The use of AC drives to start and control induction motors was a significant milestone for the appliance industry. *Source: Hobart Corp.*

DRIVING LONGEVITY

The Impact of Drives on the Lifespan of Appliances.

by david schrader

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Countless articles have been published for appliance owners offering tips on extending the lifespan of appliances, and extended warranties are snatched up in droves in an effort to protect against unforeseen failures. Whether the appliance is being used for household or commercial use, the goal is the same: Make the equipment last as long as possible, and keep repairs to a minimum. Particularly when dealing with commercial products, total cost of ownership is a major factor to consider when evaluating appliances. Conversely, on the manufacturing side of the equation, equipment manufacturers are faced with the challenge of producing appliances riddled with the latest technology and reliable components at competitive prices.

The induction motor is one of the most common electromechanical energy conversion devices used in appliances today. Starting and controlling induction motors is critical to appliance operation and longevity. AC drives, one of the innovative components now being integrated into commercial appliances, can and should be a major consideration when product functionality, quality and longevity are the goals. In these applications, AC drives provide the right speed for the job to maximize optimization of the production process. Their ability to easily make and control process changes in speed, torque or power helps to increase both productivity and profitability. AC drives introduce the capability of process automation through local recipes or remote process control. Batch uniformity and repeatability can be significantly improved through the use of AC drives, and users also benefit from the ability to send or communicate information about the products produced to data bases. Data logs can track items such as consumption of raw materials, power used, and time of production. This valuable data proves extremely useful during efforts to control costs and quality, as well as offering insight on predictive maintenance for the machine.

When induction motors are connected directly across electrical distribution systems, large voltage disturbances are created. These voltage disturbances are created by the large initial current required at standstill, called "locked rotor current." For most induction motors this initial current will be from 600% to 800% of the motor's running amperes. Therefore, electrical distribution systems must be sized accordingly to support the starting currents of induction motors or the result will be continuing nuisance trips of circuit protective devices such as circuit breakers or fuses. In addition, the voltage disturbances may negatively affect other electrical devices connected to the electrical distribution system, including mis-operation and, in some cases, failure. The impacts of "across the line starting" on the applied motor include:

Stress on Stator Windings

Very high starting currents put mechanical stress on the stator windings. These stresses can contribute to winding fatigue and ultimately stator insulation failures.

Elevated Temperature of Windings

The high current through the stator quickly raises the temperature of the windings. The elevation of temperature at each acceleration of the motor reduces the life of the motor windings insulation. Particularly when large inertia loads are being driven, longer acceleration times generate even more heat in the stator. Repeated starts under these conditions can cause irreparable damage to the windings. For this reason, induction motors are designed with an allowable limit on the number of across the line starts per hour. The deteriorations of electrical insulation is estimated to double for every 10°C in excess temperature. Excessive temperature also causes separation of greases and breakdown of oils to cause bearing failure, the primary failure mode of induction motors.

AC drives provide the ability to start at zero frequency and voltage, which significantly reduces the impact on both the electrical distribution system as well as the motor. By controlling the application of voltage and frequency, locked rotor currents can be eliminated.

As equipment suppliers broaden the geographies they serve, supply voltages become a concern. Induction motors are designed to a specific volt/hertz ratio. For example, in 230 Vac 60 Hz machines this is 3.83 V/Hz, in 380 Vac 50 Hz machines this is 6.33 V/Hz, and in 460 Vac 60 Hz machines this is 7.6 V/Hz. The mechanical power the motor is able to produce is based on the V/Hz ratio as well as a design current. In cases where the V/Hz ratio is maintained and low voltage conditions exist, the motor must draw higher currents in order to produce the needed mechanical torque. If the V/Hz ratio is not maintained the motor torque will be reduced as a function of (V/Hz) 2. Most of us are familiar with this phenomenon, which is often referred to as a "brown out"; in both cases, excess heat is generated and can damage or destroy the motor.

One common misconception about voltage is the assumption that, if too little voltage is a problem, then increasing the voltage must be good for the motor, right? Wrong. High voltage on a motor causes motor "saturation," which causes the motor to draw excessive current in an effort to magnetize the iron beyond the point where magnetizing is practical. Voltages above the design V/Hz ratio will impact the amperage, leading to an increase in motor heating and reduced motor life. Such sensitivity to voltage is not unique to motors. In fact, voltage variations affect other magnetic devices in similar ways. The solenoids and coils found in relays and starters are impacted in a similar fashion when exposed to low or high voltages. AC drives, by virtue of their power architecture, can operate over wide ranges of voltages – 200 – 230 Vac plus or minus 10% and 380 -460 Vac plus or minus 10% while providing the design V/Hz ratio to the applied motor.

The impact of across the line starting of induction motors on the driven mechanical system is also a key consideration. This reason for applying reduced voltage has multiple names; it may be called mechanical shock, mechanical stress, or various other names. The effect is the same: When a motor is started at full voltage, the torque being applied from the motor to the driven load rises to a very high value almost immediately. This can cause damage to the bearings in the motor or the load, the rotor of the motor, or to the mechanical coupling method which connects the motor to the load. The load itself can sustain damage depending on what the application may be. In the case of conveyor application, if the load is started too quickly, the belts of the conveyor can be stretched or broken. Sudden changes in force, as in across the line motor starting where the motor is connected to the load via chains or belts, can cause the coupling means to be damaged as well as mechanical stress to gear boxes or belt drive systems. This may create pressure surges or water hammer in pumping applications. Structural damage to welds, rivets, bolts and keys can also be caused by instantaneous changes in speed and or direction. This effectively reduces machine life, which in turn increases the total cost of ownership over the product's lifetime.

The use of AC drives to start and control induction motors was a significant milestone for the appliance industry, and the innovation has been instrumental in optimizing performance and extending the lifespan of the commercial equipment. End-users benefit from the increase in productivity, and reducing the total cost of ownership of the appliance results in greater profitability. Or, in other terms, less money in a repairman's wallet, and who doesn't like that? ■

This commercial mixer uses AC Drive technology for optimal control and efficiency. *Source: Hobart Corp.*