Role of Wind Tunnels in Aircraft Design

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Aircraft of various types are necessary for meeting the defence and air transport requirements of any country. Till recently a large fraction of the Indian aircraft requirements have been met by imports or licensed production. However there is a trend towards design and manufacture of aircraft within the country. Among the recent design projects are the Light Combat Aircraft (LCA), Light Transport Aircraft (LTA), Advanced Light Helicopter (ALH), Hindustan Jet Trainer (HJT-16), Light Trainer (HANSA) and the unmanned air vehicles – Lakshya and Nishant.

A typical air vehicle development project progresses in stages. In the preliminary design stage, several configurations of the proposed air vehicle are evaluated in the light of their mission requirements. In this phase, databases are used and a minimum of wind tunnel (Box 1) tests are undertaken. Once a configuration is chosen, the project moves to the next phase where the configuration is thoroughly evaluated for performance, stability and controllability under normal and unusual but safety critical operating conditions (like one engine failure on a twin-engined airplane). Minor modifications are studied and incorporated as required at this stage. The evaluation process is carried out using data from computational and other methods. However, most data is obtained by direct wind tunnel testing in large wind tunnels simulating the actual flight conditions as nearly as possible. Often, several wind tunnels each simulating one regime of flow (like low speed flow, supersonic flow, etc.) are employed in this process. Considering the stringent requirements imposed by the mission, the evaluation process for the flight vehicle must lead to highly reliable, accurate and rapid estimates of performance and controllability and this in turn makes severe demands on the speed and accuracy of wind tunnel studies. The variety and complexity of wind tunnel tests are a
Box 1. Wind Tunnel

Wind tunnel is an aerodynamic test facility. It is mostly used to study flow patterns around bodies and measure aerodynamic forces on them. The bodies (called models) are usually scaled down but geometrically similar versions of bodies of interest like an airplane or an automobile. The results from wind tunnel tests can be 'scaled' to the actual velocity and actual body size using suitable scaling laws.

A typical wind tunnel consists of a test section in which the model is kept, a contraction section and settling section before the test section, and a diffuser after the test section. A fan after the diffuser creates the wind. The given figure is a schematic of the IISc open circuit wind tunnel. Wind tunnels are designed to have a uniform velocity in the test section with minimum fluctuations in the velocity. The honeycomb, screens and contraction, all are used to this end. By reducing the velocity, the diffuser reduces losses and thus the power consumption to run the wind tunnel.

In open circuit wind tunnels like the one shown in the figure the air is sucked in from outside and blown out. In the recirculating type of wind tunnel the same air circulates in a closed loop. High speed wind tunnels are often of blowdown type: a gust of compressed air blows down the test section for a short time during which the tests are conducted.

![Wind Tunnel Diagram]

Typical wind tunnel tests include static force measurements of complete aircraft configurations and components, air intake tests for power plant – intake compatibility studies, small oscil-