Technologies to Improve the Performance of A/C Systems in Hot Climate Regions

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Presentation Outlines

- Motivation
- Objectives
- Baseline System
- Liquid Flooded Compression with Regeneration System
- Vapor Injection Compression with Economizing System
- Results and Comparison
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Motivation

- Air conditioning (AC) contributes significantly to building energy consumption in hot climate regions.
- Need to limit AC energy consumption as its use increases worldwide.
  - For environmental and economic reasons.
  - Especially, in hot climate regions.
- Since system performance decreases with increasing ambient temperature, providing energy efficient AC is a challenge.
Objectives

- Simulate vapor compression systems using two novel compression technologies for application in high ambient temperature air conditioning
  - Liquid–flooded compression with regeneration
  - Vapor injected compression with economizing
- Working fluids:
  - R410A, Propane (R290), R32, R1234yf
- Conduct system performance comparisons
  - Predict coefficient of performance (COP) at various operating temperatures
  - Compare with conventional R410 A vapor compression system
Baseline System

COP = \frac{\dot{Q}_{\text{evap}}}{\dot{W}_{\text{comp}}}

*Schematic vapor compression cycle (Bell, 2011)
Liquid Flooded Compression with Regeneration System

\[ h_m = x_l h_l + (1 - x_l) h_g \]

\[ s_m = x_l s_l + (1 - x_l) s_g \]

\[ x_l = \frac{\dot{m}_l}{\dot{m}_l + \dot{m}_g} \]

*Schematic of flooded vapor compression with regeneration system (Bell, 2011)*
Design Conditions and Model Assumptions

- POE Oil is used as a flooding agent for liquid flooded compression
- Compressor isentropic efficiency is fixed at 70%
- Regenerator effectiveness 90%
- All the state points are subcritical
- Pressure drop in heat exchangers is neglected
- Process in expansion valve is isenthalpic
- $\Delta T_{\text{pinch}} = 5^\circ\text{C}$, $\Delta T_{\text{SuperHeat}} = 5^\circ\text{C}$ and $\Delta T_{\text{Subcool}} = 7^\circ\text{C}$ for the outlet of the heat exchangers.
- The ambient temperature ranging between 20°C to 55°C and the source temperature ($T_L$) is kept at 23.88°C
- The cooling capacity is fixed at 3 tons
- Model solved for compressor suction state
Vapor Injection Compression with Economizing System

*Schematic of a flash tank vapor injection cycle (Ramaraj, 2012)
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- Only a single port is used in the A/C system
- The refrigerant drawn from the flash tank is saturated vapor
Design Conditions and Model Assumptions

- The injection pressures were selected to result in equal pressure ratios between the injection points
- Compressor isentropic efficiency is fixed at 70%
- Compressor volume efficiency is fixed at 100%
- All the state points are subcritical
- Pressure drop in heat exchangers is neglected
- Process in expansion valve is isenthalpic
- $\Delta T_{\text{pinch}} = 5^\circ\text{C}$, $\Delta T_{\text{SuperHeat}} = 5^\circ\text{C}$ and $\Delta T_{\text{Subcool}} = 7^\circ\text{C}$ for the outlet of the heat exchangers.
- Fan work is neglected
- The ambient temperature ranging between 20°C to 55°C and the source temperature ($T_L$) is kept
- The cooling capacity is fixed at 3 tons
Results and Comparison

![Graphs showing the performance of A/C systems in hot climate regions using different technologies such as Oil Flooding, Vapor Injection, and Conventional. The graphs compare TH (C) against Compressor Discharge T (C) for R410A, R290, R-1234yf, and R32.]
Results and Comparison

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Conclusions and Recommendations

- **Discharge Temperature**
  - Vapor injection technology shows better improvement
  - Oil flooding shows more improvement in reduction of discharge temperature in contrast to improving COP

- **COP**
  - Vapor injection technology shows higher improvement for all refrigerants except R1234yf
  - Vapor injection technology with R410A is best option
  - R1234yf shows 14% improvement using oil flooding technology ➔ recommended for experimental investigation

- Vapor injection model could be improved by controlling the injection quality

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THANK YOU