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Flow induced acoustic resonance in tubular heat exchangers

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THE PREPARATION OF THIS DATA ITEM

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FLOW INDUCED ACOUSTIC RESONANCE IN TUBULAR HEAT EXCHANGERS

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FLOW INDUCED ACOUSTIC RESONANCE IN TUBULAR HEAT EXCHANGERS

1. NOTATION AND UNITS

		Units	
		SI	*British*
c	velocity of sound (Equation (4.5))	m/s	ft/s
D	inside diameter of shell of circular duct	m	ft
d	outside diameter of tube	m	ft
f	frequency	Hz	Hz
g_c	constant of proportionality in Newton's second law of motion	– (1.0)	lb ft/s^2 lbf (32.18)
L	rectangular duct dimension	m	ft
M	Mach number, ratio of flow velocity to local speed of sound in fluid medium	–	–
MW	relative molecular mass (molecular weight)	kg/kmol	lb/lbmol
n , m , p	rectangular duct mode numbers for transverse, tube axis and gas flow directions respectively (Equation (4.1))	–	–
P	pressure	N/m^2 (Pa)	lbf/ft^2
p	tube pitch (Sketch 4.3)	m	ft
p_l	longitudinal tube pitch (Sketch 5.1)	m	ft
p_t	transverse tube pitch (Sketch 5.1)	m	ft
R	universal gas constant	J/kg mol K (8314.3)	ft lbf/lb mol°R (1545)
Re	Reynolds number = $\rho V d/\eta$	–	–
S	Strouhal number = $f\,d/V$	–	–
T	absolute temperature	K	°R
V	flow velocity based on straight line gap or transverse flow area (Sketch 5.1)	m/s	ft/s
X_l	longitudinal tube pitch ratio, p_l/d (Sketch 5.1)	–	–

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X_t	transverse tube pitch ratio, p_t/d (Sketch 5.1)	–	–
x_g	vapour mass fraction (mass flow rate of vapour/total mass flow rate)	–	–
Z	gas compression factor	–	–
γ	ratio of gas specific heat capacities	–	–
Δ^*	Fitzpatrick's acoustic damping parameter, defined in Equation (6.3)	–	–
η	dynamic viscosity of gas	kg/m s	lb/ft s
λ	mode constant (Equation (4.3))	–	–
ρ	density	kg/m^3	lb/ft^3
ρ_g, ρ_l	gas and liquid phase densities respectively in a two-phase vapour-liquid flow	kg/m^3	lb/ft^3
σ	bundle solidity (Sketch (4.3))	–	–
ψ	Chen's acoustic damping parameter, defined in Equation (6.2)	–	–

Extra subscripts

a	acoustic
e	excitation
eff	effective
g	gas or vapour phase
tp	two-phase
x, *y*, *z*	rectangular duct dimensions in transverse, tube axis and gas flow directions respectively
α	number of diametral pressure nodes in circular duct
β	number of concentric circular pressure nodes in circular duct