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Comparing the Performance of Asynchronous and Permanent Magnet Motors

Bauer Gear Motor®
Altra Industrial Motion

Comparing the Performance of Asynchronous and Permanent Magnet Motors

A great deal has been written about the benefits of using IE3 motors and the efficiency savings that can be made when compared to a similar IE2 motor. However, having decided to implement the benefits of an IE3 electric motor, it is also important to ensure that the design of the motor is properly suited to the application in order to maximize the benefits.

Making the correct specification is a relatively simple task for constant speed applications, but applying these principles to a task that requires different speeds, directions and loads can be slightly more complex. Moreover, making theoretical calculations is just the beginning; these need to be proven in a real life situation in order to have any credibility.

With this in mind, Bauer Gear Motor, which is part of the Altra Industrial Motion Corporation and one of the world's leading manufacturers of geared motor solutions, arranged to demonstrate the advantages of a permanent magnet synchronous motor (PMSM) in a genuine industrial application.

The treatment of wastewater is a true 24/7 operation and most of the processes require electric motors to power them. Operating around the clock means that any energy-saving project will deliver results and payback of the initial investment quickly. It also means that the equipment has to be reliable in order to minimize downtime.

Part of the wastewater treatment process involves dewatering sludge so that the solid material can be efficiently transported away to create fertilizer, while the liquid is reprocessed at the plant. One piece of equipment that is utilized in this process uses a 2.2 kW motor to turn a conical Archimedes screw that squeezes the sludge and removes the liquid portion. It was here that Bauer installed its demo motor.

The initial setup of the sludge press involved a Danfoss frequency inverter which powered the motor and gearbox arrangement to turn the conical screw. The frequency inverter was programmed to monitor the loads on each motor to ensure they ran at optimal efficiency. To ensure that any differences in efficiency could be attributed to the motors, each drive used the same Bauer gearbox. The settings for speed and pressure were determined by the plant operator, which had defined the required moisture content of the solid material for transport.

The operation of a sludge press usually involves two processes – pressing and rinsing – and these make very different demands on the drive motor: For the pressing operation, which makes up the majority of the process, the motor runs at a lower speed, between 10-20 Hz on the frequency inverter. The load on the motor depends on the moisture content required by the plant operator, but as a guide it is approximately 70% of the nominal load. This can increase at start-up due to the inertia of the screw that must be overcome as well as the increased load from sludge that has dried out inside the press.

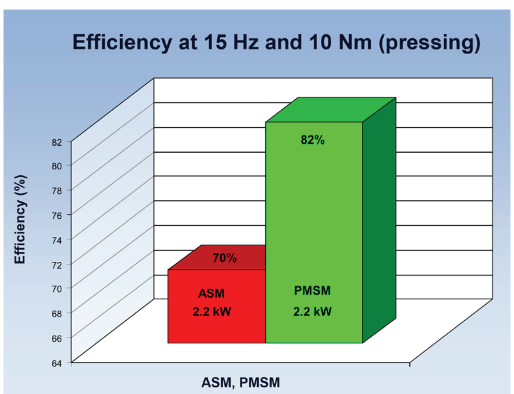

Figure 1: The efficiency comparison during the pressing process (ASM vs PMSM)

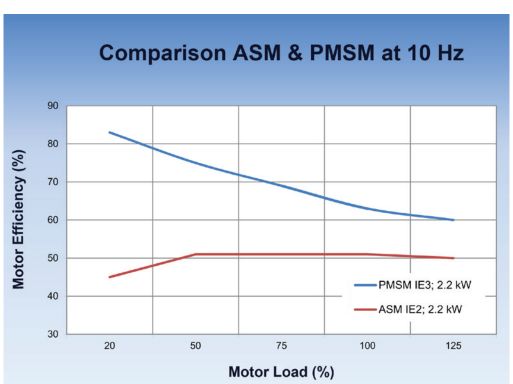

Figure 2: A comparison of motor efficiencies for low speed operation

After several cycles of sludge pressing, the screw and screen must be cleaned. This is achieved by reversing the direction of the drive motor and using spray bars to rinse the internal components. There is relatively little load – approximately 35 % of nominal – on the motor, but the speed is greatly increased to between 50 and 80 Hz.

In the first instance, the 2.2 kW, IE2, asynchronous motor (ASM) was installed on the sludge press and the frequency inverter was configured to record all of the speed, load and efficiency data, which could then be reproduced in graphical form for analysis.

