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Saving Energy and money in Mills with Drives

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1.0 INTRODUCTION
The majority of AC motor speed controllers also known as Variable Frequency Drives (VFD’s) are primarily applied for reasons of energy saving, process control or process improvement. Often there are many hidden benefits to be gained as well. These benefits are listed and discussed. Some disadvantages exist also - these are discussed as well.

2.0 BENEFITS OF VARIABLE FREQUENCY DRIVES

2.1 PROCESS BENEFITS

Process Control -
A variety of analogue and digital controls are possible. Modern drives include serial communications, PID control, PLC onboard functions and specific control setups which simplify the implementation of common applications.

Process Monitoring -
Digital, analogue and serial outputs provide ready information to monitor both the motor condition and process variations through load changes. It is important to note here that what you can monitor and measure, you can manage and improve.

Process Improvement -
Process improvement is often a side effect of the primary objectives such as energy saving. For example – Common DC bus applications can recycle power from a regenerating load to motoring loads.

Electricity consumption

- For processes and building utilities
- Electric motors consume 72% of the total electricity used
- 63% of this energy is used to circulate fluids and gases

2.2 ELECTRICAL BENEFITS

Repetitive Starts -
Due to the Variable Voltage Variable Frequency (VVVF or V/f) nature of the AC motor controller, repetitive starts may be carried out without having to be concerned about the thermal capacity of the motor.
**Electrical Protection** -
The drive shields the motor from electrical disturbances and can often provide improved immunity to stall and overload. The motor does not see electrical transients from the supply. Modern drives offer accurate motor overload protection. The drive also shields the motor from slight supply imbalances.

**Efficiency** -
Modern AC PWM variable speed drives are very efficient and cause minimal additional losses in the motor. They are much more efficient than eddy current drives.

2.3 **POWER SYSTEM BENEFITS**

**Soft Start** -
The near perfect starting current characteristic of VFD’s minimises the disturbances placed on the AC supply. Effects on other equipment are minimised. Switchgear capacity may be significantly reduced, with major savings. For systems requiring stand-by alternators, the alternator sizing may often be reduced to 30-50%.

**Power Factor** -
The displacement factor (cosØ) is always near unity, even at light loads. No power factor capacitors are required.

**Short Circuit Ratings** -
There is no short circuit contribution from the motor loads to the supply, reducing the duty required of the switchgear.

2.4 **ADDITIONAL BENEFITS IN PUMP, FAN AND COMPRESSOR CONTROLS**

**Broad Benefits** -
- Eliminates the need for pressure tanks.
- Much better control than intermittent duty systems.
- Can simplify multimeter/pump systems by use of only one motor/speed controller.
- Eliminates pressure surges during start and stop, extending pump, bearing, valve and pipe-work life.
- Longer pump seal and impeller life.
- Provides wider range of operation than damper or throttle control.
- Provides greater linearity of control than valves.
- Allows for maximum pressure control to protect old pipes (e.g. water reticulation).

**NOTE THE AFFINITY LAWS**

- **FLOW** is proportional to the motor **SPEED**
- **PRESSURE** is proportional to the motor **SPEED SQUARED**
- **POWER** is proportional to the motor **SPEED CUBED**

The example shown below demonstrates the energy saving feature of VSD’s on fans.
3.0 DISADVANTAGES OF VFD’S

**Power Loss** -
Fitting a modern AC drive into a motor system adds between 3-5% additional losses over DOL operation (typically 2-3% in the motor controller and 0-3% in the motor).

**Harmonic Currents** -
The primary stage input rectifier in VFD’s draws non-sinusoidal, i.e. harmonic currents. These are minimised in drive designs by the use of DC bus or AC line reactors.

It is necessary to consider these effects of harmonic currents if the motor controller load exceeds about 30-40% of the supply capacity, or if reactors are not included.

The harmonic effects caused by the drives are much less disturbing of other equipment than equivalent sized DC drives.

**Radio Frequency Interference** -
The high speed switching edges inherent in the PWM process can radiate radio frequency noise. Most drives are designed to minimise this effect, however interference, particularly to weak AM radio bands, can occur. In such cases additional RFI filters may be necessary.

**Motor Noise** -
Older designs of Drives generated considerable additional motor noise. Current designs minimise this through the use of high switching frequencies and masking techniques (Whisper wave). In such designs no more than 2-3 dB are added at rated frequency and load, and noise levels are generally less than DOL levels at frequencies and loads below rated.
**Motor Cable length** -
The drive output (or motor) cable length has distance limitations to limit cable capacitance charging issues. Using an output choke or motor choke lowers the dV/dt switching at motor terminals and allows longer cable lengths. Generally, output choke is an expensive solution.

**Electrical Discharge Machining (EDM)** -
VSD’s on motor’s above 100kW range can induce bearing currents in the motor shaft which can be discharged over the bearings. This phenomenon is known as EDM. Approaches to reduce high frequency common mode current viz. motor design and proper cabling practices prevent bearing damage.

4.0 **SUMMARY**
VFD’s offers many benefits and has minimised most of the disadvantages. As a result, the popularity of such controllers continues to grow at a compounding rate of around 10% per year.