Technical Note

AM Technology
Engineering Chemistry

AMT TN-05

Effect of Heat Transfer Fluid Flow Rate on the Heat Transfer Coefficient at Various Process Flow Rates in the Coflore® ACR

Introduction

In thermodynamics, the heat transfer coefficient is the proportionality constant between the heat flux and the thermodynamic driving force for the flow of heat (i.e., the temperature difference, ΔT). With regard to chemical reactions, the ability to control the temperature within a reactor is critical, for example to control exotherms, or for improved reaction selectivity. The heat transfer coefficient is one way to compare the temperature control performance of different types of reactors (i.e. a batch vessel vs a flow reactor).

$$h = \frac{q}{\Delta T}$$

Equation 1: h: heat transfer coefficient, W/(m^{2}K), q: heat flux, W/m^2, ΔT: difference in temperature between the solid surface and surrounding fluid area, K

Experimental Work

The Coflore® ACR system was connected to a Huber Unistat P915W with thermocouples placed to monitor and record the temperature at the Huber inlet & outlet, the ACR reactor cell block inlet & outlet, and across the ACR reactor cell block. The *h* value was calculated at three heat transfer fluid (HTF) flow rates (1.19 L/min, 1.87 L/min and 0.31 L/min) for the following process flow rates: 90, 45, 18, 10 and 2.4 mL/min (spanning nominal reactor residence times between 1 minute and 30 minutes). The process fluid was water, and the heat transfer fluid was M90 silicon oil.

Figure 1: The Coflore® ACR and Huber Unistat P915W.

Results & Conclusion

Varying the HTF flow rate was found to have minimal impact on the heat transfer coefficient, *h*, with *h* increasing modestly as the HTF flow rate increased (Figure 2). The effect of HTF flow rate on the *h* value was more pronounced at higher process flowrates.

At lower process flowrates, the heat flux drastically decreases since the process temperature near instantly reaches the pinch temperature (the point at which the difference in temperature between the process fluid and heat transfer fluid is smallest). The *h* value determined at higher flow rates is more critical for the Coflore ACR since at lower residence times, a higher h value is required to maintain good temperature control.

A typical 50 L jacketed glass vessel has a *h* value of ~50-100.[1] The Coflore ACR was found to have a *h* value of ~2,140 at a process flow rate of 90 mL/min and heat transfer fluid flow rate of 1.87 L/min. At higher process flowrates (i.e. at shorter residence times) the Coflore ACR is around 20x more efficient at heat transfer than a typical batch vessel!

AM Technology Berkeley Court, Cheshire, United Kingdom +44 1928 237 420 info@amt.uk

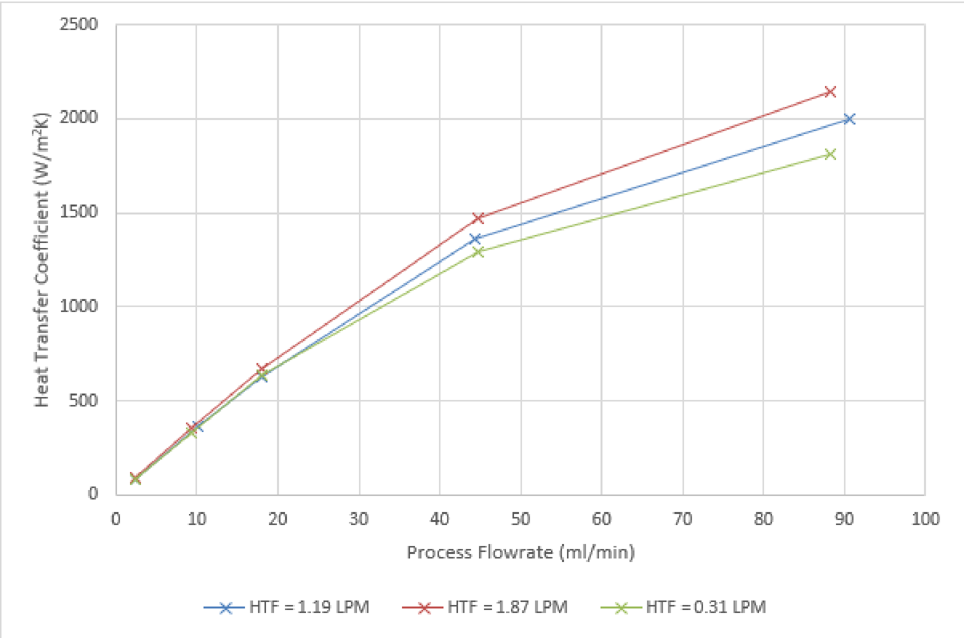

Figure 2: A graph showing the impact of process flowrate on the heat transfer coefficient, h, at various heat transfer fluid flowrates in the Coflore ACR.

Nominal ACR Residence Time (min)	***h*-Value when heat transfer fluid flowrate = 1.87 LPM (W/m^2K)**	***h*-Value when heat transfer fluid flowrate = 1.19 LPM (W/m^2K)**	***h*-Value when heat transfer fluid flowrate = 0.31 LPM (W/m^2K)**
1	2140	2000	1810
2	1470	1360	1300
5	676	629	637
10	354	363	334
30	89.8	82.5	85.4

Table 1: A summary of the impact of process flowrate on the heat transfer coefficient, h, at various heat transfer fluid flowrates in the Coflore ACR.

1. Determined from CS1104 Case Study Here.

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