Analysis of heat and mass transfer by CFD for performance enhancement in direct contact membrane distillation

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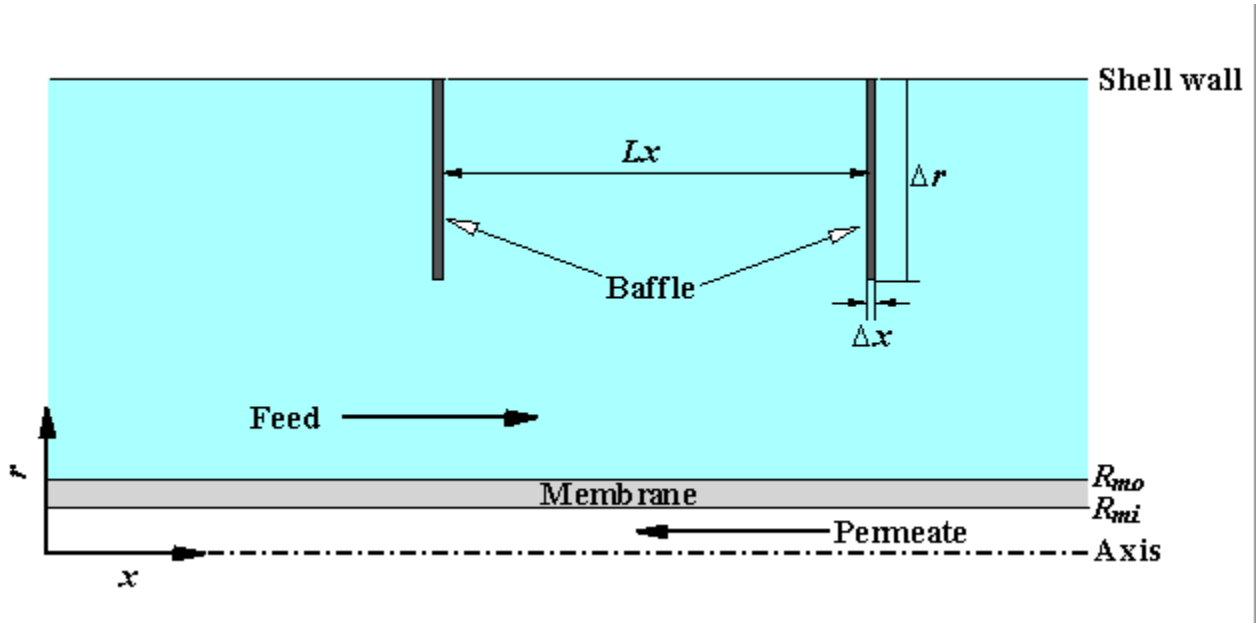


Fig. 1. Schematic of axially-symmetry single fiber module in CFD simulating domain

