Pump ED 101

Off BEP Energy Cost

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Last month, I discussed my Draw Down calculator and its role in determining the actual operating point of wastewater pumps. Like several of my previous articles, it focused on off BEP operation and the damage that can occur due to unbalanced radial forces and recirculation. The premature failures that occur in these pumps increases down time and the repeated repairs are extremely costly. You will probably think that I am beating a dead horse as this month's article also addresses off BEP operation. But, this time it is from a different perspective. Instead of the cost due to increased maintenance and repair, we will review how it can affect electrical power costs.

Lev Nelik's July, 2011 Pumps & Systems column discussed the energy savings that can be achieved by replacing the impeller on a particular pump with one that is designed to operate at BEP under existing system conditions. The example he used was a rather large pump (40,000 GPM) operating at 50% of BEP flow (20,000 GPM). The energy wasted by this pump annually was a whopping 3.1 million kWh! You may be surprised how much can be wasted by much smaller pumps operating at 80 to 85% of BEP.

One of the seminars that I present at various water and wastewater conferences is "Determining the Long & Short Term Costs of Pump System Efficiency". In this seminar I break down a pumping system (either installed or proposed) into it various components and evaluate their individual contribution to the overall efficiency of the system. Achieving higher efficiency in a pumping system usually increases the initial costs but, those costs are often offset by the long term savings. When you break a system down into individual components it is easier to assess those short and long term costs.

Obviously, pump and motor efficiency are major contributors to overall system efficiency. As would be expected, higher efficiency pumps will typically have a higher first cost because, quite frankly, they are usually designed and built to a higher standard. One or two efficiency points may not have much of an effect in some applications but when the difference is 5 percent or more, the long term return should be evaluated. Installed pumps will lose efficiency over time due to wear and corrosion. My 2010, two part series on restoration and coating showed how the Monroe County Water Authority in Rochester, N.Y. reduced electrical consumption substantially. Even though the procedures appeared quite expensive (4k$ to 13k$), the payback period was often less than one year.

With the advent of EISA all three phase motors from 1 to 500 HP manufactured after 12/19/2010 must meet the premium efficiency standard. Therefore new installations will take advantage of increased motor efficiency unless, of course, you have an old motor in your warehouse. EISA standards do not apply to motors purchased prior to its inception and those motors can also be rewound and continue to be used. When evaluating the efficiency of existing pumping systems the cost of replacing older, lower efficiency motors should be evaluated.

One of the examples I use in my seminar is an Excel calculator that compares the wire to water efficiency of two different pump and motor combinations. It was the subject of my March 2010 Pumps & Systems article. It provides a simple payback analysis that allows you to compare the short and long term costs of two different pump and motor combinations with different operating efficiencies.

Although the pump and motor have a major effect upon the overall system efficiency, the piping system can have an even greater influence. Poorly designed piping systems typically require increased head which translates into increased horsepower. Older piping is also problematic. Not only does friction increase over time due to corrosion and build up, but increased demand will over tax their original design capability. The starting point is always the system curve as it shows the pump performance (head and flow) that is necessary to meet various conditions. When existing pumps run to the left of BEP, they will run longer at a lower efficiency and energy costs can increase substantially.

Another example that I use in my seminar is shown in Figure 1. This spreadsheet compares the same pump and motor when operating at BEP and off BEP conditions. The example included shows a pump system that

Off BEP Energy Cost Calculator

REQUIRED DATA	BEP	Off BEP
Pump Operation - Hours / Day	8	10
Pump Operation - Days / Year	365	365
Pump Flow - GPM	5000	4000
Pump Head - Feet	130	147
Pump Efficiency - %	87%	81%
Motor Efficiency - %	95.0%	95.0%
Energy Cost in $/kWh	$0.10	$0.10
RESULTS		
BHP At Operating Point	188.7	183.3
Wire to Water Efficiency (%)	83%	77%
Annual Pumpage (gal)	876,000,000	876,000,000
Annual Energy Consumption (kWh)	432,610	525,418
Annual Energy Cost	$43,261.04	$52,541.83
kW Per 1000 Gallons Pumped	0.494	0.600
Cost Per 1000 Gallons Pumped	$0.049	$0.060

was designed for 5000 GPM @ 130'. Due to a design error, friction was miscalculated so the actual flow is limited to a maximum of 4000 GPM @ 147'. In order to meet the required daily flow, the pump must run an additional two hours each day. In addition to the longer pumping cycle, it is also operating at a lower hydraulic efficiency and the head required is higher. These last two factors increase energy consumption and results in an increased cost per 1000 gallons pumped.

So, what are the options? The most obvious fix would be to modify the piping and get the pump back to BEP flow. If this is not cost effective, a smaller pump with a better efficiency should be selected. An increase in efficiency from 81% to 85% at 4000 GPM would reduce the cost per 1000 gallons to $0.057 and save almost $2500.00 per year in electrical costs. A more efficient fix would be to select a pump with a BEP flow that reduces the system head to its original calculated value – say 3000 GPM @ 130' for example. Although the pump would run several hours longer than the one pumping 4000 GPM, energy costs would be close to the original 5000 GPM estimates.

Energy consumption for a given volume of pumped fluid can be a bit perplexing. It has nothing to do with the flow rate of the pump. It is all about wire to water efficiency and the head required. An increased flow rate will increase the horsepower required but horsepower is an indication of the work performed per unit of time, so a higher flow rate does more work in a shorter period of time. For example, if a 500 GPM pump and a 1000 GPM pump have the same wire to water efficiency and are pumping against the same head, the energy required to pump 1000 gallons will be the same for both. If you increase the head or lower the efficiency of either, its energy consumption per given volume will increase.

Joe Evans is responsible for customer and employee education at PumpTech Inc, a pump & packaged systems manufacturer & 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.