Discussion of

Assessing variable speed pump efficiency in water distribution systems

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By Thomas Walski

The authors have done a very nice job in their overview of efficiency of variable speed pumping. Their discussion on motor efficiency fills a niche in the water literature. This writer would like to provide some additional information in terms of: 1. Terminology, 2. Use of variable speed pumping with storage and 3. Use of variable speed pumping with no storage.

Terminology

What the authors refer to as an "inverter" is what is referred to as a "variable frequency drive (VFD)" in the Americas, Europe and the Middle East. In my experience, an inverter is a device that converts DC power into AC power, which is one component of a VFD.

An inverter (or VFD) is just the latest in a string of different electrical and mechanical technologies to control the speed of pumps. Others include hydraulic couplings (hydroconstant), eddy current drives, DC voltage control, and slip recovery to name a few.

Use of variable speed pumping with storage

I have conducted numerous analyses comparing variable speed pumping to constant speed pump in systems for the relatively flat system head curves in water distribution systems (Walski, 2001, 2005, 2111; Walski, Bowdler and Wu, 2005). In each case, when a pump is selected to correctly match the system, the constant speed pump has a lower energy cost than the variable speed pump whether the storage is on the discharge side as in elevated water storage or on the suction side as in a wet well at a sewage pumping station.

I have done these comparisons so many times that I jokingly refer to it as Walski's Law, "The most efficient speed to run a variable speed pump is OFF." As long as there is storage to enable the pump to be turned off, it is best to run it at an efficient point and then turn it off. Running a variable speed pump at a low speed is inefficient.

I'm sure there are exceptions somewhere but given the flat nature of water distribution system head curves and most sewage force (rising) mains, constant speed pumping uses less energy and the author's example case is probably not a good one to illustrate the comparison that they want. This is because real water system demand curves show a fairly large variability in demand over the course of the day and the authors did not account for such large variations. If they had based their analysis on an extended period simulation, they would have seen how inefficient variable speed pumping can be.

So why bother with variable speed pumping?

Use of variable speed pumping with no storage

Variable speed pumping becomes more attractive in distribution systems that have no discharge side pumping and hence the pumps cannot be turned off. Instead, they must be run continuously. However, a constant speed pump will produce excessive head during low demand periods. This lack of elevated storage usually is found in small pressure zones although there are some very large pressure zones with no floating storage (usually very flat areas where elevated storage is expensive or cold areas where freezing is a problem).

In these cases, the inverter (VFD) is almost always controlled by the pressure immediately downstream of the pump. Since suction side pressure usually doesn’t vary by much, the system head curve is essentially flat.

In these cases, the analysis usually boils down to comparing variable speed pumping with constant speed pump plus storage. This becomes more than a comparison of the present worth of energy cost as the cost of installing storage must be compared with the cost of the inverter, standby generator and additional fire pumps since storage tanks can provide fire and emergency flow. The transients caused by start up and shut down of the fire pump can also be problematic. Because of the flat system head curve, the energy cost of the storage system will be lower than the variable speed system but the entire life cycle cost of the system must be analyzed.

As an example, I ran of small model with realistic demand patterns and pump characteristics using the WaterGEMS software (Bentley, 2012). The overall energy use was 99 kwhr/ML for constant speed vs. 115 kwhr/ML for variable speed pumping. Figure 1 shows a comparison of flow, wire-to water efficiency and cost per unit of pumping for a scenario with a constant speed pump and an elevated storage tank vs. a variable speed pump. Notice that as the flow approached that corresponding to full pump speed, the efficiency and unit cost of variable speed pumping approached that of the constant speed pump.

Another way of viewing the data is to look at the actual operating points for the pumps. Figure 2a shows the operating points for the constant speed pump while 2b shows the points for the variable speed pump at three times corresponding to low, medium and high demand. Notice how the head stayed the same for both types of pumps but the variables speed pump showed widely varying efficiencies.

Summary

The authors are to be commended for the insights they provide on this important problem. There is not a simple answer to whether variable speed pumping is advantageous and the authors did a nice job of pointing out many of the issues. I hope that I have provided some perspective to the paper with the comments based on my experience.

