Pump ED 101

Variable Speed Pump Selection – Part 2 Vp-Vf

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Last month we reviewed the pump selection criteria for a typical constant pressure – variable flow (Cp-Vf) application that utilized variable speed (VFD) control. This month we will take a look at an application where pressure varies in proportion to a change in flow.

Two of the most common variable pressure – variable flow (Vp-Vf) applications are closed and open loop circulation. In closed loop systems, the piping system extends from the pump discharge back to its suction. Once the loop is full and flow is initiated, the only force that acts against that flow is friction. Even when pumping to a higher elevation, as in a high rise building, the weight of the water in the down leg counterbalances the weight of the water in the up leg. Because the weight is neutralized, the pump can be located any where in the loop. In fact, if we could come up with a way to eliminate the friction we could shut off the pump and the loop would become a perpetual motion (flow) machine!

Open loop systems are a little different - - instead of a continuous piping system, there will be a "break" somewhere in the down leg and suction lift can also be involved. Thus both elevation and friction will act against flow. Because of the elevation component, the pump selection process can be slightly different for these two applications. This month we will look at a closed loop example.

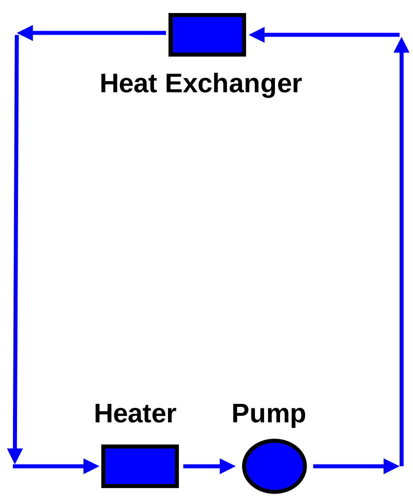
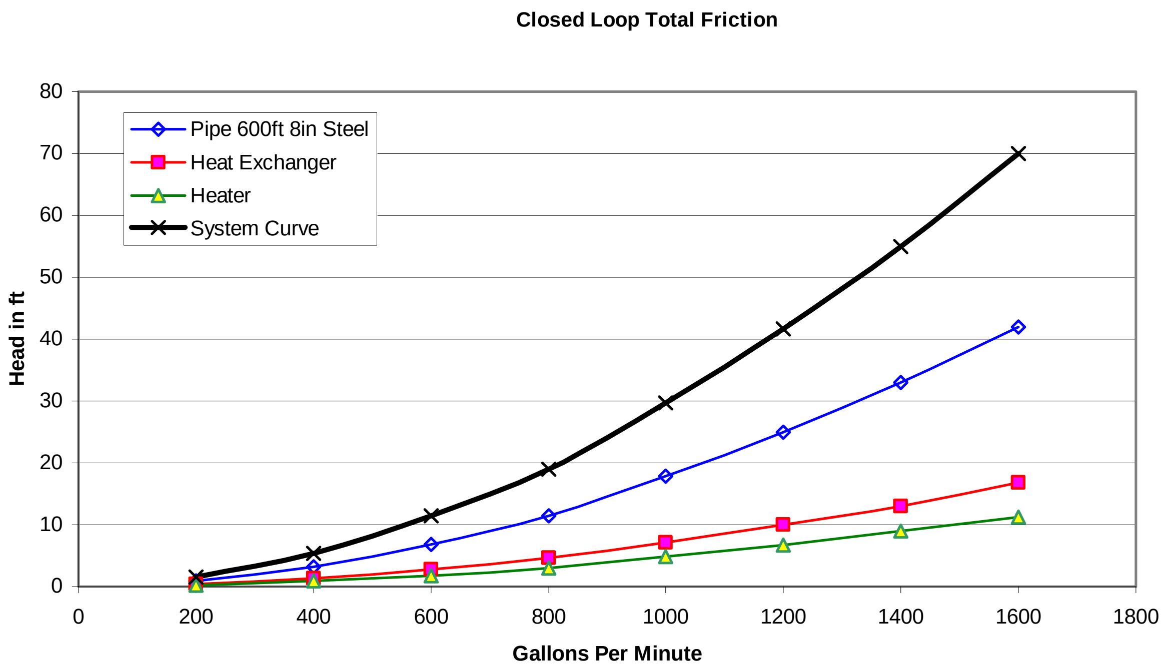


Figure 1 is a very simple closed loop application that circulates heated water through a heat exchanger. As I said elevation is not a factor but there are three components that will contribute to friction within the system. The first one is the friction that arises in the piping system. It will be determined from a friction table and is based upon the flow rate and the length, diameter and composition of the pipe and fittings. The second and third involve the friction that arises within the heater and heat exchanger passages at various flows. These tables or curves are provided by the manufacturer.

