FRESH ADVANCES IN THE DRIVE FOR SUSTAINABILITY

SUBSTANTIAL GAINS IN THE SUSTAINABILITY, OPERATING ECONOMY AND RELIABILITY OF COOLING AND REFRIGERATION SYSTEMS CAN BE ACHIEVED SIMPLY BY APPLYING VARIABLE SPEED DRIVES (VSDS) TO ELECTRIC MOTORS.

Brith Isaksson, Global Segment Manager Food and Beverage at ABB Motion, explains the huge untapped potential for improvements in this sector.

The industry's number one priority, of course, is food safety. This requires assurance that the right temperature is maintained, uninterrupted, at every stage in the value chain from farm to fork. Through their precise regulation of motor speeds, combined with enhanced control, VSDs both enable accurate temperature control and reduce the risk of equipment failure.

Electric motors account for around 30% of global electricity consumption, and a large proportion of this is taken by energy-intensive refrigeration and cooling set-ups. The more electricity that is consumed, the more CO_2 is emitted – further fueling climate change which will make cold storage even more challenging. VSDs hold the key to saving energy and reducing emissions. That makes them a key element in meeting the sustainability aims which are high on the food industry's agenda.

Spoilage of food, due to inadequate or failing refrigeration, has another serious impact on the environment in terms of wasting the energy and other resources which went into producing it. About 30 to 40% of food is wasted somewhere in the supply chain. As the world's population is expected to rise from 7.3 to 9.7 billion by 2050, with an anticipated 50% increase in food demand, wasteful production processes and energy usage cannot be tolerated. VSDs help by improving system reliability.

A further consideration is the energy and raw materials expended in constructing and maintaining refrigeration systems. VSDs help extend equipment life and reduce maintenance needs.

These are all attractive benefits to any responsible business, and as well as helping people and the planet they make excellent economic sense. Saving money on energy, while reducing ongoing equipment-related costs and product losses, will boost profits and long-term viability.

The scope for savings and improvements by applying VSDs and highly efficient motors is enormous, given the scale and diversity of cooling and refrigeration systems in operation today. Each system consists of several key elements, often installed in multiple installations, with each part depending on motor-driven functions. In particular, these elements include cooling compressors, pumps, evaporators and condensers. Yet a substantial proportion of the equipment currently installed don't benefit from the use of VSD.

What VSDs Do in Cooling and Refrigeration

Put simply, VSDs constantly adjust the speed of the motor, and hence the performance of the equipment driven by it, to match varying needs. Take, for example, a cooling fan in a refrigeration system's evaporator. Without a VSD, the fan will run constantly at full speed, even when that is unnecessary. It will deliver the same amount of cooling power, regardless of hourly, daily and seasonal variations in external temperature, product volume and other factors influencing cooling demand. This is a waste of energy.

Some non-VSD set-ups do have mechanical methods of varying speed, but these are relatively inefficient, energy-wise, and do not allow the refined, accurate load matching which a VSD's electronics and software make possible. Importantly, even a small reduction in motor speed can make a significant saving in energy consumption. Broadly speaking, adding a VSD to a motor-driven fan, pump or compressor can cut its energy use up to 25%.

Additional VSD benefits relate to slowing down overall average speeds and replacing shock-inducing stop-start motion with smooth acceleration and deceleration. This lowers heat generation and mechanical stress in bearings and other components of motors, fans, pumps and associated machinery. The result is longer life, lower maintenance needs and less risk of breakdown. This is accompanied by lower noise and vibration, which makes for more pleasant working conditions.

VSDs Throughout the Value Chain

Most food and beverage products or ingredients need to be cooled or refrigerated at some time as they go through the stages between farm and fork. The farm stage is this sector's biggest energy consumer, and a portion of that relates to refrigeration in large, on-site cold storage facilities. The usual types of produce range from fruit and vegetables, to milk and other dairy foods, to meat and products from aquaculture, each with different needs.

The next stage requiring large-scale refrigeration is the food and drink

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processing and packaging plants. In some cases, cooling may use up to 60% of a plant's energy budget. Then there are large central storage, distribution and logistics centers, where appropriate temperatures must be maintained before shipping of products to supermarkets and other outlets. Some of the facilities in this value chain are equipped with many motors, all with the potential for VSDs to make improvements.

