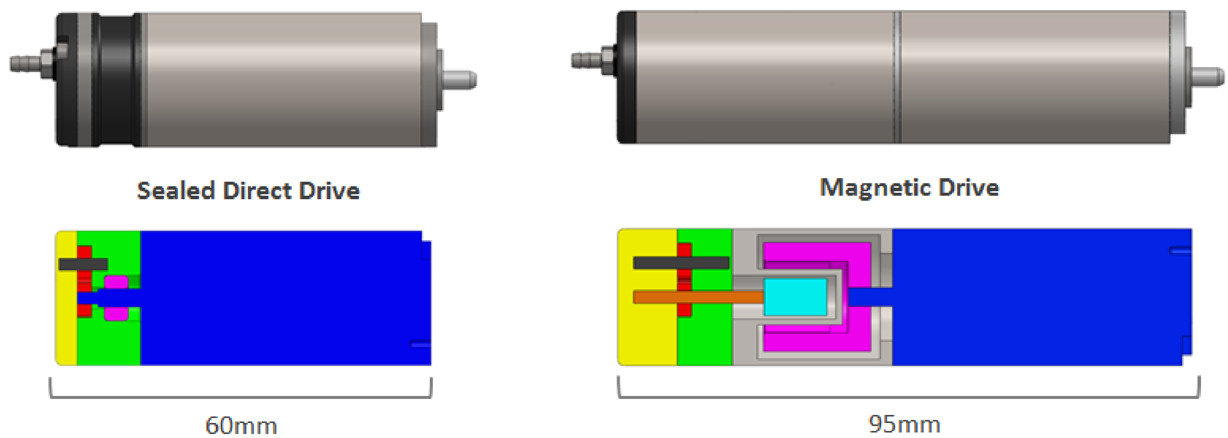
Sealed Direct Drive or Magnetic Drive:
A Comparison of Technologies and Suitable Use

Flight Works, Inc. — February 2016

INTRODUCTION

Pumps driven by electric motors can be driven either directly by the motor shaft (“direct drive”) or indirectly via a magnetic coupling (“mag-drive”). In the direct drive case, though some applications allow the motor to be flooded by fluid (such as in automotive fuel pumps), most require the motor to be protected from the fluid by a dynamic seal.

Figure 1 - Size & Design Comparison for 2222-X01 Pump



Since their invention in the mid-20th century, magnetically driven pumps have been carving out a growing foothold in the pump business. Despite sharing similar or sometimes identical pump head designs with their direct drive equivalents, mag-drive pumps and their reimagined driving mechanism bring a host of fundamental changes. These changes have allowed pump manufacturers to tap new markets, meet new requirements, and solve enduring pump issues. Still, both designs offer unique advantages and face unique limitations, and understanding these myriad distinctions can be an important step in selecting the right pump. These items are discussed in this paper for both the sealed direct drive and magnetic drive designs; the case of the flooded motor is not discussed.

DIRECT DRIVE

Most of the advantages found in direct drive pumps stem from their relative simplicity. The external gear pumps in the Flight Works C- and X-Series product lines, for example, use an electric motor shaft directly driving a set of gears in order to create flow. By using the existing shaft and bearings of the motor to transfer torque and support radial load, a number of extraneous parts are eliminated. This in turn can lead to a reduced part count, smaller size and weight, reduced risks of manufacturing defect failures, and, in the end, lower costs. When requirements are relatively mild, and size or budget are driving factors, a direct drive pump can be an ideal solution.

Offsetting the positive features of this pump design are a few drawbacks that can sometimes hamper its viability for a customer application. These are largely found in systems that could be considered harsh or taxing: the use of “challenging” fluids, long life applications, extreme environments, etc. In these systems, the shaft seal of a direct drive pump can become a liability, as the available materials and designs often involve limitations on life (due to the high rotational speed encountered), compatibility, operating temperatures, and more. The shaft of the vendor-supplied motor can come with similar restrictions (materials, surface finish, etc.), as well as limitations on pump head sizing.

