DKV Research Report No 80

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Condensation of Pure Refrigerants and Their Zeotropic Mixtures in Plate Heat Exchangers

Abstract

Design methods need to be developed so that plate heat exchangers can be used for the condensation of mixtures. The aim of this study is to contribute to this development with an improved description of heat transfer and pressure drop in corrugated channels through experiments for single-phase flow, adiabatic two-phase flow, convective condensation, and finally condensation of zeotropic mixtures. Typical studies on plate heat exchangers concern experiments for one of these processes in several channel geometries; here, the same geometry was used to study successively all of these increasingly more complex processes so that analogy concepts can be exploited.

Single-phase flow correlations covering a large range of Reynolds numbers are determined for the Fanning friction factor and the Nusselt number. A flow-pattern map for adiabatic two-phase flow of air and water is presented. Furthermore the pressure drop is correlated based on the results for single-phase flow. The model on which the correlation is based is coherent with the observed flow patterns and represents the measurements well.

For the condensation experiments with refrigerant fluids a test section was developed that allows the measurement of the heat transfer coefficient and the vapor quality for five zones. The boundary element method is used to solve the inverse heat conduction problem in the wall and thereby to calculate the temperature and the heat flux on the corrugated plate surface. This measuring method differs significantly from previous approaches for determining local values, which relied on thermocouples on the cooling surface.

For condensation of R134a the influence of the vapor quality on the Nusselt number is greater than previously reported. Correlations are determined both for zonewise and for average values. The heat transfer performance is on average a factor 2.5 better than that of a vertical tube. The pressure drop of condensing R134a can be predicted to within ±25% with the correlations determined for adiabatic two-phase flow.

Although the heat transfer coefficients for the condensation of the zeotropic mixture R134a/R123 are smaller than for condensation of pure R134a, the difference decreases as condensation proceeds and is smaller for lower mass fractions of R123 in the vapor, even for condensation of zeotropic mixtures the heat transfer is better than in a vertical tube.

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