



The Necessity of Fluid Control

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Pulsation and water hammer can be limited with proper forethought and equipment.

The control of fluid dynamics is essential to ensure efficient, reliable and safe operation of pumping systems. A pump puts fluid in motion by adding energy to it. This kinetic energy, observed as pressure, is carried in the fluid and slowly lost to friction in the piping system. Uncontrolled fluid in motion can physically destroy the pump, piping, valves, meters and other system components.

Positive Displacement Pumps

Positive displacement pumps rapidly accelerate and decelerate fluids that are in motion. They derive their pumping action by capturing a specific quantity of process fluid in a chamber and then pushing it out of the pump's discharge. During the pump's suction stroke an inlet valve is raised and an outlet valve is closed, allowing fluid to enter the pumping chamber. On the discharge stroke, the inlet valve is forced closed. Hydraulic pressure created by the pump's piston opens the outlet valve to push the fluid out the discharge. This start and stop pumping action accelerates and decelerates the fluid creating units of uncontrolled kinetic energy resulting in pulsations observed as pressure spikes. Vibration is the most visible effect of pulsation and the problem that most often leads to system component failure.

Single diaphragm metering pumps create a start and stop action resulting in wide pressure fluctuations. With each stroke of the pump a small volume of fluid is discharged that must re-accelerate the fluid in the piping. The pump then has to overcome the resulting spike in pressure to continue to discharge process fluid.

A peristaltic pump, also called a hose pump, has a hose inside the case. A roller shoe at the pump inlet squeezes the hose trapping liquid in the tube ahead of it. As the roller shoe rotates, liquid is pushed out the pump's discharge. When the roller shoe releases the hose after discharge, a momentary void is created, and a partial vacuum results as some product is sucked backed to the discharge. This action, along with the normal pulsations from the pump's positive displacement nature, makes dampening the discharge flow on a peristaltic pump difficult.

The same pulsing action and pressure variations occur at the pump's inlet. As a roller shoe passes across the pump inlet and closes it off, flow into the pump momentarily stops. If the pump inlet is under positive pressure, acceleration head will cause damaging pressure spikes and vibration. If the pump inlet is under vacuum, cavitation and pump starvation can occur.

Pulsation Control

Options for minimizing pulsation damage include using heavy walled pipe; additional pipe braces; snubbing devices on equipment; and sometimes, back pressure valves. Generally, dampeners provide the most compact, efficient and cost-effective method available to control pulsation. The most common type of dampener is a hydro-pneumatic pressure vessel containing compressed air or nitrogen and a bladder or bellows that separates the process fluid from the gas charge. The dampener is installed as close as possible to the pump discharge with a gas charge that is slightly below normal system pressure.

The amount of pulsation absorbed is a function of the dampener size to pump stroke volume. The pulsation dampener absorbs the pressure spikes created by the rapid acceleration of fluid from the pump's discharge. On each pump stroke, the dampener fills with process fluid and then discharges some of the accumulated fluid when the pump is on its suction stroke to keep the fluid in motion. By controlling the fluid in motion, the dampener prevents system piping fatigue, enhances meter performance and protects gauges and other inline instrumentation. By minimizing pulsation, dampeners can be particularly beneficial in filling, spraying and chemical injection applications where an even and continuous flow is required.

Water Hammer/Hydraulic Shock

While pulsation is the effect of rapid acceleration and deceleration of fluid in motion, water hammer occurs when fluid in motion is suddenly started, stopped or forced to change direction. Whenever fluid velocity changes rapidly, water hammer should be anticipated.

Fluid velocity, volume and density all contribute to the pressure spike created when fluid in motion suddenly stops and kinetic energy is released. The kinetic energy, released as pressure, can spike up to six times the system's operating pressure, destroying system instrumentation, pumps, pipes, fittings and valves. Unrestricted, this high-pressure surge, commonly referred to as hydraulic shock or water hammer, will rapidly accelerate to the speed of sound in liquid creating an acoustic wave or transient which can exceed 4,000 feet per second. The water hammer shock wave travels the length of the pipe back to the pump, and then reverses again. It oscillates back and forth until friction dissipates the pressure spike or the weakest component in the system fails. Water hammer should be suspect whenever fluid velocity is 5 feet per second or greater.

Quick closing valves, rapid pump startup/shutdown and even changes in the pipe profile can cause an abrupt change in fluid velocity, which can produce violent and sometimes catastrophic water hammer. For

example, if the pipe is full of liquid at pump startup, that stationary liquid must be accelerated. When the pump pushes liquid into the pipe it hits the stationary liquid. When a pump shuts down, liquid continues to move down the pipe due to momentum resulting in a void at the pump discharge that is an area of low pressure. The liquid in the pipe can reverse direction into this area striking a check valve or the pump itself. A momentary power failure can create even greater hydraulic shock. When the pump stops, flow will reverse back to the pump just as power is restored and flow is restarted causing a head-on collision between the two water columns.

Generally, the most common cause of hydraulic shock is a quickly closing valve usually defined as a valve closing in 1½ seconds or less—typically a ball or butterfly type. Flow velocity is stopped rapidly, energy is concentrated and an acoustic shock wave is created. Air relief valves, vacuum breaker valves and pressure relief valves are often used in specific areas to help mitigate hydraulic shock resulting from fast closing valves.

One commonly used solution for controlling hydraulic shock is a surge suppressor. This device is similar in construction to a pulsation dampener but sized and installed differently. The surge suppressor acts as a reservoir or accumulator to absorb and release fluid as needed. By doing so, it controls the rate of velocity

change to a level slow enough to prevent water hammer. Three guidelines must be followed when using surge suppressors to prevent or minimize water hammer:

- The device must be located in the correct area.
- It must be sized properly to accumulate the correct amount of liquid.
- It must be pre-charged with nitrogen to provide the proper shock control.

Every fluid system is different and many can be complicated. This article is designed only as an introduction, and in many situations, professionals in the field of hydraulic shock should be consulted, especially before construction of a new system.

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