



The Motor Control Warehouse

Energy Saving Using Variable Speed Drives

MCW Hints & Tips 0005

Energy Saving - An introduction

Many systems use constant speed motors and control process flow rates or pressures by mechanically regulation using throttling valves, dampers, fluid couplings or variable inlet vanes etc. These devices generally do not control flow or pressure efficiently because energy is dissipated across the throttling device.

Running a motor at full speed while throttling the input or output is like driving a car with one foot on the accelerator and the other on the brake; a part of the produced output immediately goes to waste.

A variable speed drive can save over 60% of the energy. This is possible as it controls the energy at source, only using as much as is necessary to run the motor with the required speed and torque - much in the same way as the accelerator in the car controls the engine revs and without the foot on the brake.

Types of loads - which are suitable for energy saving?

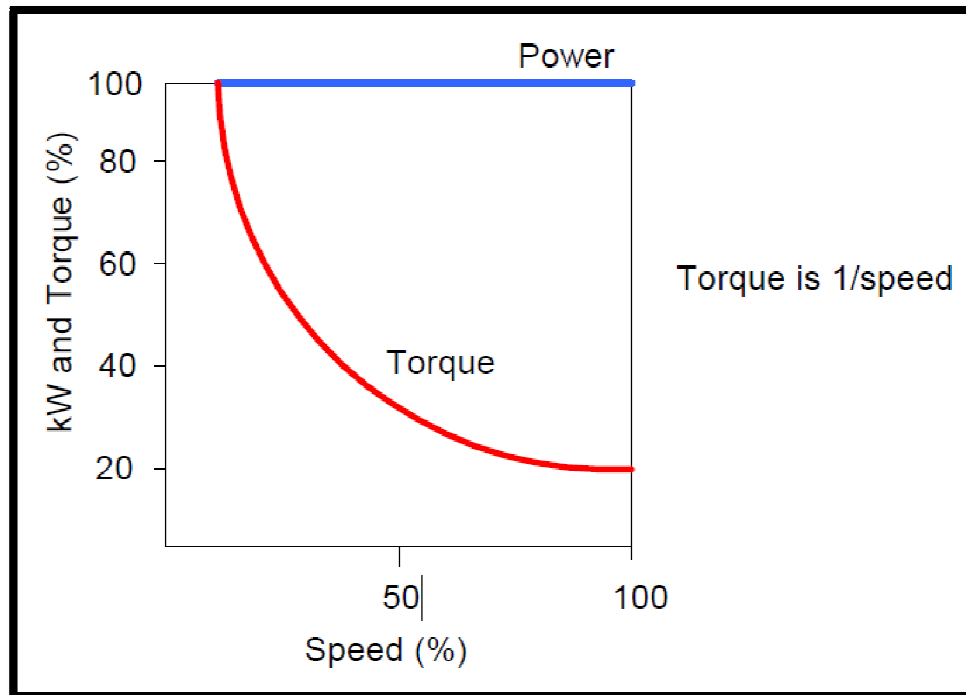
Drive applications are categorized with respect to power and torque changes in response to the motors speed. It is important to understand the type of load for a particular application because not all are equally good energy saving opportunities for the application of a variable speed drive. In fact, if a variable speed drive is used on some loads there will be little or no energy savings.



Variable speed drives and the loads they are applied to can generally be divided into 3 groups:

