Energy Savings with Pumps – VSD vs Softstarter

It is well known that centrifugal pumps make up a large proportion of driven motor load and hence considered the largest single consumer item of energy globally. Accordingly, improving energy efficiency of pumps and pump systems is therefore a prime focus worldwide.

It has been widely accepted that the use of Variable Speed Drives (VSD) can significantly reduce the energy consumption of a centrifugal pump motor, particularly where process pressure and hence flow control is required.

Where pressure or flow control is not required, for example for simple water transfer installations such as from a reservoir to a water tank, soft starters are often used due to lower capex. Energy savings are generally not considered as it is assumed that the pump needs to run at full speed, when water transfer is required. We acknowledge that yes, by introducing a VSD you introduce additional losses – an additional 2-3% in fact and you may be better served with a softstarter.
There are however other considerations before just opting for a softstarter by default for a water transfer application:

- <u>A very high head and very long pipe length</u>
  Remembering that just varying the motor voltage up or down, as is the case with basic soft starters, the available motor torque will vary as a square of the voltage ($T \alpha V^2$) which can often lead to pressure surges during acceleration or a sudden stop of the pump on deceleration where high back pressure exists that overcomes the available motor torque resulting in the motor stalling, well and truly before the fluid velocity has been significantly reduced - subsequently significant water hammer can occur.
  Most high-end softstarters offer a controlled ramp up and controlled ramp down function that will manage the motor to ensure linear acceleration and deceleration, unlike the standard voltage ramp offered by simpler starters that offer no controlled motor ramp at all.
  With softstarters, the starting current would still be in the order of 300%-350% for centrifugal pump applications. Please note that the starter will draw current also on deceleration to ensure the motor continues to decelerate in a controlled manner and maintain a motor torque to prevent the back pressure in the pipe stalling the motor as discussed above.
  Most water transfer applications will have a non-return valve installed in the pipework to prevent the higher tank from draining back into the reservoir. If the pipe length is considerable and the Static Head is quite high, there will be considerably more motor control required than a softstarter is able to offer because the sheer volume and weight of water to accelerate or stop. More often than not this requires much longer ramp times than the 20 – 30 seconds any softstarter typically has available to allow smooth and controlled closing of the non-return valve.
  The problem with long ramp times and softstarters is that the inbuilt I^2t motor protection will trip before the acceleration or deceleration cycle has been completed. If a trip occurs, the pump will freewheel before the non-return valve has closed and the downward water velocity will force the valve to crash shut, in turn causing very high stresses on both the non-return valve and pipework that can lead to rupturing in extreme situations.
  A VSD would be a much better selection in these situations as the acceleration times can be as long as 10 minutes while the motor current will be less than the motor full load current and line with the power consumption of the pump during the entire acceleration and deceleration cycle.

- Energy Savings by transfer flow reduction.

  Moving away from the standard mindset that water transfer occurs at full speed and that therefore by default a softstarter is the motor controller of choice, it may surprising what energy savings are actually possible if a VSD was installed in an existing system by running the pump at a lower speed.

  For a typical centrifugal pump controlled by a VSD, the power used is proportional to a cubic function of speed – ie $P \propto n^3$.

  For example:

  If a centrifugal pump's motor speed is reduced from full speed by 30% to 70% speed (35Hz), the power reduces to approximately 0.7^3 = 35% of the power used at at full speed. This may vary depending on where the pump operates on its efficiency curve, so in practice the power may reduce to say 40%.

  Also, note that Flow α speed (n)

  Let's assume that a 220kW motor runs at 185kW load at full speed, that the cost of energy is $0.25/kWh, excluding demand charges or other charges that vary from one supply authority to another, and that is takes four (4) hours to fill the tank at full speed from a low level trigger point to run the pump until the tank is full.

  The cost to run the pump would be:
  185kW x 4hrs x$0.25/kWh x365 = $67,525 per annum.

  If it is possible to extend the tank fill time and we reduced the pump speed to 35Hz (70%) as per above, the power reduces to 40%(approx.) = 74kW and the flow reduces to 70%, hence to pump the same volume of water, we need to run the pump for 30% longer.

  The cost to run the pump now would be:
  74kW x 4hrs x 1.3 x$0.25/kWh x365 = $35,113 per annum, which is a $32,412 saving and payback for the 220kW drive itself is around one year, so worth the consideration.

Electronic Power Solutions have many years of experience in motor control applications for pump systems. There are many options for single and multiple VSD based pump systems, softstarter based pump systems, as well as systems that combine both technologies.

Evolving motor technologies to further improve energy efficiencies, such as Permanent Magnet Motors (PM) and Synchronous Reluctance Motors (SRM) are being designed to operate only with VSD's rather than DOL or Softstarter control. Various efficiency standards have already been adopted in Europe and the USA that require these standard be met.
Australia will follow the same path and will mostly adopt the same standards to force increased energy efficiency in motor driven systems into the market, likely by mid 2016.

In addition to only considering energy savings when deciding whether to use a VSD or a Softstarter in a pumping application, many pump-specific control functions are built into quality VSDs as standard to overcome common hydraulic issues, including Deragging, Pipe Fill, Initial Ramp, Flow detection, Lubrication control, Broken pipe detection, Dry run detection, Check valve ramp, etc.
More information is available from EPS on request:

We will be happy to discuss your pump system requirements with you to help select the best technology and functionality for your application.

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