How to Choose a Spray Dryer Feed Pump

Take into consideration temperature, volume and—most importantly—liquid feed control.

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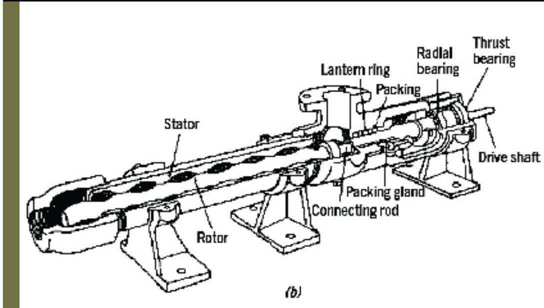
A spray dryer is a device in which a specific solution or suspension of solids and liquids is fed through spray nozzles into a drying chamber. There, it is mixed with heated air or gas to accomplish evaporation of the carrier liquid so the solids of a particular size and shape remain as the finished product.

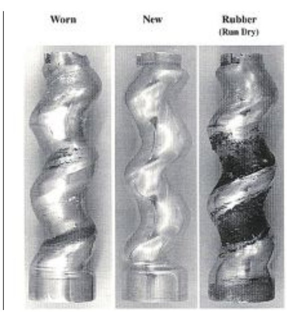
To obtain the required particle size, shape and dryness of the finished solid product, several factors must be closely controlled. While the temperature and volume of air play important roles in the drying process, they are fairly easy to control. The liquid feed step in this process, however, can be a bit more difficult.

Proper atomization of the solution or suspension is just as vital to the success of the operation and presents many more challenges when dealing with solids containing slurries. Of utmost importance is the selection of the proper spray dryer feed pump. The feed pump type and construction depend on the following variables:

- capacity
- pressure
- viscosity
- slurry shear sensitivity
- solids characteristics
    - o abrasiveness
    - o sticky/agglomerating
    - o attrition sensitivity
- liquid characteristics
    - o corrosiveness
    - o temperature
    - o net positive suction head (NPSH)

Figure 1. Typical progressing cavity pump. Figure 2. Worn rotor *(Images and graphics courtesy of FELUWA Pumps)*





The more challenging spray dryer feed pump applications involve a slurry/suspension feed that contains abrasive or agglomerating solids at pressures over 200 pounds per square inch gauge (psig). These applications have presented operational and reliability issues for many pump types that have been used historically.

Because this application requires a metering capability at relatively low flow rates (0.25 gallons per minute [gpm] to 200 gpm) against relatively high discharge pressures (200 psi to 2,500 psi), positive displacement pumps are typically required. Many types of positive displacement pumps have been used or trialed on this application with varying levels of success. This article will discuss the three most common types: progressing cavity pumps, flat diaphragm pumps and hose diaphragm pumps.

Progressing Cavity Pumps

Progressing cavity pumps (PCPs), also known as progressive cavity pumps, consist of a single helical metal rotor rotating inside a double helical elastomeric stator, which inherently forms cavities in the portions of the double helix that are not occupied by the rotor. As the rotor turns, the cavity progresses through the stator. The steel rotor seals against the elastomeric stator resulting in a pumping action that is similar to a piston pump, which is always in its forward stroke. This type of pump offers the perceived benefit of no pulsations, no check valves, relatively small installation footprint and low initial cost.

However, in abrasive duties such as spray dryer feeding, there can be a high rate of wear—first in the elastomeric stator and then in the steel rotor. As the elastomeric stator begins to wear, the seal between rotor and stator is compromised, which results in slip of high pressure slurry back to the lower pressure suction. This slip accelerates the wear and pump performance diminishes until the parts are replaced.

Because this is a rotary motion pump, shaft seals or packing are required to keep the process fluid from leaking out of the rotating input shaft. Additionally, universal joints are required to connect the concentric input shaft to the eccentric motion helical rotor. Since these universal joints operate within the solids-laden process fluid, they can also be problematic. The maintenance costs of PCPs can eclipse the low initial costs very quickly.

Figure 3. Typical flat diaphragm pumps
Figure 4. Typical check valve component
Figure 5. Ruptured/torn diaphragm

Flat Diaphragm Pumps

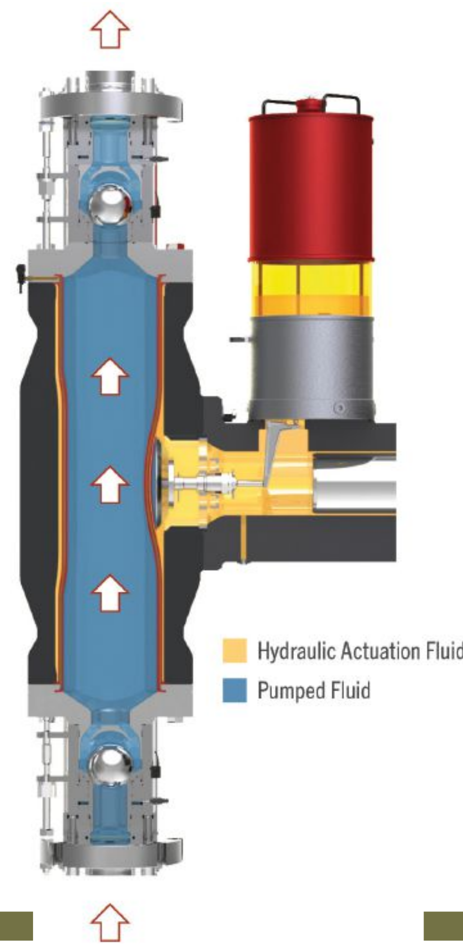
Flat diaphragm pumps use an elastomeric diaphragm typically actuated by a propellant fluid, which is actuated by a piston. Slurry is segregated from the hydraulic fluid via the diaphragm and directed in and out of the pump by means of metal check valves. This style of pump is considered a sealless design. Pulsations generated by this reciprocating pump are controlled to a process acceptable level via a downstream pulsation dampener.

