

Complex Equilibrium of Laterally Curved Wakes

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(Abstract)

Turbulent wakes generated from an aircraft or submarine vehicles has been of main interest to researchers due to the broad band noise associated with such wakes. One such case is the noise generated by spiral vortices shed of from one blade interacting with another oncoming blade of helicopter rotor. Consequently, researchers have been trying to understand the basic physics and evolution of such wakes. Although there has been numerous studies done on plane wakes, there has been little research being done on laterally curved wakes.

Single and two-point velocity measurements were taken on a plane and laterally curved turbulent wakes to understand the evolution and effect of lateral curvature into the far wake region. The analyses provide useful information in modeling curved or spiral wakes such as turbulence field surrounding tip vortices shed from a wing. In order to achieve our objectives, the Virginia Tech 3' x 2' subsonic wind tunnel was used to take velocity measurements of toroidal ring model and a straight cylinder as a control case. Velocity measurements were done using four sensor hot-wire anemometers, to obtain all mean velocity, Reynolds stress, triple product components of the turbulence field. Single point, spectra and two-point measurements of the wakes were performed throughout the development into the far wake region. The single point results reveal the universality of the mean axial velocity, however the Reynolds stresses and triple products were not universal illustrating that the turbulence field has its own length and velocity scales different from that of the mean flow. The effect of lateral curvature is mainly evidenced in the early development of the curved ring wake. The turbulent energy budget reveals

similar trend for both wakes and plane wake achieves approximate equilibrium. The spectra result reveals for the plane wake that self-preservation is achieved for all scales of motion, while the ring wake does not achieve such a state. While the longitudinal correlations of both wakes are similar in form, in general difference in form and orientation prevailed over all indicating the difference in the turbulent structure of both wakes. Linear stochastic estimation reveals the presence of spanwise and double-roller eddy structures in the plane wake and only spanwise eddies were detected for the ring wake.