Symbols and Units Commonly Used in Thermal Process Safety

Symbol	Name	Practical unit	SI-Unit
a	Thermal diffusivity	$m^2 \cdot s^{-1}$	$m^2 \cdot s^{-1}$
A	Heat exchange Area	m^2	m^2
A, b, c	Polynomial coefficients	-	-
$A,B,C,P,R..$	Chemical compounds	-	-
B	Reaction number	-	-
C	Concentration	$mol \cdot l^{-1}$	$mol \cdot m^{-3}$
C'	Concentration (in mass units)	$mol.kg^{-1}$	$mol.kg^{-1}$
c_P	Heat capacity	$J \cdot K^{-1}$	$J \cdot K^{-1}$
c_P'	Specific Heat capacity	$kJ \cdot kg^{-1} \cdot K^{-1}$	$J \cdot g^{-1} \cdot K^{-1}$
d	Diameter or thickness	m	M
E	Activation energy	$J \cdot mol^{-1}$	$J \cdot mol^{-1}$
F	Molar flow rate	$mol \cdot h^{-1}$	$mol \cdot s^{-1}$
g	Acceleration of gravity	$m \cdot s^{-2}$	$m \cdot s^{-2}$
G	Controller Gain	-	-
h	Fi heat transfer coefficient	$W \cdot m^{-2} \cdot K^{-1}$	$W \cdot m^{-2} \cdot K^{-1}$
H	Height	m	m
ΔH	Molar enthalpy	$kJ \cdot mol^{-1}$	$J \cdot mol^{-1}$
$\Delta H'$	Specific enthalpy	$kJ \cdot kg^{-1}$	$J \cdot g^{-1}$
K	constant esp. Equilibrium constant	-	-
k	Form coefficient	-	-
k	Kinetic rate constant	function of rate law	function of rate law
k_0	Frequency factor	function of rate law	function of rate law
l	Length	m	m
$\dot{m}$	Mass flow rate	kg·h-1	g·s-1
M	Mass	kg	g

Symbol	Name	Practical unit	SI-Unit
M_w	Mol weight	$g \cdot mol^{-1}$	$g \cdot mol^{-1}$
n	Order of reaction	-	-
n	revolution frequency	rpm	s^{-1}
N	Number of moles	-	-
P	Pressure	bar	Pa
q	Heat release rate	W	W
q'	Specific heat release rate	$W \cdot kg^{-1}$	$W \cdot g^{-1}$
Q	Thermal energy (heat)	kJ	J
Q'	Specific energy	$kJ \cdot kg^{-1}$	$J \cdot g^{-1}$
r	Reaction rate	$mol \cdot m^{-3} \cdot h^{-1}$	$mol \cdot m^{-3} \cdot s^{-1}$
r	Radius	m	m
R	Universal gas constant	$J \cdot mol^{-1}.K^{-1}$ $l \cdot mbar \cdot mol^{-1} K^{-1}$	$J \cdot mol^{-1} \cdot K^{-1}$
S	cross section	m^2	m^2
t	Time	h	s
T	Temperature	°C	K
ΔT_{ad}	Adiabatic temperature rise	°C	K
u	Linear velocity	$m \cdot s^{-1}$	$m \cdot s^{-1}$
U	Overall heat transfer coefficient	$W \cdot m^{-2} \cdot K^{-1}$	$W \cdot m^{-2} \cdot K^{-1}$
$\dot{v}$	Volume flow rate	$m^3 \cdot h^{-1}$	$m^3 \cdot s^{-1}$
V	Volume	m^3	m^3
X	Conversion	-	-
z	Length coordinate	m	m
z	Equipment constant (stirred tank)	-	-

Subscripts

Subscript	Meaning	Example	
0	Initial value	T_0	initial temperature
A,B,P,R,S	Reference to chemical compounds	C_A	concentration of A
ac	accumulation	X_{ac}	degree of accumulation
ad	adiabatic	ΔT_{ad}	adiabatic temperature rise
amb	ambient	T_{amb}	ambient temperature
b	boiling	T_b	boiling point
c	coolant	T_c	temperature of coolant
cell	Calorimetric cell	M_{cell}	Mass of calorimetric cell
cf	cooling failure	T_{cf}	temperature after cooling failure
cond	condensation	q_{cond}	cooling capacity of condenser
crit	critical	T_{crit}	critical temperature
cx	convective	q_{cx}	convective heat flow
d	decomposition	ΔH_d	enthalpy of decomposition
D24	TMR_{ad} = 24 hrs	T_{D24}	Temperature atwhich TMR_{ad}=24h
ex	exchange (heat exchange)	q_{ex}	heat dissipation rate
ex	Explosion	V_{ex}	Volume of explosive atmosphere
f	final	T_f	final temperature
fd	feed	T_{fd}	feed temperature
g	gas	ρ_G	gas density
H	hydraulic	d_h	hydraulic diameter
i	index	*Ci*	concentration of ith compound
l	liquid	ρ_l	liquid density
loss	loss	*qloss*	rate of heat loss
max	maximum	*Tmax*	maximum temperature
mes	measure	T_{mes}	measurement temperature
p	process	T_P	process temperature
r	reactor, reaction mass	d_r	diameter of reactor
ref	Reference	T_{ref}	Reference temperature
rx	reaction	q_{rx}	heat release rate of reaction
s	stirrer	d_s	stirrer diameter
st	stoichiometric	$M_{R,st}$	reaction mass at stoichiometry
tox	toxic	V_{tox}	volume of toxic atmosphere
v	vapour	ΔH_v	latent enthalpy of evaporation
w	wall	T_w	wall temperature

