FACT SHEET

SELECTING A SLUDGE PUMP

Sludge Pump Selection and Cost Information
Fact Sheet Series
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This fact sheet provides criteria for piggery and feedlot operators to select the appropriate sludge pump to suit their requirements. For detailed information regarding the different types of sludge pumps refer to the 'Types of Sludge Pumps' fact sheet. For commercially available products refer to the 'Commercial Sludge Pumps' fact sheet.

Sludge Properties Influencing Pumping

Sludge is a mixture of water and solid materials (total solids (TS)). The TS component can be inorganic material (any materials such as debris, sand or rocks plus the ash component of organic wastes), slowly digestible organic material or dead microbial cell mass. The ratio of water to solids (TS content) can vary considerably.

The physical characteristics of the sludge or slurry are vital in determining the appropriate pumping method. Particle size distribution (PSD) and bulk density are important but the rheological properties have the greatest influence. Rheology is the study of the flow of matter, primarily liquid, under conditions in which they respond with plastic flow rather than deforming elastically in response to an applied force.

Several studies have been conducted into the rheological properties of piggery and feedlot sludge and slurry. Researchers found that resistance to pumping increased with increasing TS content and decreased with higher temperature. Sludge with a high TS content also causes more wear and tear on pumps and creates excessive flow resistance in pipes.

Figure 1 – Sludge removal via pumping

- Effluent with a TS content <2 per cent is easily pumped with conventional centrifugal pumps.
- Slurries with a TS content of about 2–10 per cent TS can be pumped with various types of positive displacement pumps or centrifugal pumps with modified impellers (i.e. chopper pumps).
- Sludge with a TS content above 15 per cent is virtually impossible to pump.
- Regular desludging of ponds will avoid TS concentrations exceeding 10%, making sludge removal easier.

What is a Slurry Pump?

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.

Centrifugal sludge pumps differ in design from conventional centrifugal pumps due to the abrasive and corrosive nature of the sludge. Sludge pumps need to consider impeller size and design, type of shaft seal and the choice of materials. Centrifugal sludge pumps must have wider and heavier impellers to allow the passage of large solid particles. They also require special materials to prevent internal wear.

Improving Pumping Ability of Sludge

Guidelines for improving the pumping ability and avoiding settling and blockages include;

1. Avoid excessive dilution of the sludge, this ensures solids stay entrained in the mixture.
2. Maintain sufficient flow velocity, usually at least one m/s.
3. Ensure pipe diameter is sufficient, use quality pipe material and joints. Pipe diameter should remain consistent through whole system to prevent solids accumulation.
4. After sludge pumping, flush pipeline with clean water or digested effluent.
5. Use variable speed pumps to operate pump at speed best suited to sludge characteristics.
6. If using centrifugal type ensure impeller has chopper design to breakdown solid material.

Pump Selection

Correct pump selection is very important because pumps are designed to suit specific pumping conditions. The following steps should be used to select the appropriate pumps (Warman International Ltd. 2000). Refer to the 'Commercial Sludge Pumps' fact sheet for retail information.

1. Determine the flow rate, usually established by the volume of solids to be pumped and the proposed concentration of solids. The flow rate through the pump is directly proportional to pump speed, head to speed squared and power to speed cubed. It means that if the pump speed is doubled, then the generated head would generally need to be four times higher and the power consumption eight times higher.
2. Determine the static head, the vertical height on both the intake and discharge side of the pump.
3. Determine the pump head and efficiency corrections, which is determined by the average particle size of the solids (d50 mm, the theoretical screen size where 50 per cent would pass and 50 per cent would be retained.), the concentration of solids (per cent by weight) and the dry specific gravity of the solids (refer to Sludge Handling and Management Investigation Fact sheet series – Characteristics and Accumulation of Sludge for more information on sludge PSD).
4. Determine the pipe diameter, which will provide the optimum velocity to minimise friction, while keeping solids in suspension.
5. Determine the friction head loss. For TS contents greater than 2 per cent, friction losses are from 1½ to 4 times the friction losses for water (Guyer 2011).
6. Calculate the total dynamic head.
7. Select pump type and materials from the supplier product catalogue.
8. Determine pump speed from the selected pump's performance curve.
9. Determine the required power, which allows the motor to be correctly sized.

Selecting a Centrifugal Sludge Pump

Some centrifugal pumps are specifically designed for pumping sludge from ponds, for example with an adjustable pump length or mounted to a tractor. The major factors to consider when sizing pumping equipment include the distance from the immediate storage to the field or drying bay and the average flow rate needed for the desired application rate.

