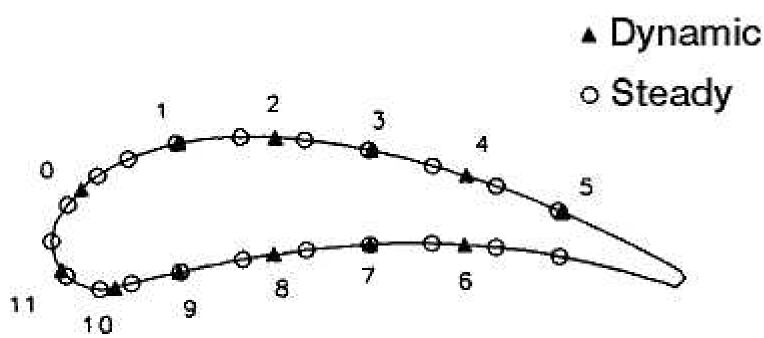
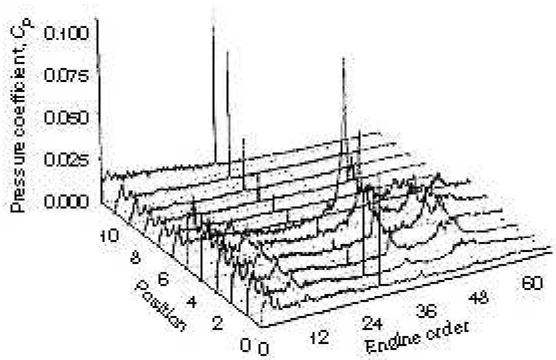
Measurement of Gust Response on a Turbine Cascade

This in-house experiment on the gust response of an annular turbine cascade was particularly designed to provide data to compare with the results of a typical, linearized gust-response analysis. Reduced frequency, Mach number, and incidence were varied independently. Except for the lowest reduced frequency, the gust velocity distribution was nearly sinusoidal. For the high inlet-velocity series of tests, the cascade was near choking. The mean flow was documented by measuring blade surface pressures and the cascade exit flow, and high-response pressure transducers were used to measure the unsteady pressure distribution. Inlet-velocity components and turbulence parameters were measured using hot wire anemometry. In addition to the synchronous time-averaged pressure spectra, typical power spectra are included for several representative conditions.



Instrumentation ports.

The gusts were generated by a rotor consisting of 3.17- or 4.76-mm-diameter pins. Either 6, 12, or 24 pins were used, resulting in a gust reduced frequency of 2.5, 5, or 10. The annular turbine cascade had 24 blades, and it was positioned 3.9 axial chordlengths behind the rotor. The figure above illustrates the positions of instrumentation ports, and the following figure illustrates representative root-mean-square (rms) spectra. The synchronous peaks could have been obtained by linear phase-lock averaging; however, the rms-averaged spectra also include the nonsynchronous origin and the random pressure fluctuations. The frequency units are engine orders; thus, the synchronous peaks appear at the frequency equal to the number of rotor pins used to generate wakes. The position-axis units correspond to the blade port numbers in the instrumentation figure; thus, position 0 corresponds to the port nearest to the leading edge on the suction surface side, and position 11 corresponds to the port nearest to the leading edge on the pressure side.



Root-mean-square pressure spectra showing the pressure coefficients, C_p, for a reduced frequency of 10, an inlet Mach number of 0.27, and a positive incidence.

The gust amplitude varied somewhat with the reduced frequency; however, it did not appear to have a dominant effect. Unsteady, synchronous-response blade pressures depend strongly on reduced frequency and incidence. Mach number dependence is weak for negative incidence and significant for positive incidence at lower reduced frequencies. The mean blade-pressure distribution depends, to some extent, on the reduced frequency, particularly for the negative incidence and the higher inlet Mach number. At a reduced frequency of 10, an inlet Mach number of 0.27, and a positive incidence, magnification of the turbulent pressure fluctuations on the suction side of the aft portion of the blade resulted in a significant excitation concentrated at an integral engine order much higher than the synchronous excitation frequency.

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