Comparing COP and COSP optimization for refrigeration systems in supermarkets

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Control Volume

- Frame of reference
- Surrounded by control surface

In steady state: \[ \sum m_{in} = \sum m_{out} \]
Control Volume

What ever you want it to be
Overview

- Definitions
- Refrigeration model
- COP vs COSP – Results
- Conclusions
Definitions: COP and COSP

- **COP**: Coefficient of performance
  - Includes only core refrigeration system
  - \[ \text{COP} = \frac{Q_e}{W_{net,in}} = \frac{\dot{Q}_e}{E_{net,in}} \]

- **(Semi)hermetic**: \[ E_{net,in} = E_{term} \]

- **COSP**: Coefficient of system performance
  - Includes all equipment (e.g. condenser fans)
COP and COSP

\[ \text{COSP} = \frac{\dot{Q}_e}{E_{\text{total}}} = \frac{\dot{Q}_e}{E_{\text{comp}} + E_{\text{fan}} + E_{\text{others}}} \]

\[ \text{COSP} \approx \frac{\dot{Q}_e}{E_{\text{comp}} + E_{\text{fan}}} \]

\[ \text{COP} = \frac{\dot{Q}_e}{E_{\text{comp}}} \quad (\text{semihermetic}) \quad \Rightarrow E_{\text{comp}} = \frac{\dot{Q}_e}{\text{COP}} \]

\[ \text{COSP} \approx \frac{\text{COP}}{1 + \text{COP} \frac{E_{\text{fan}}}{\dot{Q}_e}} \]
COP and COSP

\[ \text{COSP} \approx \frac{\text{COP}}{1 + \text{COP} \frac{E_{\text{fan}}}{\dot{Q}_e}} \]

Cooling Load
- 12.5%
- 25%
- 50%
- 100% (design)
Simple Model – Components

\[ p_{c, \text{max}} = 18.5 \text{ bar}_a \]
\[ p_{c, \text{min}} = 10.5 \text{ bar}_a \]

R404A

\[ E_{\text{fan, max}} = 2.9 \text{ kW} \]
Heat rejection at condenser

- Heat rejection rate

\[ \dot{Q}_c = c \rho \dot{V} \Delta T \]

- Air through condenser
- f(Condenser temperature)
- Condenser fan
- f(Compressor)

\[ E_{\text{fan}} \propto \dot{V}^3 \]

\[ E_{\text{comp}} \propto T_{\text{cond}} \]
Compressor and total power

Load: 7.5 kW

Fan power (max) = 2.9 kW
Total power: $\text{COP}_{\text{max}}$ vs $\text{COSP}_{\text{max}}$
Conclusions

- Including sufficient components in control volume

- Fan power can be significant proportion at low load

- Future work
  Control method: \( \text{Min}[E_{\text{comp}} + E_{\text{fan}}] \Rightarrow \text{Max}[\text{COSP}] \)
Thank you for your attention!