Variable Frequency Drive (VFD) benefits with Pumps
Energy Efficiency in Pumping Systems

- Motor costs

Where does your money go?

Energy 95%

Installation & Maintenance: 3%

Investment: 2%

Large Motor:
1 Month Energy Bill = Motor Cost
Energy Efficiency in Pumps

- Energy wastes

How your **money** is **wasted**!

Car example:
...try to regulate the speed of your car
- keeping one foot on the accelerator
- the other on the brake.

Pump example:
...try to adjust the pump output
- running the motor at full speed
- control the flow with a throttle valve

Still one of the most common control methods in industry with a considerable waste of energy!
VFD Benefits with Pumps

- Physical laws for centrifugal loads

It’s pure physics: Due to the laws that govern centrifugal pumps, the flow of water decreases directly with pump speed

Affinity laws of centrifugal loads:

- Flow = f (motor speed)
- Pressure = f (motor speed)^2
- Power = f (motor speed)^3
VFD Benefits with Pumps

- Physical laws for centrifugal loads

A motor running at 80% of full speed requires 51% of the electricity of a motor running at full speed.

(\(0.8 \times 0.8 \times 0.8 = 0.512\))
VFD Benefits with Pumps

- Physical laws for centrifugal loads

A motor running at 50% of full speed requires 12.5% of the electricity of a motor running at full speed.

\[
\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 0.125
\]
VFD Benefits with Pumps

• Physical laws for centrifugal loads
  • A small reduction in speed produces a significant reduction in power
  • Relevant applications: Pumps
  • The resisting torque of centrifugal pumps varies with the square of the speed: \( T = kN^2 \)
  • Power is a cubed function \( P = kN^3 \)

EX 50HP 10Hrs/day, 250 days @ $.08
With 15% average speed reduction
ATL = $7,460
VFD = $4,188
Savings = $3,272

Today, less than 10% of these motors are controlled with variable speed drives
Efficiency of pumping systems
VFD Benefits with Pumps

Other Benefits

In addition to energy savings, using a VFD has many other advantages:

- Less mechanical stress on motor and system
- Less mechanical devices - Less maintenance
- Process regulation with PID regulators, load management functions
- Reduce noise, resonance avoidance
- Performance and flexibility, range settings, above base operations
- Easier installation and settings, drive mechanics
- Can be controlled with automation, communication networks
Steps to obtain pump optimization
Pump Optimization

Complete a detailed Pump Assessment

Pumps are usually consuming more energy than necessary:
- The pump is oversized and has to be throttled to deliver the right amount of flow. Energy is lost in the valve.
- Pumps that are not running close to their best efficiency points (BEP) operate at lower efficiency. Throttled pumps usually fall into this category.
- Pumps are running with by-pass, or recirculation, lines open.
- Pumps are running although they could be turned off.
- The pump is worn and the efficiency has deteriorated.
- The pump/system was installed or designed incorrectly (piping, base plate etc.)
Pump Optimization

Complete a detailed Pump Assessment

To determine whether these reasons apply, some basic information is needed:

- Actual system demand (flow and pressure)
- Operational flow rate as a function of time (the duration curve)
- Flow controls
- The pump curve
- Where the pump operates on the curve
Process Energy Optimization

Automation is the key

- Develop consistent and appropriate milestone and deliverable expectations
- Standardize program schedule tracking requirements
- Establish key energy management performance metrics
- Produce meaningful reports that allow for clear and concise decision-making
- Install additional monitoring equipment as needed
VFD Application Considerations

- Keep motor lead lengths as short as possible
- VFD environment (0-40°C), clean and non-condensing
- Enclosure rating (NEMA 1, NEMA 12, NEMA 3R)
- Ensure 3 metallic conduits are used (motor, power, and controls) Be careful with underground runs!
- Dedicated ground wires from motor to VFD and from power source to VFD
- Use line reactors for harmonic distortion control and enhanced protection from AC line transients
- Size VFD based on amp rating (6-pole motors and up)
- Disconnect Issues
- Harmonic calculations
Quiz

• For a centrifugal pump load, a motor running at 80% of full speed requires ___% of the electricity of a motor running at full speed

• For a centrifugal pump load, a motor running at 50% of full speed requires ___% of the electricity of a motor running at full speed

• True of False: in spite of the above physical relationships, throttling a pump’s output remains the best way to adjust flow rate