$$dq = Hp\,dx\,(T-t)$$

$$dq = -GC\,(T_{x+dx} - T_x)$$ fluido caldo $T(x) > T(x+dx)$

$$dq = \pm gc\,(t_{x+dx} - t_x)$$ fluido freddo

equicorrente $t(x+dx) > t(x)$

controcorrente $t(x+dx) < t(x)$

$$dT = -\frac{dq}{GC} \qquad dt = \pm\frac{dq}{gc}$$

$$d(T-t) = -\frac{dq}{GC} \mp \frac{dq}{gc} = dq\left(-\frac{1}{GC} \mp \frac{1}{gc}\right)$$

$$dq = \frac{d(T-t)}{-\frac{1}{GC} \mp \frac{1}{gc}} = Hp\,dx\,(T-t)$$

$$\frac{d(T-t)}{T-t} = -Hp\left(\frac{1}{GC} \pm \frac{1}{gc}\right)dx$$

supponiamo costante con x $Hp\left(\frac{1}{GC} \pm \frac{1}{gc}\right)$

$$\left[\ln(T-t)\right]_0^x = \left[-Hp\left(\frac{1}{GC} \pm \frac{1}{gc}\right)x\right]_0^x$$

$$\ln\frac{T-t}{T_1-t_1} = -Hp\left(\frac{1}{GC} \pm \frac{1}{gc}\right)x$$

$$\boxed{T-t = (T_1-t_1)\,e^{-Hp\left(\frac{1}{GC} \pm \frac{1}{gc}\right)x}}$$

$$dq = -GC\,dT \qquad\Rightarrow\qquad Q = -GC(T_2 - T_1) \;\Rightarrow\; T_2 - T_1 = -\frac{Q}{GC}$$

$$dq = gc\,dt \qquad\qquad Q = gc(t_2 - t_1) \qquad\quad t_2 - t_1 = \pm\frac{Q}{gc}$$

$$dq = Hp\,dx\,(T - t)$$

$$(T_2 - T_1) - (t_2 - t_1) = Q\left(-\frac{1}{GC} \mp \frac{1}{gc}\right)$$

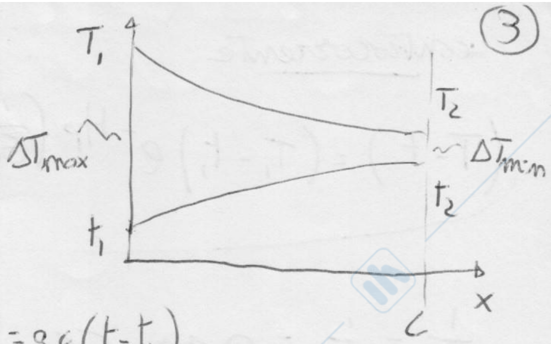
$$-\frac{1}{GC} \mp \frac{1}{gc} = \frac{T_2 - T_1 - t_2 + t_1}{Q}$$

$$\ln\frac{T - t}{T_1 - t_1} = -Hp\left(\frac{1}{GC} \pm \frac{1}{gc}\right)x$$

$$\ln\frac{T_2 - t_2}{T_1 - t_1} = -Hp\left(\frac{1}{GC} \pm \frac{1}{gc}\right)L \;\Rightarrow\; \ln\frac{T_2 - t_2}{T_1 - t_1} = HpL\,\frac{T_2 - T_1 - t_2 + t_1}{Q}$$

$$\boxed{Q = HA\,\frac{(T_2 - t_2) - (T_1 - t_1)}{\ln\frac{T_2 - t_2}{T_1 - t_1}} = HA\,\Delta T_{ml} = HA\,\frac{\Delta T_{max} - \Delta T_{min}}{\ln\frac{\Delta T_{max}}{\Delta T_{min}}}}$$

$$T-t=(T_1-t_1)e^{-Hp\left(\frac{1}{GC}\pm\frac{1}{gc}\right)x}$$



equicorrente

$$Q=-GC(T-T_1)$$
$$Q=gc(t-t_1) \Rightarrow -GC(T-T_1)=gc(t-t_1)$$

$$T=T_1-\frac{gc}{GC}(t-t_1)$$

$$t=T-(T_1-t_1)e^{-Hp\left(\frac{1}{GC}+\frac{1}{gc}\right)x}$$

$$=\left[T_1-\frac{gc}{GC}(t-t_1)\right]-(T_1-t_1)e^{-Hp\left(\frac{1}{GC}+\frac{1}{gc}\right)x}$$

