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EXPERIMENTAL AERODYNAMICS DIVISION

SUMMARY

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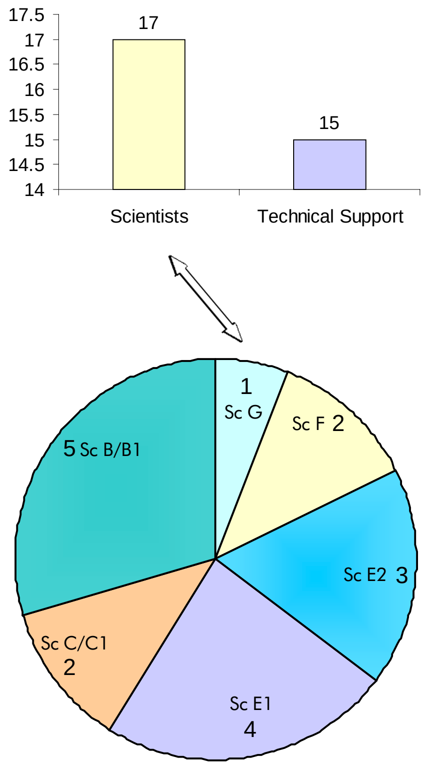

The R&D activities of the Division are reported under three major disciplines: flow structure and management, flow diagnostics and aircraft and spacecraft aerodynamics. Several new projects were initiated during the year. These include: development of a half-model balance for the 1.5m low speed wind tunnel, 2-channel burst spectrum analyser for LDV measurements, quantitative Schlieren technique (BOS), and data generation related to hypersonic inlets; a beginning has been made to set up aero-acoustic instrumentation for studying noise problems relevant to SARAS aircraft and high speed jets. The highlights of work done are briefly summarized.

FLOW STRUCTURE AND MANAGEMENT

A major thrust of the Division is to study some of the aerodynamic problems relevant to the SARAS aircraft and suggest improvements: specific topics of interest include high-lift aerodynamics, drag reduction methodologies and noise reduction of propellers.

A detailed experimental programme has been in progress studying aspects of hysteresis at high-lift on a 1:6 scale SARAS wing-flap combination at low speeds. Measurements of aero-dynamic loads were made over a range of flap overlap and gap values, and typical results displaying hysteresis were reported last year. Additional measurements and data analysis have been made. The study of surface pressure distributions has revealed that the separated flow around the mid-flap region and on the flap contributes most to hysteresis effects. Measurements were also made to assess the variation of the magnitude of hysteresis effects with time at each angle of attack. Additional work is planned currently to control these effects by passive means.

It is well known that the rear fuselage of a transport aircraft can result in large drag if not optimized properly. Towards this goal, as a first step, measurement of the drag characteristics of the rear fuselage of SARAS over a range of Mach numbers was completed. The base flow wind tunnel was exploited for this test and the total drag of the rear fuselage (without horizontal tail) was directly measured using a 3-component, special, annular strain gauge balance. Measurement of pressure distributions and surface flow visualisation studies were carried out as well.

A novel concept of separation control involving tangential blowing inside the bubble has been in progress for some years. The concept has been extended to trailing-edge separated flows and additional measurements of turbulent shear stress and kinetic energy profiles made in the separated zone, both with and without blowing, reveal the complex nature of flow with blowing. Limited measurements assessing the effects of tangential blowing upstream of separation (as in classical boundary layer control approach) have been completed recently for comparison.

The study of relaminarising boundary layers at low speeds under the combined influence of acceleration and convex surface curvature was completed. The measurements on the convex surface and calculations made using the quasi-laminar equations (ignoring curvature effects) indicate stabilizing effects of convex surface curvature in promoting relaminarization.

