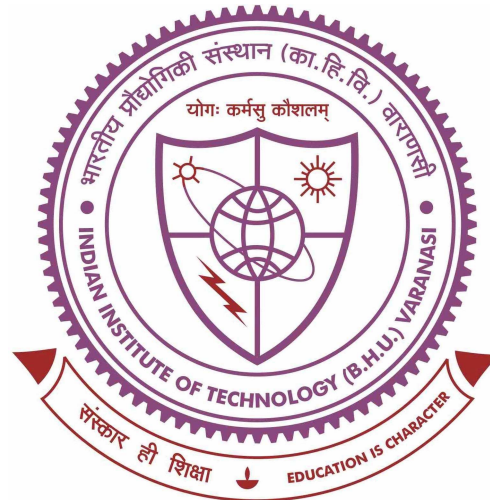


# Experimental and numerical analysis of turbulent jet on a wavy surface



*Thesis submitted in partial fulfillment  
of the requirements for the degree of*  
**Doctor of Philosophy**

by

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## List of Symbols and Abbreviations

$a$	slotted jet height, $mm$
$A$	normalised amplitude ( $A = \text{amplitude} / a$ )
$f_x$	local frictional factor coefficient $f_x = 8\tau_w / \rho U_0^2$
$f_{avg}$	average frictional factor coefficient $f_{avg} = (1/S) \Delta_0^S f_x ds$
$h$	convective heat transfer coefficient, $W / (m^2 K)$
$L$	total domain length 75a
$N$	number of cycle
$Nu_x$	local Nusselt number $Nu_x = (q_{wx} Pr Re) / (\rho C_p U_0 (T_0 - T_\infty))$
$Nu_{avg}$	average Nusselt number $Nu_{avg} = (1/S) \Delta_0^S Nu_x ds$
$Q$	volume flow rate in the streamwise direction, $m^3 / s$
$Re$	Reynolds number, $Re = (\rho u h) / \mu$
$S$	total arc length of the wavy wall
$T_0$	inlet temperature, $K$
$T_\infty$	surrounding temperature, $K$
$t_{rms}$	fluctuating temperature
$\langle t' u' \rangle$	streamwise turbulent heat flux
$\langle t' v' \rangle$	cross-stream turbulent heat flux
$T$	temperature at specific location, $K$
$U$	normalised streamwise velocity, $u / U_0$
$U_0$	inlet velocity, $m s^{-1}$
$U_{max}$	normalised local Streamwise maximum velocity
$u, v$	local mean velocities in x and y direction, $m s^{-1}$
$X, Y$	normalised x and y coordinates, $x / a, y / a$
$Y_1$	normal distance of wavy surface from the x- axis
$Y_{0.5}$	normalised transverse location from the bottom wall where ( $U = U_{max} / 2$ )
$Y_{T0.5}$	normalised transverse location from the bottom wall where ( $\theta = \theta_{max} / 2$ )
$Y_{max}$	normalised transverse location from the bottom wall where ( $U = U_{max}$ )
$Y_{Tmax}$	normalised transverse location from the bottom wall where ( $\theta = \theta_{max}$ )
$\theta$	normalised local temperature $\frac{T - T_\infty}{T_0 - T_\infty}$
$\theta_{max}$	normalised local maximum temperature

$\theta_w$	normalised local wall temperature $\frac{T_w - T_\infty}{T_0 - T_\infty}$
$k$	Turbulent kinetic energy
$\omega_n$	frequency
<b>Greek symbols</b>	
$\alpha, \alpha_t$	laminar and turbulent thermal diffusivities, $m^2/s$
$\alpha_{t,n}$	non-dimensional thermal diffusivity
$\varepsilon$	Dissipation of turbulent kinetic energy, $m^2/s^3$
$\omega$	specific dissipation rate, $s^{-1}$
$\nu, \nu_t$	Laminar and turbulent kinematic viscosity respectively, $m^2/s$
$\tau_{wall}$	Wall shear stress, $\mu \left( \frac{d\bar{u}}{dy} \right)_{y=0}$
$\mu$	Dynamic viscosity
$\rho$	Density of the fluid (air), $kg/m^3$
$\theta'$	$\langle (t - t_{mean})^2 \rangle^{1/2}$
$\sigma_k, \sigma_\varepsilon, \sigma_{1\varepsilon}, \sigma_{2\varepsilon}, \sigma_\varepsilon$	Model constants
<b>Subscript</b>	
$max$	maximum
$min$	minimum
$avg$	average
$n$	non-dimensional parameters
$o$	inlet condition
$\infty$	ambient condition
$x$	Local value
<b>Acronym and other notations</b>	
2D	Two-dimensional
3D	Three-dimensional
Re	Reynolds number
THP	Thermal Hydraulic Performance
LD	Linearly decaying
PSD	Power spectral density
PIV	Particle Image Velocimetry
LDA	Laser Doppler Anemometer
RANS	Reynolds Average Navier Stokes
LES	Large Eddy Simulation
DNS	Direct Numerical Simulation