Refrigeration System Trends

Reflect Economic Concerns

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Distributed refrigeration systems gain ground due to energy efficiency and lower startup and operating costs.

In a world where excessive energy consumption and the ever-increasing cost of oil and global warming are major concerns, retailers, contractors and equipment manufacturers alike are considering new ways to reduce energy loss. One of the main culprits of excessive energy consumption in the supermarket and retail environment is the commercial refrigeration system.

As retailers look to update their store designs or prepare to replace or retrofit their refrigeration equipment, distributed refrigeration systems are gaining popularity as an energy-efficient, environmentally considerate solution to the standard centralized system.

Today's supermarket refrige-ration systems commonly use large, rack-mounted reciprocating compressors in one or more refrigeration machine houses. The racks are connected with extensive piping to various refrigeration cases and freezers.

This extensive piping network is the primary source of energy consumption and environmental concerns. Significant amounts of refrigerant are required in long pipe runs, and more joints increase refrigerant leak opportunities. Plus centralized systems require large floor or roof space.

System Benefits

Distributed refrigeration systems gained popularity over the last 50 years, largely because they offer smaller, more manageble units that are closely located to targeted loads. This reduces complexity as well as both initial and annual costs.

It also improves flexibility and removes structural considerations associated with heavy, concentrated rack systems. Pipe runs are significantly reduced and floor space opens up for merchandise. Most importantly, the amount of refrigerant needed is reduced by up to 70 percent - an important environmental consideration.

In addition, distributed systems operate more efficiently than traditional racks. The distributed architecture allows better matching of the condensing unit to the suction group. Contractors know that operating cases at different temperatures requires that the suction header be split into one circuit for each suction temperature.

Inefficiency is created when the refrigerant is run through an evaporator pressure regulator (EPR)

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valve for each suction temperature group. Additional pressure drops in the long lines also lower efficiency. Distributed refrigeration systems use much shorter lines and thus are affected less by suction line pressure drop.

Additional benefits of distributed refrigeration systems include :

- Lower operating costs.
- Lower installation costs.
- Improved in-store flexibility.
- Faster startup time compared to large systems.
- Larger diversity in food selection.
- Less expensive components and materials.

Distributed refrigeration systems can cut down on costs during store construction and commissioning. Reductions in structural steel, refrigerant piping and refrigerant can reduce first costs by as much as $200,000 during store construction.

As retail environments become more refrigeration intensive, distributed refrigeration systems enable variety in store architecture, which can impact merchandising. Stores now offer more specialty items such as designer coffees, premade gourmet and organic foods, and other refrigeration-dependent services. This diverse layout requires more flexibility in the location of refrigeration equipment.

The bottom line also is affected by distributing the refrigeration and reducing annual operating and maintenance costs. Reduced piping eliminates thousands of braze joints and reduces the risk for refrigerant leaks.

Advancements in Components

Distributed refrigeration systems have become an energy-efficient solution simply through the advancements in component technology such as scroll compressors. These technological advancements help optimize efficiency through a combination of simple modulation, extremely precise temperature control and linear power reduction.

Semi-hemetic compressors power most centralized refrigeration systems. These large compressors, when piped in parallel, can provide the required refrigeration for an entire store. Compressor efficiency is generally quite high and compressor reliability is good.

But to reduce energy consumption, retailers are considering retooling the system to introduce high-efficiency scroll compressors. Recent performance improvements and advanced modulation technologies in scroll compressors make scroll a viable alternative to semi-hermetic compressors in distributed systems.

In terms of more advanced modulation, one company's digital scroll compressors, for instance, are capable of adjusting their cooling output from 10 percent to 100 percent to respond to changes in the load from the merchandising display cases. Matching the load requirements helps to greatly reduce compressor cycling, while maintaining optimal case temperatures, ideal in supermarkets, where food quality is paramount and profit margins are thin.

Scroll compressors have fewer moving parts than reciprocating compressors and are more reliable by design. Typical reciprocating compressors contain nine moving parts for every cylinder. In comparison, scroll compressors have only two moving parts, which eliminate opportunities for failure. The typical compressor parts most susceptible to failure, such as wrist pins and connecting rods, have been removed in scrolls.

A common failure for refrigeration equipment is liquid returning to the compressor. Because liquids are incompressible, they will fail a compressor faster than any other system problem.

Some manufacturers have built the ability to handle liquid into their compressors by utilizing both axial and radial scroll compliance. Compliance is the ability of scrolls to separate under abnormal conditions, which provides the capability of allowing liquid to pass through the scroll without damaging it.

Since scroll compressors do not use pistons to compress gas, there is very little volumetric efficiency loss through re-expansion, which typically occurs with each piston stroke in reciprocating models. Similarly because valves are eliminated there are no losses at valves.

During the operation of a scroll, centrifugal force maintains nearly continuous compression and constant, leak-free contact. The separation of suction and discharge gases reduces heat-transfer loss.

