Topic - Heat Exchanger Analysis-NTU - Effectiveness

Effectiveness of A HX

- Ratio of the actual heat transfer rate to maximum available heat transfer rate.

$$\varepsilon = \frac{\dot{Q}_{act}}{\dot{Q}_{\max}}$$

- Maximum available temperature difference of minimum thermal capacity fluid.

$$\Delta T_{\max, fluid} = T_{h,i} - T_{c,i}$$

- Actual heat transfer rate:

$$\dot{Q}_{act} = UA\Delta T_{LMTD}$$

$\dot{Q}_{DT} = \dot{m}_{DT} C_{pDT} (T_{DTe} - T_{DTi})$

$\dot{Q}_{hw} = \dot{m}_{hw} c_{hw} (T_{hwi} - T_{hwe})$

$\dot{Q}_{DT} = \dot{Q}_{hw}$ = Maximum

Option 1: $T_{DTe} = 95^\circ C = T_{hwi}$

Option 2: $T_{hwe} = 15^\circ C = T_{DTi}$

$C_{DT} = \dot{m}_{DT} \times C_{pDT}$

$C_{hw} = \dot{m}_{hw} \times C_{hw}$

Dimensionless Groups for HXs

- Thermal capacity Ratio:

$$R = \frac{(\dot{m}c_p)_{\min}}{(\dot{m}c_p)_{\max}} = \frac{C_{\min}}{C_{\max}}$$

- $R = 0$ corresponds to condensing or evaporating HX.
- $R < 1$ *a general heat exchanger.*

- Exchanger heat communicative Effectiveness:

$$\varepsilon = \frac{\dot{Q}_{act}}{\dot{Q}_{\max}}$$

$\dot{Q}_{\max}$: Thermodynamically limited maximum possible heat transfer

Number of Transfer Units

$$\varepsilon = \frac{UA\Delta T_{LMTD}}{(\dot{m}c_p)_{min}(T_{h,i} - T_{c,i})}$$

$$\varepsilon = NTU_{max}\frac{\Delta T_{LMTD}}{(T_{h,i} - T_{c,i})}$$

$$\varepsilon = NTU_{max}\frac{\dfrac{(\Delta T_{comm,2} - \Delta T_{comm,1})}{\ln\left[\dfrac{\Delta T_{comm,2}}{\Delta T_{comm,1}}\right]}}{(T_{h,i} - T_{c,i})}$$

Arithmetic of A Simple Counter Flow HX

Gn	UA
1	26587
2	26467
3	26541

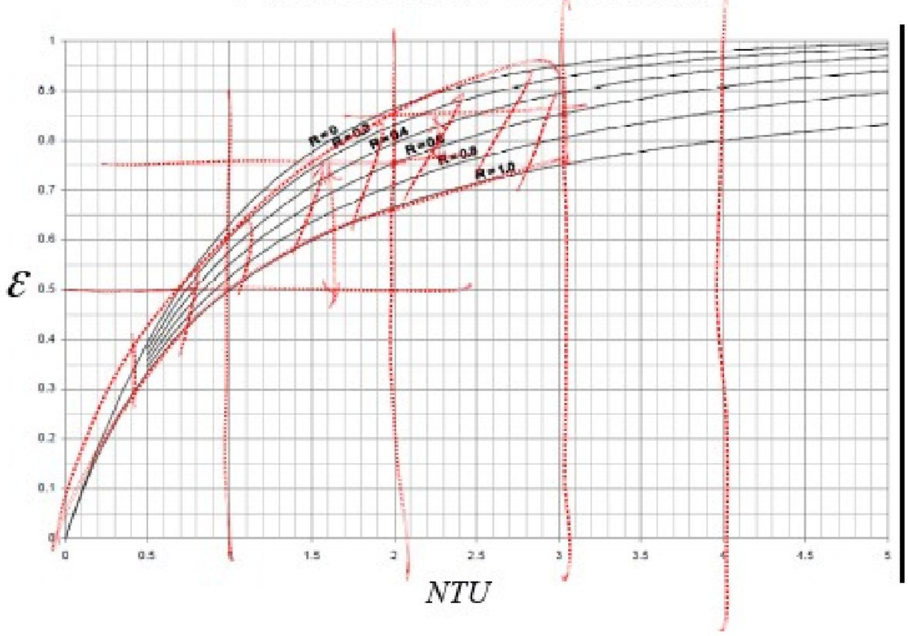
$$\varepsilon = \frac{1 - \exp[NTU \times [R - 1]]}{1 - R\times\exp[NTU \times [R - 1]]} = 0.86$$

$$NTU = \frac{\ln\left\{\dfrac{(1-\varepsilon)}{(1-R\varepsilon)}\right\}}{1 - R}$$

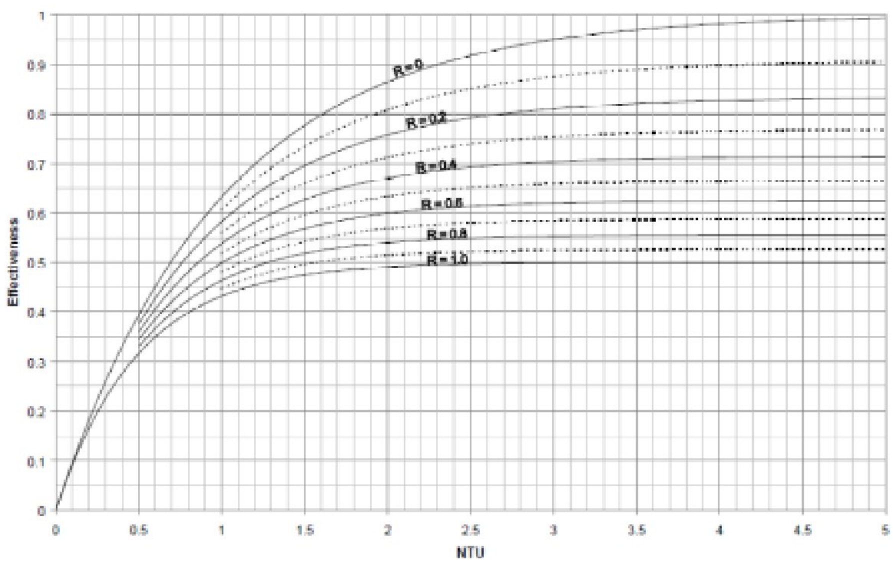
$$R = \frac{(\dot{m}c_p)_{min}}{(\dot{m}c_p)_{max}} = \frac{C_{min}}{C_{max}} = 0.57$$

$$NTU = \frac{UA}{C_{min}} = 3.195$$

ε- NTU Curves: Counter flow



ε- NTU Curves: Counter Vs parallel flow



References:

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2. Frank P. Incropera and David P. DeWitt, “Fundamentals of Heat and Mass Transfer”, John Wiley and Sons, New Jersey,6th Edition1998(Unit I,II,III,IV, V)
3. MIT open courseware – https://ocw.mit.edu/courses/mechanical-engineering

   Other web sources