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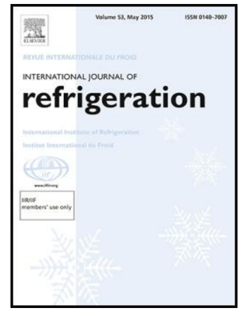

Title: Experimental investigation on flow condensation of zeotropic mixtures of methane/ethane in a horizontal smooth tube

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Experimental investigation on flow condensation of zeotropic mixtures of methane/ethane in a horizontal smooth tube

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Highlights

- Condensation flow patterns of methane/ethane mixtures were investigated.
- A new flow pattern transition criteria for zeotropic mixtures was proposed.
- Condensation heat transfer of methane/ethane mixtures was studied experimentally.
- An improved heat transfer correlation for different flow patterns was carried out.

Abstract: An experimental investigation on condensation flow pattern and heat transfer coefficient of methane/ethane mixtures (0.27/0.73, 0.54/0.46 and 0.7/0.3 by mole) in a horizontal smooth tube with inner diameter of 4 mm was carried out. The tests were conducted at saturation pressure of 1.5-2.5 MPa with mass flux of 98-257 kg m^{-2} s^{-1} and heat flux of 15.1-44.4 kW m^{-2} over the entire vapor quality range. The effects of concentration, saturation pressure, heat flux, mass flux and vapor quality were analyzed and discussed. A new annular/non-annular flow pattern transition criteria on condensation for zeotropic mixtures was carried out. The new transition criteria took the influence of mass transfer resistance into consideration and had satisfactory predictive ability in present study. Moreover, the experimental data were compared with many condensation heat transfer correlations of mixtures. An improved heat transfer correlation for zeotropic mixtures based on flow patterns was proposed. The new correlation combined with the equilibrium method and introduced a new correction factor (F_m). It achieves better predicting results with a mean absolute relative deviation of 8.02%.

Keywords: Condensation; Zeotropic mixtures; Heat transfer; Flow pattern; Methane/ethane; Horizontal tube

Nomenclature

c_p	specific heat capacity (J kg^{-1} K^{-1})
D	inner diameter (m)
D_{1-2}	binary diffusion coefficient (m^2 s^{-1})
F_m	non-equilibrium factor of mixture
G	mass flux (kg m^{-2} s^{-1})
h	heat transfer coefficient (W m^{-2} K^{-1})
H	enthalpy (J kg^{-1})
Le_v	vapor Lewis number, $Le_v = \lambda_v/(\rho_v c_{p,v} D_{1-2})$
M	mass flow rate (kg s^{-1})
p	pressure (kPa)
Pr_v	vapor Prandtl number, $Pr_v=\mu_v c_{p,v}/\lambda_v$
q	heat flux (W m^{-2})
Q	heat power or heat duty (W)
R_m	additional heat transfer resistance
Re_l	liquid Reynolds number, $Re_l=G(1-x)D/\mu_l$
Re_v	vapor Reynolds number, $Re_v=GxD/\mu_v$
S	area (m^2)
Su_v	vapor Suratman number, $Su_v=\rho_v\sigma D/\mu_v^2$