

Table 10-3 | Heat-exchanger effectiveness relations.

$N = NTU = \frac{UA}{C_{\min}} \quad C = \frac{C_{\min}}{C_{\max}}$	
Flow geometry	Relation
Double pipe:	
Parallel flow	$\epsilon = \frac{1 - \exp[-N(1 + C)]}{1 + C}$
Counterflow	$\epsilon = \frac{1 - \exp[-N(1 - C)]}{1 - C \exp[-N(1 - C)]}$
Counterflow, $C = 1$	$\epsilon = \frac{N}{N + 1}$
Cross flow:	
Both fluids unmixed	$\epsilon = 1 - \exp\left[\frac{\exp(-NCn) - 1}{Cn}\right]$ where $n = N^{-0.22}$
Both fluids mixed	$\epsilon = \left[\frac{1}{1 - \exp(-N)} + \frac{C}{1 - \exp(-NC)} - \frac{1}{N}\right]^{-1}$
C_{\max} mixed, C_{\min} unmixed	$\epsilon = (1/C)\{1 - \exp[-C(1 - e^{-N})]\}$
C_{\max} unmixed, C_{\min} mixed	$\epsilon = 1 - \exp\{- (1/C)[1 - \exp(-NC)]\}$
Shell and tube:	
One shell pass, 2, 4, 6, tube passes	$\epsilon = 2\left\{1 + C + (1 + C^2)^{1/2}\right.$ $\left. \times \frac{1 + \exp[-N(1 + C^2)^{1/2}]}{1 - \exp[-N(1 + C^2)^{1/2}]} \right\}^{-1}$
Multiple shell passes, $2n, 4n, 6n$ tube passes (ϵ_p = effectiveness of each shell pass, n = number of shell passes)	$\epsilon = \frac{[(1 - \epsilon_p C)/(1 - \epsilon_p)]^n - 1}{[(1 - \epsilon_p C)/(1 - \epsilon_p)]^n - C}$
Special case for $C = 1$	$\epsilon = \frac{n\epsilon_p}{1 + (n - 1)\epsilon_p}$
All exchangers with $C = 0$	$\epsilon = 1 - e^{-N}$

Table 10-4 | NTU relations for heat exchangers.

$C = C_{\min}/C_{\max}$	$\epsilon = \text{effectiveness}$	$N = NTU = UA/C_{\min}$
Flow geometry	Relation	
Double pipe:		
Parallel flow	$N = \frac{-\ln[1 - (1 + C)\epsilon]}{1 + C}$	
Counterflow	$N = \frac{1}{C - 1} \ln\left(\frac{\epsilon - 1}{C\epsilon - 1}\right)$	
Counterflow, $C = 1$	$N = \frac{\epsilon}{1 - \epsilon}$	
Cross flow:		
C_{\max} mixed, C_{\min} unmixed	$N = -\ln\left[1 + \frac{1}{C} \ln(1 - C\epsilon)\right]$	
C_{\max} unmixed, C_{\min} mixed	$N = \frac{-1}{C} \ln[1 + C \ln(1 - \epsilon)]$	
Shell and tube:		
One shell pass, 2, 4, 6, tube passes	$N = -(1 + C^2)^{-1/2}$ $\times \ln\left[\frac{2/\epsilon - 1 - C - (1 + C^2)^{1/2}}{2/\epsilon - 1 - C + (1 + C^2)^{1/2}}\right]$	
All exchangers, $C = 0$	$N = -\ln(1 - \epsilon)$	