Heat Exchanger Lab

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Table 1a. Table showing flow rates, change in temperatures, and heat transfer rates for both the cold and hot fluids of a single tube-pass, single-shell pass counterflow heat exchanger. The overall heat transfer coefficient U_i is also shown.

Case	Flow Rate (kg/s)				Temperature (°C)		U_i (W/K m²)	Heat Transfer Rate (kW)		
	$\dot{m}_c$		$\dot{m}_h$		ΔT_h	ΔT_c		q_c	q_h	Δq (%)
1a	0.240	(fast)	0.288	(fast)	5.17	6.78	1973.454	6.80	6.21	9.11
1b	0.233	(fast)	0.188	(slow)	7.00	6.78	1738.278	6.63	5.49	18.78
2a	0.202	(slow)	0.325	(fast)	4.00	7.17	1705.013	6.06	5.44	10.85
2b	0.214	(slow)	0.188	(slow)	6.89	7.00	1684.432	6.29	5.40	15.19

Table 1b. Table showing flow rates, the ratio of heat capacities (C_r), number of transfer units (NTU), and effectiveness (ε) for a single tube-pass, single-shell pass counterflow heat exchanger. For the effectiveness both the measured value and the

Case	Flow Rate (kg/s)				C_r	NTU	ε		
	$\dot{m}_c$		$\dot{m}_h$				measured	theory	Δε (%)
1a	0.240	(fast)	0.288	(fast)	0.835	0.216	0.178	0.180	0.865
1b	0.233	(fast)	0.188	(slow)	0.802	0.243	0.196	0.199	1.616
2a	0.202	(slow)	0.325	(fast)	0.622	0.221	0.185	0.188	1.098
2b	0.214	(slow)	0.188	(slow)	0.873	0.236	0.190	0.193	1.360

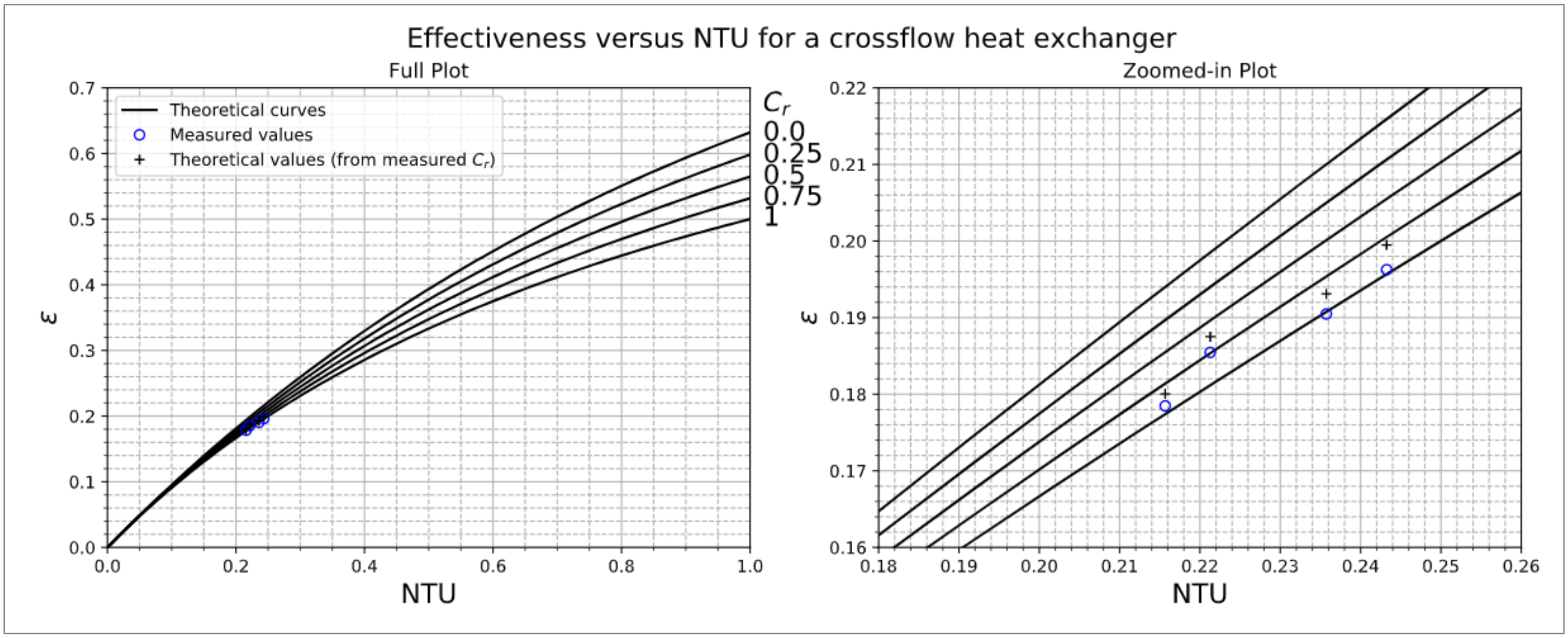

Figure 1c. Plot of effectiveness (ε) versus number of transfer units (NTU) for a single tube-pass, single-shell pass counterflow heat exchanger. The full scale plot is shown on the left with theoretical curves, measured values from the experiment, and theoretical values which were found using measured C_r values. On the right is a zoomed in view of the same plot which highlights the difference between the measured and theoretical values.

2a.

The largest percent relative difference Δq was 18.78% and the smallest was 9.11%. The largest percent relative uncertainty of heat transfer rates was 6.05% for the cold fluid and 6.82% for the hot fluid. The smallest percent relative uncertainty of heat transfer rates was 5.47% for the cold fluid and 4.59% for the hot fluid. The relative percent uncertainty of the heat transfer rates lies around 5% for both the hot and cold fluid so that does explain some of the difference between q_h and q_c but does not explain all of it. It is likely that the relative percent difference Δq is not zero because of other heat losses from the system to the surroundings combined with the relative uncertainty in the heat transfer rates as previously mentioned.

2b.

The percent difference in effectiveness values obtained from the measurements compared to theory ($\Delta\varepsilon$) was 0.87%, 1.62%, 1.10%, and 1.36% for case 1a, 1b, 2a, and 2b, respectively. The theory does seem to adequately describe the observations since percent error is around 1% for all cases. Thus, it is reasonable to predict the effectiveness of a heat exchanger using theory. For example, for m_c_dot =0.3 kg/s and m_h_dot=0.4 kg/s it would be possible to find C_h and C_c then the ratio of the minimum to the maximum of these quantities (C_r) could be found. Next, using the inlet and outlet temperatures of the hot and cold fluid NTU could be found. Then using an empirical relation as used in this lab ε could be found. The percent difference in the effectiveness value predicted by this theory would likely be close to 1% since the mass flow rates given are close to those used in this lab.

2c.

It was found that q_{conv} on average was 0.0026kW and q_{rad} on average was 0.0033kW. These losses do not seem important when compared to the heat transfer rates of around 6kW that were occurring for this experiment. Thus, I would not recommend insulating/covering the shell casing to mitigate these losses since it would not be worth the small improvement in performance.