Summary of fluid dynamic parameters (ACML lab, GNU, South Korea) 2019

Non-dimensional parameters					
Parameters	***Definition***	***Qualitative ratio of effects***	***Importance***	***Priority (isothermal or non-isothermal)***	***Priority (conserved or non-conserved)***
Flow variables					
Density	$\frac{\rho}{\rho_{ref}}$	-	Always	Isothermal	Conserved
Temperature	$\frac{T}{T_{ref}}$	-	Always	Non-isothermal	Conserved
Pressure	$\frac{P}{P_{ref}}$ or, $\frac{P}{\rho_{ref} u_{ref}^2}$	-	Always	Isothermal	Conserved
Velocity	$\frac{V}{u_{ref}}$	-	Always	Isothermal	Conserved
Total Energy	$\frac{E}{u_{ref}^2}$	-	Heat transfer	Non-isothermal	Conserved
Shear stress	$\frac{\Pi}{\left(\mu_{ref} u_{ref} / L\right)}$ or, $\frac{\Pi}{\rho_{ref} u_{ref}^2}$	-	Viscous fluid	Isothermal	Non-conserved
Excess normal stress	$\frac{\Delta}{\left(\mu_{ref} u_{ref} / L\right)}$	-	Non-monatomic gases in thermal nonequilibrium	Isothermal	Non-conserved
Heat flux	$\frac{Q}{\left(k_{ref} \Delta T / L\right)}$ or, $\frac{Q}{\rho_{ref} u_{ref}^3}$	-	Heat transfer	Non-isothermal	Non-conserved
Rayleigh-Onsager dissipation	$R^2 = \hat{\Pi} : \hat{\Pi} + \frac{2\gamma}{f_b} \hat{\Delta}^2 + \hat{Q} : \hat{Q}$	-	Flows in thermal nonequilibrium	Non-isothermal	Non-conserved
Vorticity	$\Omega_z = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$	-	Rotational	Isothermal	-

Sound pressure	$\frac{p - p_s}{p_s}$	-	Vortex flow	Isothermal	-
Enstrophy evolution	$\int_{dA} \Omega_z (x, y, z, t) dxdy$	-	Vortex flow	Isothermal	-
Dissipation rate evolution	$\int_{dA} E(x, y, z, t) dxdy$	-	Flow in thermal nonequilibrium	Isothermal	Non-conserved
Vorticity transportation	$\frac{\partial \Omega_z (x, y, z, t)}{\partial t}$	-	Vortex flow	Isothermal	-
Time averaged vorticity	$\bar{\Omega}_z = \lim_{T \to \infty} \frac{1}{T} \int_0^T \Omega_z (t) dt$	-	Turbulence	Isothermal	-
Volume fraction	$\frac{V_s}{V_{total}}$	Volume of solid / Total Volume	Multiphase flow	Isothermal	Conserved
Particulate loading	$\frac{\alpha_s \rho_s}{\alpha_g \rho_g}$	Mass of solid / Mass of gas	Multiphase flow	Isothermal	-
Normalized diffusivity	$\frac{K_s}{K_d}$	Scalar diffusivity / Molecular diffusivity	Turbulence	Non-isothermal	-
Roughness ratio	$= \frac{\varepsilon}{L}$	Wall roughness / Body length	Turbulent, rough walls	Isothermal	-
Wall distance	$y_{plus} = y^+ = \frac{y u_T}{\nu}$	-	Turbulence	Isothermal	-
Frictional velocity	$u_T = \sqrt{\frac{\tau_W}{\rho}}$	-	Turbulence	Isothermal	-
Near wall velocity	$u^+ = \frac{u}{u_T}$	-	Turbulence	Isothermal	-
Mean velocity (time averaged)	$\frac{\bar{u}}{u_{ref}} = \lim_{T \to \infty} \frac{1}{T} \int_0^T \frac{u(t)}{u_{ref}} dt$	-	Turbulence	Isothermal	-

