Variable Speed Drives for Energy and Process Efficiency

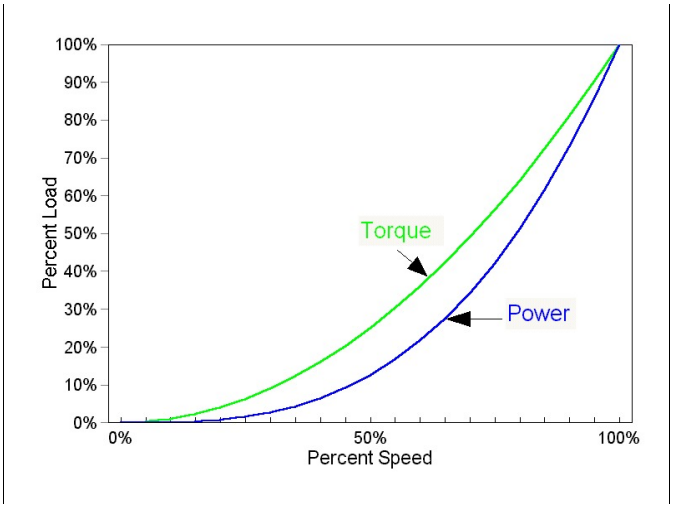
by Denis Cooke

VSDs have applications in modern high tech processing plants. The main reasons for installing variable speed AC motor control drives are for process control which for reliability and performance, energy efficiency, and cost. VSDs allow drives to be brought on line seamlessly so there may be an advantage in using VSDs for both the main and backup drives.

Variable speed drives allow many advantages over other methods of process control. For example centrifugal pump and fan applications are quite common with speed control used to regulate the flow of a liquid or gas. VSDs are used in preference to other methods of regulating flow because varying the speed is the most energy efficient method of flow control and VSDs are able to control the speed of standard AC motors.

VSDs for Fans and Pumps

Centrifugal pumps and fans are variable torque loads. With a variable torque load, the torque required to drive the load increases in proportion to the square of speed as shown in the figure below:

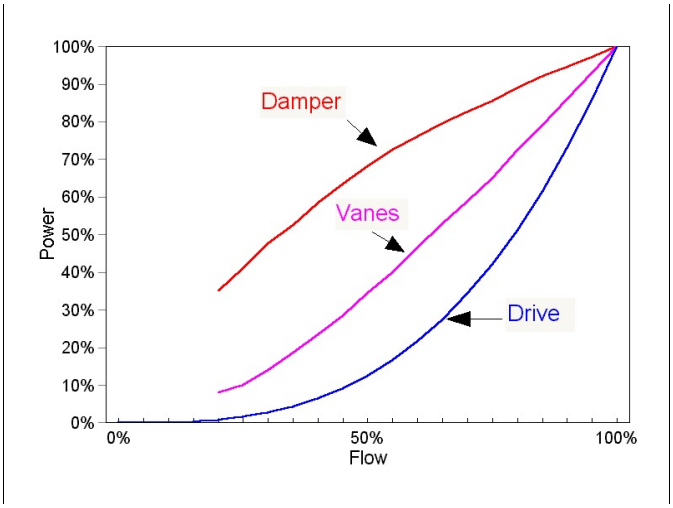


The load increases from zero torque at zero speed through 25% torque at 50% speed to 100% torque at maximum (100%) speed. Since power is proportional to torque multiplied by speed, the power is proportional to the speed cubed. As can be seen, at 50% speed the load requires only 12.5% of maximum power so there is a substantial reduction in the energy needs when a variable torque load is operated at reduced speed.