The System Curve

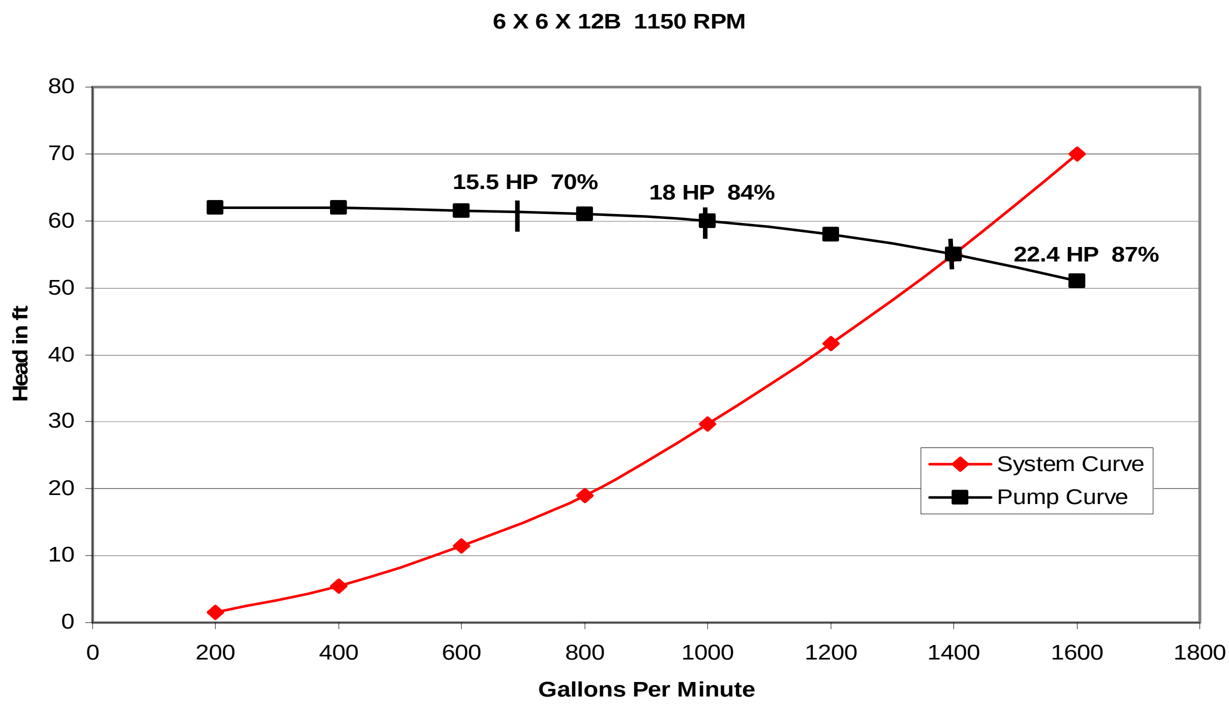
Figure 2 shows the system curve for this application and the curves for the three frictional components we just discussed. The blue, red, and green curves



represent the friction generated by the piping, heat exchanger, and heater. The black system curve is simply the sum of those three curves at each flow point. The total system friction ranges from about 2 feet at 200 GPM to about 70 feet at 1600 GPM.