Once a significant set of data had been collected, the ASM was removed and the 2.2 kW IE3 PMSM was installed and configured for the same operation on the sludge press. Once again the data was recorded and reproduced in graphical form for analysis.

The initial results showed that the PMSM offered considerably greater efficiency during the pressing cycle, which was set at 15 Hz motor speed and 10 Nm load, as represented in the graph, Figure 1.

The data also allowed a comparison to be made as the load on the motors was increased but the speed reduced to 10 Hz. This clearly showed an advantage for the PMSM where the operating efficiency was much greater, especially when under partial load, as shown in Figure 2.

For the rinsing cycle, again the ASM was at a disadvantage because of the partial loading, while the PMSM was able to deliver improved figures. The overall performance of each motor is best illustrated using a 3-dimensional graph that plots efficiency against load and speed. Figure 3 illustrates the ASM performance, and Figure 4 that of the PMSM.

The improvements in efficiency can then be translated into financial savings which have a significant impact on the total cost of ownership.

Markus Kutny, product specialist for Bauer Gear Motor's PMSM range, comments: "In today's market, energy efficiency has to be one of the key determining factors when specifying geared motor solutions. Energy prices are only going to go one way, so it's important that a drive's lifelong running costs are considered, rather than simply the cost of procurement. We have developed the new motor range in anticipation of the new IE4 classification and to offer our customers the very best in terms of efficiency.

"The wide speed setting range, as well as the high efficiency in the partial load range, makes the design task very simple for engineers since oversizing does not have any major impact on efficiency.

"In addition, PMSM technology can cut down the wide range of variants considerably as a PMSM motor can cover three to five ASM motors, resulting in reduced storage costs and a narrower variety of different motors."

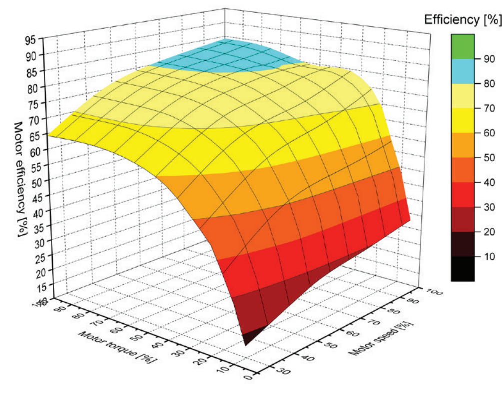

Figure 3: ASM IE2 (2.2kW) efficiency performance

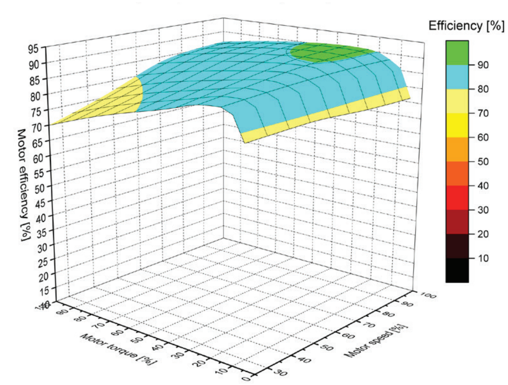

Figure 4: PMSM IE3 (2.2kW) efficiency performance

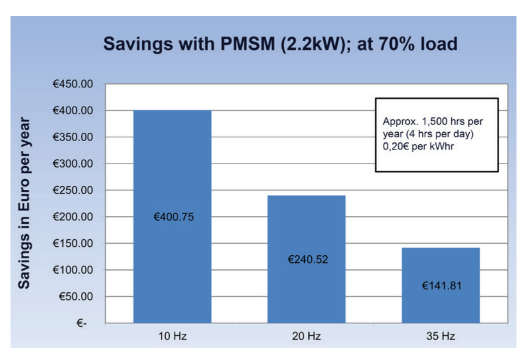

Figure 5: Savings of the PMSM vs ASM per year based on the pressing cycle

About Altra Industrial Motion

Altra is a leading global designer and manufacturer of quality power transmission and motion control products utilized on a wide variety of industrial drivetrain applications. Altra clutches and brakes, couplings, gearing and PT component product lines are marketed under the industries' most well known manufacturing brands. Each brand is committed to the guiding principles of operational excellence, continuous improvement and customer satisfaction. Highly engineered Altra solutions are sold in over 70 countries and utilized in a variety of major industrial markets, including food processing, material handling, packaging machinery, mining, energy, automotive, primary metals, turf and garden and many others.

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