- Constant power
- Constant torque
- Variable torque

Constant Power Loads

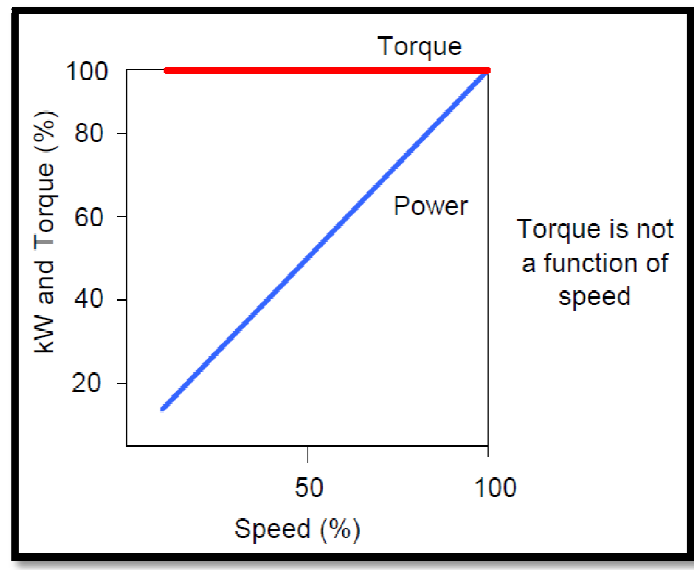


In constant power applications, the power requirement remains constant at all speeds, and the torque requirement varies inversely with speed. One example of this type of load would be a lathe. At low speeds, the machinist takes heavy cuts, using high levels of torque. At high speeds, the operator makes finishing passes that require much less torque. Other examples are drilling and milling machines.

Typically, these applications offer no energy savings at reduced speeds.

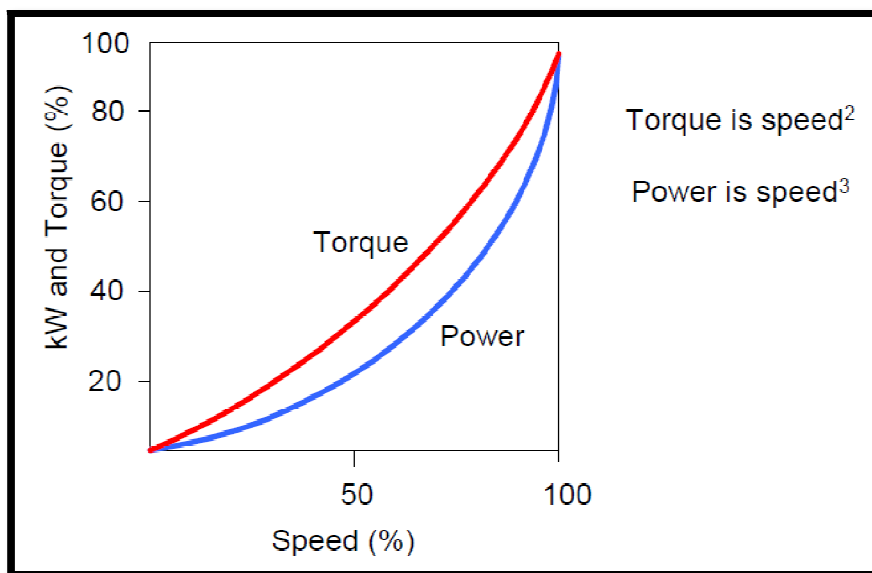


Constant Torque Loads



In constant torque loads, the power is directly proportional to the operating speed. Since torque is not a function of speed, it remains constant while the power and speed vary proportionately. Typical examples of constant torque applications include conveyors, extruders, mixers and positive displacement pumps.

Usually these applications result in moderate energy savings at lower speeds.



In variable torque load applications, both torque and power change with speed. Torque varies with speed squared, and power varies with speed cubed. This means that at half speed, the power required is approximately one eighth of rated maximum. Common examples of variable torque loads are centrifugal fans, blowers and variable discharge pressure pumps.

The use of a variable speed drive with a variable torque load often returns significant energy savings. In these applications the drive can be used to maintain various process flows or pressures while minimizing power consumption. In addition, a drive also offers the benefits of increased process control, which often improves product quality and reduces scrap.

