White Paper

Capacity Modulation Comparison for Hot Gas Bypass, Rawal APR Valves, Digital Scroll, and Inverter Scroll Compressors in Rooftops

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By YORK Commercial
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Introduction

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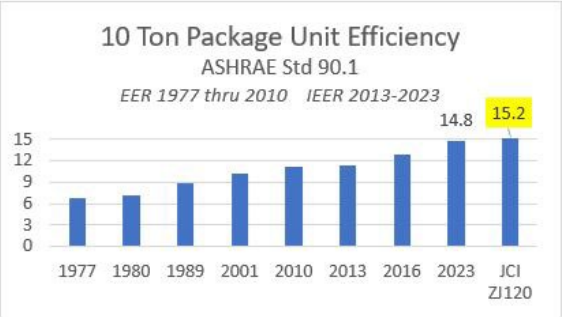

Package unit capacity control historically referred to compressor staging commonly from 1 to 3 stages of capacity control for light commercial tonnages. Capacity modulation now includes inverter-controlled compressors, digital compressors, RAWAL devices, and hot-gas-bypass. The key advantages of modulation for package units are reduced energy usage, increased product applications, and improved space humidity control.

Increased efficiency and reduced energy usage

Part load capacity control allows units to reach very high IEER which, in turn, directly relates to lower energy usage. It also allows the use of air-side economizers while using 1 or more stages of mechanical cooling. Utilizing an economizer combined with mechanical cooling is a relatively new capability now available because of improved part load control.

Increased applications

Improved capacity control allows smaller tonnage light commercial units to be used in more applications such as Single Zone VAV (SZVAV), Variable Air Volume (VAV), Variable Volume and Temperature Control (VVT), and Change-Over Bypass (COBP) applications. These applications often use less energy when compared to traditional thermostat controls by using lower supply fan airflows and less mechanical capacity.

Increased Humidity Control

The added benefit of capacity control is a more stable leaving air temperature from the evaporator coil in part load conditions. The evaporator coil reaches 55°F leaving air temperature more frequently which results in superior space humidity control. A unit leaving air dewpoint of 55°F results in a 52% space relative humidity at 74°F space temperature.

Hot Gas Bypass

A Hot Gas Bypass (HGBP) is installed in direct expansion (DX) equipment to reduce coil freeze-up and keep the system operating longer. HGBP works by allowing a percentage of hot discharge gas to bypass the condenser coil and go directly into the evaporator coil.

A valve is used to regulate the amount of bypass refrigerant. The hot gas essentially puts a false load on the system, thereby, keeping the evaporator from freezing in low load and low airflow conditions. The disadvantage of HGBP is that the operation creates an inherently inefficient operation – wasted energy.

ANSI/ASHRAE/IES Standard 90.1 limits the use of HGBP to systems that have multiple steps of refrigeration system capacity control. HGBP is not allowed in systems with only one on/off compressor. Systems ≤ 240,000 Btu/h are limited to a Total Bypass Capacity of 15% and systems > 240,000 Btu/h are limited to a Total Bypass Capacity of 10%.

Rawal APR Valve

The APR Control is an external compressor unloader that reduces the compression ratio as it diverts refrigerant from the outlet of the compressor back to the suction inlet. As a continuous capacity modulation device, the APR Control externally unloads the compressor, thus reducing the energy consumption of the system. The APR Control provides continuous capacity modulation and dehumidification for DX air-conditioning systems.

The APR Control is a mechanical device that maintains suction pressure, allowing the system capacity to match the ever-changing load and space requirements. APR Control is sized to provide the maximum amount of capacity modulation based on the minimum tonnage of refrigerant that could be flowing throughout the system (circuit or stage) at low load conditions.

Since its introduction, the APR Control has been referred to as a continuous capacity modulation device based on the theory of modulating the adiabatic process of a refrigeration system. The APR was an unprecedented offering with no equivalent in the market. As APR Control was embraced by the industry, the most common and comparable reference was hot gas bypass.

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While both APR Controls and HGBP affect the compression ratio of the compressor, only the APR Control improves the “refrigeration effect” during part-load operation while reducing the compression ratio.

Digital Scroll

Scroll digital technology is applied as a modulation solution. The modulation is achieved with a cycle time-based Pulse Width Modulation (PWM) control of a solenoid valve that operates a piston fitted rigidly to the upper scroll. This piston is actuated by gas pressure. The solenoid opens to allow the modulation chamber to communicate with suction via the external tube. Discharge pressure on the lower side of the piston forces it upwards, bringing with it the upper scroll – there is no compression. When the solenoid closes, pressure builds up in the modulation chamber. A small bleed hole speeds the pressure build-up in the chamber.

The upper scroll moves down to its normal contact position – compression resumes. Scroll Digital technology thus provides continuous, stepless modulation from 10% to 100% with no operating envelope restriction.

Digital scrolls are simple to use in the field as they have the same physical properties as the standard fixed-speed compressors with only the addition of the unloading solenoid valve. This is a less complex, more balanced, quieter way to modulate capacity than some other methods. Digital scrolls are designed

for capacity modulation and do not provide the energy savings that Variable Speed Drive (VSD) compressors do.

Inverter Scroll

Variable speed control can be used to regulate the speed of the compressor motor which in turn varies the refrigeration capacity. Variable Frequency Drives (VFD) are also known as Adjustable-Frequency Drives (AFD), Variable Speed Drives (VSD), AC drives, micro-drives, or inverter drives. Compressors with inverter technology use a permanent magnet rotor. This type of motor comes with some unique characteristics, including smoother torque output, superior speed control, and higher efficiency under part-load conditions resulting in an average 30-50% IEER improvement.

Cooling and heating applications require stable temperatures to guarantee the best humidity control and comfort in all commercial areas. In addition to comfort, precise cooling or accurate temperature control have become even more important in applications such as process cooling or data centers. Variable speed technology allows system manufacturers to match the load needed for accurate temperature control and the best comfort thanks to a wide turndown ratio of up to 7:1 and its full modulation capabilities. IT cooling equipment in data centers is an increasing challenge for operators and design engineers. Power management is a major concern, followed by energy consumption and heat loads: best modulation is needed to better respond to load changes and reduce power consumption when the load is reduced. Meeting these challenges is essential for ensuring data safety and availability. Variable speed solutions enable the optimization of both process and data center systems, which contributes to reducing running costs.

Conclusion

The application of capacity control methods to refrigeration systems offers the potential for substantial energy saving or energy efficiency. Also, it is known that the overall energy consumption of a refrigeration, air-conditioning, or heat pump during its service life is a considerable cost factor and frequently is a multiple of the initial investment.

Consequently, with a view to indirect environmental impact (CO2 emission due to power generation), optimum capacity control should be aimed for, that is, closely matched to demand. Our factory offers inverter capacity control on Sun™ Premier and Sun™ Choice RTUs, and the Norman Modification Center offers RAWAL capacity control for Small Sunline, Sun™ Core, and Sun™ Pro RTUs.

Please contact the presale application support team if you need further assistance at 1-877-334-9209 or email lightcommercialsalessupport@jci.com or applieddxsalessupport@jci.com.

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