ONE-DIMENSIONAL DYNAMIC WAKE RESPONSE IN AN ISOLATED ROTOR DUE TO INLET TOTAL PRESSURE DISTORTION

by

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(ABSTRACT)

An experimental investigation of the wake of a low-speed axial-flow compressor rotor was conducted with and without the presence of steady inlet total pressure distortions. The steady three-dimensional rotor inlet flow was obtained by a five-hole pneumatic pressure probe, while the one-dimensional rotor exit data were obtained using a piggyback steady/unsteady total pressure probe in non-nulling mode. Both inlet and exit flow conditions were measured in the stationary frame of reference.

Results indicate increases in wake thickness and magnitude of total pressure defect as blade loading increased into the distortion cycle. The wake suction side jet increased in width and magnitude as blade loading increased, which appears to be a response to flow blockage caused by the growing boundary layer on the blades. Based on one-dimensional exit total pressure conditions with respect to the distortion screen, the dynamic response of the intra-blade passage flow does not appear to be a function of blade loading, measurement span, or distortion intensity within the ranges tested. Unsteady one-dimensional rotor exit suction side jet width and magnitude varied a great deal within and outside of the distorted region, and were only moderately correlated to inlet flow conditions. Changes in the unsteady one-dimensional rotor wake width and magnitude were usually in phase with and strongly correlated to changes in the inlet flow conditions.

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NOMENCLATURE

A	Amperes
A	Area
AC	Alternating current
Ann	Annulus
Atm	Atmospheric
Ave	Average
C	Chord length
Cp_{static}	Five-hole probe static pressure calibration coefficient
Cp_{total}	Five-hole probe total calibration coefficient
Cp_{yaw}	Five-hole probe yaw angle calibration coefficient
Cp_{pitch}	Five-hole probe pitch angle calibration coefficient
C_x	Axial velocity
cm	Centimeters
d	Wire diameter
dB	Decibels
DC	Direct current
FM	Frequency modulation
ft	Feet
Hp	Horsepower
H_2O	Water
i	Blade incidence angle
I/O	Input/Output
IGV	Inlet guide vane
m	Meters
mA	MilliAmperes
med	Median
m	Meridional direction

msec	Milliseconds
P	Pressure
$\bar{P}$	Average of five-hole probe pressures
p_i	Five-hole probe pressures
PSD	Power spectral density
Psig	Pounds per square inch of gauge pressure
R	Ideal gas constant
rpm	Revolutions per minute
SS	Steady-state
s	Pitch length
sec	Seconds
T	Temperature
t	Blade thickness
U	Wheel speed
V_i	Absolute flow velocity
W_i	Relative flow velocity
W	Uncertainty

Greek Symbols

α_i	Absolute Flow Angle
α	Flow pitch angle
β_i	Relative Flow Angle
β	Flow yaw angle
θ	Circumferential direction
ψ	Non-dimensionalized machine total pressure rise
Ω	Ohms resistance
ρ	Fluid Density
ξ	Stagger Angle