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
- Conclusions and Recommendations

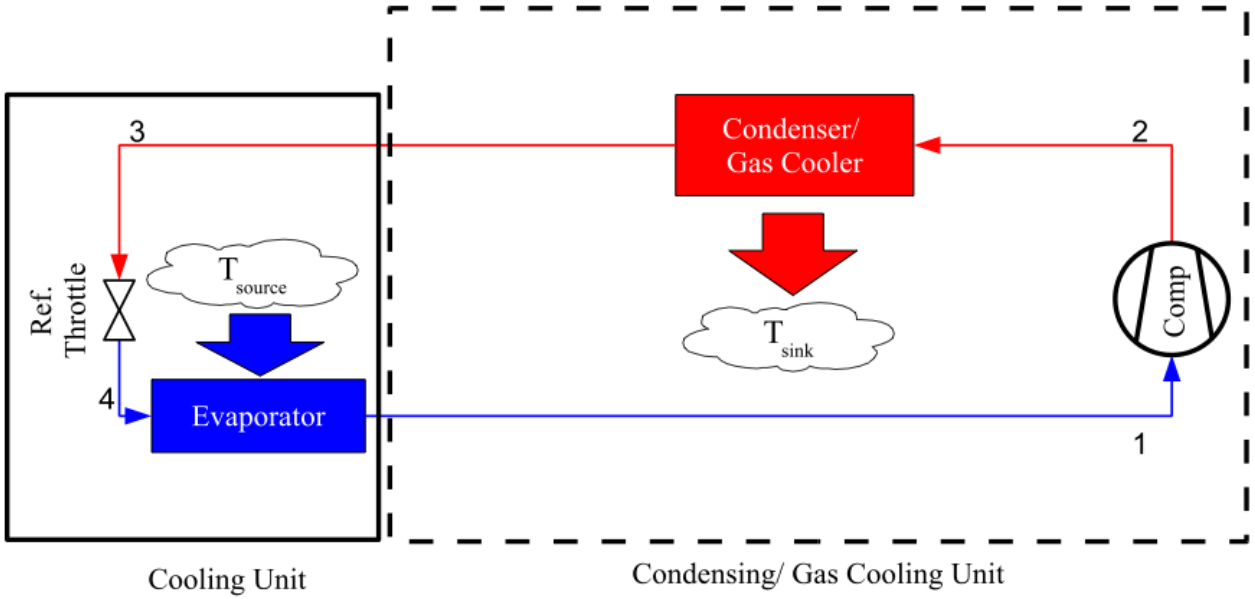
Motivation

- 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

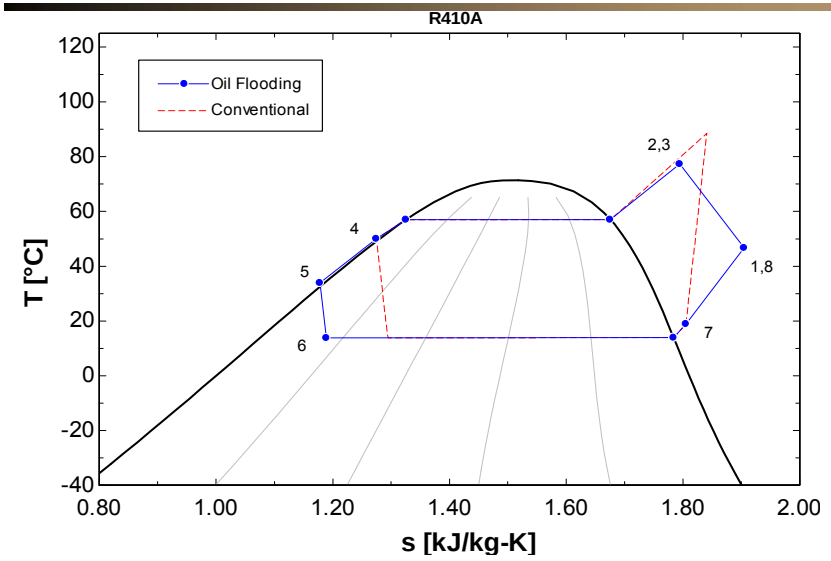
