Study of Packed Bed Distillation Column

The goal of this experiment was to study the characteristics of a packed bed distillation column under normal operation. Water - methanol mixture was fed to a distillation column of 0.10 diameter and 1.35 m height, and containing random Pall Ring packing. Vapor mass flow rate and reflux ratio were manipulated individually with vapor mass flow rates varied between 13.6 to 25.5 kg/h and reflux ratio varied between 0.85 to 2.5.

The objectives of this experiment were to determine the pressure drop (ΔP) and experimental height equivalent to a theoretical plate (HETP) of the column as a function of the vapour rate and reflux ratio under normal operation. The results were compared with predicted values and trends.

All of the data cleaning, calculations, statistical analysis and modeling as well as model evaluations were automated via the creation of the **Excel VBA code**. The macro buttons were designed in the user interface. All of the input data can be analyzed and the resulting tables and figures (see below) can be generated by clicking those buttons.

The following figures and tables are some featured results for demonstration purpose:

1. Mass and Energy Balance:

2. Experimental and predicted HETP calculations

3. Experimental and Predicted Pressure Drop calculations

Raw data from experiment (One part of the data):
https://docs.google.com/spreadsheets/d/1BXnj6JIG0Fg-S4qg8IGJadkRW6ozpZZHqdiKoiDR5pE/edit#gid=973042511

Code (Excel VBA) for Demo:
https://drive.google.com/drive/folders/1NUPo3KXETfQpC0PI8-5zN1lCGYt7EC-l