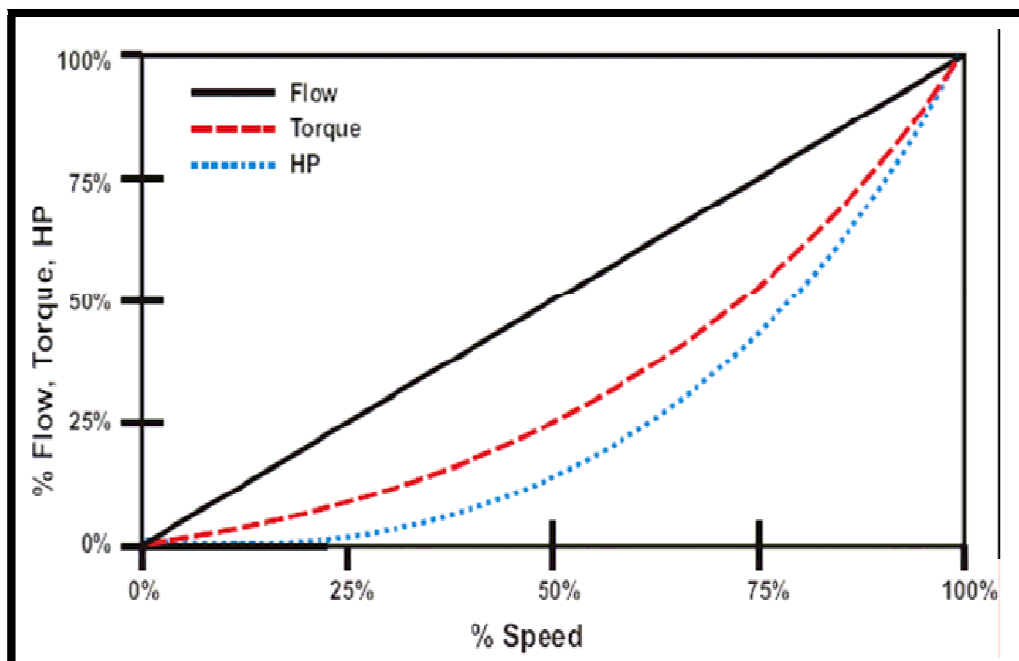
Effective speed ranges are from 50% to 100% of maximum speed and can result in substantial energy savings.

How do variable speed drives achieve energy saving with variable torque loads?

Variable speed drives regulate the speed of motors and in turn the speed of the fan or pump by controlling the energy that goes into the motor rather than restricting the flow of a process running constantly at full speed.

A variable speed drive can save over 60% of the energy as it controls the energy at source, only using as much as is necessary to run the motor with the minimum speed and torque.

Large amounts of energy can be saved on fan and pump systems, because of the affinity laws for pressure and flow rates.



The Affinity laws state –

Flow is directly proportional to speed

Torque is directly proportional to speed squared

Power required is proportional to speed cubed

Therefore, this means that if 100% flow requires full power

75% flow requires $0.75^3 = 42\%$ of full power

50% flow requires $0.5^3 = 12.5\%$ of the power

Mechanical control methods such as inlet guide vanes, throttling valves, discharge dampers do not take advantage of the affinity laws.

With mechanical flow control methods the motor always runs at full speed and the flow is mechanically restricted.

A variable speed drive saves energy by reducing the actual speed of the motor when full flow is not required.

