FACT SHEET

TYPES OF SLUDGE PUMPS

Sludge Pump Selection and Cost Information
Fact Sheet Series
May 2014

This fact sheet provides information on the two types of sludge pumps, centrifugal and positive displacement pumps.

Pumping Sludge, Slurries and Effluent

There are two major categories of sludge pumps: centrifugal (dynamic) pumps where continuous energy increases the flow velocity of the fluid, which is later converted to lift or pressure; and positive displacement pumps in which periodically added energy directly increases pressure or lift.

- Effluent with a total solids (TS) content <2 per cent is easily pumped with conventional centrifugal pumps.
- Slurries with a TS content of 2–10 per cent TS can be pumped with various types of positive displacement pumps or specifically designed centrifugal pumps (i.e. chopper pumps).
- Once sludge exceeds 15 per cent TS it is virtually impossible to pump unless diluted with water.
- Regular desludging of ponds prevents TS concentrations of >10 per cent, making sludge removal easier.

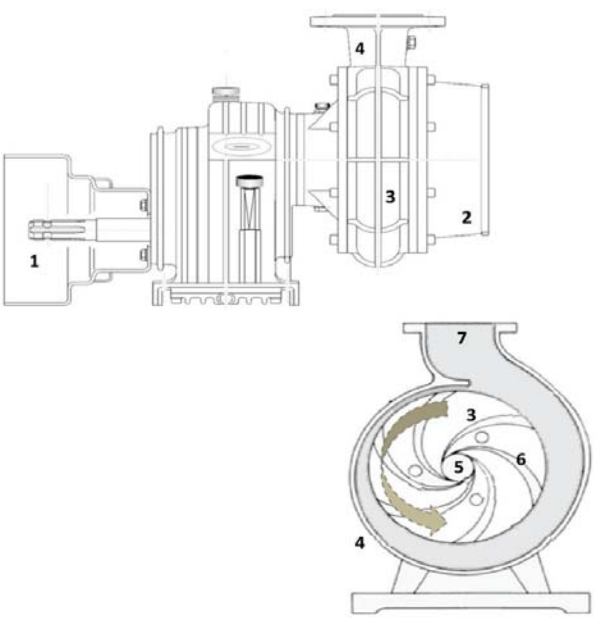

Figure 1 – Centrifugal pump: 1 = power take-off, 2 = inlet with suction nozzle, 3 = impeller, 4 = volute case, 5 = suction nozzle, 6 = vane, and 7 = volute discharge (Brambilla et al. 2013)

Centrifugal Pumps

Centrifugal pumps are commonly used to pump effluent. They are equipped with a revolving impeller that converts electric energy from the motor into kinetic energy. The volute (stationary component) transforms kinetic energy into pressure energy, creating flow. A schematic of a centrifugal pump is shown in Figure 1.

Centrifugal pumps provide flow rates from a few litres to thousands of litres per second and can handle solid particle sizes from microscopic to sand. Their main limitation is that they cannot develop pressures higher than 1000 psi (7 MPa) even when they are arranged in series.

Impellers can be modified on centrifugal pumps to semi-open or vortex (chopper) so that slurries with up to 10 per cent TS can be pumped. Pumps with modified impellers can also reduce blockages in long pipe installations, due to their open vortex design and lower starting torque. Blockages can also be avoided by equipping the pump with a vertical or inclined shaft. This reduces pump efficiency but allows it to handle semi-solid materials by minimising flow cavitation and solid blockages. An example of a centrifugal slurry pump with a chopper used to breakdown solid waste material is provided in Figure 2.

Figure 2 – Centrifugal slurry pump with chopper

Positive Displacement Pumps

Positive displacement pumps are either reciprocating (piston-and-diaphragm or piston-and-cylinder design (plunger or piston) with inlet and outlet poppet valves) or rotary (progressing-cavity pump, rotary-vane vacuum pumps and lobe pumps). They generate much higher pressures than centrifugal pumps but their flow rate range is limited from 50 to 1000 L/s, due to their large physical sizes.

Diaphragm Pumps

A diaphragm pump is a reciprocating pump also known as a membrane pump, air operated double diaphragm pump (AODD) or pneumatic diaphragm pump. They use a combination of the reciprocating action of a rubber, thermoplastic or Teflon diaphragm and suitable valves either side of the diaphragm (check valve, butterfly valves, flap valves etc.) to pump a fluid. Diaphragm pumps are self priming and are ideal for viscous liquids such as wastewater.