MAGNETIC DRIVE

The mag-drive pump design provides a number of advantages and capabilities that are otherwise difficult to achieve with a direct drive design. Primarily, these improvements come from the separation of the pump section and the motor, and the elimination of any form of shaft seal. This alternative design can allow the use of more aggressive, corrosive, hazardous, or low-viscosity fluids that would otherwise be incompatible, unreliable, or unsafe. It can extend operating hours by removing the shaft seal as a limiting wear component and reducing the radial load on the motor bearings, which increases the life of the motor. Risks associated with fluid leaks or contamination due to seal failure are eliminated, especially in extreme environments. Additionally, the mag-drive design allows for optimized performance specifications, including lower power consumption and higher overall operating pressure, as well as a wider range of fluid temperatures (from cryogenic to extremely high temperatures, with the more heat-sensitive motor separated from the fluid).

Meanwhile, while the magnetic drive has very few downsides from a technical standpoint, its more complex design and larger number of components leads to higher manufacturing costs, which can be prohibitive in some applications. Additionally, the magnetic drive version of a pump does add both size and weight in comparison to its direct drive counterpart, making it a less ideal option in systems requiring the smallest possible form factor. Integration of mag-drive pumps can also be a concern, as potential magnetic field interference must be addressed. Mounting the magnetic coupling (reference Figure 1) in close proximity to low-resistivity materials, such as aluminum, can cause increased pump current and heating of the materials. These issues can be mitigated by mounting the pump as recommended by Flight Works (at least two centimeters away from low-resistivity materials), or with optional shielding (which adds minimal weight and current increase).

One particularly unique feature of magnetic drive pumps is the phenomenon of “decoupling,” which can be either a benefit or a hindrance depending on the system. Decoupling occurs when the load on the pump becomes too great for the available magnetic torque between drive and driven sections, leading to a “slip” between the two. This decoupling is associated with a reduction in current and loss of flow and pressure. This is often due to a spike in pressure, a blockage in the system, or other unexpected occurrences that can be difficult to prevent or quickly detect. In a direct drive pump, such irregularities can lead to overloading of the motor and damage to the pump or even the whole system. In a mag-drive, however, decoupling immediately removes any such danger and allows for the issue(s) to be assessed before component damage can occur. On the other hand, when operating a mag-drive pump at the upper end of its allowable load, there can be a risk of unintentional decoupling during small fluctuations in the system. Without a proper recovery procedure, this can lead to pump downtime. Fortunately, such a procedure is relatively simple, as the coupling can usually be restored by cycling the pump off and then back on, with a quick system check for irregular restrictions or other issues. While some magnets are subject to demagnetization when such decoupling occurs, Flight Works pumps are designed to handle these decoupling events without any reduction in magnetic torque capability.

CONCLUSION

Ultimately, the comparison between direct and magnetic drive pumps is not so much one of superiority, but rather suitability. Each can be an ideal solution depending on the customer's requirements, budget, and system conditions. When operated properly, both can form high-reliability, high-performance products with their own unique advantages. This is why Flight Works manufactures gear pumps of both designs, opening the door to a wider variety of applications and customer needs. Additionally, Flight Works can customize many components to increase the range of operations of the C-, X-, and M-series in order to meet specific customer requirements.

Table 1 - Capabilities Comparison for 2222-X01 Pump (Jet-A)

	Dynamic Seal Pump	Magnetic Drive Pump
Nominal Flow Rate	250 ml/min @ 100 psid	250 ml/min @ 100 psid
Nominal Current	1.1 A @ 100 psid	0.9 A @ 100 psid
Nominal Pressure	1-150 psid	1-300 psid
Max Pressure (intermittent)	200 psid	500+ psid (1000+ psid on custom pump designs)
Temperature Range	0° C to 100° C (limited by dynamic seal)	-30° C to 130° C (limited by static seals)
Mounting Recommendations	No specific requirement	Special mounting per FW recommendations (or optional shielding)
Primary Limitation	Dynamic seal failure	Decoupling condition

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