Department of Aerospace and Mechanical Engineering

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Vortex formation in flapping dynamics and energy harvesting

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Lower Level Auditorium, Geddes Hall

Refreshments served at 3:00 p.m. in the Geddes Hall Coffee House

The study on vortex formation and unsteady force generation offers insights into understanding the dynamics of flapping found in nature and the performance of novel, bio-inspired energy harvesting systems. First, in order to find the effect of wing aspect ratio on thrust generation, three-dimensional vortex structures are investigated experimentally using a model that mimics the clapping motion of butterfly wings. The strength of the vortex structure generated by the model increases with decreasing aspect ratio, and the inner area enclosed by the vortex structure becomes larger as the aspect ratio decreases. Hence, in contrast to the traditional aerodynamic theory, the low aspect-ratio wings produce larger thrust than the high aspect-ratio wings in some unsteady modes. In addition, self-excited flapping dynamics and instability are discussed for an inverted flag configuration with a free leading edge and a fixed trailing edge, which reveals quite distinct dynamical behaviors from those of a general flag. This inverted flag configuration was motivated by the tree leaves fluttering in a breeze regardless of their orientation relative to the wind direction. For the flapping inverted flag, the time scale of optimal vortex formation correlates with the energy conversion of fluid kinetic energy to elastic strain energy. Lastly, the energy harvesting performance of a periodically pitching and heaving hydrofoil similar to the flapping propulsors of aquatic animals is examined. Flow visualization shows that the shedding of bound vortices critically limits the overall power generation of the hydrofoil while the development of leading-edge vortices contributes to improved efficiency.

If you are interested in meeting individually with Dr. Kim, please contact Linda at 631-5431.