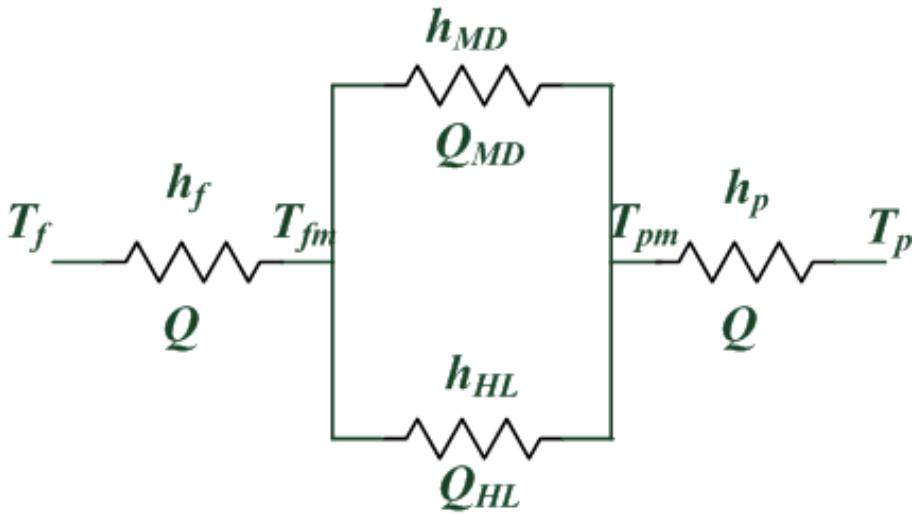


Fig. 2. Schematic of heat transfer process in MD

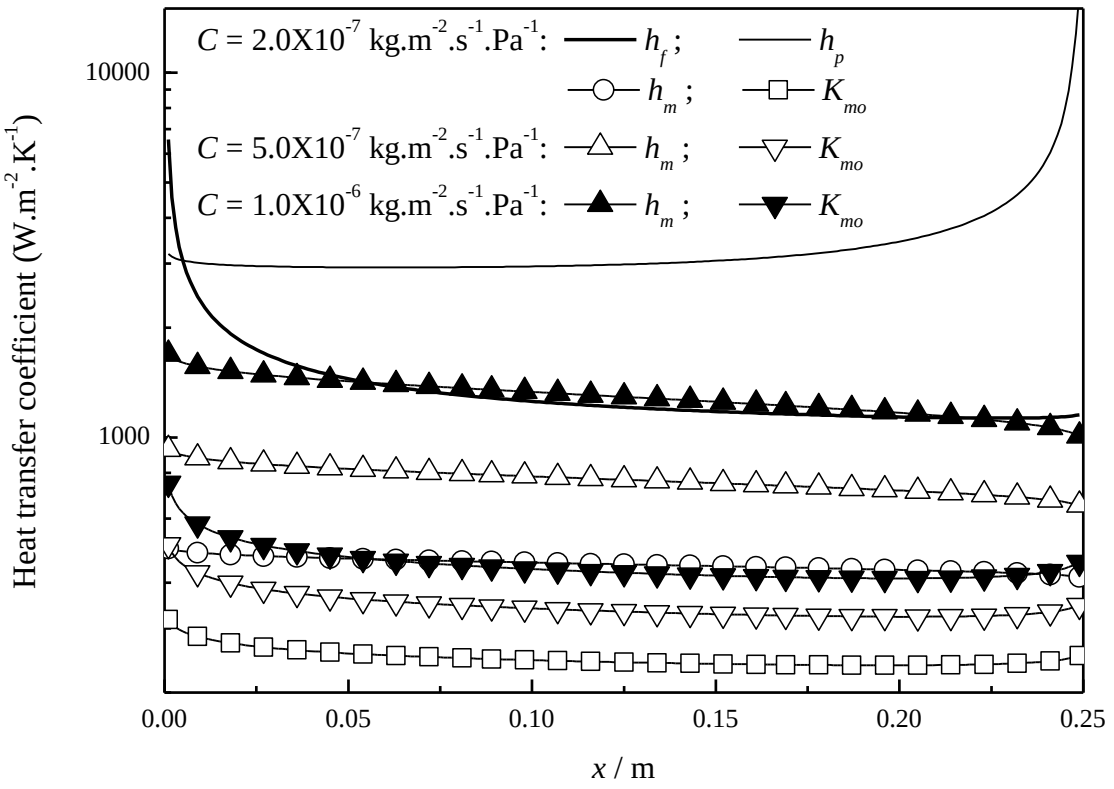


Fig. 3. Heat-transfer coefficient distributions along the module length for membranes with different C values (T_{fi} = 327.2 K, T_{pi} = 294.0 K, u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} to 1.0×10^{-6} kg·m^{-2}·s^{-1}·Pa^{-1})

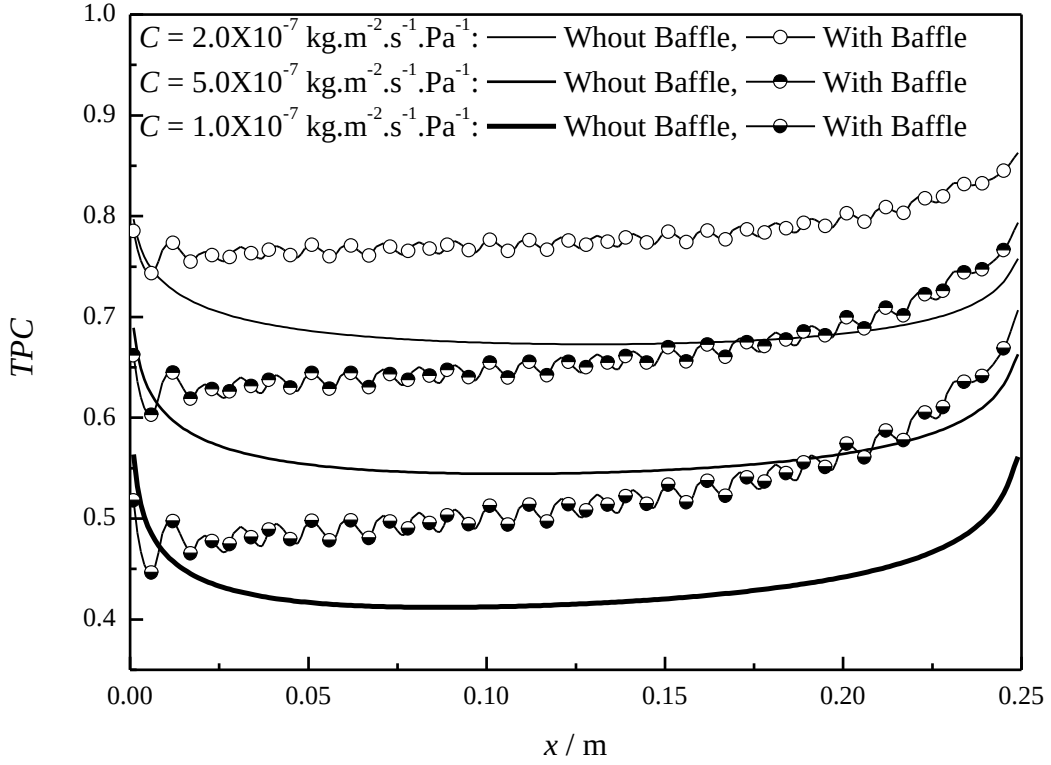


Fig. 4. *TPC* distributions along the module length for non-baffled and baffled modules with membranes of different *C* values (T_{fi} = 327.2 K, T_{pi} = 294.0 K, u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} to 1.0×10^{-6} kg·m^{-2}·s^{-1}·Pa^{-1})

