Relationship of Flowrate and Pressure for Positive Displacement and Centrifugal Pumps

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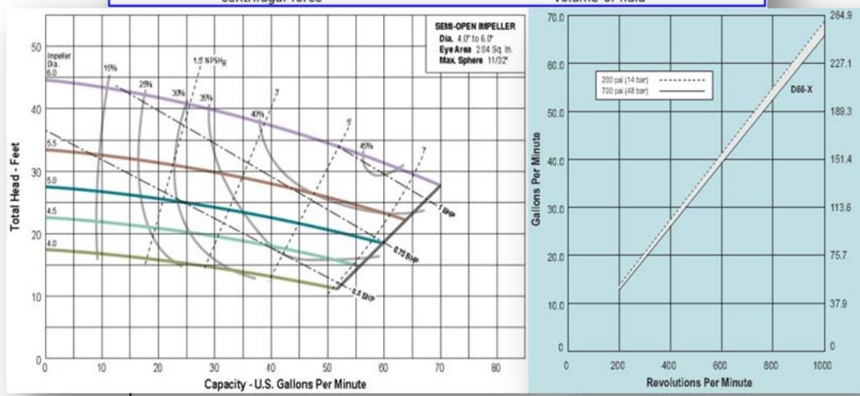
The relationship of flowrate and pressure differs for centrifugal and positive displacement pumps. This article explains this relationship using Wanner Engineering's sealless positive displacement Hydra-Cell pumps and their Stan-Cor centrifugal pumps as examples.

Centrifugal pumps increase fluid velocity due to centrifugal force

Positive displacement pumps displace a fixed volume of fluid



Pumps Create Flow, Not Pressure.

A pressure gauge reflects measurement of the resistance to the flowrate and the performance of a centrifugal pump reacts differently to that resistance than a positive displacement pump does.

The flow rate for a given size centrifugal pump at a specific shaft speed is intertwined with the discharge pressure; higher pressures are only obtained at lower flowrates. The reason for this is due to the limitations of the velocity generated and inefficiencies inherent with the spacing between the impeller and volute.

Positive displacement pumps displace a fixed volume of fluid per pump shaft rotation; flow rate is negligibly affected by higher pressures due to check valves within the pump head to control the direction of flow. The slight decrease in flow rate at higher pressures equates to about 1% for each 100% increase of pressure.

Comparing Performance Curves

Referring to the semi-open impeller performance curve, at about 34 total head feet (almost 15 PSI) a 6" diameter impeller would result in a flowrate of approximately 50 GPM. The addition of piping and related components would result in a decrease in flowrate because additional pressure is required to overcome those losses. In this example, when the pressure increases by about 14% to 40 total head feet, the flow rate is reduced by 40% (to about 30 GPM).

Referring to the positive displacement pump curve, when operated at approximately 740 RPM the flow rate will be approximately 50 GPM at 200 PSI and about 48.6 GPM at 700 PSI; a decrease in flow of about 3% based upon a 350% increase in pressure.

Therefore, centrifugal pumps have a flow rate proportional to the pressure they are pumping against whereas positive displacement pumps have a flowrate proportional to the pumps shaft speed.

Troubleshooting Lack of Pressure

Since gauge pressure is a function of flowrate, the causes for lack of pressure are really issues regarding flowrate. While there are many factors to consider including improper electrical wiring and aerated/turbulent fluids, below is a summary for common system issues resulting in reduced flowrate for both centrifugal and positive displacement pumps:

Inlet Related

Inadequate Net Positive Suction Head Available (NPSHa) which could involve clogged filtration

Pump Related

Component wear or material clogging within the pump

Outlet Related

A worn bypass valve might contribute to loss of flow/pressure

Troubleshooting Hydra-Cell Pumps

Hydra-Cell pumps are a type of sealless, positive displacement pump, using a hydraulically balanced diaphragm as the displacement mechanism. As such, Hydra-Cell pumps do not have a dynamic seal interface which plunger and piston style positive displacement pumps have and thus are more reliable, especially for difficult to pump fluids. The simplified design of Hydra-Cell pumps also simplifies troubleshooting.

