FOSSEE, IIT Bombay
OpenFOAM Case Study Project
June 2024

Aerodynamics of Bristled Wings

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August 6, 2024

Synopsis

Microscopic flying insects like thrips and fairyflies possess a distinct wing structure characterized by several bristles extending from a main frame. At low Reynolds numbers of $O(10)$, bristled wings exhibit enhanced aerodynamic efficiency compared to solid membranous wings. This study presents a numerical investigation of bristled wing models at two different angles of attack and a Reynolds number of 30 using the open-source computational fluid dynamics (CFD) package OpenFOAM. Three bristled wing geometries with 4, 5 and 6 bristles were examined. Results indicate that force coefficients increased with the number of bristles, while decreasing gap width between bristles minimized flow leakage through strong viscous diffusion, creating a virtual fluid barrier resulting it to act like a membranous wing. Among the studied bristled wing models, the 6-bristled wing model demonstrated comparable drag to the solid wing model despite its smaller surface area. However, achieving an optimal bristled wing configuration requires a systematic investigation comparing various wing models with different bristle numbers based on generated lift, drag, lift-to-drag ratio, and other parameters.