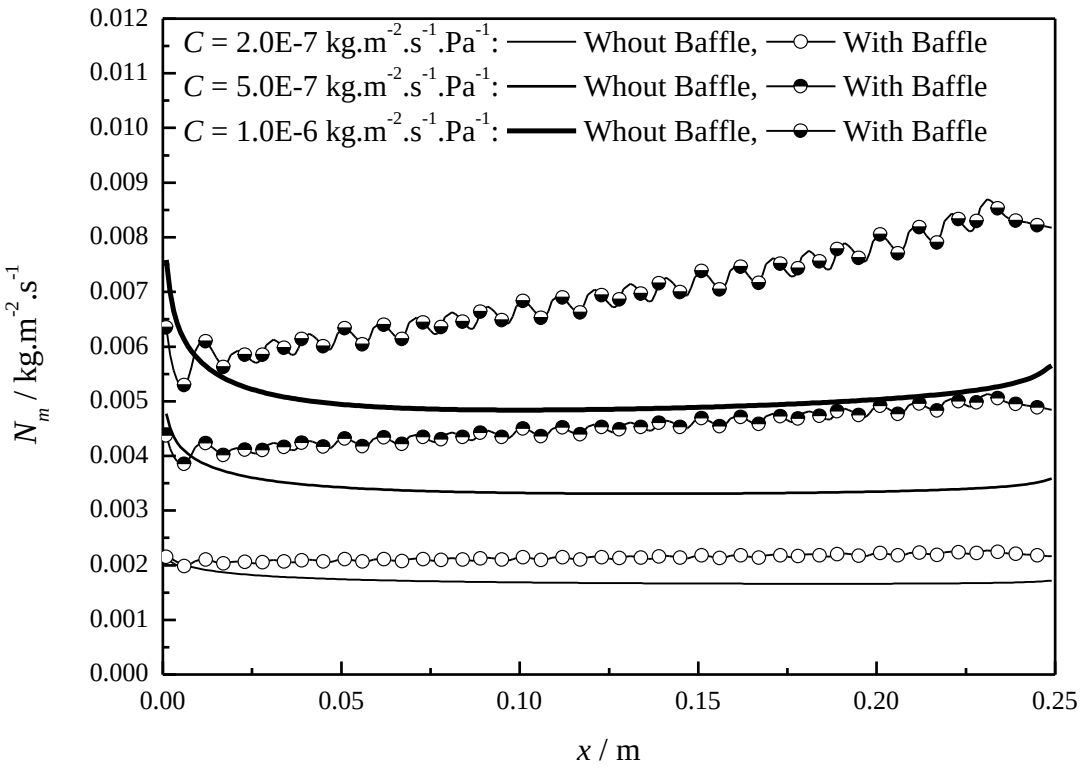


Fig. 5. N_m distributions along the module length for non-baffled and baffled modules with membranes of different C values

(T_{fi} = 327.2 K, T_{pi} = 294.0 K, u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} to 1.0×10^{-6} kg·m^{-2}·s^{-1}·Pa^{-1})

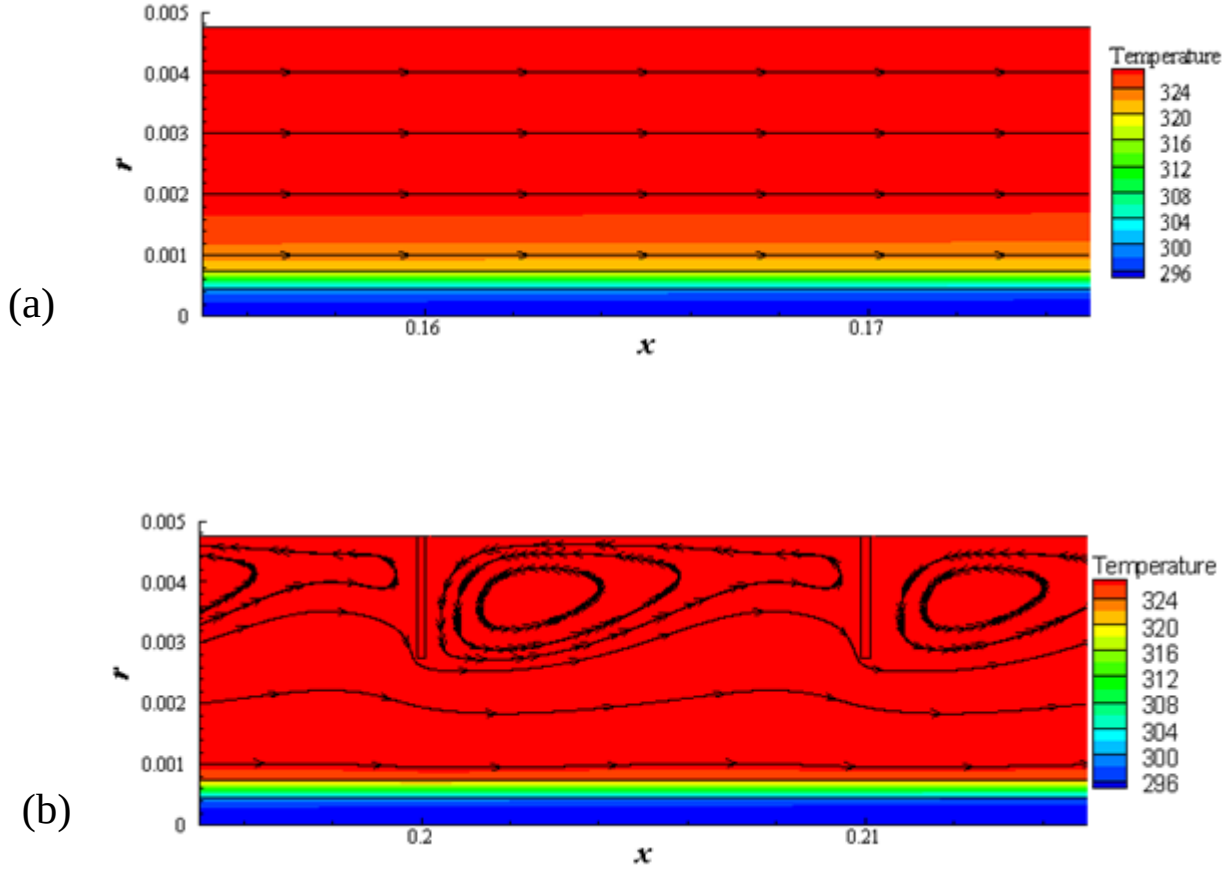


Fig. 6. Temperature distributions and flow fields at the shell side of 0.25m modules (local snapshots)
(a) without baffles; (b) with baffles
(T_{fi} = 327.2 K, T_{pi} = 294.0 K, u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} kg·m^{-2}·s^{-1}·Pa^{-1})

