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Numerical Investigation of Film Cooling from Two Rows of Holes with Anti-Vortex Holes Attached to the Upstream Row

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Abstract

Computational analysis of film cooling effectiveness from two rows of holes inclined with 30^{o} on a flat surface in case of in-line and staggered arrangements has been carried out. The upstream row is supplemented with anti-vortex holes. The addition of anti-vortex holes is presented as a new technique depends on adding two cylindrical holes branching out from the main holes. Three different positions of anti-vortex holes are studied with three different values of velocity ratios. The study is carried out using realizable *k-ϵ model* in FLUENT commercial code. The numerical model is verified by comparing a single row of film cooling holes results with available experimental works in literature. The results ensure that the staggered arrangement gives higher film cooling effectiveness than the in-line one for all studied velocity ratios. The use of anti-vortex holes increases the film cooling effectiveness. The position of anti-vortex holes shows a significant effect, especially with high velocity ratios.

Keywords: Film Cooling; Two rows; Anti-Vortex; CFD

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Nomenclature

D	Film cooling main hole diameter (m)	T_f	Local film temperature (K)
d	Film cooling anti-vortex hole diameter (m)	T_m	Mainstream air temperature (K)
VR	Velocity Ratio = U_c/U_m	U_c	Coolant air velocity (m/s)
BR	Blowing Ratio =$(\rho_c U_c/\rho_m U_m)$	U_m	Mainstream air velocity (m/s)
MR	Momentum Ratio = $(\rho_c U_c^2/\rho_m U_m^2)$	x	Distance from the upstream row centerline (m)
Re_x	Free stream Reynolds number = U_m*x/ν_m	ν	Kinematic viscosity of the fluid (m^2/s)
Re_D	Injectant Reynolds number = U_c*D/ν_c	$\bar{\eta}$	Average film cooling effectiveness
T_{aw}	Adiabatic wall temperature (K)	$\bar{\bar{\eta}}$	Overall film cooling effectiveness
T_c	Coolant air temperature (K)		