Maximizing Pump Reliability, Minimizing Cost

Choosing the best pump for a system is not a simple task, as many engineers know. At minimum, the pump must deliver the required flow rate. However, a better pump will not only operate at the required flow rate, but it will also be reasonably priced, cause minimal downtimes, be easy to maintain, and have a long operational lifetime. In the oil and gas industry, all these points are important to ensure safe and profitable operation. Designing with efficiency as the primary goal will allow all the conditions above to be met. It is therefore important to understand why pump efficiency is important, and how to increase efficiency during the design process.

By Stephanie Villars, Applications Engineer, Applied Flow Technology (AFT)

Pump Best Efficiency Point

High efficiency not only affects the energy costs for operating a pump, it also impacts the wear on the pump. Operating at flowrates above the best efficiency point (BEP) can result in cavitation, as well as excessive vibration and heat at the pump. When operating below BEP there are risks of pump seizure, low flow cavitation, fluid recirculation and high temperatures. All of these occurrences can damage the pump, thus decreasing the reliability and lifetime of the pump.

Since it is not practical to operate directly at BEP, a preferred operating region is provided by API 610, API's published standard for the petroleum, petrochemical, and natural gas industries. Operating within the preferred operating region will minimize the negative effects caused by operating away from BEP. Section 6.1.12 of the standard defines the preferred operating region for pumps to be within 70% to 120% of the BEP flowrate.

There are a few exceptions to this rule, which are mentioned in the standard. For low specific speed pumps, it is noted that the pump may not be able to operate above 105% - 110% of BEP. This will be clearly specified on the manufacturer's provided pump curve. The standard also allows for pumps that operate outside of the preferred operating range if they have been proven to operate reliably in similar systems.

Determining an Accurate Operating Point

Choosing an effective pump based on BEP requires the engineer to determine the required head, flow, and power based on the system. This is simple for a relatively new system with information available on the pipes and components. The process becomes more complex when there is not much information available, the system is old, and when there are branching points in the pipeline.

To get the best estimated operating point, several factors should be taken into account:

1) Consider both maximum and minimum cases

Designing a pump for the maximum flow case is important, but this does not mean that other flow cases should be neglected during the sizing process. If variable demand is anticipated, due to factors such as the market demand, then considering the full range is important to ensure that the pump operates within the preferred operating range for all conditions.

For systems with a large range of flows, a variable speed drive may be useful to keep the pump operating within the preferred operating region at reduced flow rates. Though this is more expensive than simply using a valve to throttle the pump, the maintenance costs over time will be significantly decreased.

2) Use design factors wisely

There are uncertainties in all engineering calculations when determining the system loss. Generally, the philosophy to account for this is to design 'conservatively' and overestimate the head loss in the system. While it is good engineering practice to make conservative estimates, it is important not to overestimate. Exceeding the preferred operating region can be just as damaging to the system as operating below the required flow. Field measurements and experience with similar systems can help with determining an appropriate safety margin to apply to your head loss estimates.

3) Use pipe system modeling software to simplify calculations

A good hydraulic simulation software can provide a more efficient process for evaluating the proposed pump and system. This reduces the possibility for error as compared to spreadsheet calculations. Simulation software can also be a good tool to evaluate different operating cases for a single system. Automated sizing tools might be considered to speed up this process further.

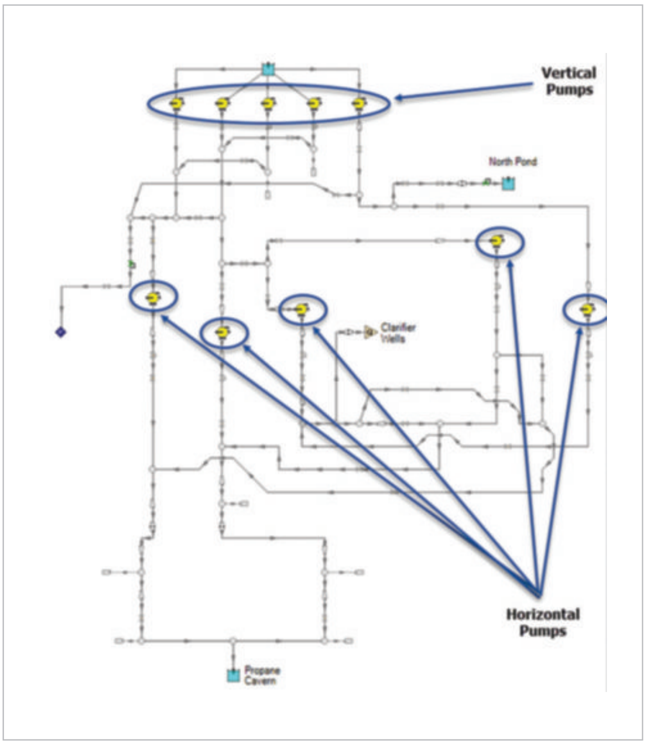

Figure 1: Simplified AFT Fathom flow model highlighting the locations of the five horizontal and five vertical pumps used in the system. Multiple cases were evaluated for the system by closing and opening different pump combinations.

Pump Configurations

A project that involved a raw brine injection system for a North American chemical plant can provide an example of the problems a system can face when pumps are sized without keeping pump efficiency in mind.

In this case, the pumping system was being used to deliver product from underground caverns and clarifier wells. Over the course of five years of operation, 41 repairs were required on the system costing over $1.23 million dollars. An AFT Fathom model of the pump system can be seen in Figure 1. A consulting group was requested to perform a reliability study on the system and found that the current pump configuration was causing the pumps in the system to compete hydraulically, and to operate in the range of 30% - 50% of BEP.

Modeling different combinations of pumps allowed the consulting company to recommend an alternative method to operate the existing pumps in order to achieve the desired flowrate. The proposed combination allowed the operating pumps to achieve a flowrate at 75% of the BEP flowrate for each of the pumps.

Final Thoughts

Maintaining a high standard for pump efficiency has many clear benefits, including higher reliability, reduced pump maintenance, and decreased energy costs. To reach these goals, a thorough understanding of the operating system is important. Using poor estimates for the system resistance can lead to the pump operating far from the preferred operating region. This can be an expensive mistake due to added maintenance costs over the pump lifetime, and the loss of productivity during those downtimes. Investing the time into properly sizing pumps for oil & gas systems must be a priority in order to make these systems safer and maintain low costs over the system lifetime.

About the Author

Stephanie Villars is an Applications Engineer with Applied Flow Technology (AFT) where she provides technical support to individual clients using AFT products. Stephanie is a graduate of the Colorado School of Mines with her Bachelor of Science in Chemical Engineering with a minor in Computational and Applied Mathematics.