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Transonic Aerodynamics by ESDU

A thorough understanding of aerodynamics at speeds close to the speed of sound is of great importance to the aerospace industry. Most long- and medium-range airliners cruise at a speed just under the speed of sound as do many military aircraft. In military applications, too all supersonic aircraft is to pass through the transonic speed range.

This range starts when the speed of the aircraft is sufficiently high for compressibility effects to become significant and extends until a flow field is established that is fully supersonic, apart from the small subsonic areas of flow occurring near a blunt noise or leading edge. The transonic range is usually considered to occur between flights Mach numbers of 0.7 to 1.4 approximately, although local transonic features may occur at a much lower flight Mach number. For example the flow over a complex high lift system is often locally transonic at normal approach speeds.

The development of localised shock waves is associated with transonic flow. The position and strength of these shock waves is difficult to predict and they may interact with the boundary layer at the surface, causing the boundary layer to thicken or separate.

For example, the wings of transonic aircraft, designed for efficient cruise, are highly loaded over most of their chord and a shock wave is frequently present on the upper surface of such a wing. This shock wave, together with the high adverse pressure gradient near the trailing edge, leads to the onset of extensive regions of separation as the lift coefficient or Mach number is raised above the design value.

This eventually causes severe “buffet”, limiting the useful range over which the wing can be safely operated (Figure 1). The exact conditions under which these separations occur and their extent are difficult to determine accurately using either Computational Fluid Dynamics (CFD) or wind-tunnel tests.

The ESDU Transonic Aerodynamics Series is an extensive collection of design and analysis tools, including advanced software, dealing with the varied aspects of transonic aerodynamics. The Series provides the aerodynamicist with tools to predict both flows corresponding to the design condition, where separation is limited and the onset of significant separation in the flow.

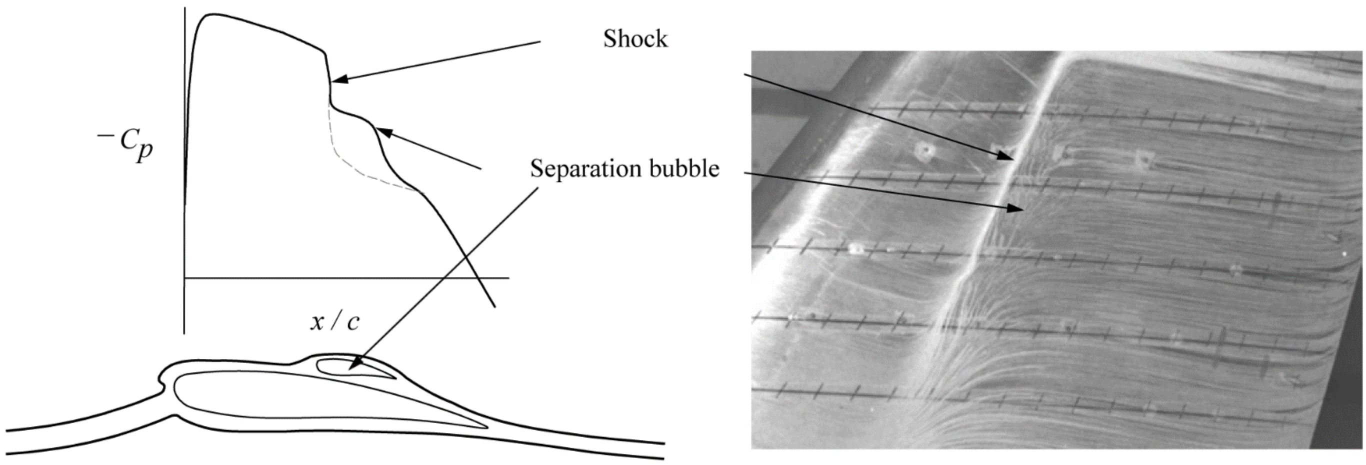

Figure 1 Oil flow picture and pressure distribution showing separation induced by a shock wave on a wing upper surface (from ESDU 03014)

Included in the Series are extensive manuals for wing design, developed by leading practitioners. They are supplemented by software relating to the design condition such as the VGK aerofoil method and VFP, a potential flow wing/body program.

Other tools deal with the prediction of the onset of separation on the wing and the associated drag rise, the drag rise on symmetrical bodies and the wave of cowls.

In order to control separation, vortex generators are frequently used and the design and use of these devices receives comprehensive coverage.

Because it is difficult to predict the shock/boundary-layer interactions that occur in transonic flow, the wind tunnel plays an important role in configurations testing and development. However, tests conducted at Reynolds numbers below the full-scale value require careful interpretation. Because of this, the Series contains a substantial amount of information devoted to wind-tunnel testing. During such testing it is essential that the designer should gain a thorough understanding of the physical nature of the flow. One Data Item aids this process with a comprehensive account of the use and interpretation of surface-flow visualization methods and includes some 400 high-quality photographs, most unpublished elsewhere.

Other publications deal with techniques by which wind-tunnel tests made at low Reynolds number may be extrapolated to full scale and specific worked examples are currently being collected.

The Transonic Aerodynamics Series is continuously reviewed to meet the needs of industry. Inevitably there is common ground between this Series and the Aerodynamics Series. Here the search facilities employed on the ESDU Website enable rapid location of all Items relevant to a particular topic

For more information www.esdu.com

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