$$\Rightarrow t+\frac{gc}{GC}t=T_1+\frac{gc}{GC}t_1-(T_1-t_1)e^{-Hp\left(\frac{1}{GC}+\frac{1}{gc}\right)x}$$

$$t=\left[T_1+\frac{gc}{GC}t_1-(T_1-t_1)e^{-Hp\left(\frac{1}{GC}+\frac{1}{gc}\right)x}\right]\frac{1}{1+\frac{gc}{GC}}$$

$$=\frac{GC}{GC+gc}T_1+\frac{gc}{GC+gc}t_1+\frac{GC}{GC+gc}(T_1-t_1)e^{-Hp\left(\frac{1}{GC}+\frac{1}{gc}\right)x}$$

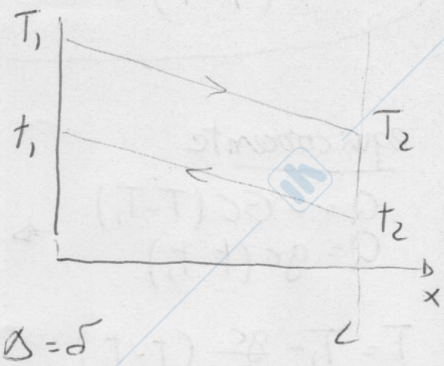
$$t=t_1+\frac{GC}{GC+gc}(T_1-t_1)\left[1-e^{-Hp\left(\frac{1}{GC}+\frac{1}{gc}\right)x}\right]$$

e

$$T=T_1-\frac{gc}{GC+gc}(T_1-t_1)\left[1-e^{-Hp\left(\frac{1}{GC}+\frac{1}{gc}\right)x}\right]$$

controcorrente

$$(T-t) = (T_1 - t_1)\, e^{-Hp\left(\frac{1}{GC} - \frac{1}{gc}\right)x}$$



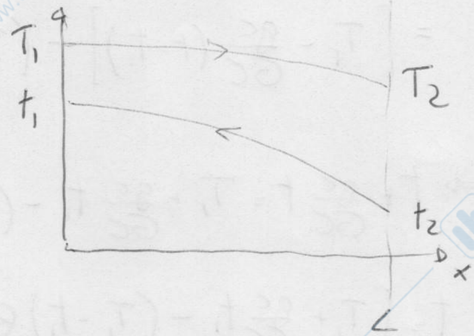
$\frac{1}{GC} - \frac{1}{gc} = 0 \Leftrightarrow GC = gc$

$Q = -GC(T - T_1)$

$Q = -gc(t - t_1)$

$\Delta = \delta$

$\frac{1}{GC} - \frac{1}{gc} < 0 \Leftrightarrow GC > gc$



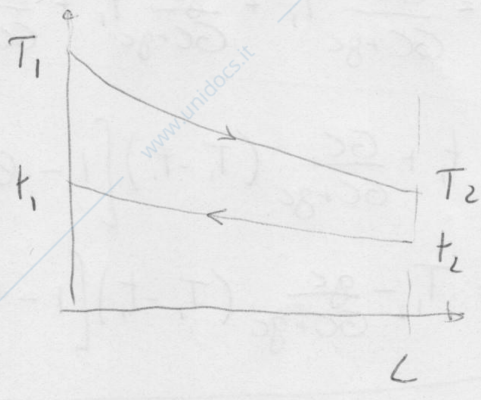
$GC(T - T_1) = cg(t - t_1)$

e elevato a exp > 0

ΔT cresce con x

$(dq = GC\, dT \rightarrow$ se $GC \rightarrow \infty$ $dT \rightarrow 0)$

$\frac{1}{GC} - \frac{1}{gc} > 0 \Leftrightarrow GC < gc$



e elevato a exp < 0

ΔT decresce con x

in uscita

equicorrente $t_2 - T_2 < 0$ sempre e se aumenta L $t_2 - T_2$ diminuisce

controcorrente $t_2 - T_2 = (t_1 - T_1)\, e^{-HpL\left(\frac{1}{GC} - \frac{1}{gc}\right)}$

$t_1 = (t_2 - T_2)\, e^{-HpL\left(\frac{1}{GC} - \frac{1}{gc}\right)} + T_1$

$t_1 - T_2 = (t_2 - T_2)\, e^{-HpL\left(\frac{1}{GC} - \frac{1}{gc}\right)} + T_1 - T_2$

$\Rightarrow t_{1\,uscita}$ può essere $> T_{2\,uscita}$ $\Rightarrow$ se aumenta L ΔT varia meno che in equicorrente