References

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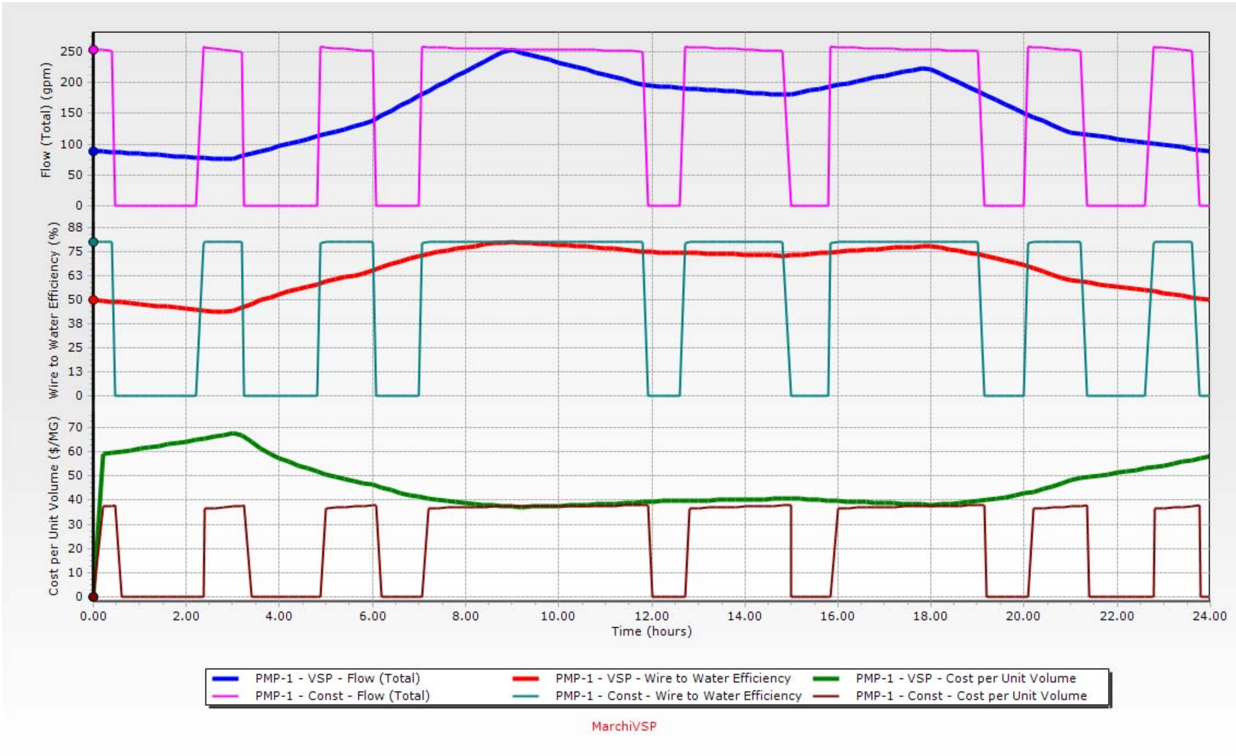

Figure 1. Time graph showing comparison of flow, efficiency and unit energy cost for constant and variable speed pumping