In some less expensive versions of this design, a hydraulic design similar to that of a lifter in an engine is used to propel hydraulic fluid to actuate the flat elastomeric diaphragm. Typically, these lower cost designs use small, stamped steel check valves and operate at relatively high speeds (100–200 strokes per minute). This kind of pump offers the perceived benefit of a small installation footprint and low initial capital investment.

However, experience has shown that these pumps can suffer from low mean time between repairs in abrasive applications such as spray dryer feed. Flat diaphragms have a tendency to fail at their clamping location (perimeter) due to work hardening of the elastomers and build-up of solids at the clamping location.

Once a diaphragm is breached, abrasive slurry will infiltrate the hydraulic components and cause extreme wear quickly—especially on high rotations per minute (rpm) designs. Check valves that are not properly designed for solids handling can plug or fail prematurely due to rapid wear. The result of this failure mode is lack of pumping or reduced capacity. This is especially true of the lower cost models that use small diaphragms, stamped steel check valves and pump speeds in excess of 60 strokes per minute.

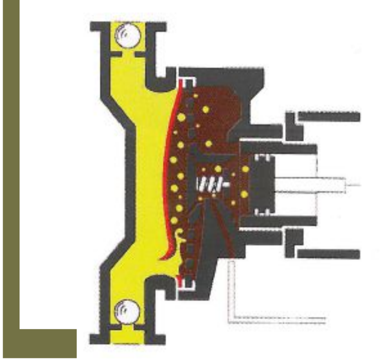
Figure 6. Double hose-diaphragm pump

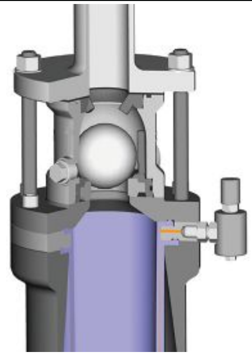


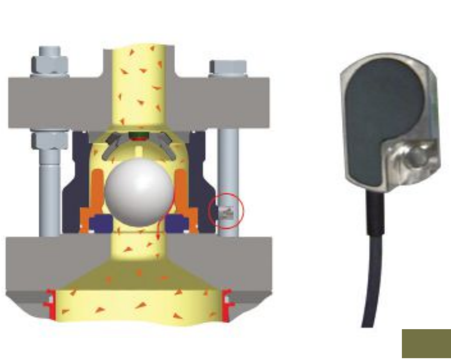
Double Hose-Diaphragm Pumps

Double hose-diaphragm pumps use a hose within a hose in place of a flat diaphragm. During operation, both hose-diaphragms are hydraulically coupled and compressed by propellant fluid, which is pressurized by a piston. The outer hose then transfers that pressure through the inner hose into

Figure 7. Hose-diaphragm clamping. Figure 8. Pressure switch at double hose-diaphragm. Figure 9. Valve performance monitoring system provides predictive maintenance.







the slurry. The slurry is directed in and out of the pump via large abrasive-resistant coated steel ball–type slurry check valves.

Pulsations generated by this reciprocating pump are controlled to a process-acceptable level via a downstream pulsation dampener. Typical operating speeds of this pump type are less than 60 strokes per minute. While this increases required installation footprint, the lower speed usually equates to much longer life of the wearing components. As a rule of thumb, wear rate is a function of the square of the difference in speed. Therefore, as a general rule with all other variables held constant, a pump operating at half the speed of another will have a service life four times the other. This style of pump is also considered a sealless design.

Because the hose-diaphragm is concentrically compressed due to its inherent design, it is subject to lower mechanical stress, which results in a longer life.

Additionally, the method of hose-diaphragm clamping prevents the accumulation of solids in this area and the resultant failures observed in many flat diaphragm pump designs.

However, unlike the flat diaphragm pump design, in the double hose-diaphragm pump design the outer hose serves as an added layer of protection of the hydraulic components from the abrasive slurry. In the event that the inner (process side) hose is breached, a pressure switch is activated to serve as notification to operations and maintenance that repair is needed. The pump is still fully operational, and slurry is still segregated from the hydraulic components allowing maintenance ample time to perform a quick routine repair instead of a complete pump overhaul.

While the check valves of double hose-diaphragm pumps are available in many different designs for suitability to different process fluids, the most typical type is large robust spherical ball check valves.

The favorable flow characteristics, good wear life and self-cleaning ability are the primary reasons they are preferred for most applications. To further decrease downtime, valves can be monitored acoustically for early detection of wear, preventing substantial loss in production due to check valve failure.

In conclusion, the spray dryer feed pump plays a very important role in the successful operation of a spray dryer system. This pump must be capable of consistently conveying sometimes aggressive, abrasive, agglomerating, shear-sensitive fluids at high pressures and variable flows depending upon the demand of the dryer. For this arduous service, special attention must be given to selection of a pump that can meet these demands with longest mean time between repair (MTBR). Pumps with inherent design advantages for abrasion resistance, low operating speeds and predictive maintenance devices will insure lowest maintenance costs and keep the spray dryer system downtime to a minimum. ■

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