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Corralling THE workhorses

Take the necessary steps to improve motor efficiency in aggregates plant facilities.

BY BRIAN RICHESSON

Adopting energy-efficient technologies offers the opportunity to cut costs, improve productivity and competitiveness while improving the environment and reducing emissions that cause climate change.

Improving motor efficiency on equipment in aggregates plant facilities can provide a significant amount of energy savings to help meet the industry's energy-reduction goals. Energy-efficient technologies for electric motors are a practical solution for variable load equipment such as crushers and conveyors.

Before implementing energy-efficient technologies for electric motors, it is important to understand electric-motor efficiency in order to find the best possible and most appropriate solutions for certain equipment.

Power losses

There are essentially five contributors to power losses in an AC induction motor: friction loss, windage loss, sound loss, copper loss and iron loss. The first three – friction, windage and sound – are mechanical losses, are fairly constant and generally represent a small fraction of the total wasted or lost power.

The copper loss is basically the energy lost to heat in the windings and is a function of the load. The iron loss is the energy lost due to eddy currents and hysteresis effects in the magnetic iron cores of the stator and rotor, and is a function of the voltage at the motor terminals – it is independent of the load. A motor is operating most efficiently when the iron loss and the copper loss are equal, which occurs when the motor is driving 75 percent to 90 percent of the full rated load. As the load increases, the copper loss dominates. When the load is low, the iron loss dominates, representing most of the energy loss.

Playing the role

Electric motors play such a significant role in our energy problems. They are the true workhorses of our industrial and commercial facilities, consuming roughly a quarter of all electricity produced in the United States and more than 60 percent of all electricity used in industrial facilities. America's most energy-intensive sector is the manufacturing sector. A recent U.S. Department of Energy (DOE) study determined that 44 percent of industrial motors operate consistently at less than 40 percent of full load.

The key to saving energy on electric-motor operations is to implement energy-management practices or apply energy-efficient technologies.

Benefits of saving energy

- **Cutting electricity costs:** In 2005, the nation's energy bill totaled $296 billion. According to DOE, a typical industrial facility can realize savings as much as 18 percent in motor systems. Investing in energy-efficient technologies will help bring electricity costs down and will reduce the number of new power plants needed. Companies affected by rising electricity costs would see an increase in their bottom line as energy efficiency improves.
- **Receiving utility rebates:** Many utilities offer rebates to customers on energy-efficient technologies and equipment installed in their facilities. Utility rebate and incentive programs are designed to facilitate the implementation of energy-efficiency improvements. This encourages electricity customers to use energy-saving technologies to cut energy usage, which will help lower the demand for electricity and will also reduce the number of new power plants needed.
- **Reducing carbon emissions:** With increasing concern about greenhouse gases and climate change, we need to take responsibility and realize that carbon dioxide emissions are polluting the environment and causing the effects of global warming. When we use less energy, the result is less pollution. Reducing carbon emissions through the use of energy-efficient technologies can make a substantial impact on our environmental challenges.

What can we glean from all of this? First, there

Take note

The efficiency of a motor is simply the ratio of the power out (useful work performed) to the power in (electrical power delivered to the motor terminals).

are quite a few motors in the field that are operating well below optimum efficiency, wasting a considerable amount of energy in the process. Second, there are a number of valid reasons for reducing the amount of energy consumption, and reducing wasted energy is basically the "low-hanging fruit."

Motor efficiency

As we have shown above, the efficiency of a motor is simply the ratio of the power out (useful work performed) to the power in (electrical power delivered to the motor terminals). Thus, the only ways to increase the efficiency of a motor are to reduce the losses or to use more of the input power to do useful work.

While it is certainly possible to reduce the mechanical losses in a motor (better lubricants and bearing systems, streamlined motor designs to reduce windage, reduction of vibration noise), since these losses represent only a tiny fraction of the total losses, it is difficult to cost-effectively do so. These are, however, some of the techniques used to produce NEMA premium efficiency motors (which helps explain the usually significant cost difference between premium and standard efficiency motors).

Reducing the copper losses (also known as I2R losses, as the power lost to heat is proportional to the resistance of the conductor as well as the square of the current) can be achieved by using larger conductors (quite expensive with the price of copper today) or reducing the current by switching to a higher mains voltage. This is usually not feasible since the main voltage level is primarily fixed by the location.

Reducing the iron core losses is accomplished by use of different materials and construction techniques. The magnitude of the eddy currents is significantly reduced by use of a core that is made up of many thin layers laminated together rather than a single monolithic core. Hysteresis effects are reduced by choice of laminate material.

Taken together, all of these measures will certainly reduce the losses significantly. Whether they are cost-effective is a different story.

Energy-efficient technologies for electric motors are a practical solution for variable load equipment such as crushers and conveyors.

However, as noted above, efficiency can also be improved by ensuring that more of the input power is used to do real work. We also noted above that a motor operates most efficiently when the load on the motor is 75 percent to 90 percent of the rated load for the motor. There are a number of ways to accomplish this.

The power switch: There is no better way to conserve energy than to simply shut off an idling motor. However, this is not always an option.

Right-sizing the motor: If the driven load is fairly constant, one can simply install a motor that is matched to that load. In fact, the DOE recommends replacing oversized motors with smaller motors sized for the load. However, there are many cases where this is not possible, because the motor is sized to accommodate a much larger peak load, however infrequently that load occurs. Jaw crushers are a perfect example of this – the motor is sized to accommodate the maximum throughput, which does not occur 100 percent of the time.

Variable frequency drives (VFDs): In certain applications, particularly those in which it is desirable to change the speed of the motor, VFDs can save energy. VFDs are commonly used in industry around the world where speed control is essential to the process and energy savings is secondary, but in applications where the motor can run at slower speeds, significant energy savings can be realized.

There are, however, some drawbacks to VFDs. They generally require more expensive, inverter-duty rated motors (or additional equipment) to ensure that the motor can operate properly and safely at reduced speeds. The standard NEMA Design B motors that are most common are not designed to operate at anything other than the standard supply frequencies of 50 or 60 hertz, and extended operation at lower speeds can cause the motors to overheat fairly rapidly.

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