TECH TIP

Centrifugal vs Positive Displacement Pumps

What are centrifugal and positive displacement pumps and how are they different? There are various designs for pumps used in the engineering industry today, but these types of pumps can usually be classified into centrifugal and positive displacement pumps. Centrifugal pumps operate using a spinning impeller which moves liquid into the pump and then discharges that fluid out the other end of the pump as shown in **Figure 1**. Centrifugal pumps are preferably used in situations where the fluids being transferred are of low viscosity and where high flow rates are required. Ideally, centrifugal pumps should also be used in settings where there will be very little changes in the inlet source pressure as the flow rate of a centrifugal pump will deviate with increasing or decreasing pressure.

Positive displacement (PD) pumps operate differently from centrifugal pumps in the sense that they draw liquid through the suction valve into a cavity, and then force that particular volume of liquid out through the discharge valve using a diaphragm, gears, screws, plunger, or piston as shown in **Figure 2.** PD pumps are ideally used in situations opposite to that of centrifugal pumps in that they produce the best results with fluids of high viscosity. Changes in pressure also have little to no effect on the flow rate of PD pumps.

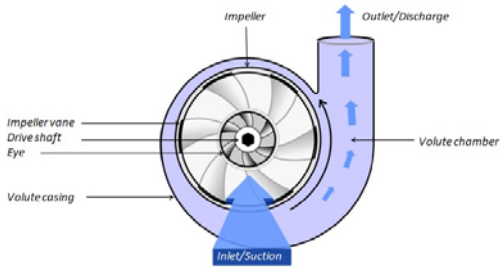

Figure 1: Centrifugal Pump

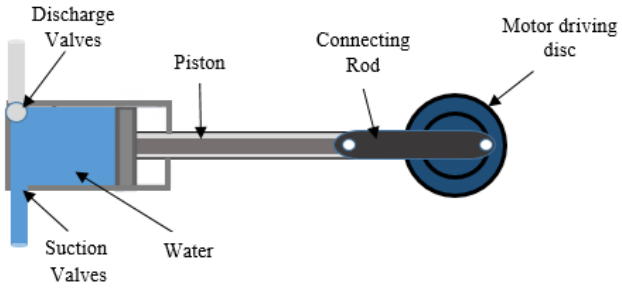

Figure 2: Positive Displacement Pump

Pump failure incidents in industry. The configuration of these pumps also affects how these pumps fail in the engineering industry. An incident in 2016 occurred at the Airgas manufacturing facility in Cantonment, Florida in which an employee was killed. The said employee was loading nitrous oxide into a trailer when the centrifugal pump inadvertently ran dry during startup which led to cavitation of the pump resulting in damage to the impeller and the pump seal. Due to this cavitation, heat was generated within the centrifugal pump which then led to a subsequent decomposition reaction of nitrous oxide and release of flammable material. The facility did have a run-dry interlock that would trigger; however, the interlock was inadequately designed for this scenario.

The next incident involved a PD pump failure in which 2 people were killed at Aghorn Operating Inc. in Odessa, Texas on October 26, 2019. In this incident, the PD pump's plunger came loose, and the pump was unable to

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discharge any liquid in the cavity of the pump. The plunger then completely broke off from the PD pump and released H2S. This pump was known to have issues in the past as was reported on October 4, 2019, in which the pump was scheduled for maintenance as there had been various incidents of packing leaks within this pump.

Why is important to understand the differences between a centrifugal and positive-displacement pump? It is important to understand the difference in operation between a centrifugal and PD pump for two reasons. The first reason is to make sure a suitable pump is used for the appropriate process. The second reason is that understanding the different variations of pumps can be valuable information when determining the risks associated with a particular pump. During a Process Hazard Analysis (PHA), safeguards are credited to mitigate the consequences that may result from deviations such as the one above. Certain pumps may require certain safeguards and being familiar with the types of pumps and how they operate will allow the PHA team to choose the appropriate safeguards and reduce the risk of hazardous events.

For example, it can be reasonable for the PHA team to say that a PD pump has no concerns with reverse flow or cavitation due to the inherent design of the pump. PD pumps are designed so that the pumping action is always forward and positive; therefore, reverse flow may not be considered credible. If there is no liquid in the cavity of the PD pump, then the pump will stop running and therefore there may be no concern for cavitation. This could save time during a PHA and allow resources to be focused on other potential consequences. However, this does not necessarily mean that failure cannot occur in PD pumps. As previously discussed with the Aghorn incident, the seal of that pump had been known to leak in the past which then eventually led to a release of H2S to the atmosphere. During a PHA, it is important to determine if the seal may be the weak point of the PD pump. If the seal is the weak point then it might be credible to cavitate and have a seal leak at the PD pump. Conversely, due to the inherent design of the PD pump, they are more susceptible to deadheading. If the discharge of a PD pump is blocked off for any reason, there is potential for a pipe rupture which could release toxic or flammable material. It is important to choose the correct type of pump based on the process being handled and the safeguards available.

Resources

1. airgas_investigation_report_-_final_-_2017-02-28.pdf (csb.gov)
2. aghorn_investigation_report_-_board_approved_version_(5-4-21)_.pdf (csb.gov)
3. Figure 1: Useful information on centrifugal pumps (michael-smith-engineers.co.uk)
4. Figure 2: Positive displacement piston pump [16]. | Download Scientific Diagram (researchgate.net)

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