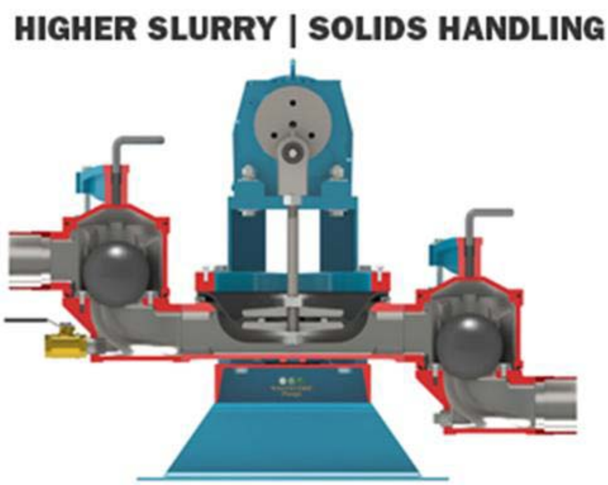

Figure 3 – Schematic of GEHO-ZPM diaphragm pump

The essential elements are a flexible diaphragm and inlet/outlet valves. It is claimed that these pumps can deliver material with a TS content of greater than 15 per cent. These pumps are expensive and require an extensive, permanent set-up, making them suited for heavy duty operations.

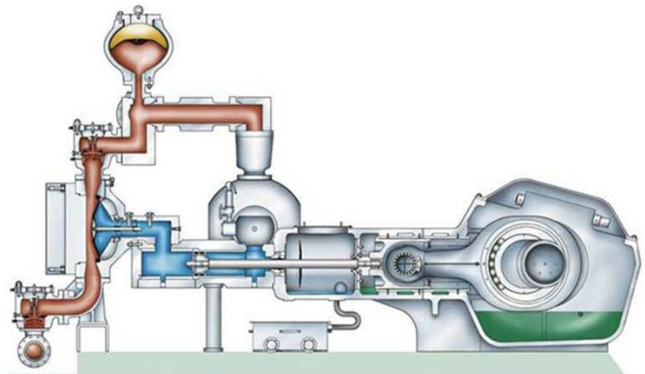

Figure 4 – Schematic of Mud Sucker diaphragm pump

Plunger and Piston Pumps

In a piston pump the high-pressure seal reciprocates with the piston (Figure 5). In a plunger pump the high-pressure seal is stationary and a smooth cylindrical plunger slides through the seal (Figure 6). The design of a plunger pump allows it to be used at higher pressures 1000–30000 psi (70–2070 bar), compared to a piston pump. This type of pump is often used to transfer municipal and industrial sewage.

Piston and plunger pumps use a crank mechanism to create a reciprocating motion along an axis, which builds pressure in a cylinder or working barrel to force fluid through the pump. The pressure in the cylinder triggers the valves at the suction and discharge points. The volume of the fluid discharged is equal to the area of the plunger or piston, multiplied by its stroke length. The overall capacity of piston pumps and plunger pumps can be calculated with the area of the piston or plunger, the stroke length, the number of pistons or plungers and the speed of the drive. The power needed from the drive is proportional to the pressure and capacity of the pump.