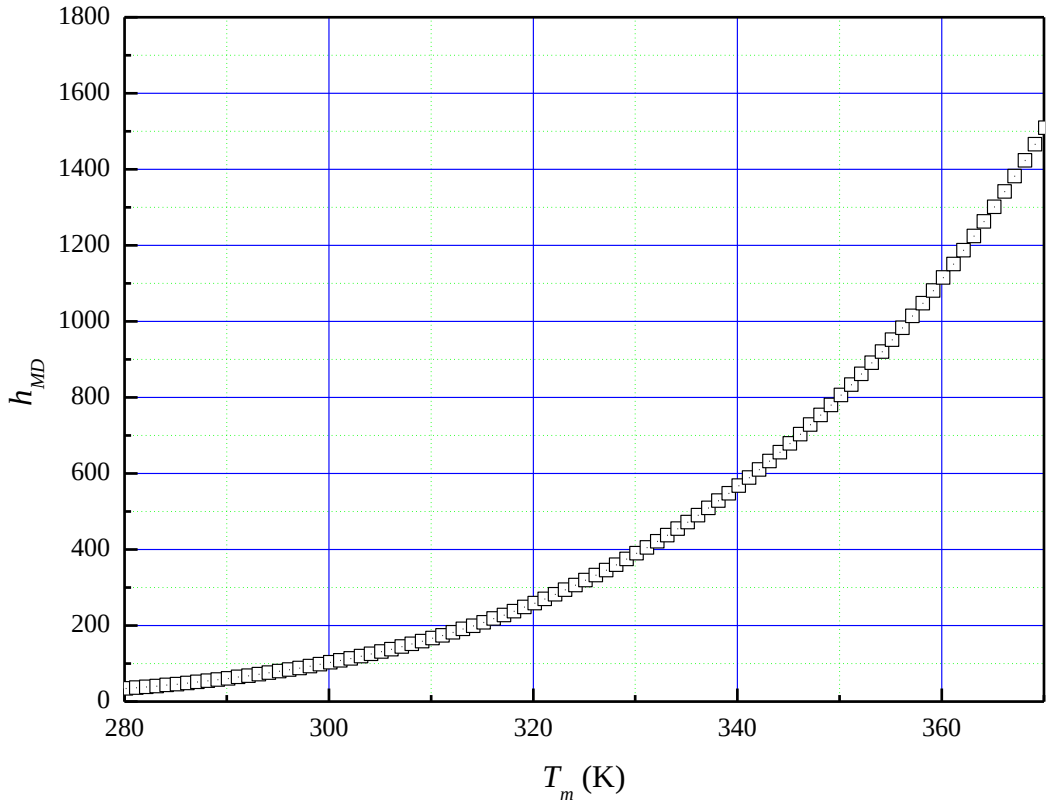


Fig. 7. h_{MD} vs. membrane temperature T_m with $C = 2.0 \times 10^{-7}$ kg·m^{-2}·s^{-1}·Pa^{-1}

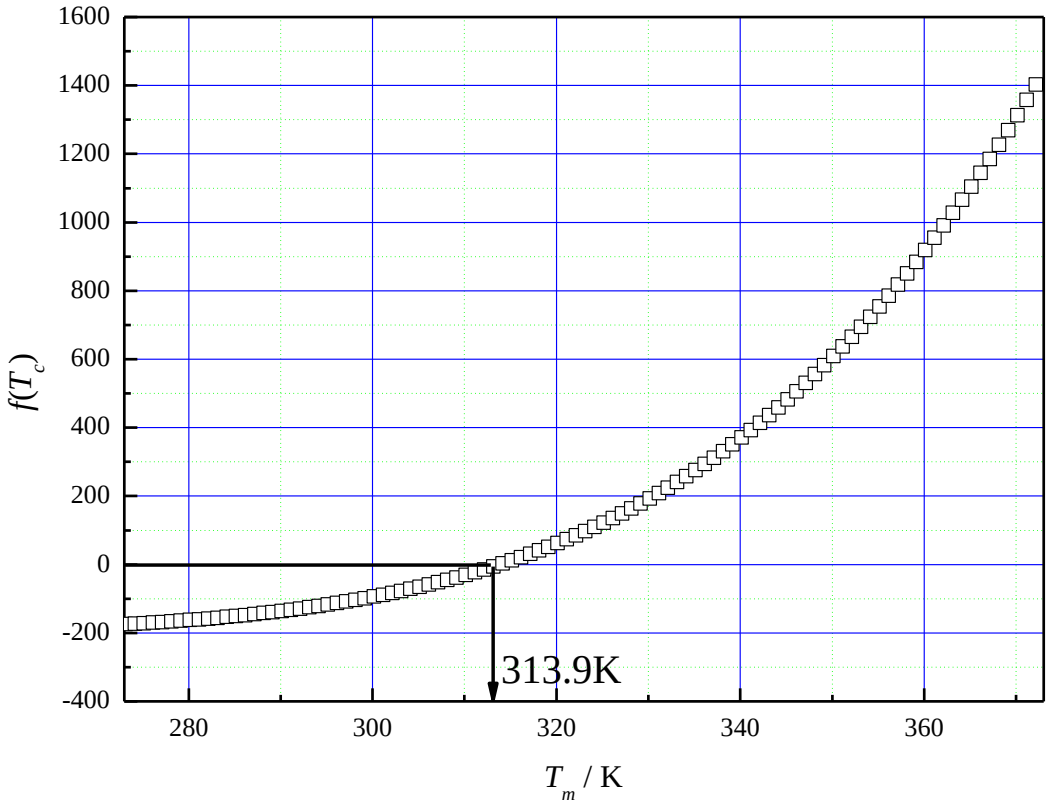


Fig. 8. Function $f(T_c)$ at varied membrane temperatures T_m with $C = 2.0 \times 10^{-7}$ kg·m^{-2}·s^{-1}·Pa^{-1}