1. Mass and Energy Balance:

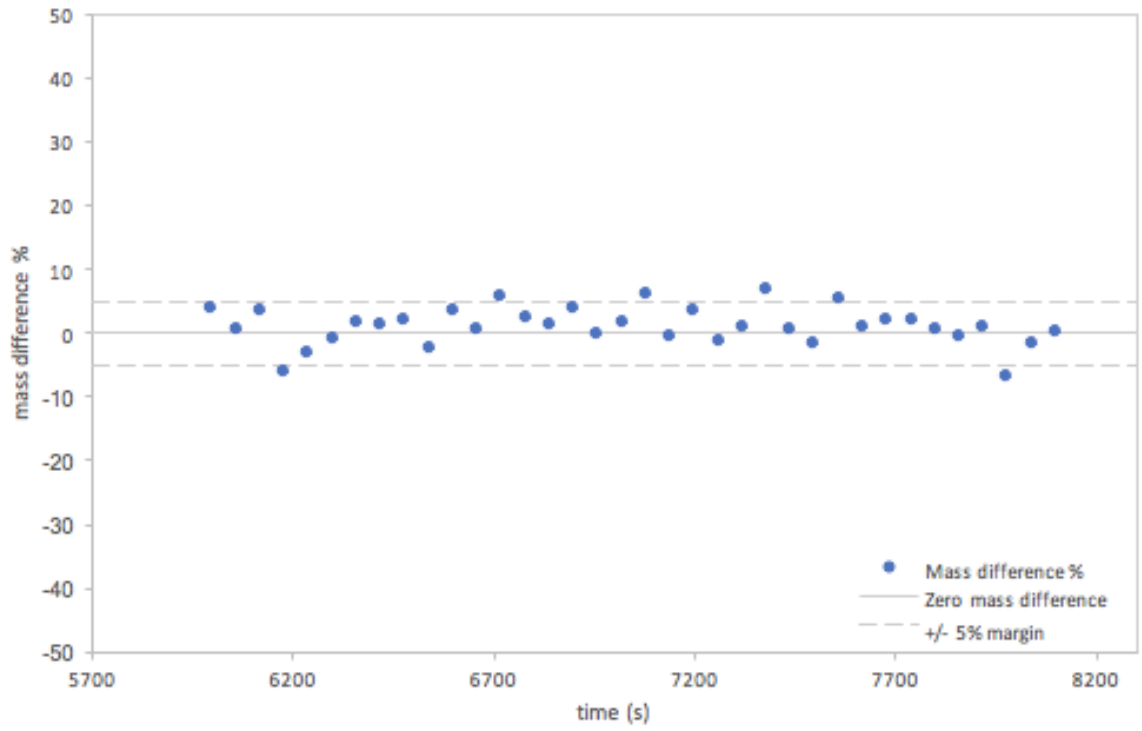

Figure 1. Total Mass Difference vs. time for Run 5

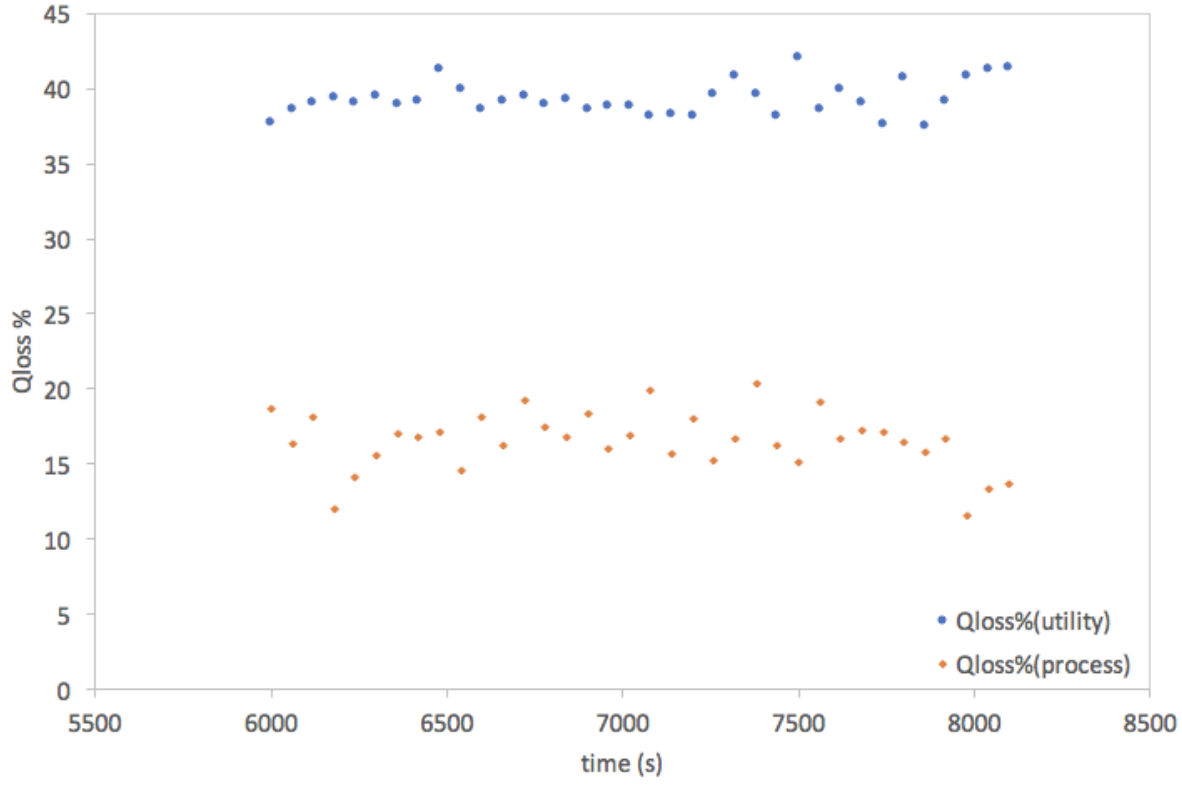

Figure 2. Energy loss vs. time for utility and process side in Run 5

Table 1. Energy difference between utility and process side for varying vapour rate

Run	Vapour rate [kg/h]	Reflux Ratio	Condenser Duty, Q (kJ/h)			Reboiler Duty, Q (kJ/h)		
			Utility Side	Process Side	% Difference	Utility Side	Process Side	% Difference
1	13.6	1.0	11013	16269	-32%	20978	22747	-8%
2	16.8	1.0	13939	20194	-31%	25216	25851	-2%
3	20.5	1.0	16023	24261	-34%	28071	31360	-10%
4	22.3	1.0	17556	26457	-34%	30454	32918	-7%
5	23.7	1.0	18372	27758	-34%	34429	35708	-4%
6	24.6	1.0	22698	31399	-28%	37670	35429	6%