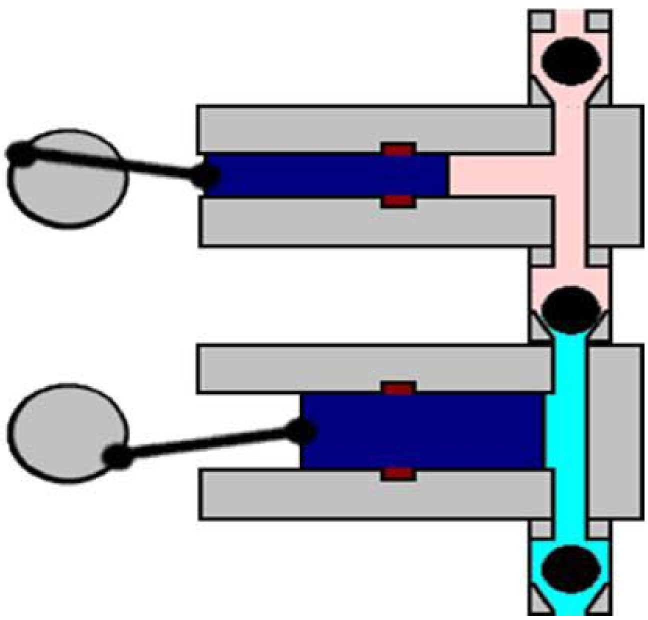

Figure 5 – Schematic of piston pump

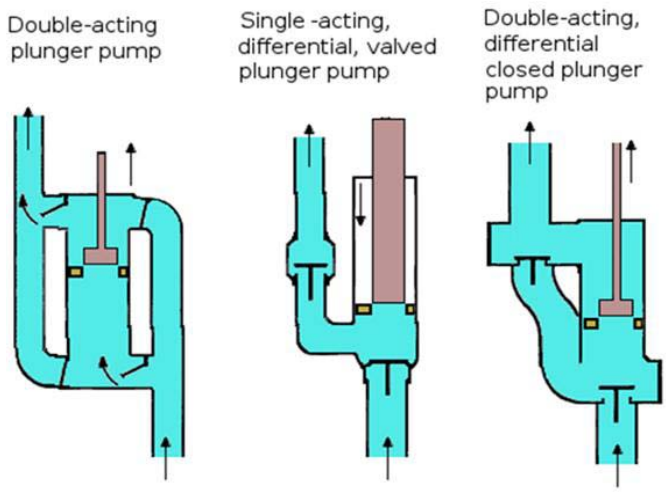

Figure 6 – Schematic of plunger pumps

Screw Pumps (Progressing-cavity)

A screw pump is a type of positive displacement rotary pump and is also known as a progressing cavity pump. The screw pump consists of a screw rotor in a rubber stator (Figure 7). The rotor seals tightly against the rubber stator as it rotates, forming a set of fixed-size cavities in between. The cavities move when the rotor is rotated but their shape or volume does not change. The pumped material is moved inside the cavities. These pumps are used in fluid metering and pumping of viscous materials.

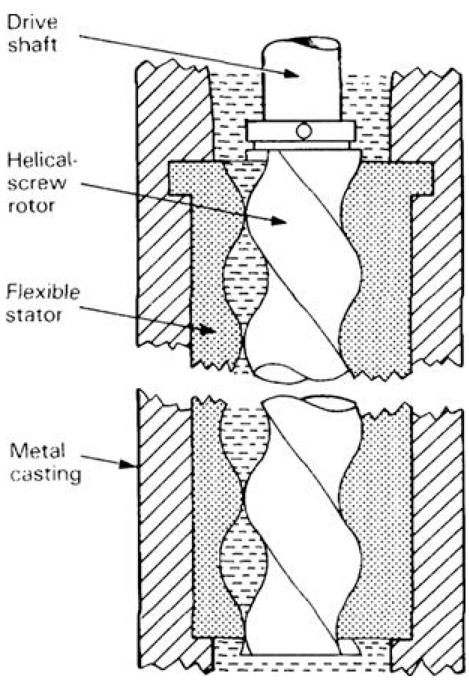

Figure 7 – Schematic of screw pump

Vane Pumps

Vane pumps are self-priming and deliver a constant, smooth flow regardless of pressure variations.

A vane pump is a positive-displacement pump that consists of vanes mounted to a rotor that rotates inside of a cavity (Figure 8). In some cases, these vanes can be variable length and/or tensioned to maintain contact with the walls as the pump rotates. Rotary vane pumps are a common type of vacuum pump, with two-stage pumps able to reach pressures well below 100 psi.

Vane pumps are the most common type of pump used on agricultural vacuum tankers.