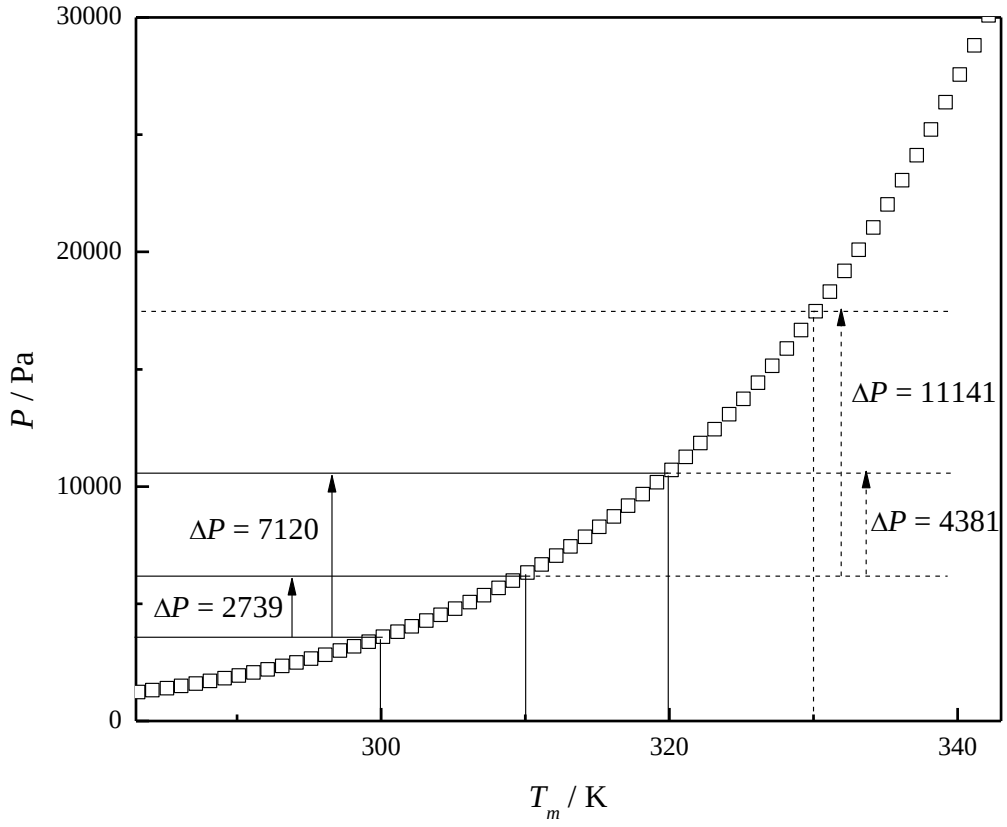


Fig. 9. The distribution of saturated vapor pressure difference ΔP at various membrane temperatures T_m

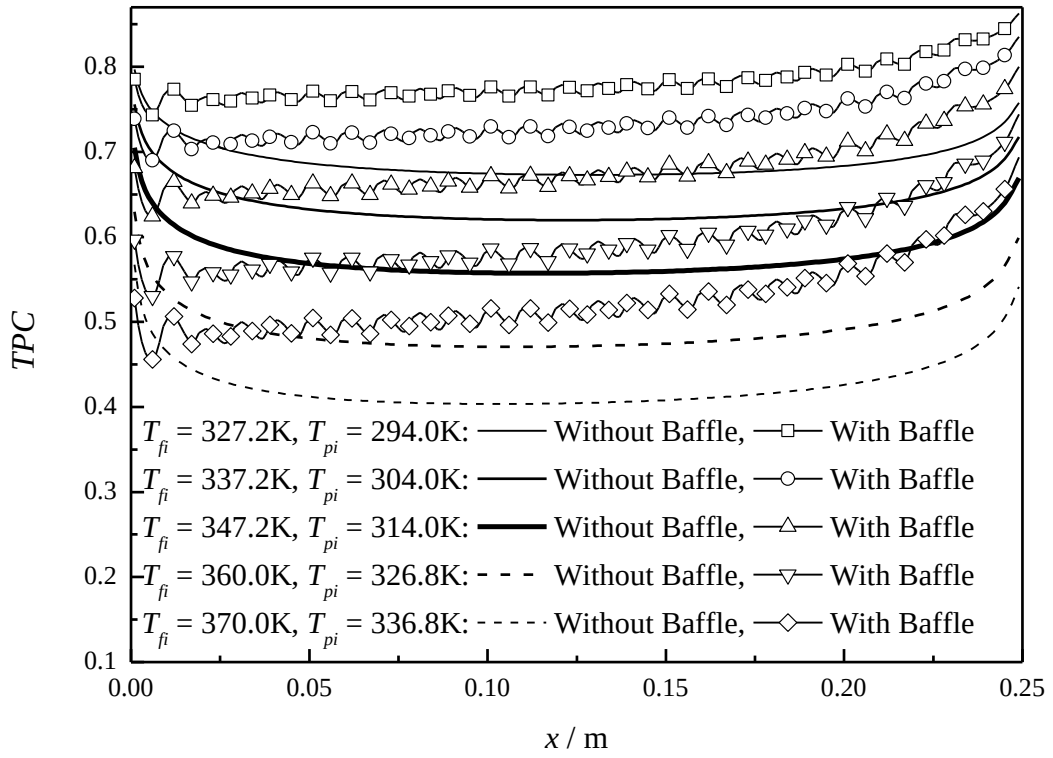
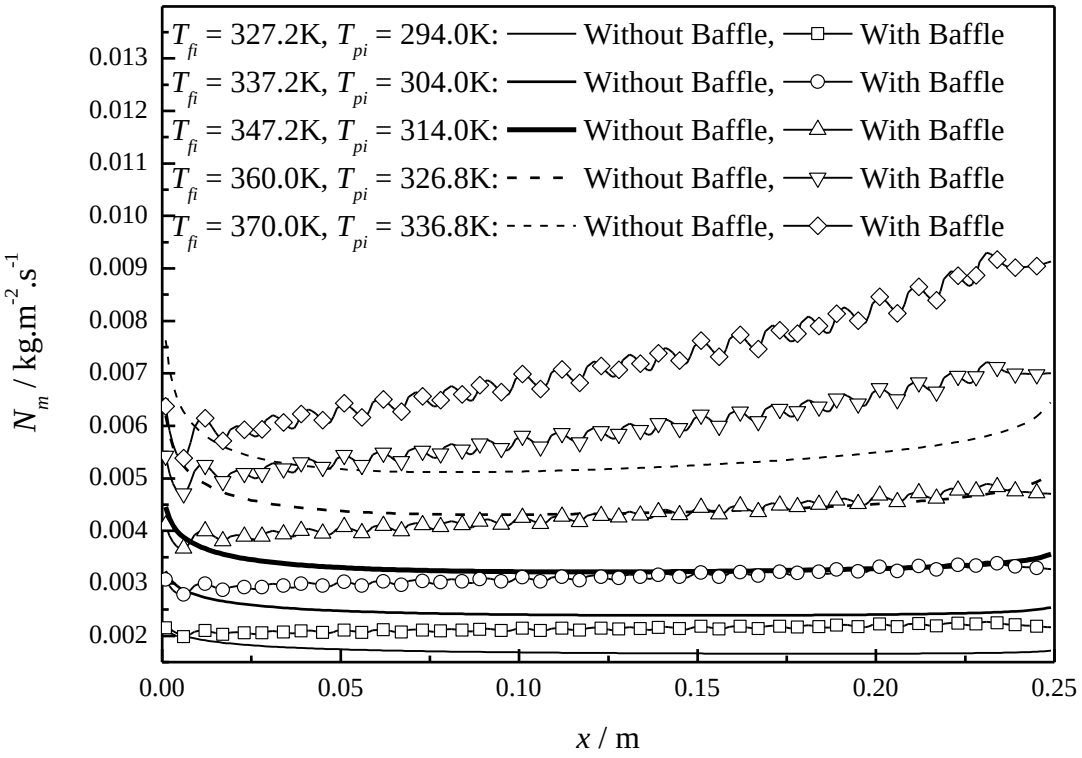


