Bumblebee Aerodynamics

R. Thiagarajan[1], A. Prasad[1], T. Nidi[1]

[1]ATOA Scientific Technologies Pvt Ltd, Bengaluru, India

Abstract

Nature inspired innovation powered many engineering innovation. For example, Bird inspired flight helped us to develop intercontinental flying long range aircraft with efficiency as comparable to transcontinental migratory birds. But, short range air travel, efficiency is much lower than shorts range flying birds and insects. There is still lot more we can learn from nature for cost effective and efficient short range personal transportation. One interesting short-range flight champion from the natural world is the humble bumble bee and dragon fly. Insect's flight is powered by both conventional aerodynamics and unsteady aerodynamics. Insects (Bumble bee, dragon fly), wing structural shape, material constituent, spatial arrangement are also optimized for efficient flight. Hence, in this paper, we investigate the aero and structural behaviour shorts range insects.

Multiphysics CAE Model of a Bumblebee in a virtual wind tunnel is developed using COMSOL®. The numerical problem is solved using the Computational Fluid Dynamics (CFD) Module. We studied the aerodynamic behaviour of bumble bee in our virtual wind tunnel. The flow and structural performance are evaluated. The unsteady aerodynamic forces acting on a 3D computational bumblebee/dragon fly wings are studied by numerically solving the Navier-Stokes equations. The incompressible Navier-Stokes equations are discretized and solved on a specified tetrahedral grid. The objective of the present study is to investigate the influence of the different aerodynamic parameters on the flight performance. Reynolds number (Re), Drag Force, Lift Force, Drag Coefficient and Lift Coefficient. The derived parameters from virtual wind tunnel experiment. Typical virtual wind tunnel experimental results are shown in figure 1 and 2 for Fluid Pressure Magnitude and Downside Fluid Velocity Magnitude as function of flapping, respectively. The Structural Mechanics module was also used to study the structural performance.
This study well benefit to develop novel light weight personal air transporter and also drones for general purpose short haul air cargo transportation.

Figures used in the abstract

Figure 1 : Fluid Pressure Magnitude as function of flapping.

Figure 2 : Downside Fluid Velocity Magnitude as function of flapping.