The solids are moved only when drag forces, generated by the faster water, overcome gravity forces. When this is not achieved, solids can settle and thus block the pipe. As a rule of thumb, the liquid velocity for pipe sizing needs to be greater than 1 m/s to keep the solids suspended.

The effect of particle sizes in the sludge has an impact when choosing a centrifugal sludge pump. Figure 2 provides a guide for choosing centrifugal pumps based on the median solid particle size. If the median solid particle size is above 15 mm the impeller, liner and casing need to be metal instead of elastomer material. For particles above 80 mm centrifugal pumps will not work and positive displacement pump types will need to be used.

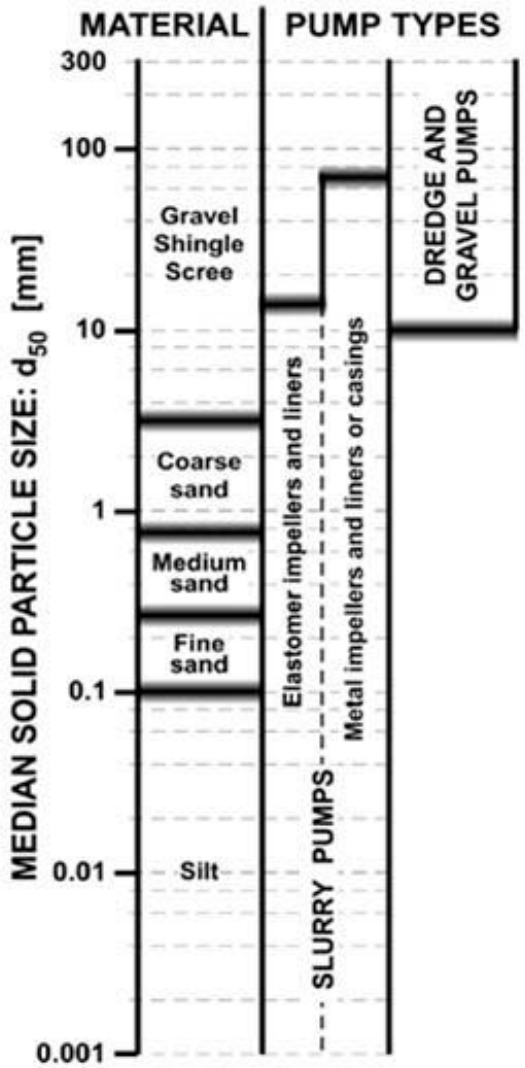

Figure 2 – Particle Size Pump Selection Guide

Selecting a Positive Displacement Pump

Positive displacement pumps can be broadly categorised as either reciprocating or rotary. Reciprocating pumps include diaphragm pumps and plunger and piston pumps. Rotary pumps include progressing-cavity pumps, rotary vane vacuum pumps and lobe pumps. The selection of pump for a particular situation needs to take into account the variables specific to the site and application. Table 1 provides some general guidelines.

Parameter	Reciprocating pumps	Rotary pumps
Capacity	Low	Low/Medium
Pressure (Head)	High	Low/Medium
Maximum Flow Rate	10,000+ GPM	10,000+ GPM
Maximum Pressure	100,000+ PSI	4,000 PSI
Requires Relief Valve	Yes	Yes
Flow Type	Constant	Constant
Flow Characteristic	Pulsating	Smooth
Space Considerations	Requires More Space	Requires Less Space
Initial Costs	Higher	Lower
Maintenance Costs	Higher	Lower
Energy Costs	Lower	Lower
Liquids Recommended	Viscous liquids, dirty chemicals, tacky glue and adhesives, oil, and lubricating fluids. Specialty fitted pumps can handle abrasives.	Optimum for viscous fluids. Requires clean, clear, non-abrasive fluid due to close tolerances.

Table 1 – General Selection Characteristics for Positive Displacement Pumps (Source: PDHengineer.com)

Key Points

- Sludge with high TS content (i.e. > 10 per cent) is more difficult to pump and will increase wear and tear on pumps.
- Two types of pumps are suitable for sludge – centrifugal and positive displacement.
- Follow recommended guidelines for improving sludge pumping ability and when selecting a sludge pump for a particular situation. If unsure seek specialist advice from pump manufacturers.
- Centrifugal pumps
  - 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
  - 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

Guyer, J 2011, Introduction to Sludge Handling, Treatment and Disposal, Continuing Education and Development, Inc.

Warman International Ltd. 2000, Warman Slurry pumping handbook (Australasian Version), February 2000, Warman International Ltd, viewed 23 September 2009, < www.pumpfundamentals.com/slurry/Warman_slurry_pumping.pdf >.

Other Fact Sheets in this Series

- Types of Sludge Pumps
- Commercial Sludge Pumps.