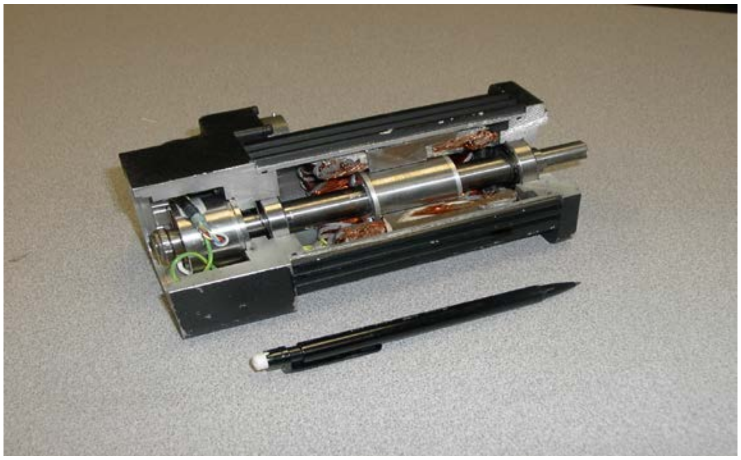

Kollmorgen B-104 PM Brushless Servomotor at 0.4 HP

Kollmorgen M-828 PM Brushless Rotor

Kollmorgen B-802 PM Brushless Servomotor at 15 HP

Kollmorgen B-808 PM Brushless Rotor

Permanent Magnet Servomotor and Induction Motor Considerations

KOLLMORGEN®

Because Motion Matters™

White Paper

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Motion long considered a mainstay of induction motors, encroachment in the area of 50 HP and greater have been seen recently for some applications by permanent magnet (PM) servomotors. These applications usually have dynamic considerations that require position-time closed loop and high accelerations. When accelerating large loads, permanent magnet servomotors can work with very high load to inertia ratios and still maintain performance requirements.

Having a lower inertia typically will allow for less energy wasted within the motor. Torque (τ), is the product of inertia (j) and rotary acceleration (α). If you require inertia matching, ½ of your energy is wasted accelerating the motor alone. If the inertia ratio from motor to load is large, then control schemes must be dynamic enough to prevent the larger load from driving the motor as opposed to the motor controlling the load. Tradeoffs and knowing what can be negotiated.

Permanent magnet servo and induction motors have long had performance areas that overlap but are not a replacement for one another. Advancements in drives and technology for the induction motors have given them dynamic performance that was once the mainstay of permanent magnet servo systems but this doesn't mean that the induction motor is a replacement for the servo; it just allows for more options.

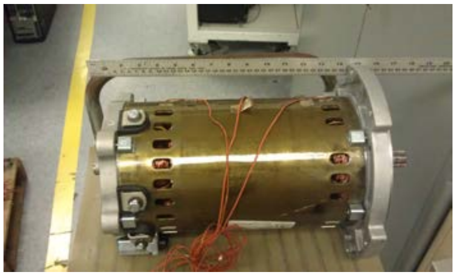
Kollmorgen Cartridge DDR® Motors combine the performance advantages of a frameless motor with the ease of installation of a full-frame motor. The largest motor shown is approximately 35 HP.

Although two motors may appear to be able to do the job related to torque, speed, and thermal considerations, choosing one technology over the other should be approached with intrinsic knowledge of each. A permanent magnet servomotor is a synchronous motor with feedback for commutation, velocity and position information. A vector driven induction motor will also require the same feedback control to compete in this performance arena but is powered completely by electro-magnetic, not permanent magnetic fields. More on that topic later.

