Turbulent-Spot Growth Characteristics: Wind-Tunnel and Flight Measurements of Natural Transition at High Reynolds and Mach Numbers

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Abstract

A series of experiments are described which examine the growth of turbulent spots on a flat plate at Reynolds and Mach numbers typical of gas-turbine blading. A short-duration piston tunnel is employed and rapid-response miniature surface-heat-transfer gauges are used to assess the state of the boundary layer. The leading- and trailing-edge velocities of spots are reported for different external pressure gradients and Mach numbers. Also, the lateral spreading angle is determined from the heat-transfer signals which demonstrate dramatically the reduction in spot growth associated with favourable pressure gradients. An associated experiment on the development of turbulent wedges is also reported where liquid-crystal heat-transfer techniques are employed in low-speed wind tunnel to visualise and measure the wedge characteristics. Finally, both liquid crystal techniques and hot-film measurements from flight tests at Mach number of 0.6 are presented.
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Turbulent-Spot Trajectories
\[ \frac{dP}{dx} = SF \]

Legend
- LE \( (C_m = 0.90) \)
- M \( (C_m = 0.74) \)
- TE \( (C_m = 0.65) \)

\[ o \rightarrow \frac{dP}{dx} = MF (3.9\pm0.1 \text{ degrees}) \]
\[ x \rightarrow \frac{dP}{dx} = SF (3.3\pm0.1 \text{ degrees}) \]