Variable Frequency Drives (VFDs)

efficiency MAINE

Leading the Way to a Brighter Future

Motors are designed to run at a constant speed. However, motor drive systems are often operated at part or variable load. In particular, fans and pumps can have highly irregular load profiles. This means, the motors on these systems either run at constant speed bypassing the excess capacity, or use some form of capacity regulation such as dampers, valves, or inlet guide vanes, all of which are very inefficient.

System output can be controlled by adjusting the speed of the motor using one of five different types of Adjustable Speed Drives (ASDs):

- Variable Frequency Drives (VFDs)
- DC Adjustable Speed Drives
- Eddy Current Drives
- Hydraulic Drives
- Mechanical Drives

Typically, VFDs offer higher efficiencies, are easier to control, require less maintenance, and have become the drive of choice in the majority of applications. In addition, speed control is generally the most energy-efficient flow control technique because it requires the least amount of energy to meet the given load.

VFDs have widespread acceptance in the industry, therefore we will focus our attention on these drives. Within the VFD family, there are several types available, each with its own practical application. All perform the job of controlling the motor speed by varying electrical voltage and frequency in response to an electric feedback from the end use. Depending on the application, VFDs, when applied correctly, can reduce energy consumption by more than 50 percent. Efficiency Maine offers prescriptive and custom incentives on VFDs, making the installation of VFDs an even more attractive investment.

What VFDs Do

The most common VFD, used for applications with motors up to 400HP, uses pulse width modulation (PWM) inverter technology. That means the PWM inverter develops the voltage output by chopping DC pulses of varying widths to synthesize the desired AC waveform. Using this method, the VFD sends the motor pulses of DC voltage in varied widths, mimicking the increasing and decreasing amplitude of an AC sine wave.

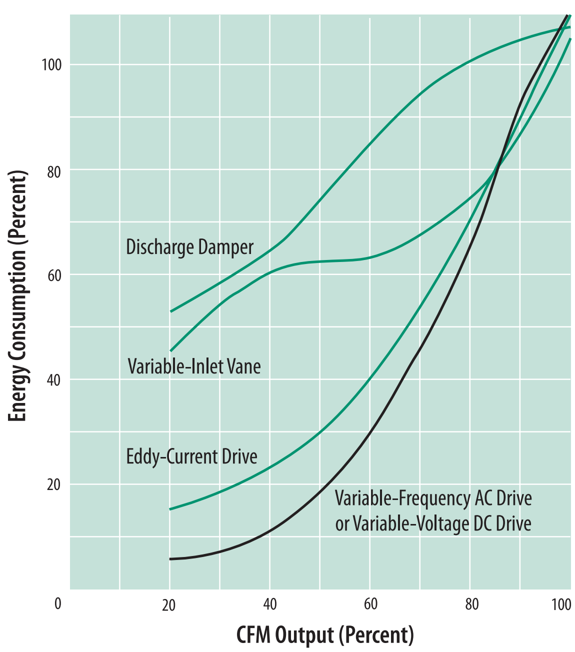
Some of the ideal applications for installing VFDs include centrifugal loads such as fan and pumping systems. Typically, fan and pump systems are designed with inherent safety factors and have variable loads. In applications without VFDs, the common methods of varying the capacities of these systems include bypassing, dampers, valves, and vanes that are very inefficient under part load conditions.

The graph below shows the higher efficiencies of VFDs compared to inlet guide vanes and damper systems in part load applications. The basis for such savings comes from applying the affinity laws for pump and fan applications. The affinity laws define the relationship of power consumption to flow or speed as follows:

In theory, a reduction of 50% flow results in an 88% reduction of

$$\frac{\text{Power}_{\text{existing}}}{\text{Power}_{\text{new}}} = \left\{\frac{\text{Flow (CFM)}_{\text{existing}}}{\text{Flow (CFM)}_{\text{new}}}\right\}^3 = \left\{\frac{\text{Speed (RPM)}_{\text{existing}}}{\text{Speed (RPM)}_{\text{new}}}\right\}^3$$

energy input. However, in real world applications, the exponent is often in the range of 2 to 3, which reduces the savings estimate somewhat, but still results in exponential energy savings.



Besides reducing electric demand and energy consumption of a motor-drive application, VFDs also improve power factor, process precision, and afford other performance benefits such as soft starting and over speed. VFDs allow the system components to work smoothly prolonging the equipment life. When VFDs are installed on new pumping or fan systems, they eliminate the installation cost of control valves, outlet dampers, and vanes.

Applications That Are Ideal For VFDs

The ideal applications for VFDs are centrifugal loads with long operating hours and variable loads such as pumps and fans. For these applications, the power required to drive them varies as the cube of the speed and, therefore, for a small reduction of speed, exponential reduction of power is achieved.

Some of the typical applications are air handling unit supply and return fans, hot water circulation pumps, chilled water supply pumps, cooling tower fans, chillers, circulation pumps in water source heat pump systems, industrial process cooling pumps, rotary screw compressors, hydraulic motors on injection molding machines and combustion blowers in boilers.

There are many other applications as well. As mentioned above, in the absence of VFD control, the output of fan and pump applications with variable loads are often varied using throttling valves, outlet dampers, or inlet guide vanes. As the graph on front shows, these methods of capacity control are very inefficient and should always be evaluated for a VFD retrofit.

Applications That Require Careful Selection of VFDs

Constant-torque applications, like hoist cranes, require the same torque regardless of speed and therefore should be carefully assessed for VFD installation. Some other common examples of applications that need careful review before consideration for VFD installation are conveyers, reciprocating compressors and positive-displacement pumps. In addition to these, fan and pump applications with small variations in loads or low operating hours should be carefully investigated before installation of VFDs.

It should be noted that energy-efficient inverter duty motors should be used when replacing standard motors for VFD applications, because they have better thermal management, wider speed ranges, and better insulation systems — further enhancing the efficiency of the equipment.

Applications That May Not Be Appropriate for VFDs

Loads in which torque decreases with speed usually involve very high inertia loads such as vehicular (for example, railway traction) drives or flywheel-loaded applications; it takes less torque to keep these loads turning than to accelerate them. Loads of these types are difficult for applying VFDs. VFDs may be utilized in some applications but custom engineered solutions are often required to handle the extra heat generated in starting and stopping such loads.

Questions To Be Asked

Q. Is there any pump or fan motor in the facility that is modulated using valves or dampers?
If yes, this is a potential candidate for VFD.

Q. Is there any drive in the facility using adjustable pulleys or other forms of mechanical speed variation?
If yes, this is a potential candidate for VFD.

Q. Does any motor require to be operated at lower speeds?
If yes, this is a potential candidate for VFD.

Q. Are you installing a new fan or pump system that would be throttled using valves or dampers?
If yes, stop and investigate installing a VFD instead.

The Future

The prices of VFDs continue to drop, making project paybacks better with improved reliability. Manufacturers recognize the benefits of this technology and are working towards integrating ASDs into control systems of such things as heating, cooling, and ventilation units.

For More Information

Learn about cash incentives offered for VFDs and other electric energy saving measures available through the Efficiency Maine Business Program by calling toll-free 866-376-2463 or visiting the website. The Efficiency Maine Business Program offers free advice to businesses and cash incentives on high-efficiency electrical equipment. Ask your vendor or contractor if they are an Efficiency Maine Qualified Partner. A complete list of these contractors and suppliers specializing in energy-efficient products and services is available at efficiencymaine.com, under Business Program. The website also provides information for new school construction projects and residential electric energy consumers.