

**In this month’s issue, we discuss system curves and how understanding the relationship between pump and system is a useful tool in system operation and troubleshooting.**

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In last month’s issue we discussed how every pump has a unique set of performance characteristics. Pump curves provide a graphical representation of these characteristics that typically display Flow, TDH, Brake power and Net Positive Suction Head Required (NPSHR) . Single line curves, such as the one shown here, are based on a fixed impeller diameter at a single speed. Most pump manufacturers also provide multi-line curves that display pump characteristics over either a range of speeds or diameters.

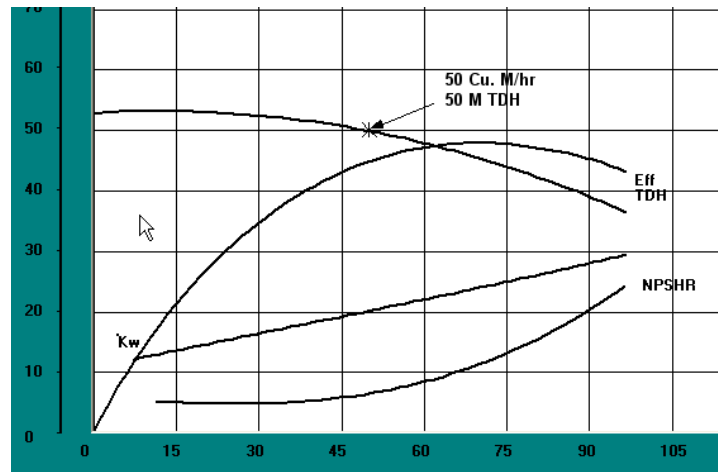
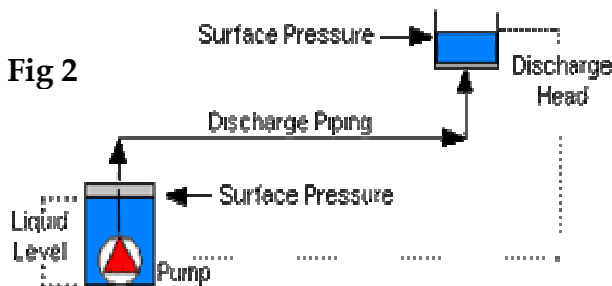


Fig 1

The pump curve in Fig 1 is marked with a rated operating point flow rate of 50 M<sup>3</sup>/hr flow and 50M Total Dynamic Head (TDH). This rated operating point, specified by the purchaser, is based on an analysis of the system where the pump is to be used.



Systems take on an almost infinite number of forms, ranging from the simple to the complex. However, regardless of the complexity, all systems have some combination of static pressure and frictional resistance that will vary with fluid characteristics and velocity.

Fig 2 is a simple schematic of a typical sump pump system where a submerged pump is moving liquid through a system of pipes and valves to another location<sup>1</sup>. In this example, we have a submersible pump located 3 M below the liquid surface in an open pit. The pump transfers water a distance of 380 M through 3in pipe to another sump. The elevation change from the pump impeller to the discharge into the 2<sup>nd</sup> sump is 8M.

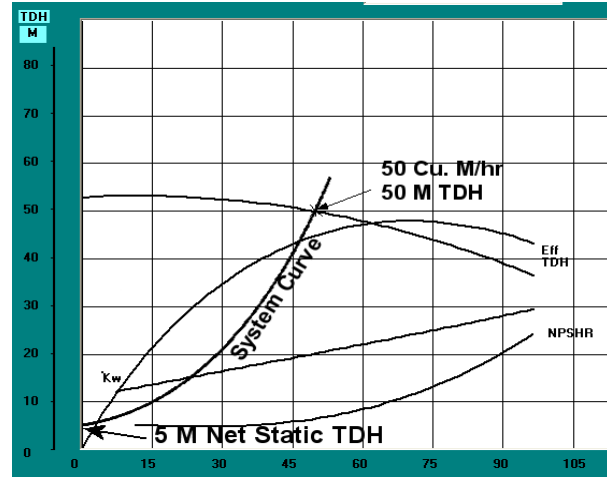


Fig 3

The amount of TDH required for any given flow may be plotted on a system curve (Fig 3). The net static head, at zero flow, is the difference between the 3 M of submergence and 8 M of discharge head, or 5 M. The engineer can then use software or published hydraulic tables to calculate the system head for any particular flow. For this application the total system resistance for our 50M<sup>3</sup> flow rate is 50 M TDH made up of 5M static head, 4M of head losses in various valves and fittings, 40M of head loss due to pipe friction, and about 0.5M of velocity head associated with the kinetic energy of the moving water. The pump produces 50M TDH at a flow rate of 50M<sup>3</sup>/hr; therefore, the pump and the system will be matched. This is graphically depicted in fig 3 above.