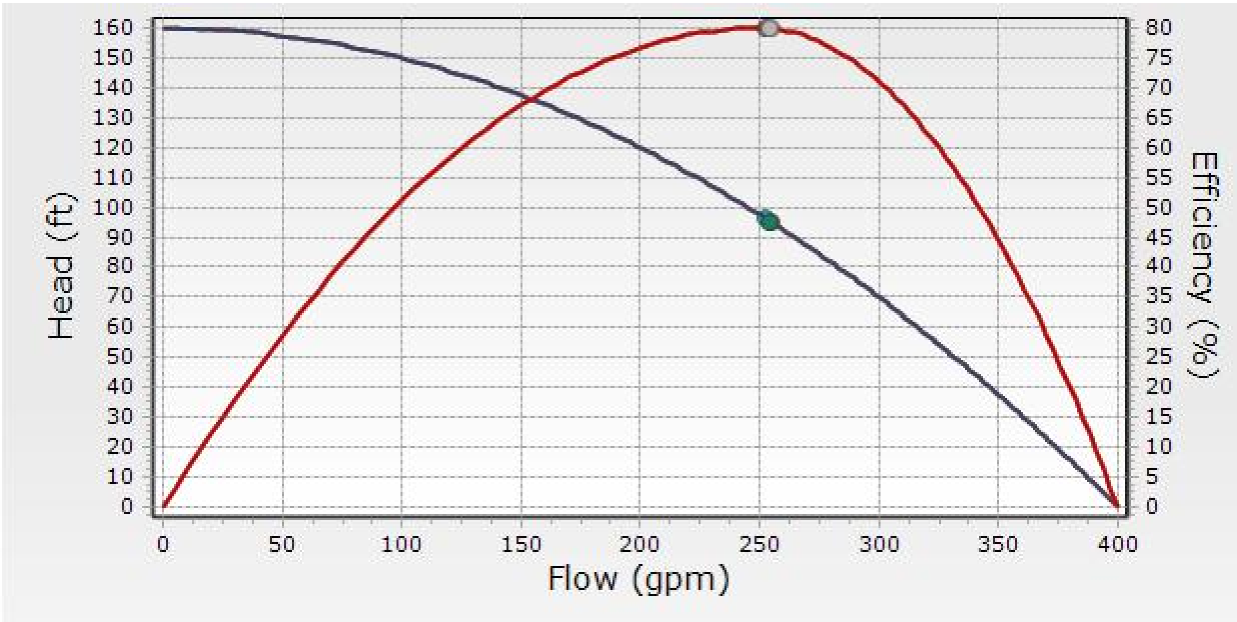

Figure 2a. Head and efficiency at three time for constant speed pump

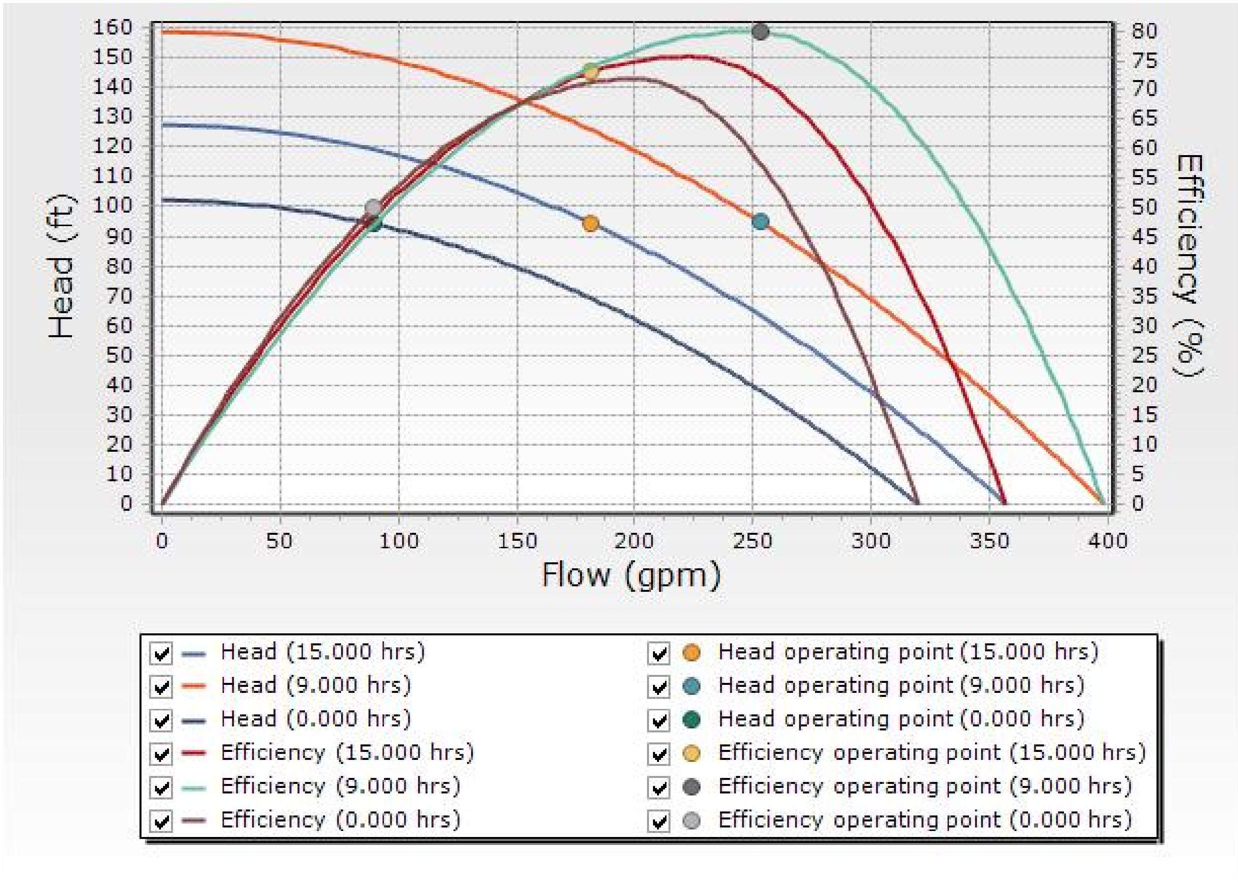

Figure 2b. Head and efficiency at three times for variable speed pumping