Baseline System

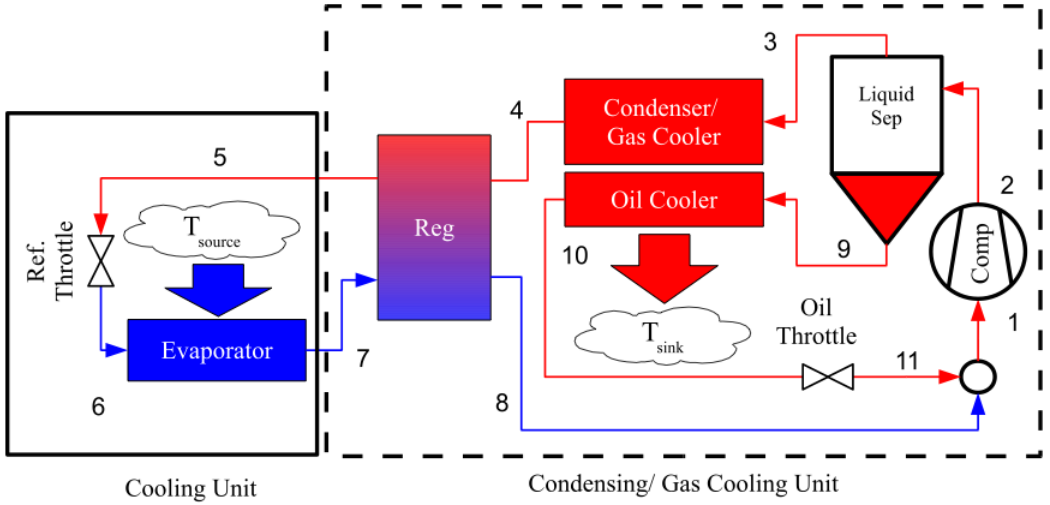


*Schematic vapor compression cycle (Bell, 2011)

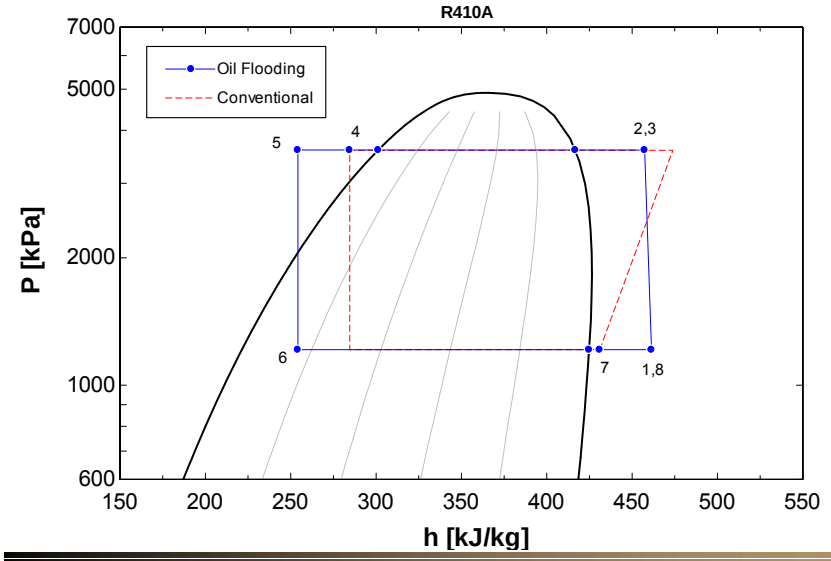
$$\mathrm{COP} = \frac{\dot{Q}_{evap}}{\dot{W}_{comp}}$$