Fig. 10. *TPC* distribution along the module length for non-baffled and baffled modules at varied feed/permeate inlet temperatures with a constant temperature difference (ΔT_{in}=33.2 K, u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} kg·m^{-2}·s^{-1}·Pa^{-1})

(a) N_m distribution along the module length



(b) Local mass fluxes N_m comparison (x=0.125m)

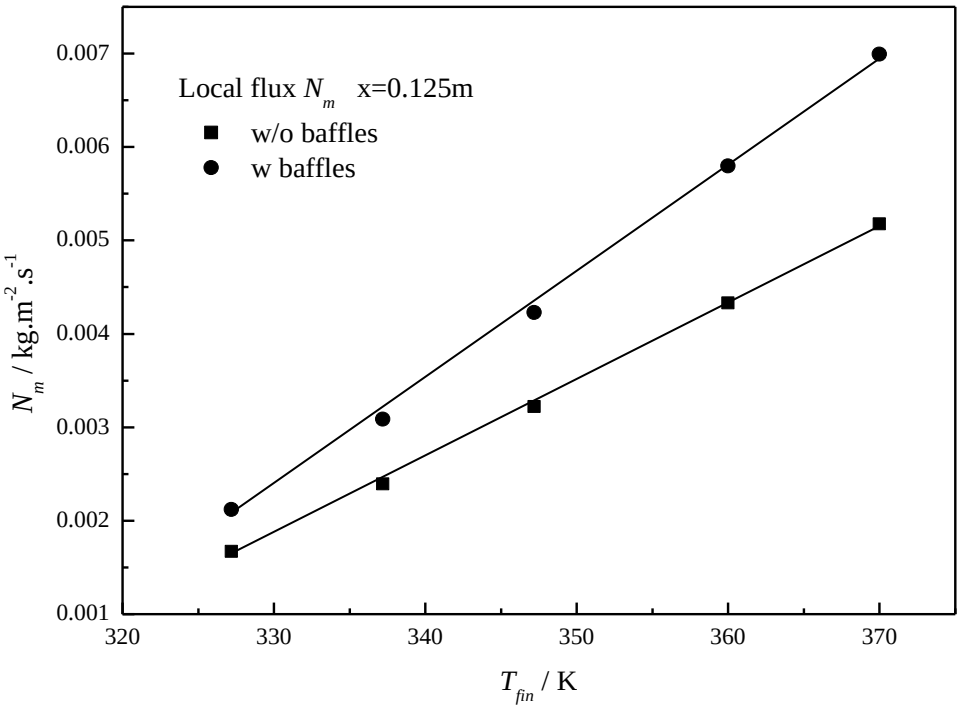


Fig. 11. N_m results for non-baffled and baffled modules at varied feed/permeate inlet temperatures with a constant temperature difference ΔT_{in} (a) N_m distribution along the module length; (b) Local mass fluxes N_m comparison x=0.125m (ΔT_{in}=33.2 K, u_{fi}=0.0602 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} kg·m^{-2}·s^{-1}·Pa^{-1})