At the moment when a pump starts, there is little frictional resistance to flow (Fig 4). Friction builds as the piping system fills. The pump operates at a very high flow rate during the period that the system is filling. In the example of our sump, the pump, at the moment of start-up, would have almost zero resistance and would operate at its right-hand most point of nearly max flow and zero TDH. Manufacturers refer to this as the run-out point. As the system fills, resistance would build until the design system curve is established. This is a characteristic of all centrifugal pump start-ups. Centrifugal pumps that have power curves that increase with flow should be started with a throttled discharge to prevent a high current condition associated with the combination of starting inrush current and

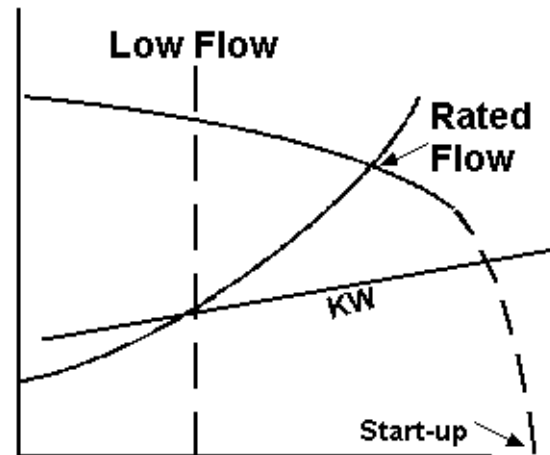


Fig 4

<sup>1</sup> Fig 2 courtesy of ePUMP-FLO® <http://www.pumpflo.com/solutions>

maximum pump load. The notable exception to this are axial flow pumps which have a power characteristic that decreases with an increase with flow. For this reason, axial pumps should be started in a valve open condition .

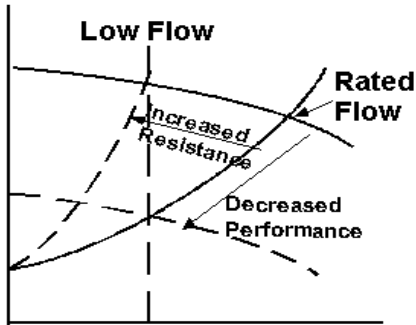


Fig 5

It is important to remember that a **pumping system will *always* operate at the intersection of the pump curve and the system curve.** The pump and system curve *always* intersect. This should be kept in mind when troubleshooting. For example: Low flow in a system suggests that either the system curve has shifted so as to cross the pump curve at a lower flow, or the pump performance has degraded so as to intersect the system curve at a lower flow (Fig 5).

An obstruction to flow downstream of the pump would result in the system curve shifting to cross the pump curve at a lower flow and higher pressure than the rated point. If the pump discharge pressure corresponds to a low flow on the original pump curve, an obstruction is a good possibility.

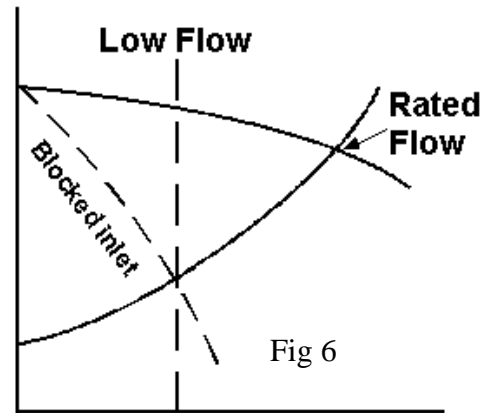


Fig 6

If the pump is momentarily run near shut-off<sup>2</sup>, a TDH that is below the original pump curve is indicative of pump wear (Fig 5). A TDH at or near the original TDH, that falls off rapidly as the discharge valve is opened, is indicative of a blockage in the pump inlet (Fig 6).

Using the 'as built' system and pump characteristics, in conjunction with collection and careful analysis of operating data, can be a time and money saving tool when troubleshooting production problems.

Next month we'll look at systems that involve parallel pump operation and the requirements for continuously rising head curves.

<sup>2</sup> Consult with the pump manufacturer before running this test to verify minimum flow rates. This test is generally only viable for pumps below 150 kW.