FLOW DIAGNOSTICS

A major activity in the Division is in the area of advanced flow diagnostics and their application to complex flow problems. Following the commissioning of the pressure sensitive paint (PSP) system in the NAL 1.2m trisonic wind tunnel last year, a high speed (generic) aircraft model has been fabricated with the main purpose of establishing temperature corrections for measured PSP data in the NAL 1.2m blowdown tunnel. The model is instrumented with a number of thermocouples and static pressure taps on the wing surface and tests are planned very soon.

To meet the future requirements of PSP applications in NAL, a PC Windows-based software development is in progress. The program has been developed in a MATLAB environment and converted to Visual C++6.0. The method aims to incorporate certain improvements like automatic marker recognition, automatic averaging and temperature compensation. Development of a pyrene based binary paint for transonic applications has been in progress in the Surface Engineering Unit of NAL. Considerable support has been given by the Division towards frequent calibration of paint samples and assessment of stability characteristics of the paint through extensive wind tunnel testing on small scale models.

There is considerable interest in the understanding of high-lift flows and PIV is an excellent tool for documenting such complex flows. Towards this broad goal, as a first step, measurements have been completed in the near-wake of a 1:6 scale SARAS wing with a deflected flap. Since the accuracy of PIV results depend on a variety of parameters (e.g. imaging area, interrogation size) in addition to good seeding, a comparative study was made with hot-wire measurements and the need for improvements are noted; this exercise will form the basis of our future work. A beginning has been made on stereoscopic PIV in an elliptic jet at low speeds.

In cooperation with the Deutsche Zentrum for Luft und Raumfahrt (DLR), Goettingen, a beginning has been made to develop a quantitative Schlieren method “BOS” (background oriented Schlieren). The density field behind the shock of a cone model at Mach 2.0 has been explored successfully. Application of the technique to other flows as well as development of a software package for BOS are planned. The Division has considerable expertise in the measurement of 2-component LDV in complex flows. A project for developing a signal processing system based on burst spectrum analysis has been initiated in collaboration with the Aerospace Electronics Division to replace the ageing counter type signal processors. The system is based on a high speed sophisticated DSP and a host computer with advanced capabilities and significant progress has been made.

AIRCRAFT AND SPACECRAFT AERODYNAMICS

In the area of intake aerodynamics, experimental studies were continued on the convergent-divergent duct at a free stream Mach number of 1.6. Efforts were made to study the effect of diverter height in the presence of splitter plate on the occurrence of flow instability (seen in the form of shock oscillations). Results reveal that, with an increase in diverter height of about 80 per cent of the local boundary layer thickness, occurrence of flow instability is delayed to lower exit areas. An increase in diverter height allows a large part of the boundary layer and also separated flow arising out of the shock boundary layer interaction into the diverter, thereby reducing ingestion of low energy fluid into the intake and delaying the occurrence of flow instability.

Air breathing propulsion concepts are being seriously considered for slender bodies and launch vehicles from the consideration of extending their speed envelope. Towards this goal, wind tunnel studies have been carried out assessing the effect of various intake geometries on the aerodynamics characteristics of a generic slender body at supersonic speeds. These studies have shown significant effect of the intake geometry on the aerodynamic characteristics of the body, and an optimization of certain geometric parameters of the intake need to be carried for a practical design. In a related study, work has been initiated to generate a database for an understanding of the broad flow features associated with intake systems relevant to a generic hypersonic research vehicle; both side wall and top and bottom wall compression intakes will be studied.

Development of a software including a novel scheme for redundancy management for use with a flush air data system (FADS) was successfully carried out recently. Development of a neural network software for air data computation through FADS is currently in progress in cooperation with the Flight Mechanics & Control Division. Algorithms with neural network techniques are inherently stable and allow easy calibration of wind tunnel data involving a large number of air data parameters; furthermore, they can also take care of non-linear relationships among air data and orifice pressure values.

The Model Shop II continued to provide accurate composite wind tunnel models for different projects in the Division.

INTERNATIONAL COLLABORATION

The Division has a project on "Advanced Flow Diagnostic Techniques" with the DLR Institute of Fluid Mechanics, Goettingen.