Table 2. Energy difference between utility and process side for varying reflux ratio

Run	Vapour rate [kg/h]	Reflux Ratio	Condenser Duty, Q (kJ/h)			Reboiler Duty, Q (kJ/h)		
			Utility Side	Process Side	% Difference	Utility Side	Process Side	% Difference
7	25.0	0.9	19132	27428	-30%	34023	38891	-13%
8	25.5	1.0	18096	28217	-36%	33479	40637	-18%
9	24.9	1.2	18853	29108	-35%	33451	38375	-13%
10	24.9	1.4	19033	29478	-35%	33502	46804	-28%
11	24.0	2.1	18607	28861	-36%	33634	36995	-9%
12	23.0	2.5	18759	28705	-35%	33757	40574	-17%

2. Experimental and predicted HETP calculations:

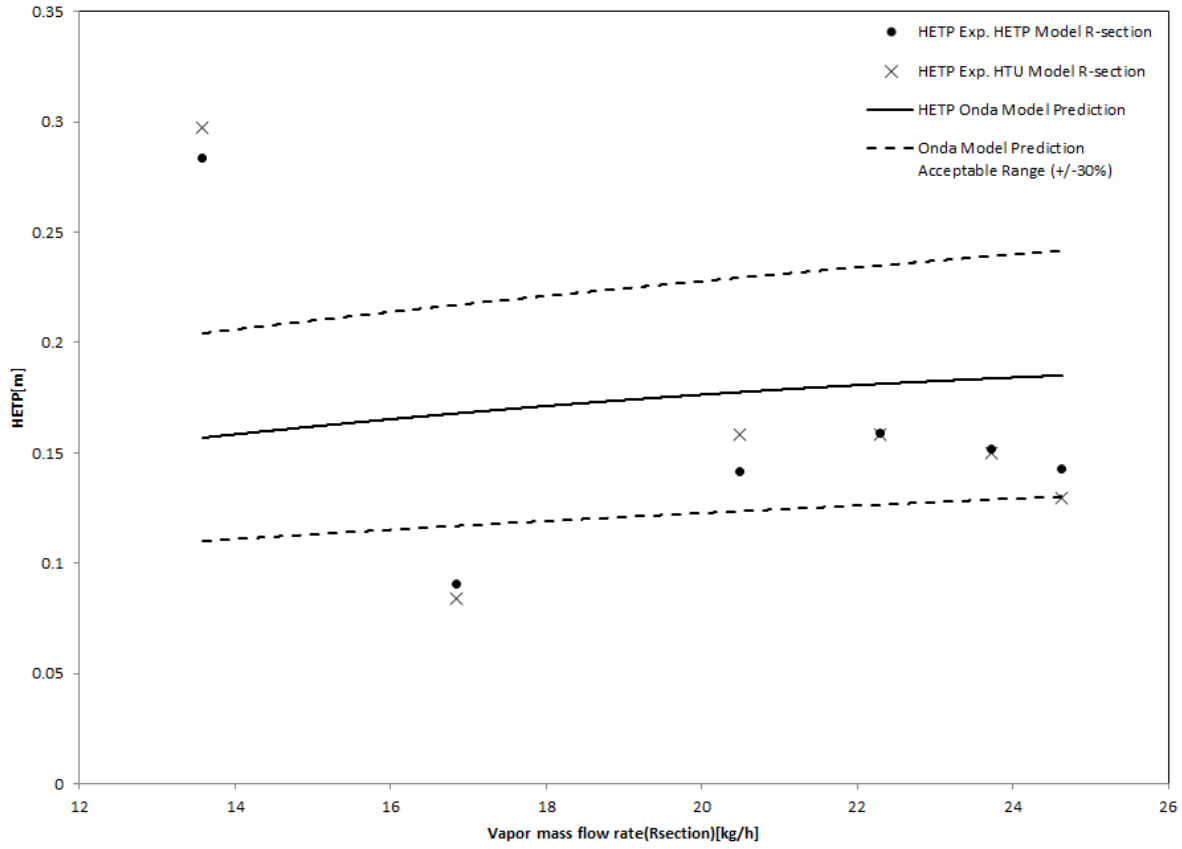

Figure 3. HETP with varying vapour mass flow rate

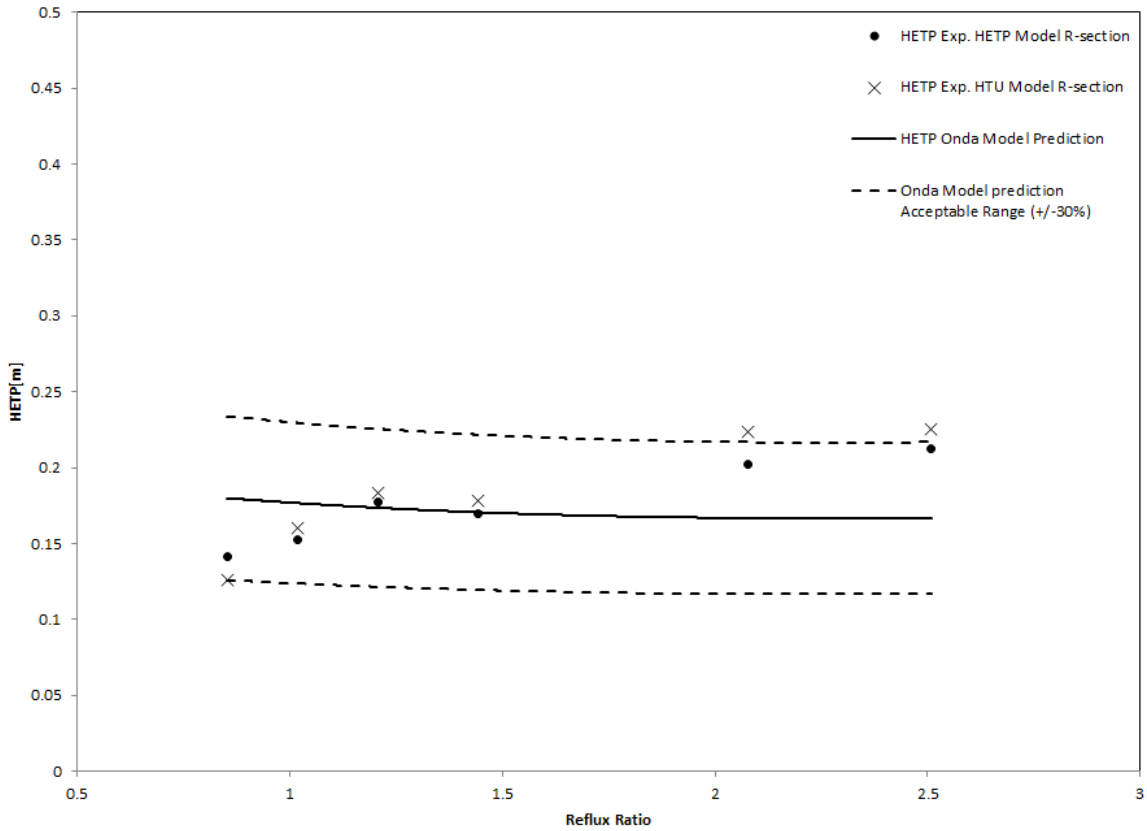

Figure 4. HETP with varying reflux ratio

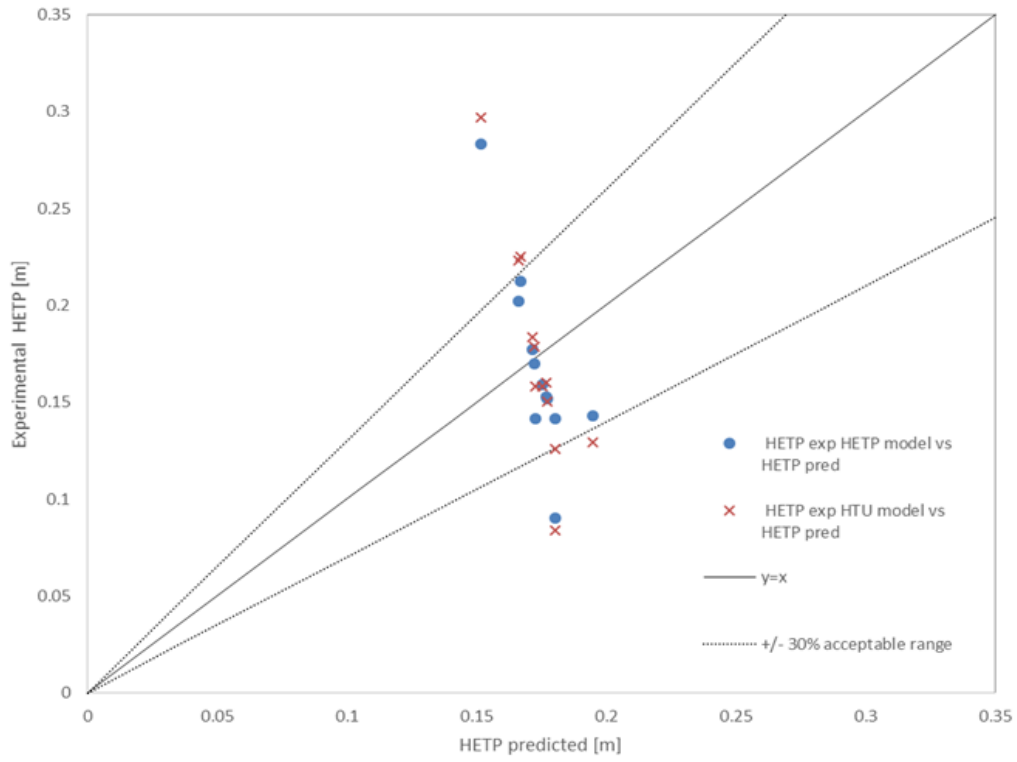

