Pump ED 101

Calculating Pump Starts & Cycle Time

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Starting can have a significant effect upon the life of the winding insulation of an AC motor. For this reason motor manufacturers often limit the number of starts per hour and may also require some minimum run time and off time between starts. There are two events that occur during across the line starting that can reduce insulation life.

When started across the line, a typical AC induction motor experiences an inrush current that can be ten to twenty times greater than its full load current. This higher current is required to establish the magnetic field in the stator core. Its intensity and duration (a fraction of a second) is independent of the load and depends entirely upon the motor design. Another starting component, known as locked rotor current, can also be very high (five to seven times full load current) and its intensity and duration depends upon the load type and the time required to attain normal slip speed. In variable torque loads (centrifugal pumps), the intensity and duration of locked rotor current depends upon the inertial loads contributed by the various components of the system. Even though both of these high current levels exist for a relatively short period of time, they can create hot spots in the stator which can lead to local failures and also contribute to an increase in overall winding temperature. Since insulation life is reduced as temperature rises, the additional heat generated during starting can be a major factor if starts exceed the recommended number per hour.

In addition to increased temperature, motor starting has another effect upon the stator windings. According to Newton's third law of motion, for every action there is an equal and opposite reaction (an interaction). In any interaction (in the case of an AC motor, interaction is between the magnetic fields of the stator and rotor) there is always a pair of forces that are equal in magnitude but opposite in direction. During starting, the action is the force of the rotating magnetic field in the stator on the stationary rotor. The equal but opposite reaction is the force on the rotating magnetic field that arises from the inertia of the rotor and the load it is driving. The effect of this interaction is a minute movement of the stator windings which, over time, can erode the insulation.

Although there are a variety of pump applications that utilize across the line starting, one of the more popular is wastewater pump down. In these applications, the pump starts when the wet well reaches some maximum level and shuts off at some minimum level. The run time and starts per hour depend upon the pump flow rate, wet well capacity, and the inflow volume. It is very important that all three of these factors be integrated into the design of a pump down system in order to meet the motor manufacturer's requirement for maximum starts and minimum on and off times.

PUMP CYCLE CALCULATOR	Joe Evans		www.PumpEd101.com			
Enter the required data in cells C8 - C12. You may enter additional inflows in cells D12 - H12 for a comparison. If a sircharge volume is entered in D11, it will be included in all calculations.						
INPUT DATA						
Wet Well Diameter (inches)	84					
Pump Down Distance (feet)	3.0					
Average Pump Flow (gpm)	450					
Surcharge Volume (if applicable)	0					
Average InFlow (gpm)	50	100	150	200	250	300
CALCULATED RESULTS						
Pump Down Volume (gal)	863					
Wet Well Fill Time (min)	17.3	8.6	5.8	4.3	3.5	2.9
Run Time (min) No inflow	1.9					
Run Time (min) With Inflow	2.2	2.5	2.9	3.5	4.3	5.8
Starts / hr With Inflow	3.1	5.4	7.0	7.7	7.7	7.0

The screen shot shown in Figure 1 is my Excel based Pump Cycle Calculator. Once a system curve has been developed, it will allow you to evaluate a particular pump selection based upon the three factors mentioned above. Upon entry of the required data, the calculator computes the pump down volume, the fill time at various inflow rates, minimum run time, run time at various inflow rates, and the starts per hour. At an inflow of 250 GPM, the pump shown in the example would start about eight times per hour and remain off just 3.5 minutes between starts. If this were a higher head pump that requires 10 HP or more, these conditions would probably be unacceptable. There are several ways to fix this problem. If the entered flow rate must be maintained, the wet well diameter and / or pump down distance can be increased. If wet well changes are not practical, a pump with a reduced flow rate can be substituted.

You may have noticed an optional piece of input data that you did not recognize – -

surcharge volume. Up here in the Northwest the surcharge volume is most often associated with storm water pumping systems but it is sometimes seen in traditional wastewater applications. It represents the additional volume that can be stored in the inflow piping and manholes, a lagoon or even a street. These areas can provide a substantial storage volume and inflow duration. The maximum elevation of the surcharge storage will be the same as the maximum allowable wet well level. This calculator is also designed for use with systems that utilize surcharge areas. If a surcharge volume is entered, the average inflow values should reflect the effect of surcharge volume on maximum inflow.

Joe Evans is responsible for customer and employee education at PumpTech Inc, a pumps and packaged systems manufacturer and distributor with branches throughout the Pacific Northwest. He can be reached via his website www.pumped101.com. If there are topics that you would like to see discussed in future columns, drop him an email.