Turbulent fluctuation	$\frac{u'}{u_{ref}}=\frac{u'(t)}{u_{ref}}=\frac{u(t)-\bar{u}}{u_{ref}}$	-	Turbulence	Isothermal	-
RMS value of velocity fluctuation	$\frac{u_{rms}}{u_{ref}}=\sqrt{\frac{\overline{u'^2}}{u_{ref}^2}}$	-	Turbulence	Isothermal	-
Turbulence Intensity	$u_{rms}/\bar{u}$	RMS velocity Mean velocity	Turbulence	Isothermal	-
Reynolds stress	$\frac{\overline{u'u'}}{u_{ref}^2}=\frac{L\nu_t}{u_{ref}^2}\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)-\frac{2}{3}K\delta_{ij}$	-	Turbulence	Isothermal	Non-conserved
Stream wise Reynolds normal stress	$\frac{\overline{u'u'}}{u_{ref}^2}$	-	Turbulence	Isothermal	Non-conserved
Reynolds shear stress	$\frac{\overline{u'v'}}{u_{ref}^2}$	-	Turbulence	Isothermal	Non-conserved
Transverse Reynolds stress	$\frac{\overline{v'v'}}{u_{ref}^2}$	-	Turbulence	Isothermal	Non-conserved
Turbulent kinetic energy	$\left(\overline{u'u'}+\overline{v'v'}+\overline{w'w'}\right)/2$	-	Turbulence	Isothermal	Non-conserved
Skewness factor of velocity fluctuation	$S_u=\overline{\left(\frac{\partial u_i}{\partial x_i}\right)^3}\Bigg/\left[\overline{\left(\frac{\partial u_i}{\partial x_i}\right)^2}\right]^{3/2}$	Ratio of velocity derivative	Turbulence	Isothermal	-
Flatness factor of velocity fluctuation	$F_u=\overline{\left(\frac{\partial u_i}{\partial x_i}\right)^4}\Bigg/\left[\overline{\left(\frac{\partial u_i}{\partial x_i}\right)^2}\right]^{2}$	Ratio of velocity derivative	Turbulence	Isothermal	-
Mean dissipation rate of turbulent kinetic energy	$\bar{\varepsilon}=\nu_t\overline{\frac{\partial u_i'}{\partial x_j}\left(\frac{\partial u_i'}{\partial x_j}+\frac{\partial u_j'}{\partial x_i}\right)}$	-	Turbulence	Isothermal	Non-conserved

Mean Kolmogorov length scale	$\eta = \left(\nu^3/\bar{\varepsilon}\right)^{1/4}$	-	Turbulence	Isothermal	-
Mean Kolmogorov velocity scale	$u_\eta = \left(\nu\bar{\varepsilon}\right)^{1/4}$	-	Turbulence	Isothermal	-
Mean Kolmogorov time scale	$\tau_\eta = \left(\nu/\bar{\varepsilon}\right)^{1/2}$	-	Turbulence	Isothermal	-
Fluid property					
Viscosity	$\dfrac{\mu}{\mu_{ref}}$	-	Viscous	Isothermal	-
Thermal conductivity	$\dfrac{k}{k_{ref}}$	-	Heat transfer	Non-isothermal	-
Heat capacity	$\dfrac{C_P}{C_{P\,ref}}$	-	Heat transfer, compressible	Non-isothermal	-
Specific heat ratio	$\gamma = \dfrac{C_p}{C_v}$	Enthalpy / Internal energy	Compressible	Non-isothermal	-
Gas constant	$R = C_p - C_v$	-	Compressible	Non-isothermal	-
Numbers					
Reynolds	$\mathrm{Re} = \dfrac{\rho VL}{\mu}$	Inertia force / Viscous force	Always	Isothermal	-
Mach	$Ma = \dfrac{V}{C}$	Inertia force / Compressibility force	Compressible	Non-isothermal	-
Cauchy	$Ca = Ma^2 = \dfrac{\rho V^2}{E_v}$	Inertia force / Compressibility force	Compressible	Non-isothermal	-
Froude	$Fr = \dfrac{V}{\sqrt{gL}}$	Inertia force / Gravity force	Free-surface flow	Isothermal	-