Figure 5. HETP parity plot

3. Experimental and Predicted Pressure Drop calculations:

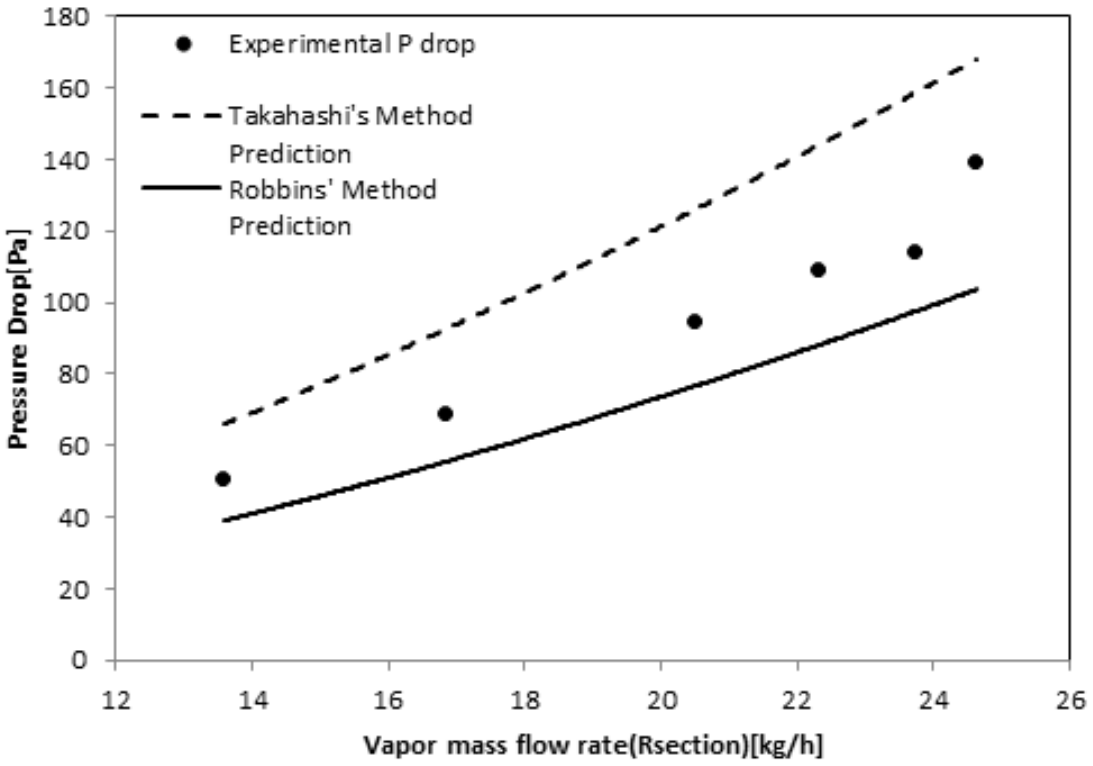

Figure 6. Pressure drop with varying vapour mass flow rate

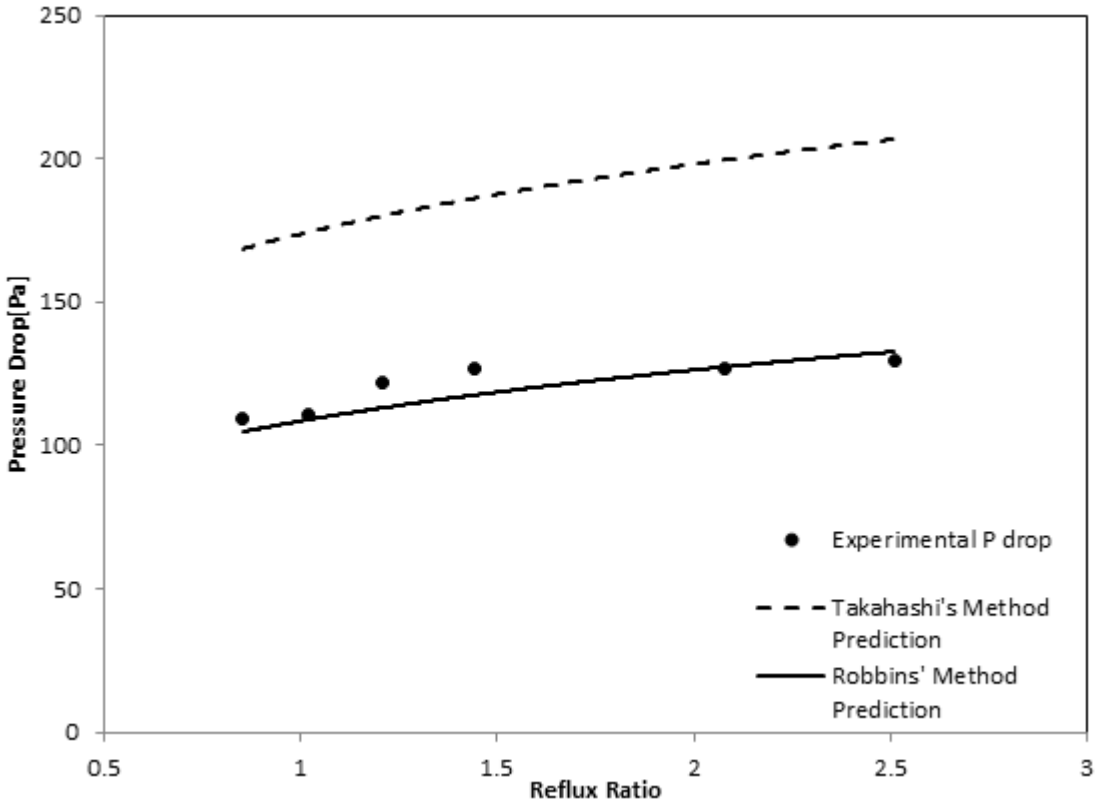

Figure 7. Pressure drop with varying reflux ratio