Troubleshooting New Hydra-Cell Pumps

If you are not receiving the pressure/flow desired, the likelihood that you have a system issue is very high because Hydra-Cell pumps are tested at full flowrate and pressure prior to shipment. Unlike other manufacturers, which test only a percentage of their products, 100% of Hydra-Cell pumps are tested prior to shipment so you can be confident it was working when it was shipped.

In my experience, most flowrate issues are related to the inlet side of a system. You need to ensure that there is sufficient fluid available to support the desired flowrate. Even though Hydra-Cells have some suction lift capabilities and will self-prime, insufficient NPSHa will starve the pump of adequate fluid resulting in cavitation. Simply put, trying to displace more fluid than available results in a vacuum condition allowing the liquid to change to its vapor phase; this violent phase change results in rough running (flow/pressure) and operating this way for prolonged periods can damage the check valves.

A way to check if this is an issue is to slow the pump speed down to see if the pumping action becomes smoother and quieter. If it does, it is confirmation of inadequate NPSHa.

Pumps which start-up as expected but begin to operate roughly after a period of time might be symptomatic of clogged filtration, aeration of fluid due to a high percentage of recirculation or a change in the head pressure available as the feed tank volume decreases (lack of NPSHa).

Newer pump systems which initially worked well, but then sat idle for months will sometimes have “stuck” internal check valves due to residual fluid remaining within the pump which dried out or otherwise left a sticky residue. A pressurized inlet, such as city water pressure, can free-up sticky valves.

On the discharge side of a new pump system, make sure that your pressure-regulating valve is set properly. Generally you should set the pressure regulating valve to the maximum allowable pressure you wish to operate at after the pump has primed itself and if you are not receiving the desired pressure, is there fluid being bypassed? Since pressure is a function of flowrate, there needs to be adequate restriction, so bypasses, leaks and oversized/worn spray nozzles are factors to consider.

Troubleshooting Existing Hydra-Cell Pumps

Pumps which have a history of performing satisfactorily are often easier to troubleshoot because rough running is typically related to worn check valves. The check valves within the pump head can cycle up to 29 times per second when operated at 1750 RPM, so eventually the interface of the valve and seat wears. Worn check valves reduce sealing efficiency and the flowrate decreases as a result. This is especially noticeable when pumping at elevated pressures. Check valves are easy to replace and are offered in many materials to maximize both chemical resistance and abrasive wear.

Check Valves for Hydra-Cell Pumps

Hydra-Cell pump elastomers (o-rings and diaphragms) are not typically wear items; whereas you can predict check valve wear with some success, o-rings and diaphragms do not exhibit that type of wear. Chemical and temperature incompatibility can degrade these elastomers but when that is not an issue, o-rings and diaphragms last years. Many customers elect to replace the elastomers when they replace their check valves because it does not add much to the overhaul kit cost and the pump head is already opened to replace the check valves, so it is a prudent, proactive approach to pump maintenance.

Chemically Attacked Diaphragms

Fluid End Kits for Hydra-Cell Pumps

Troubleshooting Stan-Cor Centrifugal Pumps

NPSHa, excessive aeration of the pumped fluid and clogs restricting flow in piping or the pump head affect the flowrate for centrifugal pumps just as they do positive displacement pumps. In addition to the aforementioned troubleshooting suggestions, centrifugal pumps have additional factors to consider.

Stan-Cor centrifugal pumps, like many centrifugal pumps, are not self-priming. They require filling the pump and inlet line with fluid prior to start-up. After start-up the resulting vacuum created will provide some suction though the inlet side of the system.

Even though check valves are not used to control flow direction, the clearance between the impeller and volute is critical to generate the required discharge velocity. Clogged or worn volutes and impellers may significantly reduce the flowrate.

Selecting the Right Pump for Your Application

Generally speaking, centrifugal pumps are best suited for applications involving water-like viscosities and transferring higher flowrates at lower pressures whereas positive displacement pumps are required for higher pressures and often used for difficult to pump fluids.

The best pump for your application depends upon many factors, so even if different style pumps can provide the desired flowrate, some designs are better suited than others when considering reliability and cost of ownership. The next time you have a pump application reach out to us using one of our special web based inquiry forms, send an email or call our office; we will put our decades of experience to work for you!

Visit us at https://innovativepumps.com/ and let us know how we can assist you with your pumping application!

Chris Pasquali has provided sales and engineering support for Wanner Engineering since 1991