Study of mosquito aerodynamics for imitation as a small robot 2 and flight in a low-density environment

ABSTRACT

In terms of their flight and unusual aerodynamic characteristics, mosquitoes have become a new insect of interest. Despite transmitting the most significant infectious diseases globally, mosquitoes are still among the great flyers. Depending on their size, they typically beat at a high flapping frequency in the range of 600 to 800 Hz. Flapping also lets them conceal their presence, flirt, and help them remain aloft. Their long, slender wings navigate between the most anterior and posterior wing positions through a stroke amplitude about 40 to 45°, way different from their natural counterparts (>120°). Most insects use leading-edge vortex for lift, but mosquitoes have additional aerodynamic characteristics: rotational drag, wake capture reinforcement of the trailing-edge vortex, and added mass effect. A comprehensive look at the use of these three mechanisms needs to be undertaken—the pros and cons of high-frequency, low-stroke angles, operating far beyond the normal kinematic boundary compared to other insects, and the impact on the design improvements of miniature drones and for flight in low-density atmospheres such as Mars. This paper systematically reviews these unique unsteady aerodynamic characteristics of mosquito flight, responding to the potential questions from some of these discoveries as per the existing literature. This paper also reviews state-of-the-art insect-inspired robots that are close in design to mosquitoes. The findings suggest that mosquito-based small robots can be an excellent choice for flight in a low-density environment such as Mars.

Keyword: Flapping frequency; Stroke amplitude; Wake capture; Wing flexibility; Rotational drag; Low-density