Variable Speed Drives for Evaporative Condensers

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Evaporative Condenser in an Industrial Refrigeration System
Variable Speed Drives (VFDs)

- Modulate fan speed in refrigeration systems
  - Goal: Maximize energy efficiency

- 3 most common fan capacity controllers:
  - On/off control, single speed
  - High/low/off control, 2 speeds
  - Variable speed
Condensing Capacity

- Greater condensing capacity means condenser fan is operating at part-load conditions for longer time periods

- VFDs take advantage of the reduced power requirement to achieve required refrigeration
Power Reduction with VFD Fan Control

At 80% capacity, VFD cuts power requirement in half, from 80% to 40%
Heat Rejection Rate, $\dot{Q}$

- Condenser heat rejection capacity, $Q$
  - how much heat the condenser can remove from the refrigerated area

- Heat rejection rate is a function of fan speed:

$$\dot{Q}_{\text{cond,actual}} = \dot{Q}_{\text{cond,rated}} \times \left( \frac{\text{FanSpeed}_{\text{actual}}}{\text{FanSpeed}_{\text{rated}}} \right)^{0.76}$$
Power Required decreases Fourfold

- When required condenser capacity is reduced:
  - During low loads or low outside wet-bulb temperatures

\[
HP_{\text{cond,actual}} = HP_{\text{cond,rated}} \times \left(\frac{\dot{Q}_{\text{cond,actual}}}{\dot{Q}_{\text{cond,rated}}}\right)^{3.95}
\]

- Impact: Power required (HP) reduced by a factor of 3.95
Conclusions

- VFDs achieve 94%-96% efficiencies, exceeding required 88%-91%

- Collateral improvements:
  - Minimizes fluctuation in pressures versus on/off drives – stabilizes system operation
  - Eliminate starting/stopping of fan motors – reduces wear and tear on fan belts, bearings, shafts, blades
  - Cycling motors on/off reduces life
Thank You