An Experimental Comparison of the Refrigerant Flow along Adiabatic and Non-adiabatic Coiled Capillary Tubes

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Main topics of presentation

- Introduction
- Experimental setup
- Results and discussions
- Conclusion
Functions of expansion devices

• Reduces down stream pressure of condenser to up stream pressure of evaporator

• Regulate mass flow rate of refrigerant
Expansion device classification
(Refrigerant flow control devices)

- **Fixed Restriction Area**

- **Variable Restriction Area**
• **Variable Restriction Area**

  - Thermostatic Expansion Valve (TXV)
  - Automatic Expansion Valve (AEV)
  - Hand Expansion Valves
  - Electronic Expansion Valve (EEV)
  - ...
Expansion device classification
(Refrigerant flow control devices)

- **Fixed Restriction Area**

- **Long Capillary Tubes**
  - Straight
  - Coiled
  And

- **Short Orifices**

- Adiabatic
- Non-adiabatic
Comparison

- Expansion tubes: More durable and simpler

- Expansion Valves: Compatible with wide range of operating condition
Flow Pattern Through Capillary Tube

- Single-Phase flow
- Two-Phase flow

Diagram showing the transition from Single Phase to Two Phase with theoretical and actual flash points.
Objectives of Experiment

- Effect of heat transfer on length of metastable region by:
- Soldering a suction line with counter flow to the coiled capillary tube to cool the flow
- Using discharged vapor from evaporator
Objectives of Experiment

- Effect of mass flux ratio on length of meta-stable region and inception of flashing point through coiled tubes
- Mass flux ratio:

\[ R = \frac{G_{\text{capillary}}}{G_{\text{suction}}} \]
Experimental setup
Experimental setup
Results:

Validation with published data
(Chen and Lin, 2001)
Results:

Flash point position on adiabatic flow for mass flux ratio=568

![Graph showing flash point positions on an adiabatic flow diagram.](image)

- Refrigerant: R134a
- Diabatic
- $d=1.397$ mm
- $D_{\text{coil}}=40$ mm
- $T_{\text{cond}}=45.5^\circ\text{C}$
- $P_{\text{fr}}=8.35$ bar(abs)
- $G_{\circ}/G_s=568.7$
- $\Delta T_{\text{sub}}=14.83^\circ\text{C}$
Results:

Flash point position on adiabatic flow for mass flux ratio=343

Refrigerant: R134a
\(d_c=1.397 \text{ mm}\)
\(D_{coil}=40 \text{ mm}\)
\(T_{\text{cond}}=32.2 ^\circ C\)
\(P_{\text{in}}=874 \text{ kpa (abs)}\)
\(G_c/G_s=343.51\)
\(\Delta T_{\text{sub}}=1.75 ^\circ C\)
\(T_{\text{eva}}=-11.3 ^\circ C\)
CONCLUSIONS

1. Experimental study was presented for R134a flow through both non-adiabatic and adiabatic coiled capillary tubes
2. Maximum error of 9.5% between present and previously published data
3. Increase of heat transfer rate by decrease of the mass flux ratio in non-adiabatic condition
4. Weak heat transfer rate and metastable phenomena occurrence in mass flux ratio greater than 343
5. The present model can be used as a suitable tool for design and optimization of the vapor compression refrigeration systems (VCRS) with helical capillary tubes
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Thank you for your attention