Liquid Flooded Compression with Regeneration System





*Schematic of flooded vapor compression with regeneration system (Bell, 2011)



$$h_m = x_l h_l + (1 - x_l) h_g$$

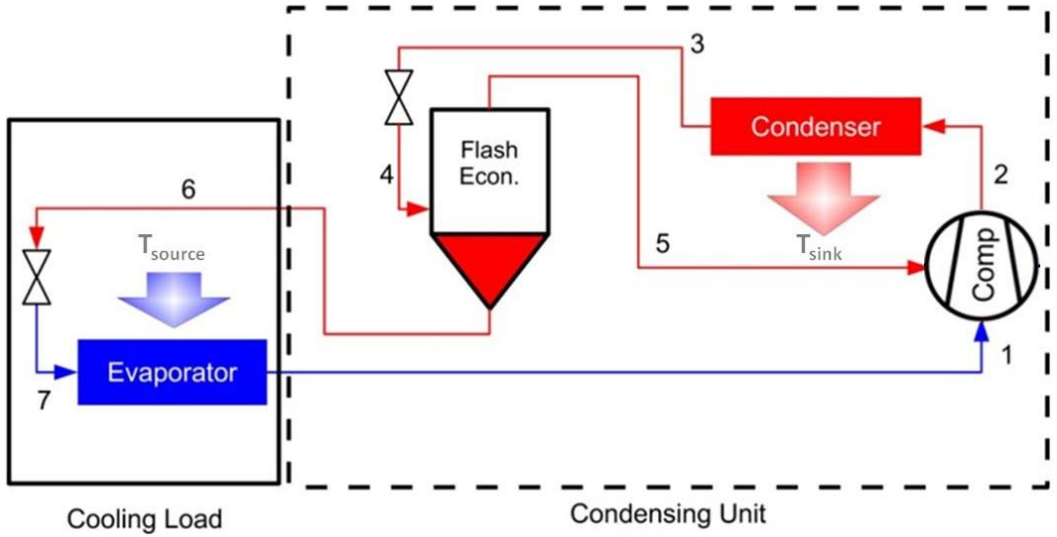
$$s_m = x_l s_l + (1 - x_l) s_g$$

$$x_l = \frac{\dot{m}_l}{\dot{m}_l + \dot{m}_g}$$

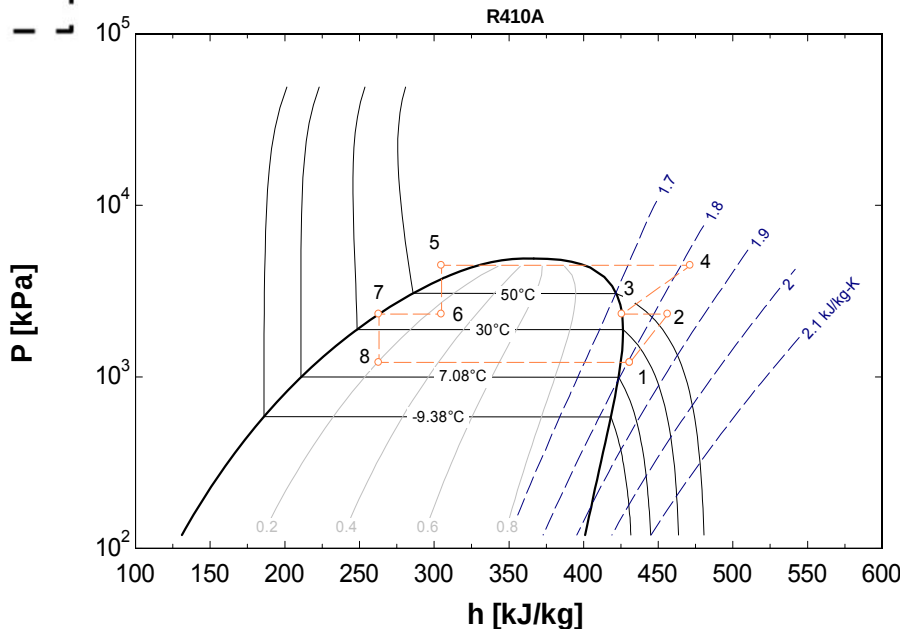
Design Conditions and Model Assumptions

- 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
- ΔT_{pinch} = 5°C, $\Delta T_{SuperHeat}$ = 5°C and $\Delta T_{Subcool}$ = 7°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