Example

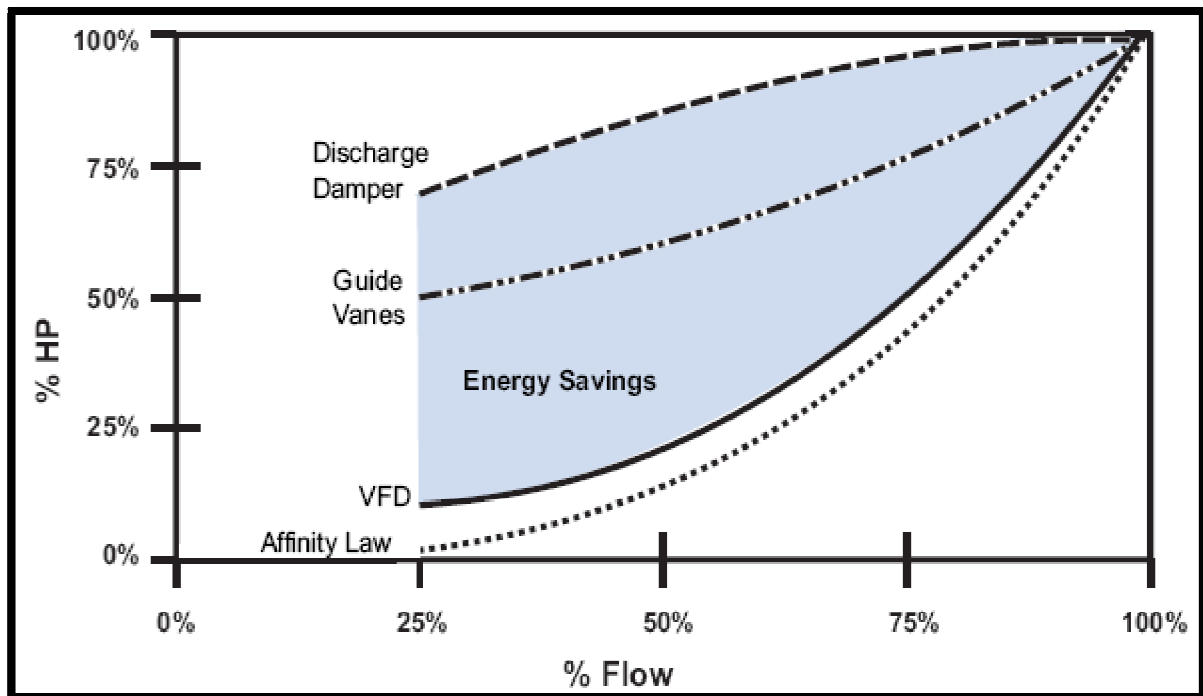
A fan is running at fixed speed (50Hz) and the output from the fan is restricted by a discharge damper to restrict airflow to the correct level for the process. The input power is typically 95% of full load power.

A variable speed drive is fitted to the system and the discharge damper removed so there is no restriction to airflow. The speed of the motor is reduced to 40Hz which gives the same airflow as before when the motor was run at full speed and a discharge damper used. Now the input power is typically 50% of full load power.

Therefore by using a variable speed drive, the power being consumed is reduced by typically 45%.



