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INFLUENCE OF AXIAL VELOCITY DENSITY RATIO IN CASCADE TESTING OF SUPERCRITICAL COMPRESSOR BLADES

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ABSTRACT

An experimental and numerical study of the influence of axial velocity density ratio (AVDR) in cascade testing of two high-turning compressor blades at supercritical flow conditions was conducted. Both solid and slotted sidewalls were used in the experiments such that the cascade performances were evaluated with the variation of AVDR at the same flow condition. In addition, the cascade flow was computed by solving 2-D and 3-D steady Navier-Stokes equations. 2-D CFD computation provided the ideal 2-D flow results (AVDR = 1.0) while 3-D CFD characterized the 3-D cascade flow in the test section with solid sidewalls. Thus, the sidewall secondary flow and the flow contraction across the blade passage were simulated (AVDR > 1.0). Detailed analysis of the AVDR influence on the flow was performed through the comparison of experimental and numerical results, including losses, blade surface Mach number, blade surface flow visualization and shadowgraph. Different AVDR influences were found on the two blades and also at different flow conditions. Nonetheless, solid sidewall cascade testing was found to be acceptable to evaluate the relative blade performances, in spite of the AVDR influence.

NOMENCLATURE

AVDR	Axial velocity density ratio $= (\rho_2 V_2 \cos\alpha_2) / (\rho_1 V_1 \cos\alpha_1)$
AR	Aspect ratio
EXP	Experiment
I	Incidence angle
M	Mach number
P.S.	Pressure surface
Ps	Static pressure
Pt	Total pressure
Re	Reynolds number
S.S.	Suction surface
Tu	Freestream turbulence intensity
V	Flow velocity
X	Distance in axial direction
α	Flow angle (with respect to axial direction)
ρ	Density
ω	Loss coefficient $= (Pt_1 - Pt_2) / (Pt_1 - Ps_1)$

Subscripts

1	Inlet plane
2	Outlet plane
is	Isentropic

INTRODUCTION

The important role of axial velocity density ratio (AVDR) in two-dimensional linear cascade testing was ascertained earlier in the 1960s (Pollard and Gostelow[1]). There were a few later studies focusing on this issue in 1970s and 1980s (Fottner[2], Stark[3], Heilmann[4], Starken et al.[5], and Stark and Hoheisel[6]). These earlier studies had found large effects of AVDR on the cascade performance: with increasing AVDR, the cascade would usually see an up-shifting of blade

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