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Motor and Drive Efficiency – A Collective Approach for Better Results

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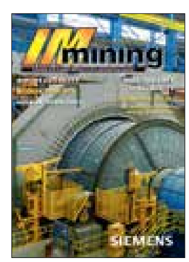


Bauer® Gear Motor
An Altra Industrial Motion Company

Motor and Drive Efficiency – A Collective Approach for Better Results

Efficiency, reliability and total cost of ownership are all terms that are at the forefront of engineering considerations, however looking at items of equipment on an individual basis may not deliver the maximum benefits. By looking at the wider picture and combining the best technology from individual areas it is possible to achieve much more significant savings and efficiencies.

Markus Kutny, Product Manager, Energy Efficiency Solutions at Bauer Gear Motor, explains: "In recent years the majority of emphasis has been on the improvements which have been made in electric motor efficiency, in part due to the changing regulations which have focussed manufacturers and customers alike. However, in terms of overall efficiency within drive systems which are powered by electric motors, the mechanical system also needs to be considered as it possesses a very significant potential for optimisation."

In between the electric motor and the final process there is usually a series of mechanical drives, gears, couplings and bearings which transmit the mechanical power supplied by the motor. By examining each component within this mechanical section and optimising the design, further efficiencies and savings can be made.

Improved Motor Efficiency

It is well known that electrical motors use 65% of the energy used in industry, but a lesser known fact is that 96% of the lifetime costs of an electric motor is associated with the energy consumption. This shows the importance of the overall efficiency compared to the initial purchase cost in the terms of importance of the total cost of ownership (TCO).

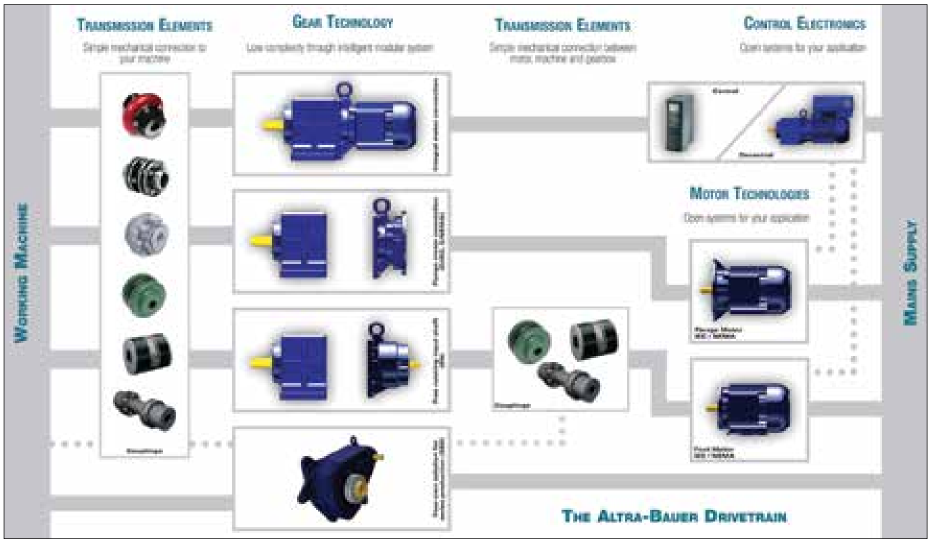
PMSM (permanent magnet synchronous motors) already fulfil the requirements of the soon-to-be-implemented IE4 (Super Premium Efficiency) classification. This is evidenced by their potential to achieve energy savings of up to 40% compared to an IE2 inverter-driven squirrel cage motor.

PMSM synchronous motors offer considerably improved efficiency when compared to induction motors even under partial load conditions; and extremely high efficiency under rated operating conditions. They also have considerably higher power density, which, for geared motors, yields higher system efficiency with minimal installation volume.

The synchronous design of the PMSM motors means that not only are they superior at converting electrical energy into mechanical power, but also offer the added benefit of maintaining constant speed independent of the load. This means that motor speed does not vary, despite overload variations, or cases of voltage drop, as long as the mains frequency is kept constant.

This design offers a number of key benefits. It reduces heat losses from the rotor by 100%, total losses by approximately 25%, and increases total efficiency by 10% or more. For the PMSM user, this improved performance translates into lower total cost of ownership, a reduction in CO_2 emissions, and ongoing savings that buffer against future increases in energy costs.

The low operating and maintenance costs of the PMSM motors



mean that they provide the optimum energy saving drive for use on fans, pumps and compressors; and for constant torque applications such as elevators and conveyors.

From January 2015 onward, energy efficiency class IE3 (Premium Efficiency) will be the standard for motors with rated power of 7.5 to 375 kW, and from January 2017 onward for motors with rated power of 0.75 to 375 kW. Motors controlled by frequency converters are exempt from this regulation. For such motors, IE2 is sufficient.

