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FREE SURFACE FLOW PAST A CIRCULAR CYLINDER UNDER FORCED ROTARY OSCILLATIONS

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Numerical results of a viscous incompressible two-fluid model with an oscillating cylinder are analyzed. Specifically, two-dimensional flow past a circular cylinder subject to forced rotational oscillations beneath a free surface is considered. Numerical method is based on the finite volume method for solving the two-dimensional continuity and unsteady Navier-Stokes equations. The numerical simulations are carried out at a Reynolds number of $R = 200$ and a Froude number $Fr = 0.2$, and the cylinder submergence depth, $h = 0.75$. The flow characteristics are examined for combinations of the maximum angular cylinder displacement and the forcing cylinder oscillation frequency-to-natural vortex shedding frequency ratio ($\theta_m = 15^\circ - 75^\circ$ and $f/f_0 = 0.5 - 4.0$). The main objective of this study is to address the alterations of the near-wake region, in particular, the flow regimes and the locked-on vortex formation modes, due to the presence of the free surface. This investigation has shown that it is possible to generate distinctly different patterns of vortex formation than that of classical vortex shedding modes in the presence of the free surface depending on the values of the maximum angular cylinder displacement and the frequency ratio. The new vortex shedding modes are the combination of the two, three and four of the well known classical modes. The effect of the maximum angular displacement amplitude, θ_m, and the frequency ratio, f/f_0, on fluid forces and the pressure field is also analyzed. Good comparisons with previous studies are obtained.