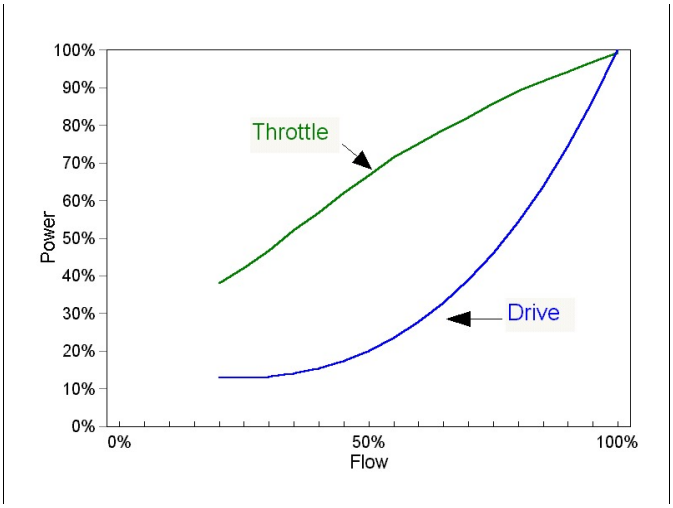
Positive displacement pumps move liquid by displacing the liquid with a solid volume such as a piston. Piston pumps, diaphragm pumps, gear pumps and all other types of positive displacement pumps are constant torque loads. Positive displacement blowers and compressors are also constant torque loads.

Speed can be varied by other methods. For example, air flow can be controlled by adjusting the position of fan inlet vanes or discharge dampers. Whilst these flow control methods offer energy savings over full flow operation, speed control is generally more efficient.

The figure below compares the power consumption for these three control methods.



Liquid flow can be controlled by throttling the liquid flow with a valve. The figure below shows the energy used by a variable speed pump compared to a constant speed pump with a throttling valve. To move the liquid, the pump must produce sufficient pressure to lift the liquid from the level of the pump inlet to the level of the liquid discharge. The lifting pressure is called the static head of the system. Also, the pump must overcome the dynamic head or resistance to flow in the system. Static head is a constant value and dynamic head varies in proportion to the flow. For the example illustrated, the static head is about 50% of the total head at 100% flow. If there was no static head, the energy consumption curves for a pump would more closely resemble the curves for a fan. The curves shown represent a hypothetical case with the actual power depending on the characteristics of the pump, motor, drive and hydraulic system.



Also, of particular importance in the use of VSDs in a process is the ability to offer precision control of the motor either by a person directly, programmed locally of remotely via computer interface.

So far we have discussed briefly how a VSD offers benefits in efficient process control and energy conservation.

Harmonics

All VSDs produce harmonics through the switching characteristics of the semiconductors in the VSD electronic controllers. Harmonics are multiples of the supply frequency which become superimposed on the supply system. Typically VSDs will generate harmonics at frequencies equal to the 5^{th}, 7^{th} and higher multiples of 50 Hertz. Depending on their level, harmonics can cause many problems such as equipment and capacitor overheating, voltage distortion and equipment malfunction.

AS2279 sets out the allowable levels of harmonic distortion on supply networks and RFI filters and chokes for each VSD would most likely be required. Alternatively, harmonic filter boards may be required for the installation.

Also, modern VSD units will allow each drive to be programmed off-site for later control information downloading and commissioning. In addition they should allow process engineers to make minor changes during commissioning.

Summary

A successful VSD project will depend on a number of factors including:

- a technically sound solution to the process variables,
- adequately addressing and catering for harmonics,
- costs and
- having a quality product that meets the specifications.

NOTE: No warranties whatsoever are given about the contents of this paper.

North Rocks NSW 2151
Phone (02) 9871 6641
Fax (02) 9614 1723
Email: denis@decoa.com.au
Web Site: http://www.decoa.com.au

Denis Cooke & Associates has been in the business of energy management and greenhouse challenge for over fifteen years. Project undertaken include:

- Auditing and project identification in mines/industry.
- Assistance with detailed project analysis and feasibility studies
- Assistance with project implementation.
- Assistance with energy monitoring techniques, data gathering equipment, (specification and installation) software, use of information and report design as part of an energy management package.
- Assistance with on-going monitoring of energy usage and appropriate management reports.
- Assistance with energy management planning and incorporation of energy management practices into the day to day management of the mines.
- Reassessment (re-evaluation of energy saved from project implementation and/or energy conservation measures) at a later stage following project implementation.
- Reappraisal of comparative performance, either as one off or occasional exercise, or on an on-going basis.
- Greenhouse gas reduction strategies
- Greenhouse Challenge Cooperative Agreements
- Greenhouse Challenge Annual Reporting