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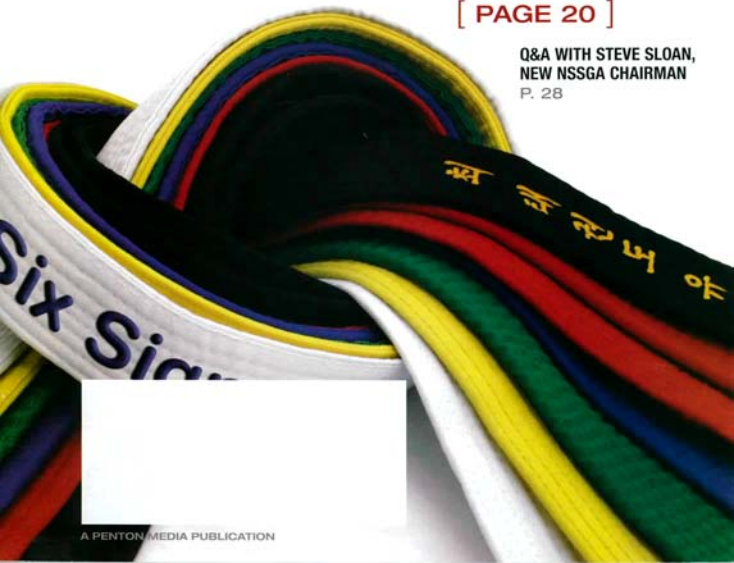
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Improving MOTOR EFFICIENCY

BY CHRISTINE TOLEDO

Mining is an energy-intensive industry that drives massive production, consuming an abundance of electricity. In 1997, according to the Department of Energy, the mining industry spent \$2 billion on electricity. In 2002, the mining industry spent \$3.2 billion on energy, or 21% of its total supplies, according to the U.S. Department of Commerce. Adopting energy-efficient technologies offers the opportunity to cut costs and improve productivity, while reducing emissions that cause climate change.

Improving motor efficiency on mining equipment 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 grinders.

Before implementing energy-efficient motor technologies, it is important to understand the principles of electric motor efficiency in order to determine the best solutions for certain types of equipment.

WHAT MAKES A MOTOR INEFFICIENT?

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; they are fairly constant, and generally represent a small fraction of the total wasted or lost power.

Copper loss is basically the energy lost to heat in the windings and is a function of the load. 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 operates most efficiently when the iron loss and the copper loss are equal, which occurs when the motor is driving ~75% to 90% of the full rated load. As the load increases, copper loss dominates. When the load is very low, iron loss dominates, which represents most of the energy loss.

Electric motors play a significant role in energy problems. They are the true workhorses of industrial and commercial facilities, consuming roughly a quarter of all electricity produced in the United States and more than 60% of all electricity used in industrial facilities. The nation's most energy-intensive sector is the manufacturing sector. A recent U.S. Department of Energy study determined that 44% of industrial motors

UNDERSTANDING ELECTRIC MOTORS IS THE KEY TO CUTTING ENERGY COSTS

operate consistently at less than 40% of full load.

The key to saving energy on electric motors is to implement energy management practices or apply energy-efficient technologies. "...the cheapest and most available source of new energy is the energy we waste. That's why the DOE is always looking for ways to promote energy savings," says Samuel Bodman, Energy Secretary at the U.S. Department of Energy.

WHAT ARE THE BENEFITS OF SAVING ENERGY?

● Cut Electrical Costs

In 2005, the nation's energy bill totaled \$296 billion. According to the U.S. Department of Energy, a typical industrial facility can realize savings of 18% in motor systems by reducing electrical costs.

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.

● Receive 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-efficient improvements. This encourages electricity customers to use energy-saving technologies to cut usage, which helps lower the demand for electricity and reduces the number of new power plants needed.

● Reduce Carbon Emissions

With increasing concern about greenhouse gases and climate change, we need to take responsibility and realize that carbon dioxide emissions are polluting our environment and causing global warming. When we use less

energy, the result is less pollution. Reducing carbon emissions through the use of energy-efficient technologies can have a substantial impact on our environmental challenges.

