R32 HEAT TRANSFER COEFFICIENT DURING CONDENSATION IN A MINI-CHANNEL MULTIPORT TUBE

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Introduction
Introduction

1. Introducción
   • Minichannels use is widely extended.
     ↑ Performance ↓ Size → ↓ System charge
     Environmental and security advantages

   • Optimal design = f(HTC, dP, flow pattern,…)
   • Power transferred 2 phase >> 1 phase
   • Pioneers in the 80’s with single mini-channels
   • Today single and multiport tubes

   • Results of HTC and dP of R32 and R410A.
2 Experimental installation

2.1. Installation description
2.2. Test section
2.3. Experimental method
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2.5. Incertidumbres
2.1. Description

- Experimental installation places at the Technical University of Cartagena.
Experimental Installation

2.2. Test section

- Mini-channel multiport tubes provided by Modine.

<table>
<thead>
<tr>
<th>Tube</th>
<th>Area (mm²)</th>
<th>Nº webbs</th>
<th>Inner perimeter (mm)</th>
<th>Outer perimeter (mm)</th>
<th>Dₜ (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square</td>
<td>12.54</td>
<td>10</td>
<td>43.22</td>
<td>40.17</td>
<td>1.16</td>
</tr>
</tbody>
</table>

Technical University of Cartagena
2.3. Experimental method (1/3)

- Based on Park et al. (2011) methodology

\[ Nu_{ref} = \frac{f/8 \times (Re - 1000)Pr}{1 + 12.7 \sqrt{f/8} \times (Pr^{2/3} - 1)} \]
2.3. Experimental method (2/3)

- Based on Park et al. (2011) methodology
2.3. Experimental method (3/3)

\[ G_{R32} = 800 \text{ kg m}^{-2} \text{ s}^{-1} \]

\[ \frac{\partial p}{\partial z}_{tp} = -\left( \frac{\partial p}{\partial z} \right)_f - \left( \frac{\partial p}{\partial z} \right)_g - \left( \frac{\partial p}{\partial z} \right)_{ac} \]

\[ HTC_{ref,j} = \frac{\dot{q}_j}{T_{ref,j} - (T_{wall\ inner})_j} \]
2.4. Experimental conditions

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Mass velocity (kg m(^{-2})s(^{-1}))</th>
<th>Saturation temperature(º C)</th>
<th>dX</th>
<th>Vapour quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>R32</td>
<td>350-800</td>
<td>20-55</td>
<td>&lt;0.08</td>
<td>0.13-0.94</td>
</tr>
<tr>
<td>R410A</td>
<td>350-800</td>
<td>20-55</td>
<td>&lt;0.08</td>
<td>0.11-0.95</td>
</tr>
</tbody>
</table>

2.5. Uncertainties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total uncertainty range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat flux</td>
<td>3.4-4.5</td>
</tr>
<tr>
<td>Vapour quality</td>
<td>2.2-12.5</td>
</tr>
<tr>
<td>Heat transfer coefficient</td>
<td>5.6-21.7</td>
</tr>
<tr>
<td>Inlet saturation pressure</td>
<td>1.6-3.4</td>
</tr>
<tr>
<td>Frictional pressure drop</td>
<td>2.2-11.9</td>
</tr>
</tbody>
</table>
3 Results

3.1. Frictional pressure gradients
3.2. Heat transfer coefficient
3.3. HTC and pressure drop analysis
3.4. Experimental data predictions
3.1. Frictional pressure gradient (1/2)

- $G \uparrow$, $X \uparrow$, $\downarrow P_{\text{red}} \rightarrow dP \uparrow$
Results

3.1. Frictional pressure gradient (2/2)

- $dP \text{(R410A)} < dP \text{(R32)} \approx 25\%$
- Clearer at $G \uparrow$, $P \downarrow$
3.2. Heat transfer coefficient

- HTC (R410A) < HTC (R32)
  - Clearer at $G \downarrow$.
  - $T \downarrow$ HTC $\uparrow$. Temperature effect not so clear
Results

3.3. HTC and pressure drop analysis

Viscosity (R410A) ≈ Viscosity (R32)
At fixed G → Reynolds (R410A) ≈ Reynolds (R32)

Velocity (R32) > Velocity (R410A)

\[\text{dP (R32)} > \text{dP (R410A)}\]

Liq. Thermal conductivity (R32) > Liq. Thermal conductivity (R410A)

Liq. Thermal conductivity differences \(\neq f(\text{Temperature})\)

Differences between both refrigerants seem to be independent of the saturation temperature
Results

3.4. Experimental data predictions
4 Conclusions
Conclusions

4. Conclusions

- Experimental measurements of R32 and R410A
- $GWP \ (R32) \approx \frac{1}{3} \ GWP \ (R410A)$
  Performance $\ (R32) \approx 1.05 \ Performance \ (R410A)$
  \[\downarrow\]
  Charge $\ (R32) \approx 0.7/0.8 \ Charge \ (R410A)$

- R32 is one single component fluid $\rightarrow$ Easier recycling process
- Some manufacturers already use R32 instead of R410A
- Not many models predict reasonably well HTC of both fluids
- Accurate predictive tools are required, not many authors have measured these fluids.
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Thermal and Energy Systems Modelling

http://www.upct.es/~ditf/investigacion_mste.php