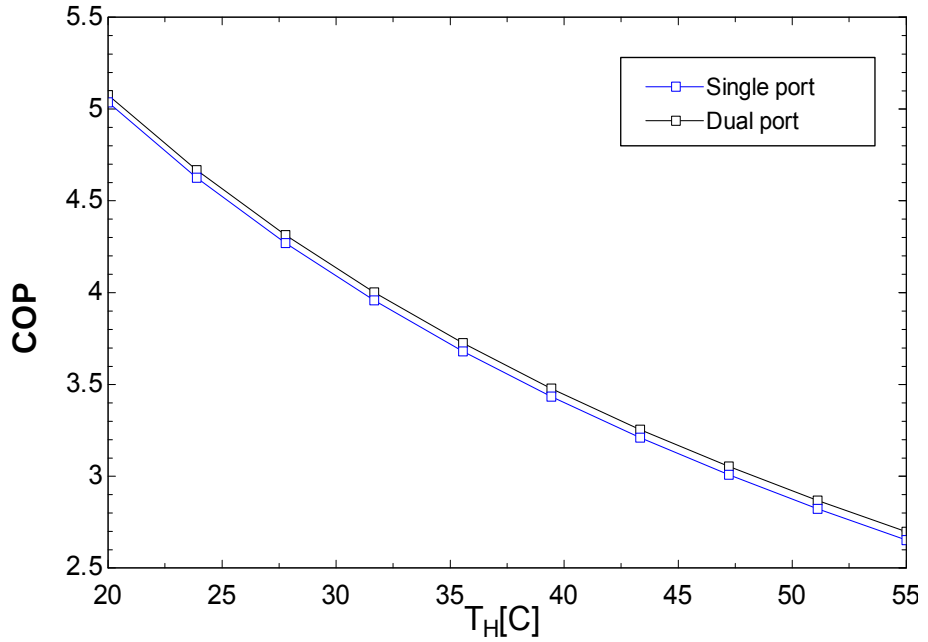


*Schematic of a flash tank vapor injection cycle (Ramaraj, 2012)



Vapor Injection Compression with Economizing System

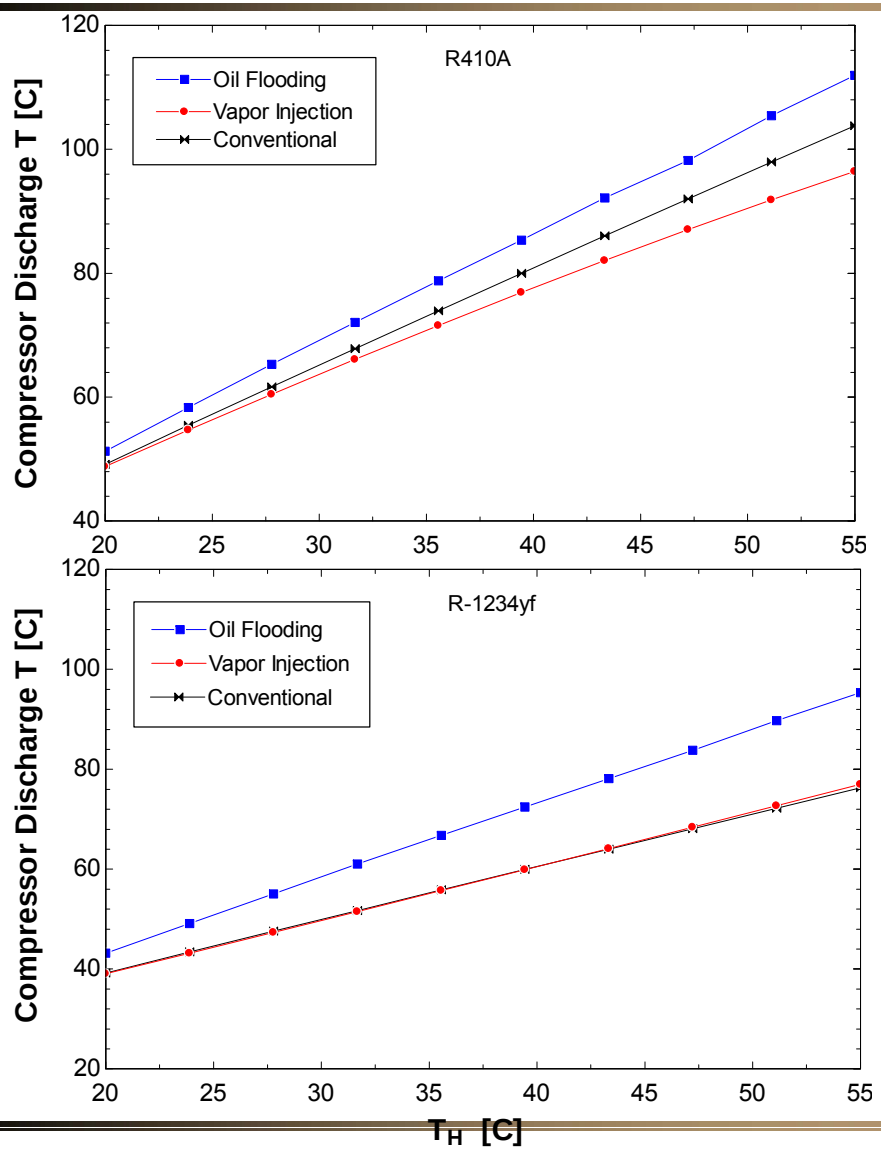
- Only a single port is used in the A/C system
- The refrigerant drawn from the flash tank is saturated vapor