INCREASING THE EFFICIENCY OF A MOTOR

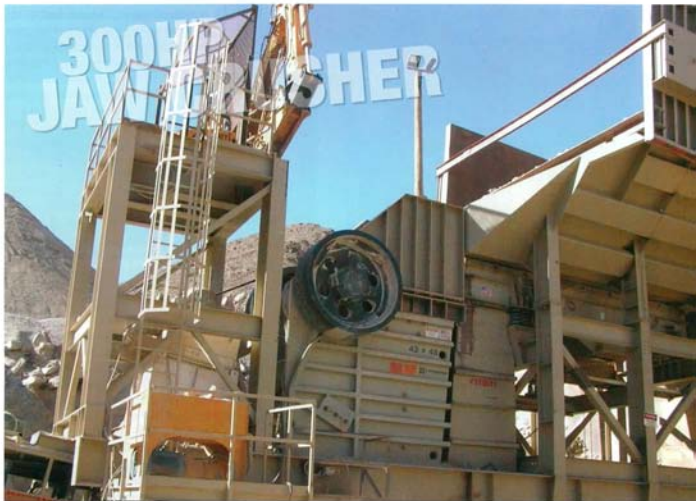
What can we glean from the above? First, quite a few motors out in the field are operating well below optimum efficiency, wasting a considerable amount of energy in the process. Second, there are a number of valid reasons for reducing the amount of energy consumption, and reducing wasted energy is basically the "low-hanging fruit".

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 termi-

nals). Thus, the only way to increase the efficiency of a motor is to reduce the losses or use more of the input power to do useful work.

There are a number of ways, including both changes in materials and design measures, to reduce mechanical losses in a motor. Reducing copper losses can be achieved by using larger conductors (quite expensive) or by switching to a higher mains voltage. This usually is not feasible since the voltage level is primarily fixed by the location. Reducing iron core losses is accomplished by using different materials and construction techniques. Taken together, all these measures will reduce energy loss. Whether they are cost effective is open to debate.

However, as noted above, efficiency can be improved by ensuring that



more input power is used to do real work. Again, a motor operates most efficiently when the load is ~75% to 90% of its rated load. 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 U.S. Department of Energy recommends replacing oversized motors with smaller motors sized for the load. However, in many

cases, 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% of the time.

Variable Frequency Drives: In certain applications, particularly when it is desirable to change motor speed, VFDs can save energy. They are commonly used where speed control is essential to the process and energy savings is secondary; however, in applications where the motor can run at slower speeds, significant energy savings can be realized.

VFDs do have some drawbacks. 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 Hz; in addition, extended operation at lower speeds can cause the motors to overheat fairly rapidly.

Many of the least expensive VFDs may require additional filtering (the reason they are inexpensive). In addition, changing the speed of a process may require additional hardware and software and a more complex control algorithm in order to ensure the system will run safely.

Reduced Voltage Motor Controllers: Reduced voltage motor controllers constantly monitor the phase lag and reduce voltage at the motor terminals to compensate. By reducing voltage, they reduce the current, particularly the magnetizing current that contributes most to losses in a lightly loaded electric motor.

Motor efficiency controllers, a new version of this concept, match the horsepower of the motor to the load on a real-time basis, consuming only the energy required to run the motor most efficiently at any given moment, while still producing the required torque to run the load.

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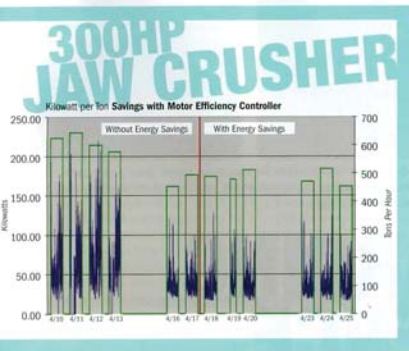
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CASE STUDY OF JAW CRUSHER USING A MOTOR CONTROLLER

In a recent case study, a motor efficiency controller was tested on a jaw crusher with a 300-hp motor in an aggregates plant. The average tons per hour from the total test period was 54.144 and operated on an average of 12.5 hours each day. The motor efficiency controller showed a 25.41% average savings. Calculations based on test data showed that the motor efficiency controller would save \$1.38 per hour (or \$0.00255 per ton). Hypothetically, if the plant were to run 15 hours per day, five days per week, it would average an annual savings of \$5,390.71 and eliminate 40 tons of CO₂ from being released into the atmosphere.

Christine Toledo is marketing communications manager for Power Efficiency Corp., Las Vegas. The company has developed a technology platform, called E-Save Technology, which is designed to improve the efficiency of electric motors. For more information, contact her at ctoledo@powerefficiency.com; www.powerefficiency.com.

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