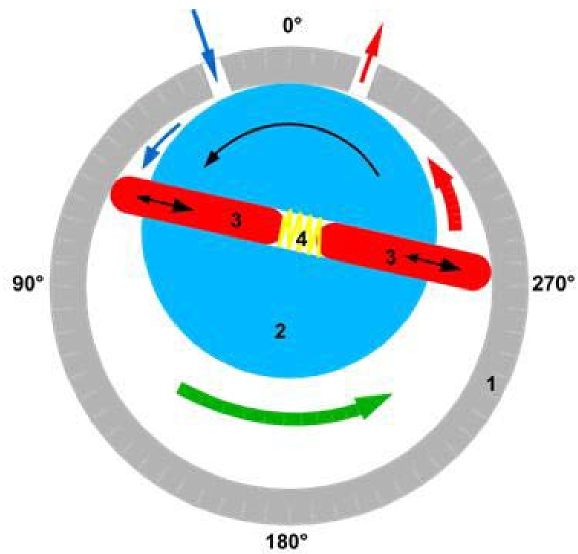

Figure 8 – Schematic of vane pump

Lobe Pumps

Lobe pumps are designed with two or three shafts and are often used to pump material with a high solids content, 10-15 per cent TS. These pumps have two or more wings that mesh together inside a housing made of two circular segments (Figure 9). The rotation of the lobes and their housing generate flow. These pumps have a fluctuating volume flow, which generates gentle pressure pulsations in the pipeline due to acceleration and deceleration of the flow. The design of the lobes allows for the pump to handle high solids content with minimal wear. Other advantages of these pumps include reversible flow and the ability to operate dry for long periods.

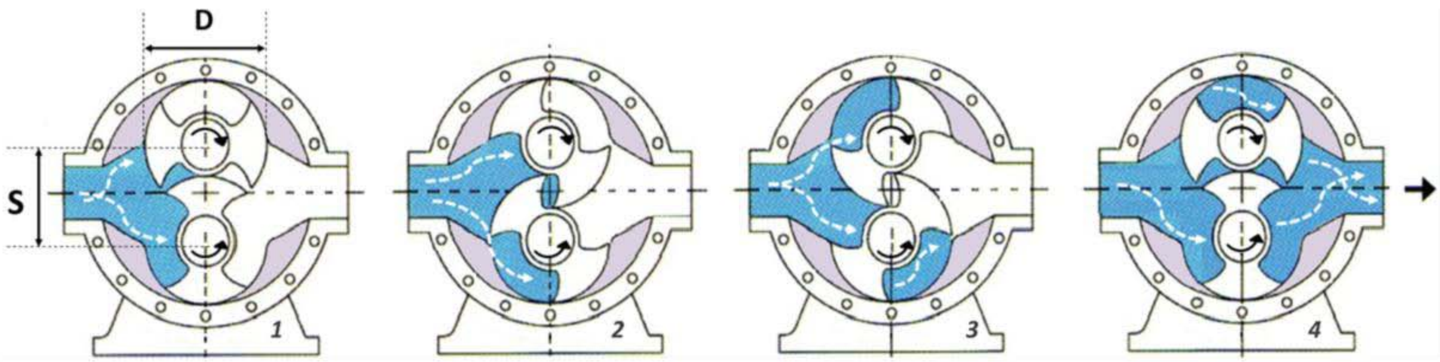

Figure 9 – Example of rotary lobe pump and its operation (S = shaft diameter and D = tip diameter). Scimitar-shaped lobes are able to reduce build-up of particles between the rotors and the case

Fact Sheet

Key Points

- Two types of pumps, centrifugal and positive displacement, are suited for pumping sludge.

- Centrifugal pumps – continuous energy increases the flow velocity of the fluid, which is later converted to lift or pressure. Require a vortex (chopper) impeller to handle TS >2 per cent:
    - Advantages – low starting torques means they are less susceptible to blockages, better for long distances.
    - Disadvantages – can't develop high pressures, affected by fluid viscosity, impeller wear reduces performance over time.

- Positive displacement pumps (diaphragm pumps, piston and plunger pumps, screw pumps, vane pumps, and lobe pumps) – periodically added energy directly increases pressure or lift:
    - Advantages – multiple designs to choose between, generate high pressures, can pump material with TS 10–15 per cent, long life expectancy.
    - Disadvantages – lower flow rates, can be expensive due to large installation requirement.

References and Further Reading

Brambilla, M et al. 2013, 'Rheological properties of manure/biomass mixtures and pumping strategies to improve ingestate formulation: A review', Transations of the ASABE vol. 56, no. 5, pp. 1905–1920.

Roos, C. J., 2007, A guide to pumping manure slurries in centralised biogas digester systems, Washington State University Extension Energy Program, U.S. Department of Energy.

Wilson, K et al. 2006, 'Slurry transport using centrifugal pumps', Springer.

Other Fact Sheets in this Series

- Selecting a Suitable Sludge Pump.
- Commercial Sludge Pumps.