Identification and Evaluation of Loss and Deviation Models for use in Transonic Compressor Stage Performance Prediction

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(ABSTRACT)

The correlation of cascade experimental data is one method for obtaining compressor stage characteristics. These correlations specify pressure loss and flow turning caused by the blades. Current open literature correlations used in streamline curvature codes are inadequate for general application to high-speed transonic axial-flow compressors. The objective of this research was to investigate and evaluate the available correlations and ultimately discover sets of correlations which best fit the empirical data to be used in streamline curvature codes.

Correlations were evaluated against experimental data from NASA Rotor 1-B and NASA Stage 35. It was found that no universal set of correlations was valid for minimum-loss point predictions. The Bloch shock loss model showed promising results in the stall regime for supersonic relative inlet Mach numbers. The Hearsey and Creveling off-minimum-loss deviation angle prediction performed consistently better than all other correlations tested.

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Nomenclature

A	Cross-sectional area of the streamtube
c	Chord length
D	Diffusion ratio
DCA	Double Circular Arc
D_{eq}	Equivalent diffusion factor
d	Uniform cascade depth
H	Form factor
h	Blade height
i	Angle of incidence
LER	Leading Edge Radius
M	Mach number
$\dot{m}$	Mass flow rate
MCA	Multiple Circular Arc
P	Pressure
R	Ideal gas constant
Re	Reynolds Number
r	Radius
s	Pitch length
s	Entropy
T	Temperature
t	Blade thickness
TER	Trailing Edge Radius
2-D	Two-dimensional
3-D	Three-dimensional
U	Wheel speed
V	Absolute flow velocity
W	Relative flow velocity
±	Plus or minus

Acronyms

AEDC	Arnold Engineering Development Center, Tullahoma, Tennessee, U.S.A.
AVDR	Axial Velocity-Density Ratio
CMLC	Compressible Meanline Code
MVDR	Meridional Velocity-Density Ratio
SLCC	Streamline Curvature Code

Greek Symbols

δ	Deviation angle
δ	Boundary layer thickness
δ^*	Boundary layer displacement thickness
α	Absolute flow angle
β	Relative flow angle
Θ	Boundary layer momentum thickness
θ	Camber angle
ρ	Fluid density
σ	Solidity
Ω	Rotational speed
ϖ	Total pressure loss coefficient
ξ	Stagger angle
$\circ$	Degree

Subscripts

i	Flow angle and velocity index for blade station
x	Axial direction
m	Meridional direction
rel	Relative reference frame
T	Total property
1	Blade inlet aerodynamic interface plane
2	Blade exit aerodynamic interface plane

Embellishments

*	At minimum-loss incidence