



DEPARTMENT OF MECHANICAL ENGINEERING, 19MEB302/ Heat and Mass Transfer – UNIT III - PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS

Topic - Heat Exchanger Analysis-NTU - Effectiveness

Effectiveness of A HX

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

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

Handwritten notes:
 $\dot{Q}_{DT} = \dot{m}_{DT} C_{pDT} (T_{DTc} - T_{DTi})$
 $\dot{Q}_{hw} = \dot{m}_{hw} C_{phw} (T_{hwi} - T_{hwc})$
 $\dot{Q}_{DT} = \dot{Q}_{hw} = \text{Maximum}$

- Maximum available temperature difference of minimum thermal capacity fluid.

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

Handwritten notes:
 Option 1 $T_{DTc} = 95^\circ C = T_{hwc}$
 Option 2 $T_{hwc} = 15^\circ C = T_{DTc}$

- Actual heat transfer rate:

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

Handwritten notes:
 $C_{DT} = \dot{m}_{DT} \times C_{pDT}$
 $C_{hw} = \dot{m}_{hw} \times C_{phw}$

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:

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

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



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Number of Transfer Units

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

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

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

Arithmetic of A Simple Counter Flow HX

Gm	UA
1	26587
2	26467
3	26541

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

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

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

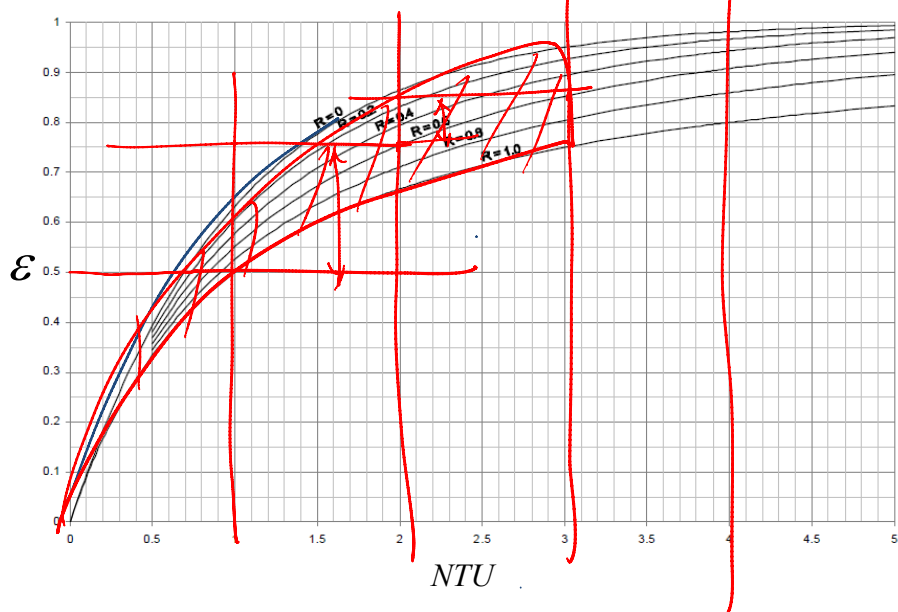
$$NTU = \frac{UA}{C_{\min}} = 3.195$$



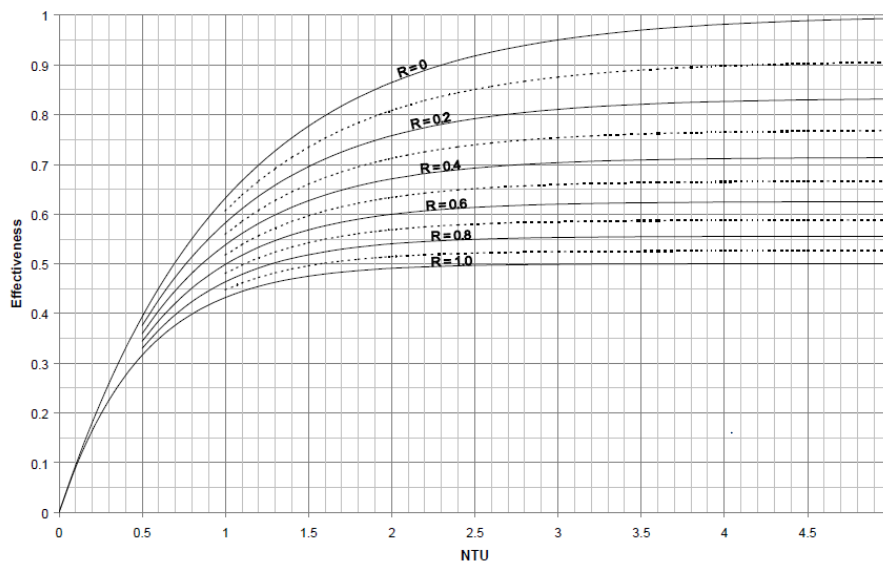
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ϵ – NTU Curves: Counter flow



ϵ – NTU Curves: Counter Vs parallel flow





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References:

1. Kothandaraman C.P “Fundamentals of Heat and Mass Transfer” New Age International, New Delhi,4th Edition 2012 (Unit I, II, III, IV, V).
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