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Experimental comparison of heat exchangers in countercurrent flow

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This study shows the results of a laboratory experience conducted by chemical engineering students using a pilot-scale heat exchanger, Armfield HT30XC and its accessories, to compare the types of heat exchangers and determine which one of them is the most efficient. The accessories used in this study were a tubular heat exchanger HT31, shell and tube heat exchanger HT33 and extended reconfigurable heat exchanger HT37.

Regarding the constructive characteristics of the accessories, the sections in charge of carrying out the thermal exchange are made of stainless steel and the external structures in acrylic that, in addition to allowing a good visualization of the construction of the equipment, it also reduces thermal losses with the environment.

The heat exchange was done in countercurrent operation. Water at room temperature was used as cooling fluid, while water heated using a resistance controlled by the software of the equipment was used as hot fluid. Both currents flow were regulated using a variable flow valve, controlled by software too. Once the steady state of the system was reached, each group obtained the results showed in the following table:

Group	Heat Exchanger	T_{ci} [°C]	T_{co} [°C]	T_{hi} [°C]	T_{ho} [°C]	Q_h [kJ/s]	Q_c [kJ/s]	Q_l [kJ/s]	η [%]
1	Tubular	18,6	25	61,9	49,6	0,81	0,43	0,38	53,1
	Shell/tube	18,2	25,1	61,1	53,3	0,98	0,57	0,41	58,16
	Plate	19,77	36,98	56,86	40,04	2,28	1,42	0,86	62,28
2	Tubular	18,6	25,2	62,8	50,6	0,85	0,45	0,4	52,9
	Shell/tube	18,9	25,6	61,1	53,3	0,98	0,55	0,43	56,12
	Plate	19,84	39	60,4	42,15	2,52	1,48	1,04	58,7
3	Tubular	18,6	25,4	63,9	50,6	0,87	0,48	0,39	55,17
	Shell/tube	18,4	25,3	61	53	1,01	0,58	0,43	57,4
	Plate	19,77	37,63	57,7	40,62	2,32	1,44	0,88	62,06

References: T_{ci} = Cold fluid temperature inlet; T_{co} = Cold fluid temperature outlet; T_{hi} = Hot fluid temperature inlet; T_{ho} = Hot fluid temperature outlet; Q_h = Hot fluid heat exchanged; Q_c = Cold fluid heat exchanged; Q_l = Heat losses; η = performance.

In the reports submitted and based on the performance obtained in the results, students concluded that the best performance is achieved in the plate heat exchanger, then the shell and tube heat exchanger and finally the double tube heat exchanger, the results are shown in the table above where the three groups obtained an average of 60% performance for the plate heat exchanger and lower in the other systems. Also they mentioned that heat losses seemed elevated and that it would be convenient to change the construction material of the heat exchanger for another with better insulation, but bearing in mind that this would increase design costs. In addition, through visual observations, they concluded that the plate heat exchanger is practically restricted to clean fluids.

Considering that these are students in the fourth year of a five-year chemical engineering career, it can be concluded that face-to-face laboratories experiences are highly satisfactory, since they will have to apply the criteria learned at this level in the final project to graduate.