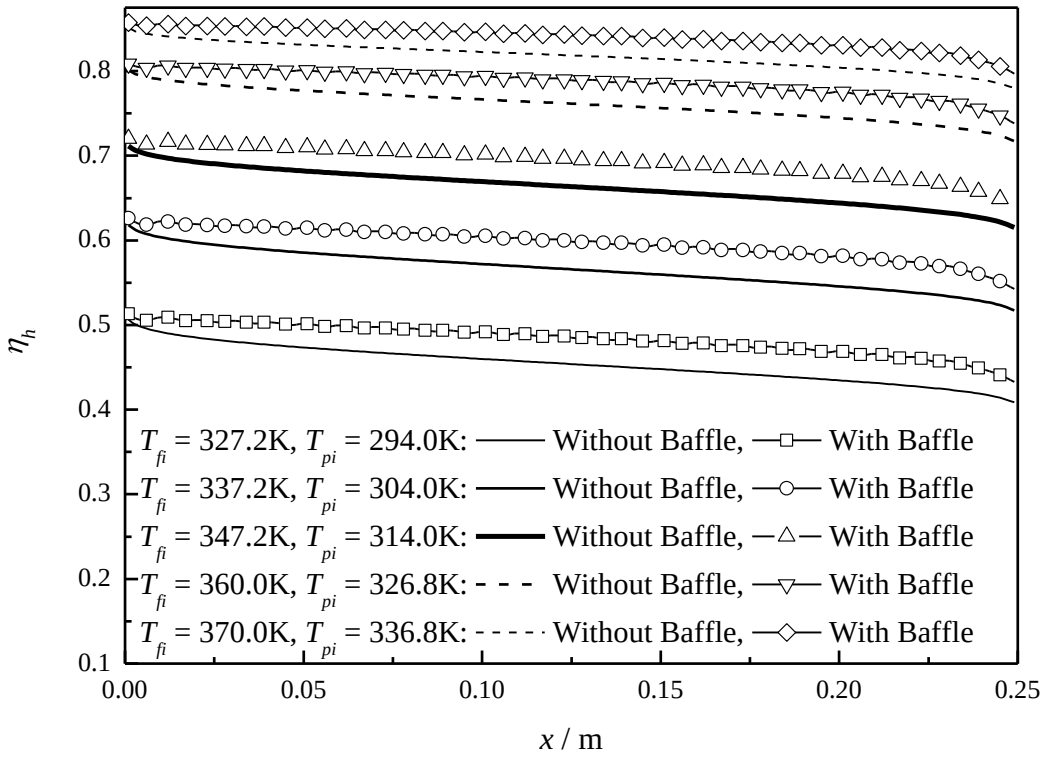


Fig. 12. η_h distribution along the module length for non-baffled and baffled modules at varied feed/permeate inlet temperatures with a constant temperature difference (ΔT_{in}=33.2 K, u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} kg·m^{-2}·s^{-1}·Pa^{-1})

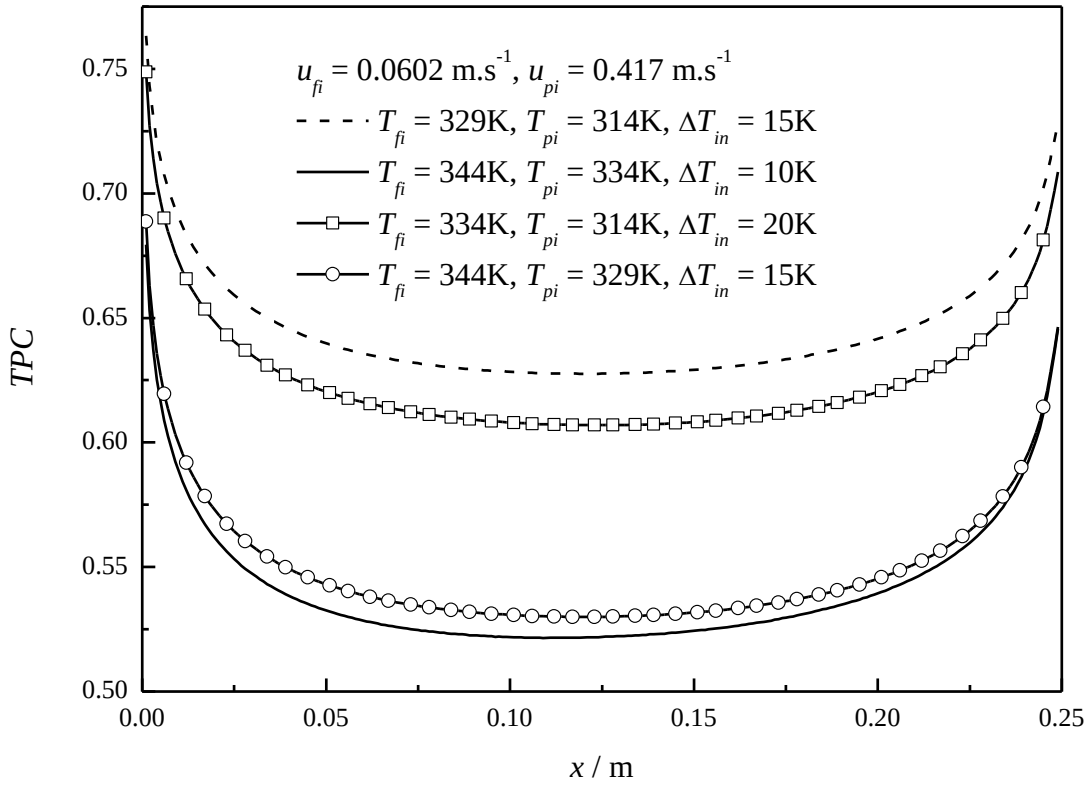


Fig. 13. *TPC* distributions along the module length at varied feed/permeate inlet temperatures T_{fi}/ T_{pi} and temperature differences ΔT_{in} (u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} kg·m^{-2}·s^{-1}·Pa^{-1})