Centrifugal Fans

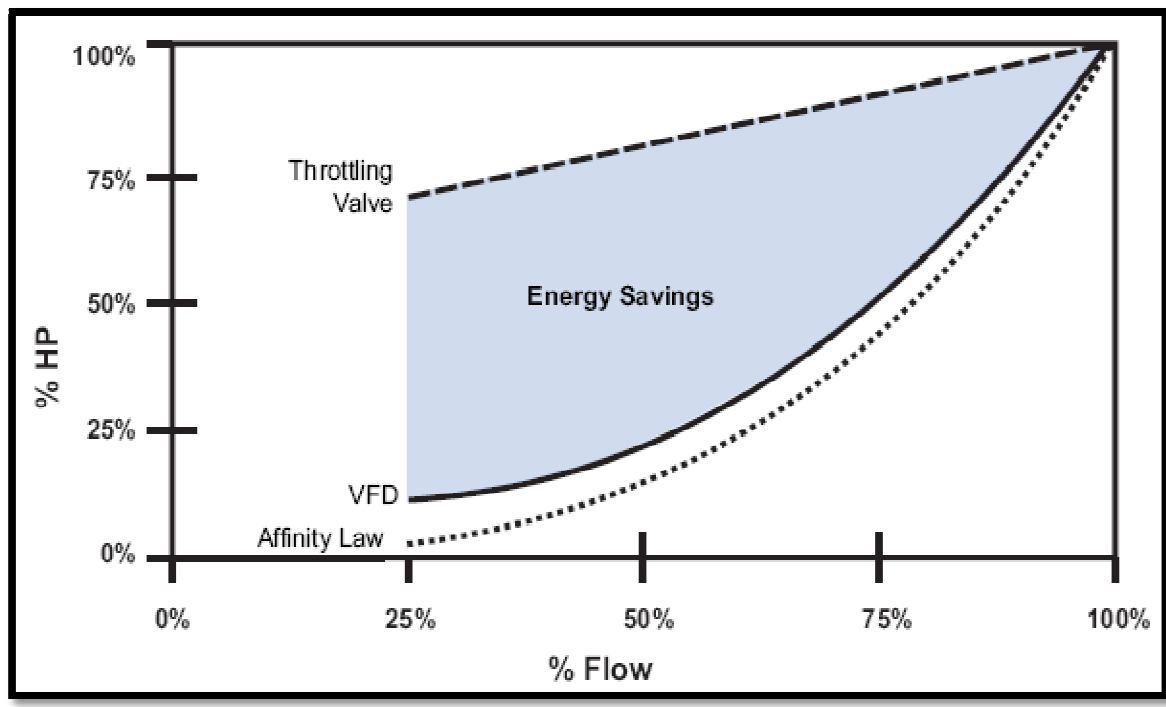


Massive potential energy savings using a variable speed drive compared to the two most common methods of flow control for fans:

- Inlet guide vanes require about 60% power to give a flow rate of 50%
- A discharge damper requires a huge 90% power to give 50% flow



Centrifugal Pump



- Operating at 75% flow requires less than 50% power, whilst the throttling valve requires around 90% power.

Centrifugal fan - Typical input powers

The following table shows the typical input power to a motor when run at full speed with flow rate is restricted by an outlet damper compared to the typical input power when the same motor is run at reduced speed from a variable speed drive, achieving the same air flow rate as with the outlet damper.

Flow Rate (% of Max.)	Typical Input Power (% of full load power)	
	Outlet Damper Control	Variable Speed Drive
100	100	100
80	95	50
60	86	28
40	72	15
20	60	5



It can be seen that if an outlet damper reducing the air flow rate to 80% uses 95% input power, a variable speed drive achieving the same air flow rate uses 50% input power.

Other advantages of variable speed drives

- A variable speed drive can also make it possible to stop a motor completely when it is not required as re-starting with a variable speed drive causes far less stress than starting direct on line - soft start is an inherent feature of the drive.
- Regulating the motor speed has the added benefit of easily accommodating capacity rises without extra investment, as speed increases of 5-20% is no problem with an AC variable speed drive as long as there is enough spare capacity in the system.
- Reduced maintenance compared to DC systems (brushes and commutators)
- Reduced motor/application noise levels.
- If the variable speed drive has an internal PID loop, it will be possible to automatically control flow or pressure based on feedback from a sensor within the system. This can make further energy savings as the motor can slow right down if very little flow or pressure is required.

Another method of saving energy

Most companies forget about the motors when considering energy saving. As well as saving money by installing a variable speed drive, installing high efficiency motors can also save energy and money.

Please see the enclosed document for further details on high efficiency motors.

Motor Control Warehouse can supply EFF1 accredited motors. Please take a look at our website for further details.

Example of energy saving using a variable speed drive

A 30kW pump operating for 16 hours during weekdays and 12 hours during week ends, total of hours per week = 92 hours.

Energy Cost at constant speed

Energy consumption per week – $30\text{kW} \times 92\text{hours} = 2760\text{kWh}$

Assume electricity rate is 10p per kWh

Energy cost per year – $2760\text{kWh} \times \text{£}0.10 \times 52 \text{ weeks} = \text{£}14352$



Energy Cost at variable speed

Assume average speed is 75% which corresponds to 42% power consumption

Energy consumption per week – $0.42 \times 30\text{kW} \times 92 \text{ hours} = 1159.2\text{kWh}$

Energy cost per year – $1159.2\text{kWh} \times \text{£}0.10 \times 52 = \text{£}6027.84$

Value of energy saved per annum by using a variable speed drive

$\text{£}14352 - \text{£}6027.84 = \text{£}8324.16$

NOTE:

This calculation is just an example using a figure of 10p/kWh but gives a good guide as to what can be saved by using variable speed drives.

For a more accurate value of possible energy savings, a full survey including tests would be required.