With the current state of rare earth magnets, it may not be practical to have a permanent magnet servomotor in an application requiring greater than 20 or 30 horsepower unless specific needs like size must be addressed. In general, the constant flux source of a permanent magnet motor can result in a greater torque density than an equivalent induction system. If size matters, then perhaps a system should use one technology over another. Speaking of size, the inertia ratio can be an important figure of merit should dynamic needs arise. If you are going to have high accelerations and decelerations, the size of the rotor will significantly increase the inertia and decrease the useable torque. Applications involving glass manufacture use a combination of these technologies and choose four permanent magnet servos rated at 72 HP due to the high dynamic loading and higher performance requirements for their new application. The size of the equipment and the dynamic needs of this are challenging. The buried magnet rotor technology of Kollmorgen B-series motors offered a significantly lower inertia than any induction motor of similar ratings. With a lower inertia, dynamic performance can be superior to any other motor technology today.

When considering the technology, the induction motor generates a magnetic field by the winding and laminated armature just like a servomotor. The similarities stop there. While there is a constant state of magnetic flux in a permanent magnet motor supplied by the rare earth magnets, the generated magnetic field will pull on the generated magnetic field of the rotor that has the current induced (hence the term induction) on a secondary winding wrapped around rotor armature laminations. The importance of the word "pull" here has to be noted. There is an interesting but often overlooked phenomena that you can't push with an electro-magnet. Repulsion forces do not work that way. The attractive force between the two currents will work, but when you generate two like poles, they cancel like a mutual inductor rather than attract when using synchronous control. This is part of the reason that a synchronous induction motor will slightly lag the field rotations. While this makes the control scheme different, it's still useable. In order to make the magnetic field rotate around the armature and have the rotor synchronize, you have to change the magnetic fields or essentially collapse all of the energy stored quickly and this is done by this canceling current. It makes the controls a little more complicated but nothing for microprocessor and FPGA technology today.

When looking at the PM servomotor, advantages when working with highly dynamic loads are apparent. Rotor size is typically smaller than the similar power induction counterpart. That will affect the inertia component, lowering it due to the smaller diameter. Like the induction motor, you must change the magnetic fields around the motor to create rotation. The motor will be exactly synchronous to the field since both push and pull the constant flux from the magnet can be obtained. It will be less sensitive to the air gap of the rotor to armature as well. This is due to the magnets having a mu of air and as such, is considered part of the air gap. This helps with the torque density of the motor. Magnetic field changes in the armature only can allow for a higher pole count at the same speed and reduced torque ripple. The rotor isn't constrained with the buildup of magnetic polarity charge time. These advantages correlate to a smaller physical size when operating less than a few horsepower.



Kollmorgen's TSP/ TSW 7 HP Induction Motor with scale for size reference.

Most servo systems can also handle large loads that are not dynamic providing that the design fits the performance. Directly coupled loads in the packaging and printing industries are typically very large.

In many cases, there is a mix of induction and permanent magnet technologies. The large Kollmorgen Cartridge DDR® motor are typical of a servomotor that encroaches on the domain of induction motors. Applications are too numerous to cite, but in the case of timing and multiple axis coordination, these permanent magnet motors more precisely control the position-time closed loop requirements than comparable induction motors and needed mechanics. The rare earth availability and price are often brought up concerning the two technologies of motor control. Rare earth materials and processing have caused uproar in the markets in recent months. The current state of the market indicates that this will not be a permanent issue. Some motors can be modified in design to obtain the same torque using different magnet materials. This hedge of one materials availability over another allows some more control over the volatility issues that can affect delivery and availability over long periods.

Conclusion

When deciding on the use of PM servomotors or induction motor systems, dynamic performance, torque density, inertia matching, and control schemes must be taken in consideration. If you need to maintain a constant velocity with a large load and very high power (>50HP), the induction motor would likely be a better choice. Should the mass of the motor, dynamic performance, or torque density be important decision factors, then the choice favors the PM servo. Understanding the gray areas helps in discerning one technology over the other. You may have to think "Outside the Box" of conventional wisdom that permanent magnet servomotors are for applications below a few horsepower.

ABOUT KOLLMORGEN

Kollmorgen is a leading provider of motion systems and components for machine builders around the globe, with over 70 years of motion control design and application expertise.

Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

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