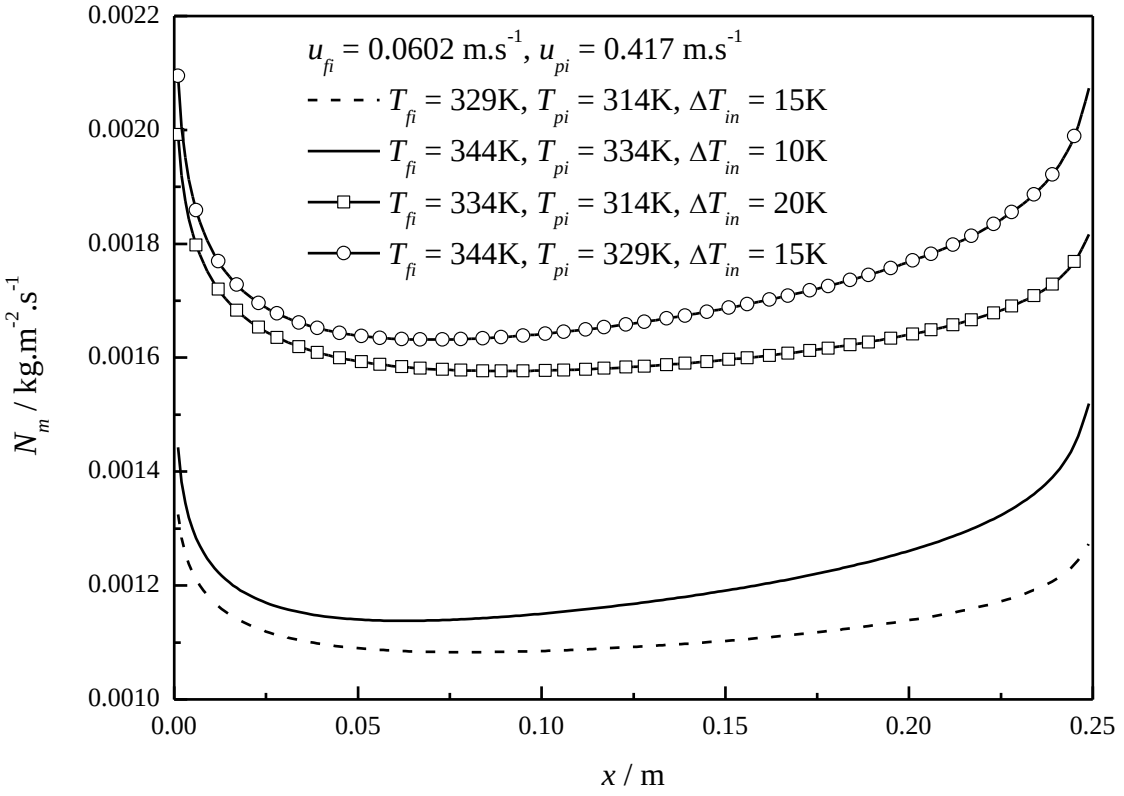


Fig. 14. N_m distributions along the module length at varied feed/permeate inlet temperatures T_{fi}/ T_{pi} and temperature differences ΔT_{in} (u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} kg·m^{-2}·s^{-1}·Pa^{-1})

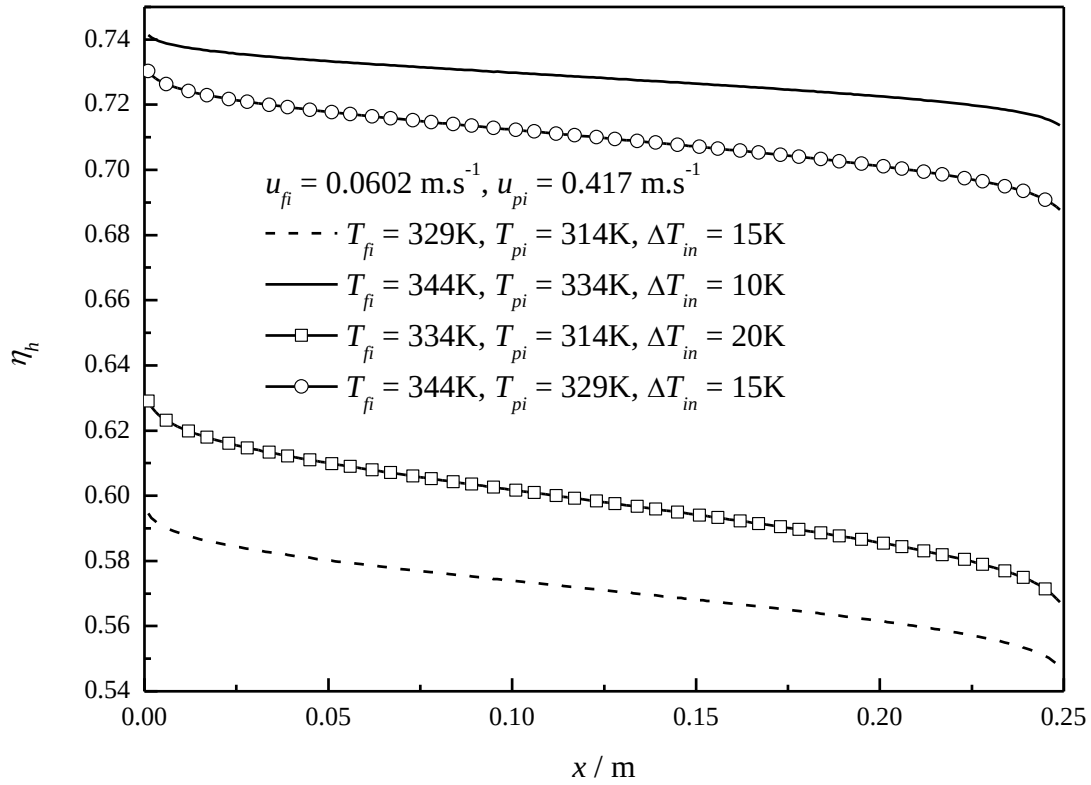


Fig. 15. η_h distributions along the module length at varied feed/permeate inlet temperatures T_{fi}/ T_{pi} and temperature differences ΔT_{in} (u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} kg·m^{-2}·s^{-1}·Pa^{-1})

Table. 1. The temperature comparison of experimental data and simulation results (u_{fi}=0.06 m·s^{-1}, u_{pi}= 0.417 m·s^{-1}, C = 2.0×10^{-7} kg·m^{-2}·s^{-1}·Pa^{-1})

L **(m)**		***T*$_{fi}$ (K)**	***T*$_{fo}$ (K)**	**Error (%)**	***T*$_{pi}$ (K)**	***T*$_{po}$ (K)**	**Error (%)**
0.25	Exp.	327.2	325.7	-	294.0	301.4	-
	Sim.	-	325.9	0.0614		300.9	-0.166
0.25	Exp.	333.9	331.6	-	294.4	302.8	-
	Sim.		332.5	-0.271		303.2	0.132
0.25	Exp.	334.8	333.8	-	312.8	317.7	-
	Sim.	-	333.6	-0.0599		318.3	0.189
0.25	Exp.	337.6	334.8	-	294.3	304.1	-
	Sim.		336.2	0.418		304.2	0.0329
0.25	Exp.	337.6	336.4	-	304.0	311.1	-
	Sim.		336.3	-0.0297		312.1	0.321