

Relazioni e - NTU

TABLE 11.3 Heat Exchanger Effectiveness Relations [5]

Flow Arrangement	Relation	
Parallel flo	$\varepsilon = \frac{1 - \exp[-NTU(1 + C_r)]}{1 + C_r}$	(11.28a)
Counterflo	$\varepsilon = \frac{1 - \exp[-NTU(1 - C_r)]}{1 - C_r \exp[-NTU(1 - C_r)]}$	$(C_r < 1)$
	$\varepsilon = \frac{NTU}{1 + NTU}$	$(C_r = 1)$ (11.29a)
Shell-and-tube		
One shell pass (2, 4, . . . tube passes)	$\varepsilon_1 = 2 \left\{ 1 + C_r + (1 + C_r^2)^{1/2} \times \frac{1 + \exp[-(NTU)_1(1 + C_r^2)^{1/2}]}{1 - \exp[-(NTU)_1(1 + C_r^2)^{1/2}]} \right\}^{-1}$	(11.30a)
n shell passes ($2n, 4n, . . .$ tube passes)	$\varepsilon = \left[\left(\frac{1 - \varepsilon_1 C_r}{1 - \varepsilon_1} \right)^n - 1 \right] \left[\left(\frac{1 - \varepsilon_1 C_r}{1 - \varepsilon_1} \right)^n - C_r \right]^{-1}$	(11.31a)
Cross-flow (single pass)		
Both fluids unmixed	$\varepsilon = 1 - \exp \left[\left(\frac{1}{C_r} \right) (NTU)^{0.22} \{ \exp[-C_r(NTU)^{0.78}] - 1 \} \right]$	(11.32)
$C_{\max}$ (mixed), $C_{\min}$ (unmixed)	$\varepsilon = \left(\frac{1}{C_r} \right) (1 - \exp \{ -C_r [1 - \exp(-NTU)] \})$	(11.33a)
$C_{\min}$ (mixed), $C_{\max}$ (unmixed)	$\varepsilon = 1 - \exp(-C_r^{-1} \{ 1 - \exp[-C_r(NTU)] \})$	(11.34a)
All exchangers ($C_r = 0$)	$\varepsilon = 1 - \exp(-NTU)$	(11.35a)

TABLE 11.4 Heat Exchanger NTU Relations

Flow Arrangement	Relation	
Parallel flo	$NTU = -\frac{\ln[1 - \varepsilon(1 + C_r)]}{1 + C_r}$	(11.28b)
Counterflo	$NTU = \frac{1}{C_r - 1} \ln \left(\frac{\varepsilon - 1}{\varepsilon C_r - 1} \right)$	$(C_r < 1)$
	$NTU = \frac{\varepsilon}{1 - \varepsilon}$	$(C_r = 1)$ (11.29b)
Shell-and-tube		
One shell pass (2, 4, . . . tube passes)	$(NTU)_1 = -(1 + C_r^2)^{-1/2} \ln \left(\frac{E - 1}{E + 1} \right)$	(11.30b)
	$E = \frac{2/\varepsilon_1 - (1 + C_r)}{(1 + C_r^2)^{1/2}}$	(11.30c)
n shell passes ($2n, 4n, . . .$ tube passes)	Use Equations 11.30b and 11.30c with $\varepsilon_1 = \frac{F - 1}{F - C_r}$ $F = \left(\frac{\varepsilon C_r - 1}{\varepsilon - 1} \right)^{1/n}$ $NTU = n(NTU)_1$	(11.31b, c, d)
Cross-flow (single pass)		
$C_{\max}$ (mixed), $C_{\min}$ (unmixed)	$NTU = -\ln \left[1 + \left(\frac{1}{C_r} \right) \ln(1 - \varepsilon C_r) \right]$	(11.33b)
$C_{\min}$ (mixed), $C_{\max}$ (unmixed)	$NTU = -\left(\frac{1}{C_r} \right) \ln[C_r \ln(1 - \varepsilon) + 1]$	(11.34b)
All exchangers ($C_r = 0$)	$NTU = -\ln(1 - \varepsilon)$	(11.35b)