Tilt Rotor Aerodynamics

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RTOP: 576-03-14

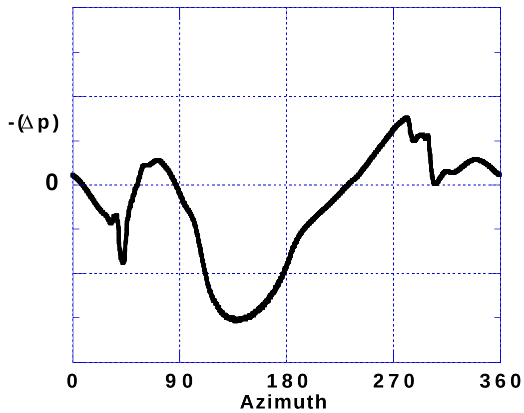

Figure 1. Differential pressure at leading edge near the blade tip.

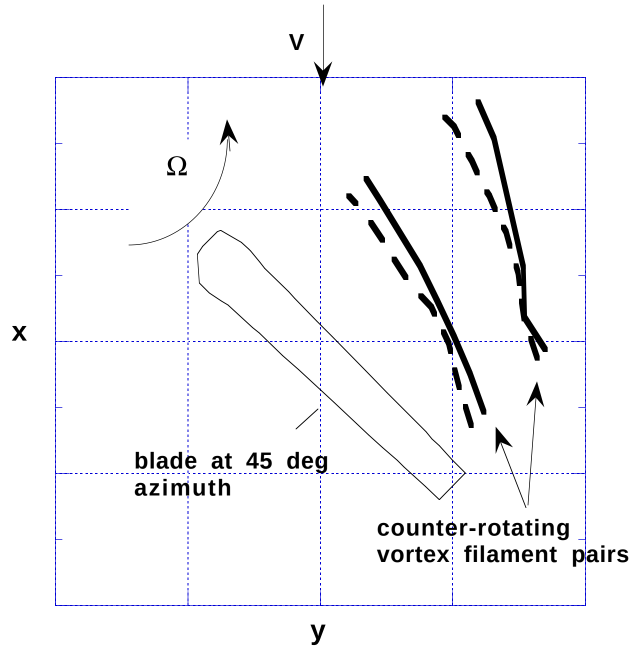

Figure 2. Planview of wake geometry on advancing side.

BACKGROUND

- Rotor acoustic analyses rely on experimental blade airloads and wake measurements for validation. Tilt rotor acoustics are more difficult to model since tilt rotor aerodynamics are more complex than that of conventional rotors. The high disk loading and large blade-twist of tilt rotors create aerodynamic phenomena unique to tilt rotors. Therefore, tilt rotor aerodynamic measurements are critical to the progress of developing a reliable tilt rotor aeroacoustic analysis, which is a key milestone in the Short Haul (Civil Tiltrotor) program. As a step toward this goal, data from a 0.25-scale V-22 rotor were acquired during April-May 1998 in the Duits-Nederlandse Windtunnel (DNW). The model tested was the isolated rotor configuration of the Tilt Rotor Aeroacoustic Model (TRAM). The aerodynamic data included blade dynamic pressures, wake geometry, and vortex velocity field measurements. Rotor performance and extensive acoustic measurements were also acquired.

OBJECTIVES

- Analyze TRAM blade pressure and wake data . Identify underlying reasons and trends for negative loading at the blade tip and how the negative loading is manifested in the wake measurements and acoustic signatures. Determine effects of rotor operating condition on wake geometry and vortex strength.

ACCOMPLISHED

- One hundred fifty dynamic pressure transducers distributed over two of the three rotor blades provided a mapping of the blade airloads. Wake geometry measurements were acquired using the laser light sheet technique, while the vortex velocity field measurements were acquired using the particle image velocimetry technique. These flow field measurements were made for a limited number of blade-vortex interaction conditions. Figure 1 represents the azimuthal pressure differential near the leading edge of the blade tip. Negative loading is clearly present on the advancing side which infers that a counter-rotating vortex pair must be present in the rotor wake for this condition. Figure 2 represents the wake geometry measurements for this condition. Two counter-rotating vortex filament pairs are shown.

FUTURE PLANS

- Vortex velocity field data obtained from the particle image velocimetry measurements will be analyzed to obtain an estimation of the vortex strength and core size. These data together with the wake geometry and airloads data will be used by analyses for predicting tilt rotor acoustics.