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A Computational Study on Flow Separation Control of Humpback Whale Inspired Sinusoidal Hydrofoils

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Abstract : A computational study on bio-inspired NACA634-021 hydrofoils with leading-edge protuberances has been carried out to investigate their hydrodynamic flow control characteristics at a Reynolds number of 14,000 and different angles-of-attack. The numerical simulations were performed using ANSYS FLUENT and based on Reynolds-Averaged Navier-Stokes (RANS) solver mode incorporated with k-ω Shear Stress Transport (SST) turbulence model. The results obtained indicate varying flow phenomenon along the peaks and troughs over the span of the hydrofoils. Compared to the baseline hydrofoil with no leading-edge protuberances, the leading-edge modified hydrofoils tend to reduce flow separation extents along the peak regions. In contrast, there are increased flow separations in the trough regions of the hydrofoil with leading-edge protuberances. Interestingly, it was observed that dissimilar flow separation behaviour is produced along different peak- or trough-planes along the hydrofoil span, even though the troughs or peaks are physically similar at each interval for a particular hydrofoil. Significant interactions between adjacent flow structures produced by the leading-edge protuberances have also been observed. These flow interactions are believed to be responsible for the dissimilar flow separation behaviour along physically similar peak- or trough-planes.

Keywords : computational fluid dynamics, flow separation control, hydrofoils, leading-edge protuberances
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