Using scroll compressors in distributed systems allows for a smaller platform and footprint. On average, scroll compressors use fewer parts than a semi-hermetic of the same capacity and take up less room. The scroll orientation inherently provides a slim and vertical build, making scroll an ideal match for the distributed refrigeration concept.

The simple design allows scroll compressors to operate at lower sound and vibration levels than reciprocating compressors. In fact, tests have shown that scroll compressors are up to three times quieter than reciprocating models.

One reason for the lower sound levels is that scroll compressors require no suction valves to achieve efficient compression. Smooth, balanced orbital motion results in quieter operation with less vibration.

Increasing Capacity and Efficiency

Traditionally, the only way to enjoy the added benefits of mechanical subcooling was with large multiple screw or semi-hermetic reciprocating compressor systems that utilized a separate compressor for the mechanical subcooler.

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Scroll compressors enable significant performance gains from a single compressor utilizing enhanced vapor injection. The vapor injection technique improves system capacity and efficiency in low and ultralow temperature commercial refrigeration applications.

Enhanced vapor injection (EVI) introduces vapor into the scroll in the middle of the compression process, achieving a subcooling effect while reducing compressor discharge temperature. A vapor injected scroll has the energy consumption numbers that rival a subcooled compressor, but without the added mechanical subcooler compressor.

When the refrigeration loads are reduced, the vapor injection circuit can be turned off as a means of capacity modulation. Suction line pressure drop effect is reduced due to a higher enthalpy change across the evaporator.

Improvements in the system electronics used in distributed refrigeration systems allow for more control over components like compressors, motors, valves and sensors. For instance, the electronic stepper regulator (ESR) is a direct-driven suction regulator that uses a linear actuating bi-polar stepper motor to maintain the highest possible constant suction pressure.

The stepper valve opens and closes to the exact opening needed to achieve the case temperature setpoint. If the case is too cold, the valve closes to increase evaporator pressure. If the case is too warm, the valve opens to decrease pressure.

The ESR is an alternative to mechanical suction pressure regulation in refrigerated-case circuits. Because ESRs are electronically controlled by an integrated control system, the need for costly valve adjustments is eliminated, unlike with mechanical EPRs.

By modulating pressure control within the evaporator, stress on piping and joints is greatly reduced. This reduces the possibility of expensive refrigerant leaks as well.

Systems with ESRs can control case temperatures to 0.1°F – a mechanical inability for a traditional mechanical EPR. This precision creates energy-efficient store operations, and eliminates product shrinkage and loss, which ultimately saves retailers money.

Even though the ESR is more advanced than the mechanical EPR, it serves the same function in the refrigeration system. The stepper expansion valve works the same way as a thermo-expansion valve, controlling the evaporator superheat by regulating the amount of refrigerant in the evaporator coil.

A stepper regulator works the same as a conventional regulator: by opening and closing to control the evaporator pressure, which in turn controls the evaporator temperature. Retailers can apply manufacturer instructions to adjust the ESR.

Sizing the valve is done much the same way. The laws of thermodynamics are not changed by the electric motor in the valve or the electronics controlling the valve. Sizing the valve till involves knowing the system refrigerant, evaporator load, liquid temperatue, desired capacity and pressure drop across the valve.

The stepper motor that drives the valve is like any other electric motor and should be thought of as such. It works, acts and behaves like an electric motor, but operates with a square wave instead of a sine wave like a standard AC motor. The average service technician is familiar working with AC and DC electric motors, so a stepper motor should not present any difficulties once he is familiar with the correct service techniques.

The 'Brains' of the Operation

As refrigeration technology has advanced, so has the ability of electronic controls to connect critical components such as compressors, motors, valves and sensors. One controller, for example, provides effective and seamless integration of refrigeration components and hvac equipment within the supermarket, as well as integration with other building control systems, such as lighting and security.

The location of case controls and expansion valves at the case level, not at the rack, puts most potential service challenges within reach. Some control systems integrate compressor electronics, electronic valves and flow controls, and online equipment monitoring. The result is an "intelligent" store environment where all components, systems and building controls are connected, managed and monitored from a centralized location.

As the central operating system gathers performance information vital to store operations, stores can collect and analyze information across the entire store chain. The predictive maintenance inherent in the system permits more cost-effective technical oversight, reduces downtime and, ultimately, helps assure food safety.

The distributed refrigeration architecture delivers significant benefits over contemporary rack refrigeration, both in first costs and daily operating and maintenance costs. Use of highly efficient scroll compressors reduces the total energy consumption on a storewide basis by 5 percent to 10 percent.

The combination of first-cost savings, annual energy and maintenance savings, and flexibility in deployment offer enterprise managers new options in store design and marketing. In addition to lower installation costs, store owners can expect quicker startup and commissioning, leading to faster store openings and a quicker start of cash flow. ❖