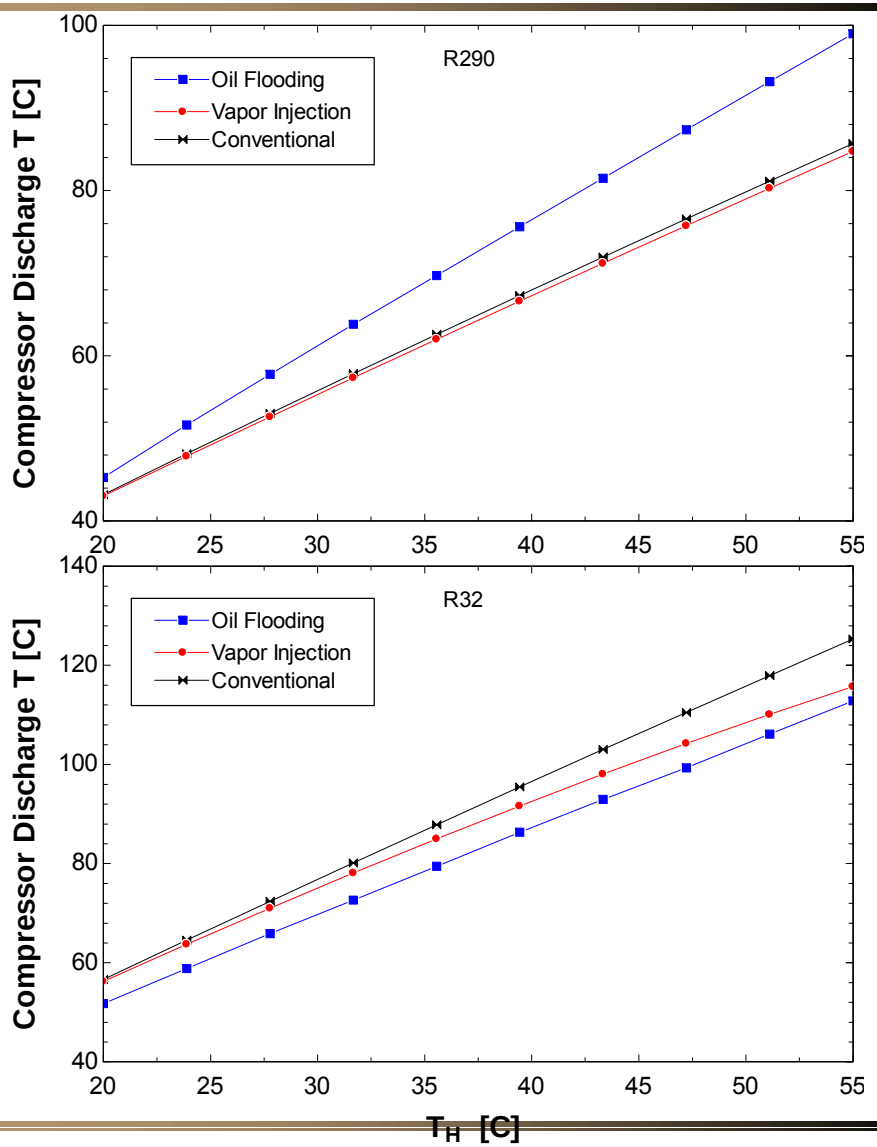


Design Conditions and Model Assumptions

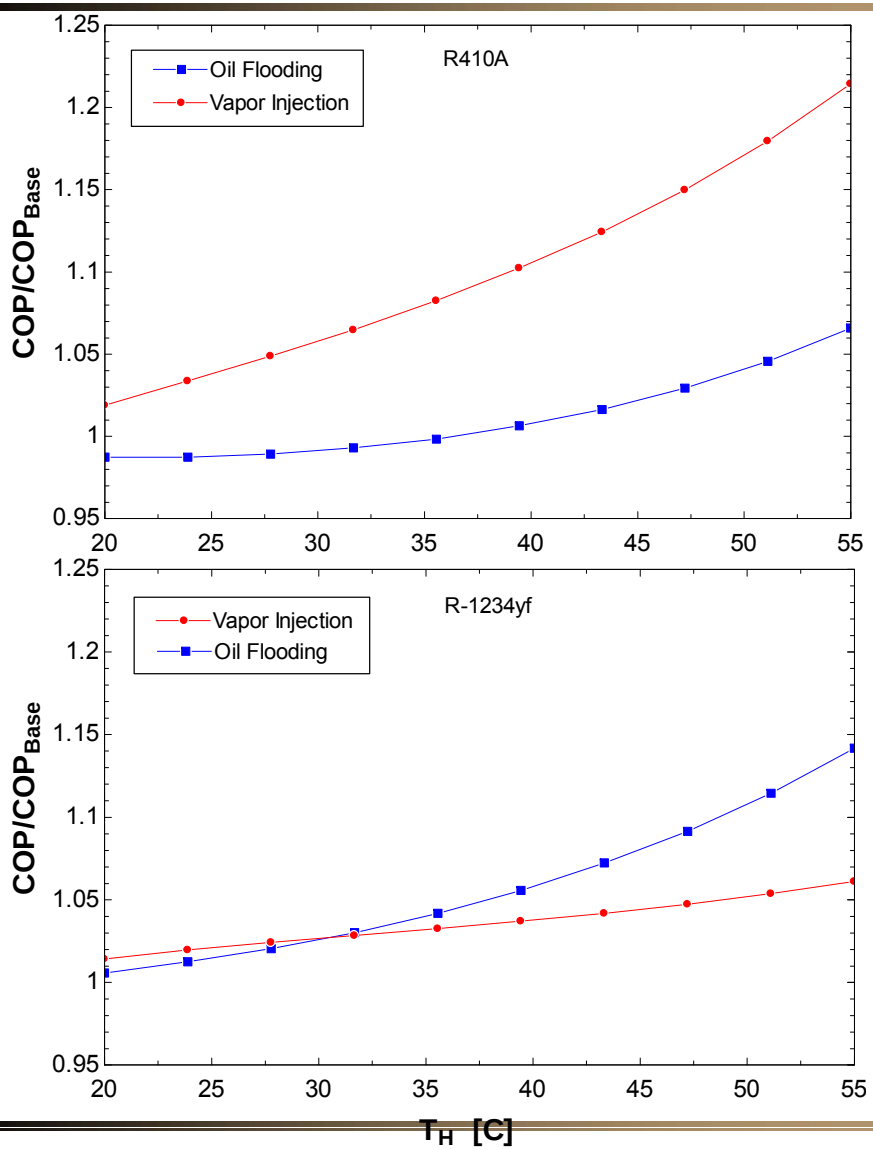
- The injection pressures were selected to result in equal pressure ratios between the injection points
- Compressor isentropic efficiency is fixed at 70%
- Compressor volume efficiency is fixed at 100%
- All the state points are subcritical
- Pressure drop in heat exchangers is neglected
- Process in expansion valve is isenthalpic
- ΔT_{pinch} = 5°C, $\Delta T_{SuperHeat}$ = 5°C and $\Delta T_{Subcool}$ = 7°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

