

Minimizing Pumping-System Friction Losses

Curtis Dietzsch

Reducing the causes of friction and choosing the proper pump will increase efficiency and cost savings.

Imagine a major-league pitcher standing on the mound. He looks for the signal, nods in agreement, starts his windup, rears back and propels the baseball toward home plate. The pitch's maximum velocity is reached at the moment the ball leaves the pitcher's hand. From that point, studies have shown that the velocity decreases by one mile-per-hour (mph) for every 7 feet traveled. If a pitch leaves the pitcher's hand at 100 mph, by the time it covers the 60 feet, 6 inches to home plate, it will be traveling at around 92 mph.

Conversely, if the mound were only 30 feet from home plate, a 100-mph pitch would be moving at 96 mph upon arrival at the plate, making the pitch much more efficient and harder to hit. A 100-mph pitch thrown from second base to home plate—a distance of approximately 128 feet—would have a velocity of only 82 mph when it crossed home plate, making it much less efficient and easier to hit.

The pitched ball slows because of air resistance, or drag, that it encounters upon leaving the pitcher's hand. Many variables contribute to the drag imparted on the ball. Among them are air density, gravity, altitude, temperature, wind velocity and direction and barometric pressure. If the pitch were delivered on the Moon, for comparison's sake, it would travel much farther—due to the Moon's gravitational pull being one-sixth that of the Earth's—and maintain its initial velocity because the Moon has no atmosphere (air) to slow it down.

Imagine a piping system, and the medium travelling through it is propelled by a mechanical pump. Much like the thrown ball, the pumping systems that operate most efficiently are those designed to have the media—which can range from water to more viscous fluids to semi-solids such as concrete—travel the shortest, most unobstructed path possible.

The Challenge

The challenge during fluid-pumping operations is the unavoidable fact that energy and efficiency losses are inevitable. The culprit in this scenario is friction. As fluids flow

through pumps, pipes and fittings, there is resistance, resulting in a decrease in pumping pressure and velocity, which adversely affects pumping efficiency.

The amount of energy lost due to friction depends on a number of factors. The losses are caused by the following:

- Friction between the fluid and piping walls
- Friction between the adjacent fluids (higher viscosity fluids have higher losses)
- Amount of surface roughness on the interior of the pipes
- Turbulence created when redirecting the fluid, via a bend in the pipe or a restriction, such as a valve, fitting or reducer

Physics also play a role in the amount of friction that is created. The higher the flow rate and the smaller the pipe, the higher the resistance—and the higher the friction and its resultant effects on energy loss. System design is also a major consideration when limiting friction and increasing efficiency. The longer the pipe in which the fluid must travel, the more energy-robbing friction is produced. Also, bends, kinks, sharp turns or anything that changes the flowing fluid's course of motion in the piping create more friction, so they must be minimized.

The Solution

Basically, four possible methods are available to reduce friction losses in a piping system:

- Increase the pipe diameter of the system.
- Minimize the length of the piping within the system.
- Minimize the number of elbows, tees, valves, fittings and other obstructions in the piping system, while simplifying the layout as much as possible. If a corner must be turned, a gentle bend is better than a sharp, 90-degree turn.
- Reduce the surface roughness of the piping in the system.

One other vital consideration is the type of pump used to move the fluid. Through the years, positive displacement

pumps that use air-operated, double-diaphragm (AODD) technology have proven to be one of the most versatile for pumping fluids, regardless of viscosity.

Diaphragm pumps can only develop a certain amount of head pressure, or pressure energy, to move a fluid from one place to another. The more efficient the piping and pumping system, the more the pressure energy can be used to actually move the fluid. If the piping system is restrictive in some way (undersized and/or excessively long with unnecessary turns or valves) much of the pump's energy is wasted attempting to overcome these limitations.

At some point, the excessive restrictions will cause the pump to dead head, meaning that it will no longer have enough pressure energy to move the fluid, causing it to stall. This can damage the pump. The design of AODD pumps allows them to handle dead-heading without being damaged, which is not the case for all positive displacement pumps.

Taking into account all the factors that contribute to friction loss and the ways to combat it, advances in AODD pumping technology have led to the creation of pumps that have been designed with the priority of minimizing friction losses. These pumps have been designed with a larger flow/wetted path that reduces internal friction and maximizes output and efficiency.

These advanced pumps can also feature a bolted configuration that ensures total product containment, while elastomer options are able to meet abrasion, temperature and chemical-compatibility requirements. Advances in air-distribution systems also help increase the efficiency of these pumps for most applications.

Conclusion

Think back to the pitcher in the baseball game. In effect, the game's creators lay out their system perfectly. In the search for competitive balance, placing the pitcher's mound 60 feet, 6 inches from home plate maximized the efficiency of both the pitcher and the hitter, making the game what it is today. If the mound were 30 feet closer, the pitcher would be at an unfair advantage. If the mound were 60 feet farther back, the score of a pitcher's duel might be 20 – 18.

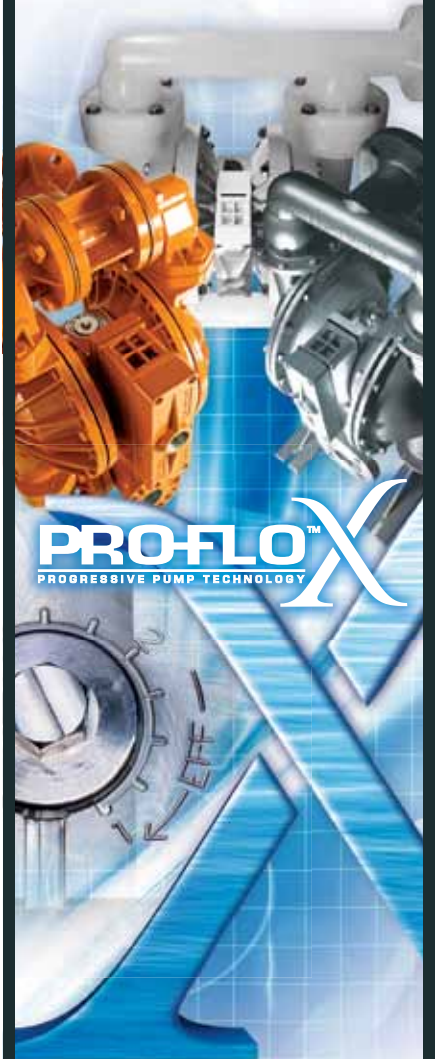
The same considerations must be taken into account when designing a piping system. The most efficient systems—ones that make the best use of a pump's pressure energy—are those designed with the least amount of impediments to maintaining the optimum flow. This means creating a piping configuration made up of the shortest possible piping runs, few or gentle pipe bends, a minimum number of obstructions and larger pipe diameters to maximize flow rate.

The best systems also need pumps that work hand-in-glove with the piping to maximize the operational ability of the system through the minimization of friction losses. AODD pumps that satisfy those parameters are those that feature advanced wetted paths that are larger and reduce energy-robbing friction losses. All these considerations will also result in a more cost-effective system with energy savings and reduced maintenance and downtime.

P&S

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