Greek

Symbol	Name	Practical unit	SI-Unit
α	Relative volume increase	-	-
α	Heat loss coefficient	$W \cdot K^{-1}$	
β	Effective Biot number	-	-
β	Volumic expansion coefficient	K^{-1}	K^{-1}
γ	Material constant for heat transfer	$W \cdot m^{-2} \cdot K^{-1}$	$W \cdot m^{-2} \cdot K^{-1}$
δ	Form factor, Frank-Kamenetskii number	-	-
Δ	Difference (used as prefix)	-	-
ε	Expansion coefficient	-	-
φ	Heat tranfer coefficient of equipment	$W \cdot m^{-2} \cdot K^{-1}$	$W \cdot m^{-2} \cdot K^{-1}$
Φ	adiabacity coefficient	-	-
λ	Thermal conductivity	$W \cdot m^{-1} \cdot K^{-1}$	$W \cdot m^{-1} \cdot K^{-1}$
μ	Dynamic viscosity	cP = mPa.s	Pa.s
ν	Kinematic viscosity	$m^2 \cdot s^{-1}$	$m^2 \cdot s^{-1}$
ν_A	Stoichiometric coefficient of A	-	-
π	3.14159.....		
θ	Dimensionless temperature	-	-
θ	Dimensionless time	-	-
ρ	Specific weight	$kg \cdot m^{-3}$	$g \cdot m^{-3}$
σ	Surface tension	$N \cdot m^{-1}$ = 103 $dyne \cdot cm^{-1}$	$N \cdot m^{-1}$ (= $kg \cdot s^{-2}$)
σ	Variance (square root of...)	-	-
τ	Time constant	h	s
τ	Space time	h	s
ψ	Semenov criterion	-	-

Acronyms

BR	Batch reactor
CSTR	Continuous stirred tank reactor
DSC	Differential scanning calorimetry
DTA	Differential thermal analysis
IDLH	Immediately dangerous to life and health
LEL	Lower explosion limit
MTSR	Maximum temperature of synthesis reaction
MTT	Maximum temperature for technical reasons
PFR	Plug flow reactor
SBR	Semi-batch reactor
TMR_{ad}	Time to maximum rate under adiabatic conditions
TNR	Time of no return

Dimensionless groups

Symbol	Name	Expression	Parameter
B	Thermal reaction number	$B = \frac{\Delta T_{ad} \cdot E}{R \cdot T^2}$	ΔT_{ad} *adiabatic temperature rise* *E* *activation energy* *R* *universal gas constant* *T* *temperature*
Bi	Biot	$Bi = \frac{h \cdot r_0}{\lambda}$	*h:* *film heat transfer coefficient* *r:* *radius* λ: *thermal conductivity*
Da	Damköhler	$Da = \frac{r_0 \cdot t}{C_0}$	r_0 *reaction rate* *t* *reaction time* C_0 *initial concentration*
Fo	Fourier	$Fo = \frac{at}{r^2}$	*a* *thermal diffusivity* *t* *time* *r* *characteristic dimension*
Gr	Grashof	$Gr = \frac{g \cdot \beta \cdot L^3 \cdot \rho^2 \cdot \Delta T}{\mu^2}$	*g* *gravity constant* β *volumic expansion* ρ: *specific weight* *L* *characteristic length* ΔT *temperature difference* μ: *dynamic viscosity* λ: *thermal conductivity*

Symbol	Name	Expression	Parameter
Nu	Nusselt	$Nu = \frac{h \cdot d}{\lambda}$	*h:* *film heat transfer coefficient* *d:* *characteristic length* λ: *thermal conductivity*
Pr	Prandtl	$Pr = \frac{\mu \cdot c'_P}{\lambda}$	μ: *dynamic viscosity* *Cp* *Specific heat capacity* λ: *Thermal conductivity*
Ra	Rayleigh	$Ra = \frac{g \cdot \beta \cdot \rho^2 \cdot c'_P \cdot L^3 \cdot \Delta T}{\mu \cdot \lambda}$	*g* *gravity constant* β *volumic expansion coefficient* ρ: *specific weight* *Cp* *specific heat capacity* *L* *characteristic length* ΔT *temperature difference* μ: *dynamic viscosity* λ: *thermal conductivity*
Re	Reynolds (tube)	$Re = \frac{u \cdot d \cdot \rho}{\mu}$	*u:* *flow velocity* *d:* *diameter* ρ: *specific weight* μ: *dynamic viscosity*
Re	Reynolds (stirred tank)	$Re = \frac{n \cdot d^2 \cdot \rho}{\mu}$	*n* *stirrer frequency* *d:* *diameter of agitator* ρ: *specific weight* μ: *dynamic viscosity*
St	Stanton (modified)	$St = \frac{U \cdot A \cdot t}{\rho \cdot V \cdot Cp'}$	*U* *heat transfer coefficient* *A* *heat tranfer area* *t* *characteristic time* ρ *specific weight* *V* *volume* *Cp'* *specific heat capacity*