Part load efficiency in HVACR systems

Frank Taaning Grundholm, Vice President HVACR sales ABB Motion
HVACR in buildings

Impact on overall building energy consumption

99% of the time buildings operate at the load below 80%

Over 50% of commercial building annual energy consumption goes for HVACR

Source: US energy information administration
Legislation on building energy performance

Key considerations

• Buildings consume most energy in Europe, absorbing about 40% of final energy.
• The numerical criteria of building energy efficiency are mostly based on energy consumption per building square meter.
• Certification systems for buildings in Germany DGNB, the USA LEED and Britain BREEAM with assessment criteria incl. more or less same aspects like water efficiency, energy and atmosphere, materials and resources, indoor environmental quality.
Legislation on HVACR system components

Key considerations

• In 2009, the European Parliament and Council passed a directive defining ecodesign requirements for energy related products ErP Directive 2009/125/EG to reduce energy consumption across EU.
• Ventilation units – Commission Regulation No 1253/2014 of 7 July 2014
• Fans driven by motors with input power 0.125 – 500 kW – Commission Regulation No 327/2011 of 30 March 2011
• Water pumps – Commission regulation No 547/2012 of 25 June 2012
• Compressors – Lot 31. Preparatory study on Low pressure & Oil-free compressor packages of 7 June 2017
• Ecodesign preparatory study for Building Automation and Control Systems (BACS)
Legislation on HVACR system components

Example: water pumps


• Energy efficiency index EEI and Minimum efficiency index MEI are calculated considering pump efficiency at part load.

Energy conservation standard for clean water pumps by Department of Energy USA, since 27.01.2020

• Pump Energy Index (PEI) represents a pump’s efficiency as compared to the minimum efficiency defined by the Department of Energy USA.

• There are separate PEI calculations depending on the load type: for constant load weighted average is taken at 75%, 100% and 110% of best efficiency point flow rate; for variable load weighted average is taken at 25%, 50%, 75% and 100% of BEP:
Specifying HVACR efficiency for buildings

Key considerations

• Nobody specifies the efficiency of HVACR system at part load.
• When the part load efficiency is significantly lower, building owners will never realize the savings that were calculated.
• Some solutions when run at part load do not give full efficiency owing to motor design and motor controls. It is important to ensure high efficiency of a motor-drive package at part loads.
• It is important to consider not only efficiency of a powertrain (HVACR application like pump, motor and drive), but also power system efficiency affected by VSDs through reactive power and harmonics.
Choosing motor technology for higher system efficiency

Part load efficiency for different motor types

- Different motor types present in the market: induction, permanent magnet, synchronous reluctance, electronically commutated.
- Important to consider efficiency at part load operation where the system is most of the time – the difference between 100% and 40% might be 10% and more.
Getting the most efficiency out of pumping system

Running pumps at part loads

\[ P = \frac{Q \rho g H}{\eta} \]

Flow control methods:

- Using throttles for flow control with no energy savings
- Using cascade control when the new pump steps in when needed
- Using pump parallel operation with drive control – pumps run at the most efficient points for current situation
Getting the most efficiency out of ventilation system

Single fans vs fan arrays

- There is potential to achieve higher efficiency in the system with multiple fans running closer to their peak efficiencies, rather one large fan controlled over a wide operating range.
- Larger fans are more efficient than smaller fans, also, larger motors are more efficient than smaller motors at peak load, but at part loads small fans in array offer a great scalability which affects system efficiency.
Overall HVACR system efficiency

Taking complex approach

- In cooling, you need to consider the whole system to optimize it. If you start controlling the condenser, it will affect the compressor, which also impacts the evaporator.
- A system approach and right balance are needed between how the compressor, condenser and evaporator are controlled.
- Sometimes, running two compressors at part load is more efficient than running one compressor at full load and another at part load.
Benefiting of HVACR system digitalization

ABB Ability™ Energy Optimization: monitor, correct, optimize throughout system lifetime

Monitoring

Cooling tower fans
Condenser circulator
Chiller compressor
Chilled water circulator

Energy consumption

Low consumption  Medium consumption  High consumption  Medium consumption
Thank You for attending this presentation

Don’t forget to collect your CPD certificate at the event from CPD collection area