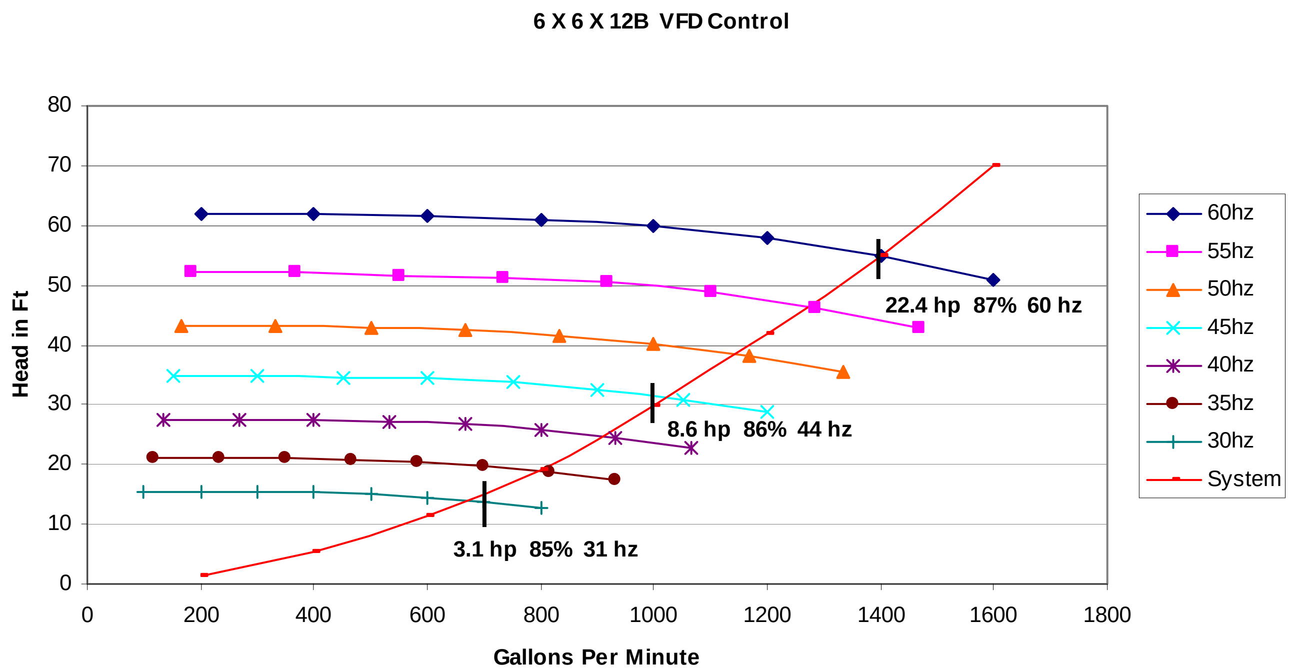
Pump Selection

Figure 3 plots the H/Q curve of a potential pump selection against the system curve we developed in Figure 2. The pump must provide flows of 700 to 1400 GPM while running at a constant speed of 1150 RPM. The plot shows a full flow efficiency of 87% and a healthy 70% at 700 GPM. The average efficiency across the full range of flow is 80%. Like the PRV controlled, constant pressure application we discussed last month, the H/Q curve I have selected for this application is quite flat. A rise of just six feet from maximum to minimum flow maximizes power savings as flow is reduced. The data labels show that BHP is reduced from 22.4 at 1400 GPM to 15.5 at 700 GPM (a 31% reduction). This pump appears to be a good candidate for this fixed speed application but, will it operate satisfactorily under variable speed control?



Last month I said that flat curves are usually not a good choice in VFD controlled constant pressure applications due to their limited control range. This is not the case when the pressure required by an application changes in proportion to a corresponding change in flow. In closed loop applications curve shape is usually not a factor because a system curve that is due solely to friction can be very similar to the BEP curve formed by a change in speed. This similarity is due to the fact that the head that arises, due to friction, mimics the second affinity law. If you check out the friction tables you will see that friction, for a given pipe diameter, increases at a rate that is just slightly less than the square of an increase in flow.

Figure 4 shows this same pump under VFD control. The variable frequency curves range from 30 to 60 hz in 5 hz increments. If you follow the BEP flow point (second point from the right) for each speed you will note that it closely matches the system curve at that point. This keeps efficiency high and provides for a major reduction in power as speed is reduced. At a mid range flow of 1000 GPM, just 8.6 HP is required compared to 18 HP in the fixed speed example. Even at the minimum flow of 700 GPM efficiency improves from 70% to 85% and BHP is reduced from 15.5 to 3.1.



So, the answer to my question is yes - - this particular pump will perform very well under variable speed control. But, unlike Cp-Vf applications, it is not due to the shape of the H/Q curve. Both steep and flat curves can perform equally well in a closed loop application. Next month we will evaluate pumps for open loop applications.

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