Proving the Point of PMSM

The improved performance of a PMSM translates into a lower total cost of ownership, a reduction in CO2 emissions and ongoing savings that help to protect against future increases in energy costs. This improved technology and efficiency translates into a higher initial purchase cost which is later recovered during the operation life of the PMSM. In order to provide supporting evidence of this, Bauer Gear Motor agreed to participate in a direct comparison where an inverter driven Asynchronous Motor (ASM) and a permanent magnet motor were set up to perform identical tasks. The comparison was conducted on an operational waste water treatment plant in Germany with both motors powering a disc thickener for seven hours every day.

The same frequency inverter, which was programmed to monitor the loads on each motor, was used to ensure that they ran at optimum efficiency. To be certain that any differences in efficiency could only be attributed to the motors, each drive system used the same gearbox. Having completed the exact same task, the results are shown in the table below:

	Torque (Nm)	Speed (RPM)	% Efficiency (kW/hr)	Energy Consumption	4-Year Consumption (kWMM)
ASM	2.62	1,350	61.5	0.26	2,657
PMSM	3.50	1,500	87.7	0.16	1,635

The trial demonstrated that the PMSM delivered a 40% saving in energy consumption against the ASM, which, when projected over a 4 year period, would have saved 1,022 kW. As the price of energy continues to rise, so the value of this saving will increase also.

Drivetrain Design

The design of modern drivetrains requires specialist knowledge and expertise in order to produce a product which will not only meet the specifications but also deliver efficiency, smoothness and low noise qualities as well as excellent reliability. However, further benefits of a good design can be gained by ensuring the drivetrain is properly integrated into the application, which requires an in-depth understanding of the given industry.

Less efficient designs such as worm geared motors can be replaced with integral helical bevel geared motors, which are much more efficient and provide a longer service life. This approach removes the need for a coupling and bearing thereby providing near perfect transmission efficiency.

In some cases it can be beneficial to streamline this process and specify a bespoke solution, which can be built from existing components but integrated seamlessly into the machine and thereby delivering the best possible solution. By involving designers at the outset of a project, greater efficiencies can be gained, both in terms of cost and energy.

Drive Couplings

Forming a crucial link between the electric motor and driveshaft, the coupling can have a significant influence on the performance of the equipment. Depending on the application, maintenance requirements and torque specification, the design of the coupling should be carefully scrutinised to ensure reliable performance as well as ease of maintenance. Specifying a coupling incorrectly can lead to inefficient power transmission as well as increased maintenance costs.

Couplings are designed to accommodate shaft misalignment, which may be present when one of the connected shafts is located by a self-aligning bearing, or when an unsupported, intermediate shaft is placed between the driver and the load. Couplings capable of overcoming true angular misalignment include the single universal joint with its capacity to handle large offsets and torsional damping.

If both shafts are assembled in self-aligning bearings then zero misalignment can be achieved, allowing the use of a solid coupling which simply supports the shaft in perfect alignment. Before installing a solid coupling, an interesting test is to try a flexible coupling first. With the machine at normal operating temperature, measure the speed and/or the current drawn by the motor. The difference between these readings and those with the solid coupling indicate the losses generated by the flexible coupling. This demonstrates the extra savings that can be made by spending some additional time attaining proper shaft alignment.

The basic construction of flexible couplings consists of two flanges or hubs, which attach to the shafts being coupled and a connecting element that may be metallic, such as in disc couplings; it may also be a sleeve made from elastomeric material, such as EPDM rubber, neoprene, Hytrel or urethane, or it may be mechanical as in a u-joint or gear coupling.

A Joint Approach

Looking at each of the aspects discussed provides an insight into the potential energy savings that can be made in the individual aspects of drivetrain design. Combining these efficiencies into one application can yield impressive results, which can be further enhanced when the overall design is undertaken by a single, specialist manufacturer. In this way, each of the components is matched and designed to operate with the others, while also providing a single point of contact for any training or maintenance issues.

Examining the mechanical efficiencies, and making significant improvements in this one area, can result in a reduction in overall power requirement from the electric motor. By installing a smaller motor, which is connected to a more efficient mechanical drive, the overall effect is to reduce energy consumption and improve reliability by using matched components.

When specifying drive systems for applications with tough environments it is important to speak to a solutions provider with the experience to understand the implications of each individual scenario. Bauer Gear Motor employs engineers with many years experience in designing bespoke power transmission systems across many industries. With experience they have learned that it is important to study the history of their field of expertise in order to continue its development.

Ultimately, Bauer Gear Motors offers a high quality, well-engineered and above all reliable and efficient solution, with responsive engineering capabilities, prototyping and delivery times as well as an extensive global sales and service network which provides local contacts and support wherever in the world the final application is located.

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