Weber	$We = \frac{\rho V^2 L}{\sigma}$	$\frac{\text{Inertia force}}{\text{Surface tension force}}$	Free-surface flow	Isothermal	-
Euler	$Eu = \frac{\Delta p}{(1/2)\rho V^2}$	$\frac{\text{Pressure force}}{\text{Inertia force}}$	Cavitation	Isothermal	-
Strouhal	$St = \frac{\omega L}{V}$	$\frac{\text{Inertia force (local)}}{\text{Inertia force (convective)}}$	Oscillating flows	Isothermal	-
Prandtl	$\Pr = \frac{\mu C_p}{k}$	$\frac{\text{Dissipation}}{\text{Conduction}}$	Heat convection	Non-isothermal	-
Turbulent Prandtl number	$\sigma_t = \frac{\nu_t}{\alpha_t}$	$\frac{\text{Turbulent eddy viscosity}}{\text{Turbulent diffusivity}}$	Turbulence	Isothermal	-
Eckert	$Ec = \frac{V^2}{c_p \Delta T}$ or, $(\gamma - 1)M^2$	$\frac{\text{Kinetic energy}}{\text{Enthalpy}}$	Dissipation	Non-isothermal	-
Grashof	$Gr = \frac{\beta(\Delta T) g L^3 \rho^2}{\mu^2}$	$\frac{\text{Buoyancy}}{\text{Viscosity}}$	Buoyancy driven flows	Non-isothermal	-
Rayleigh	$Ra = \Pr Gr = \frac{\beta(\Delta T) g L^3}{\upsilon \alpha}$	$\frac{\text{Buoyancy}}{\text{Viscosity}} \times \frac{\text{Dissipation}}{\text{Conduction}}$	Buoyancy driven flows	Non-isothermal	-
Sherwood	$Sh = \frac{KL}{\alpha}$	$\frac{\text{Convective mass}}{\text{Diffusive mass}}$	Mass transfer	Isothermal	-
Knudsen	$Kn = \frac{M}{\text{Re}} \left(\text{or } \frac{\lambda}{L} \right)$	$\frac{\text{Viscous force}}{\text{Pressure force}}$	Rarefied	Non-isothermal	-
Degree of non-equilibrium	$N_\delta = \frac{M^2}{\text{Re}}$	$\frac{\text{Viscous force}}{\text{Pressure force}}$	Rarefied, high speed flows	Non-isothermal	-
Nusselt	$Nu = \frac{hL}{k}$	$\frac{\text{Convective heat tr.}}{\text{Conductive heat tr.}}$	Heat transfer, turbulence	Non-isothermal	-
Stanton	$C_h = \frac{Nu}{\text{Re} \cdot \Pr}$	$\frac{\text{Heat transfer}}{\text{Thermal capacity}}$	Forced convection, turbulence	Non-isothermal	-
Peclet	$Pe = \frac{LV}{\alpha}$	$\frac{\text{Advection}}{\text{Diffusion}}$	Transport phenomena	Isothermal	-

Richardson	$Ri = \frac{gh}{V^2}$	Buoyancy Shear flow	Oceans, lakes and reservoirs	Isothermal	-
Lewis	α/D	Thermal diffusivity Mass diffusivity	Heat transfer, turbulence	Non-isothermal	-
Schmidt	υ/D	Viscous diffusivity Mass diffusivity	Turbulence	Isothermal	-
Deborah	$De = \frac{t_c}{t_p}$	Relaxation time Observation time	Viscoelastic	Isothermal	-
Stokes	$= \frac{\tau}{t}$	Response time Reference time	Multiphase flow	Isothermal	-
Aerodynamic					
Drag coefficient	$C_d = \frac{F_d}{(1/2)\rho V^2 S_f}$	Drag force Dynamic force	Hydro, aero	Isothermal	
Lift coefficient	$C_l = \frac{F_l}{(1/2)\rho V^2 S_f}$	Lift force Dynamic force	Hydro, aero	Isothermal	-
Pressure coefficient	$C_p = \frac{p - p_{ref}}{(1/2)\rho V^2}$	Static Pressure Dynamic Pressure	Hydrodynamic	Isothermal	-
Skin-friction coefficient	$C_f = \frac{\tau_W}{(1/2)\rho V^2}$	Stress Dynamic Pressure	Viscous flows	Isothermal	-

The **quadrant analysis** is one of the various detection techniques of **turbulent structure** which provides detailed information about the contributions to the total production from various events occurring in the turbulent flow. The analysis divides the Reynolds shear stress into four categories according to the signs of u' and v'.

Quadrant classification (turbulent flow)				
Quadrant	***Sign of*** u'	***Sign of*** v'	***Sign of*** $u'v'$	***Type of motion***
Q1	+	+	(+)	Interaction (outward)

Q2	-	+	(-)	Ejection
Q3	-	-	(+)	Interaction (wall-ward)
Q4	+	-	(-)	Sweep