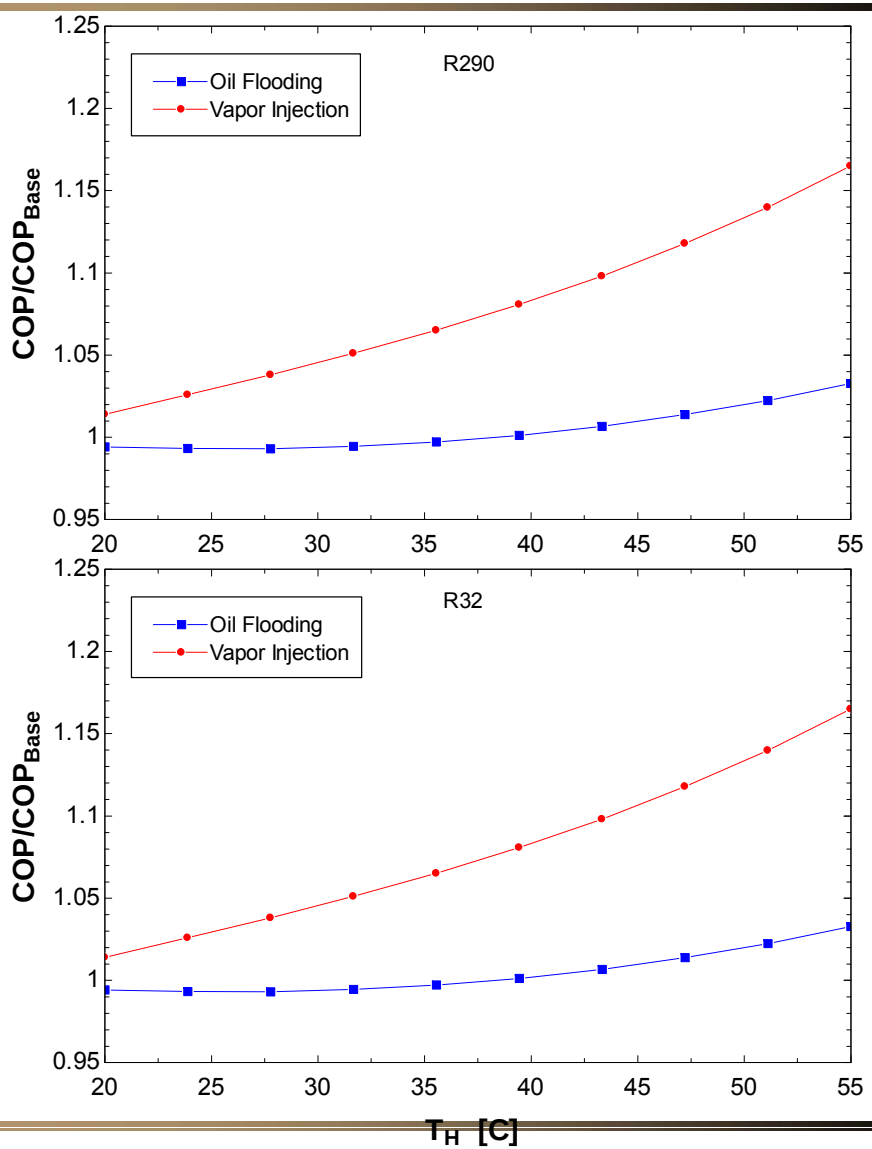
Results and Comparison





Results and Comparison





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

THANK YOU