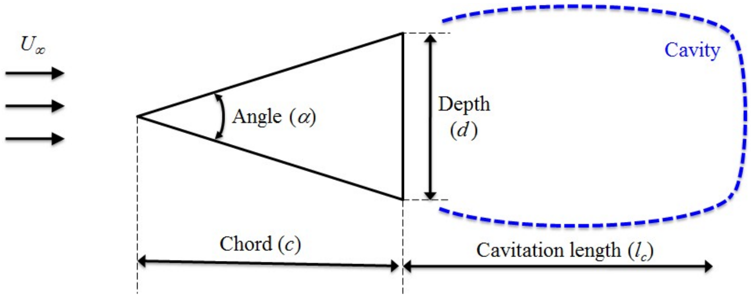

Figure 1. Problem description of wedge

The cavity characteristics of the wedge wake with varying ventilation amount were analyzed. In addition, frequency analysis confirmed that the modified solver reproduced the real physic phenomenon well.

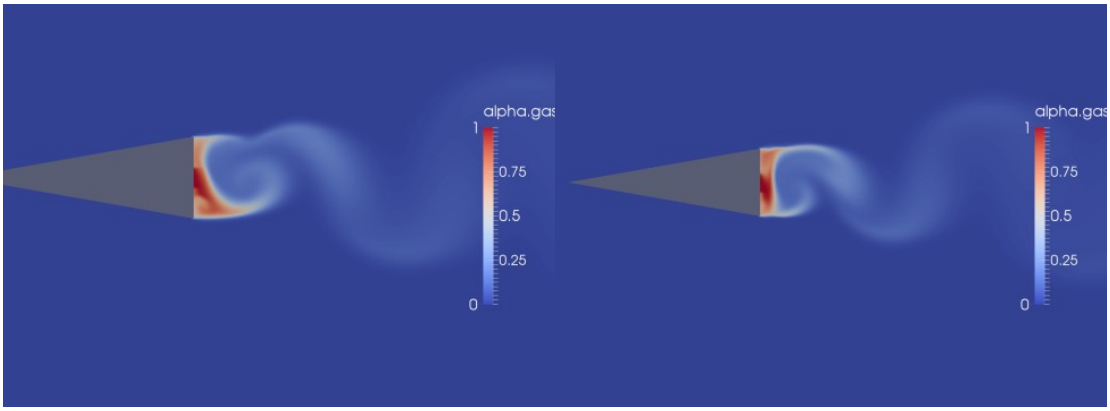

Figure 2: Liquid volume fraction contours behind wedge

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