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How Multimodal VFDs & Permanent Magnet Motors Can Save Energy in Pump Applications

Hitachi's energy-saving products can help improve the performance of your system.

Selecting or designing the proper pump for the application is key to the performance and efficiency of your system.

The relationship between the various performance indicators of a centrifugal pump is explained by a collection of equations or formulas commonly known as the affinity laws. These affinity laws are predicated on the notion that a pump's efficiency is inversely related to its impeller diameter and directly proportional to its rotational speed. In general terms, the flow rate and pressure from the pump increases with the rotational speed of the pump but the pump will become less efficient.

The three main affinity laws affecting a centrifugal pump are:

THE FLOW RATE AFFINITY LAW: The flow rate produced by a pump is directly proportional to the rotational speed of the pump and inversely proportional to impeller diameter.

THE HEAD AFFINITY LAW: The pressure or head produced by a pump is directly proportional to the rotational speed of the pump and impeller diameter.

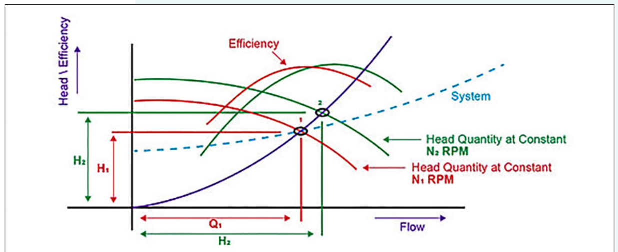
THE POWER AFFINITY LAW: The power required to operate a pump is directly proportional to the rotational speed of the pump and the cube of the impeller diameter. This is where energy savings are derived.

Hence, using the power affinity law, reducing the speed of a centrifugal pump can lead to energy savings because it can reduce the power required to operate the pump.

Unfortunately, slowing down a pump will affect the pressure it produces, according to the head affinity law. So, if you reduce the speed of the pump to increase efficiency, you may need to increase the size of the impeller to achieve the proper pressure needed for the application. The problem here is that suddenly changing out the impeller size may not always be feasible for an end user.

Besides optimizing the impeller diameter or relying on power affinity laws for energy savings, a pump system can also find energy savings through a motor technology change.

All motors operate using magnetic fields. In typical electric induction motors, an electrical current is sent through the stator as a magnetic field. As the magnetic field rotates throughout the stator, it creates a separate field in the rotor. The stator, or stationary part of the motor, is powered by an alternating current, which generates the rotating magnetic field.



$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2} \qquad \frac{H_1}{H_2} = \frac{N_1^2}{N_2^2} \qquad \frac{BHP_1}{BHP_2} = \frac{N_1^3}{N_2^3}$$

$$\frac{Flow_2}{Flow_1} = \frac{RPM_2}{RPM_1}$$

$$\frac{Pres_2}{Pres_1} = \frac{(RPM_2)^2}{(RPM_1)^2}$$

$$\frac{HP_2}{HP_1} = \frac{(RPM_2)^3}{(RPM_1)^3}$$

Where:
Pres = Pressure
RPM= Revolutions per minute

However, permanent magnet alternating current (PMAC) motors work by using a rotating magnetic field to create torque in the rotor, causing it to turn. As the stator rotates, it pulls the magnets of the rotor, causing the rotor, as well as the attached motor shaft, to turn. The rotor, the moving part of the motor, has permanent magnets embedded in it, thus saving on the excitation current normally needed in an induction motor. As the rotating magnetic field from the stator passes by the rotor, the rotor's permanent magnets are drawn toward it, causing the rotor to rotate in the same direction as the stator's magnetic field.

This process, known as electromagnetic induction, reduces the amount of electricity needed to run the machine and puts all necessary power into making the motor shaft rotate—meaning no energy is lost. Thus, a PMAC motor, by design, uses less current than its inductive motor counterpart, can run at a 90% efficiency rate and perform with no slip at a consistent speed. This reduced energy consumption also means a more environmentally and cost-friendly system.

Moreover, the PMAC's lower current and smaller, lighter design means that other parts of the system can have smaller size requirements, saving valuable facility space and cost. The use of a multi-mode variable frequency drive (VFD) with a PMAC motor, instead of the traditional inductive motor design, then becomes an extension of the optimization process of the overall pump system regardless of the predetermined system requirements or rotational speed. Multimodal VFDs' ability to continuously control the total current allows for good torque control over any speed.

The multi-mode VFD can be used to adjust the speed of the motor as required by the load placed on the motor to maintain flow and/or pressure. This allows for energy savings by only using the necessary power to run the load. By themselves, VFDs can improve the efficiency of pumping systems by only supplying the amount of energy needed for the load regardless of motor technology, but by adding a PMAC motor and a proper multi-mode VFD, it can further enhance the efficiency of a pumping system.

So, instead of redesigning the pump or operating at slower speeds to achieve better efficiency, look at the motor that is driving the pump. By using both a multi-mode VFD and PMAC motor, users can increase the efficiency of their systems by only using the necessary power the VFD needs for the load and take advantage of the extra efficiency that comes with a PMAC motor, regardless of speed. Therefore, a multimode VFD will be ready for the new motor technology such as PMAC when you are.

If you want to gain the extra efficiency for your system and save energy and costs, reach out to Hitachi for a new, better solution for pump motor control. Contact us: inverter.info@hitachi-iesa.com

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