VSDs Throughout the Cooling and Refrigeration System

Cooling compressors, evaporators and condensers all rely on pumps and/or fans, and with VSD control their speed and energy consumption can be reduced. In compressors, the relationship between motor speed and energy consumed is linear. In fans and pumps, the savings are greater as energy consumption varies according to the cube of the speed. Hence a small speed reduction gives a much larger saving in energy.

These gains are multiplied when the number of compressors, pumps, evaporators and condensers in a system is considered. It is common to install several units of each device, to enlarge the capacity of the system, to allow for variation in needs through the year, and to provide redundancy in case of component breakdowns.

Cooling Compressors

For food and beverage applications, screw compressors are most popular, followed by reciprocating compressors. Ammonia is the most common refrigerant. Cooling capacity can be varied by stopping and starting individual compressors to change the number in action. In addition, screw compressors have slide valve control and reciprocating compressors have switchable capacity control valves. In either case, reducing cooling capacity does not achieve a proportional decrease in energy consumption. With a VSD, the slide valves or switches can usually be left open, and cooling capacity is instead adjusted by varying motor speed. Typical energy savings are between 15 and 25%.

Reciprocating compressors are especially good candidates for upgrading with ABB synchronous reluctance (SynRM) motor and VSD packages. Advanced SynRM technology, with energy ratings that meet the future-proof IE5 level, use less electricity and run at lower temperatures which reduce wear, maintenance and failure risk in bearings and windings. While a VSD on its own can improve the efficiency of any motor, the greatest savings are possible with a SynRM and VSD package.

Pumps

In a system using water or glycol refrigerants, flow rate determines the

amount of cooling achieved. The rate is often pre-set during commissioning, using a throttling control valve, to meet the system's maximum need, but at other times this will be faster than required. Excessive flow, together with the throttling mechanism's energy-draining resistance effect, creates inefficiency. With a VSD, the control valve is left fully open and motor speed adjustment matches the flow with varying needs. A speed reduction of just 5% will cut energy consumption by around 15%, while a 20% speed reduction will save about 50%.

Evaporators

In conventional systems, a compressor operates at full speed and the evaporator varies the cooling effect through stopping and starting of its fans. VSDs meet variations in cooling demand by altering the fan speed instead. In some cases this can save as much as 80% of the energy consumed.

Condensers

Condensers conventionally use on-off switching to respond to changes in cooling demand, and some may offer two-speed operation. However, they cannot match performance with need as precisely and efficiently as a VSD. Applied to condenser fans, VSDs can improve overall system efficiency by up 15%.

How VSDs from ABB Motion Drive Sustainability

As a global manufacturer and supplier with a deep understanding of motors and drives, ABB can provide the equipment and support to take full advantage of the potential of VSDs. ABB works with OEMs, system integrators and others involved in the development, specification and use of refrigeration systems. VSDs are easy to incorporate into new systems and to retrofit into existing installations, whether as an add-on to the motors present or as a complete VSD and motor package.

A wide variety of VSDs can be selected from the ABB ACS580 general purpose drives and ACS880 industrial drives portfolio to meet different cooling and refrigeration needs. ABB's product developments continue at a rapid pace, with new software introductions bringing advances in, for example, the multi-compressor control and rapid parameter setting in the ACS580 VSD.

Businesses which can attest to the benefits of VSDs include the Swiss-based Coop grocery chain, which uses them in the logistics center for the country's largest bakery. Its four ultra-modern, ammonia-based refrigeration systems provide a total cooling power of 8 MW – the same as about 40,000 domestic refrigerators. The system's cooling compressors are driven by ABB IE4-rated motors with VSDs. These contribute to an overall annual saving of 10,000 tons of CO_2 – roughly equivalent to taking 2,000 cars off the road.

A UK duck meat processing company retrofitted ABB VSDs to the condenser fans of its refrigeration plant – cutting its energy consumption by more than a third. By reducing the need for on-off cycling, it saved a further 10% on compressor energy consumption.

At a Campbell's food plant in Australia, replacement of a single refrigeration compressor motor with an ABB SynRM IE5 motor and VSD package reduced energy costs by 14%. That equated to savings of over 10,000 U.S. dollars and about 131 tonnes of CO_2 annually.

The sustainability contributions and cost savings arising from these cases are impressive, and it should also be stressed that VSDs also enhance the food-safe reliability of each system. However, this is just the start. Considering the vast number and variety of food and beverage refrigeration applications, the various stages in each farm-to-fork value chain, and the multiple motorized functions in each system, the opportunity remaining for further savings is still massive.

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