GORMAN-RUPP PUMPS

HYDRO INNOVATIONS

"Efficiency is more than wire to water"

Selecting the RIGHT Wastewater Pump

Topics:

1. The (many) factors affecting sewage pump selection
2. Design considerations
3. Other types of efficiency
4. Is there an optimum design?

1. The (many) factors affecting sewage pump selection

There are many factors affecting the selection of a sewage pump. These will vary in importance with each application and will vary depending on who has been included in the decision making process.
Some of these factors include the following:

- Capital cost
- Hydraulic efficiency
- Ease of design (how easy a pump design "fits" the application)
- Hydraulic characteristics – pump curve, NPSH etc.
- Sphere size capability
- Ability to pass solids
- Ease of unclogging
- Ease of maintenance
- Reliability
- Life Expectancy
- Compatibility with existing equipment
- Availability of parts
- Cost of parts
- Availability of service
- Familiarity of Operators with equipment
- Hydraulic flexibility
- Ability to maintain efficiency
- Operator safety
- Brand preference

It will depend on the specific requirements of the application as to which type of pump best suits, but it will also depend heavily on who has the most influence in the selection.

Consulting engineers will be influenced by their client and by their past [positive and negative] experiences.

Operators and Chief Operators will be interested in safety, back-up support, reliability, non-clogging ability, ease of access, and un-clogging ability.

The asset owners will be very interested in capital cost, but they will also be influenced by operating costs (including pump energy efficiency and the costs of maintenance). The more astute asset managers will take into consideration the entire life cycle cost of the installation, including costs of parts, frequency of parts usage, costs of replacing ancillary items (such as guide rails and "duck-foot" bends), how often a pump clogs, how easy it is to un-clog and generally maintain as well as safety considerations. They will also take into account the changing energy efficiency as clearances open (not just do their calculations based on "as-new" clearances) and the increase in clogging frequency as pump clearances "open"

2. Design Considerations

Hydraulic efficiency is most important in clean water pumping applications with large flows and continuous operation. It is least important for wastewater or sludge pumping where smaller flows and intermittent operation is the “norm”.

According to The McNally Institute ... “High efficiency is desirable, but it will be a maintenance nightmare. High efficiency means tight tolerances and smooth passages...... You will spend a lot of down time and money trying to maintain those two requirements”.

The optimum pump design for hydraulic efficiency includes:

- Impeller with many thin vanes
- Impeller with sharp vane edges
- Enclosed impeller
- Impeller and volute designed for specific flow and head condition
- Dynamically balanced impeller with no balancing holes
- Impeller with smooth surfaces (no pump-out vanes)
- Smooth pump interior passages
- Minimal bends and angles (inlet piping straight into impeller eye)
- Minimal mechanical friction
- Close tolerances

Contrast these to the optimum pump design features for non-clogging and ease of maintenance design features:

- Semi-open impeller – Non-clogging and Ease of maintenance
- Clean-out cover plate – Ease of maintenance and un-clogging
- Blunt leading edge – Non-clogging
- Thick vanes – durability while pumping solids with abrasives
- Two vanes – Non-clogging plus durability
- Blunt cutwater tip – Non-clogging plus durability while pumping solids
- Clearance between cutwater tip and impeller tip – Non-clogging plus durability
- Pump-out vanes – Non-clogging plus durability
- Sloped vane inlet edge – Non-clogging

From “Centrifugal Pumps and Blowers, Austin H. Church, John Wiley and Sons, p.174”.................. “The non-clog impeller is extra wide and has few vanes. This results in low efficiencies as the liquid cannot be given much guidance, but efficiency must be sacrificed for the non-clogging feature”.

From “Pump Handbook”, Karassik et al, 1986, Second Edition, P2.204.......
“It is considered good practice to replace or repair wearing rings when the normal clearance has doubled. The presence of abrasive solids in the liquid pumped may be expected to increase wearing ring clearances rapidly.

And from “Pump Care Manual”, Goulds Pump Form A395-EL............. “The open impeller centrifugal pump offers several advantages. It is particularly suited but not restricted to liquids which contain abrasive solids.”

“Abrasive wear on an impeller is distributed over the diametrical area swept by the vanes. The resulting total wear has less effect on performance than the same total wear concentrated on the radial ring clearance of a closed impeller. The open impeller permits restoration of “New Pump” running clearance after wear has occurred without expensive parts replacement.”

"A well designed open impeller pump will feature a simple positive means for axial adjustment without necessity of disassembling the unit to add shims or gaskets"

So what does it mean to ask for an efficient pump? The Collins English Dictionary states that efficiency is:

1. The quality or state of being efficient; competence; effectiveness
2. (Physics/General Physics) the ratio of the useful work done by a machine, engine, device etc., to the energy supplied to it, often expressed as a percentage.

The American Heritage Science Dictionary describes efficiency as:

1. The ratio of the energy delivered (or work done) by a machine to the energy needed (or work required) in operating the machine. The efficiency of any machine is always less than one due to forces such as friction that use up energy unproductively.
2. The ratio of effective or useful output to the total input in any system.

These are technical meanings, but suggest that machines should deliver "useful" or "effective" work or output – not just the "hitting of a theoretical number".

I put to you that when evaluating or selecting the best or "most efficient" sewage pump, "other efficiencies" need to be considered.

3. Other Types of Efficiency

The electrical efficiency of an application has many losses to consider. These may include:

- 1-3% in wiring losses
- 2-10% in VFD losses
- 5-25% in Motor losses
- 1-5% in Coupling losses
- 15-60% in Pump Losses

These are the factors that affect the "wire to water" efficiency of a pump, but these do not include some other considerations that affect the true installed efficiency of the application. For standard submersible pumps, some of the following losses could be considered:

- Friction losses across the pump discharge connection
- Leakage from the pump discharge connection (which could go unnoticed and undetected for years, wasting energy)
- Motor efficiency (submersible motors are normally not as efficient as a TEFC motor)
- Power Cable (submersible pumps need cables that reach 6-8 metres into the wet well, making cables longer than the length needed for dry mounted pumps).

Dry mounted submersible pumps do not have leakage losses from discharge connections, but many have water cooling jackets that require additional energy to pump water through them.
So there are some hidden hydraulic inefficiencies associated with some styles of sewage pumps, but there are also some other types of efficiency that we need to evaluate to ensure a selection delivers the "useful" and "effective" total work output. And besides some "hidden" efficiency losses, consider the most efficient "wire to water" pump that clogs/chokes frequently, is difficult to remove blockages and requires much "tinkering" to maintain. A pump like this would gobble up any energy savings in added fuel bills, personnel costs, and parts usage/cost. So whether the "efficiency" was sought to save on costs or to be a good global citizen (trying to reduce carbon footprint), the efficiency game would be lost.

So the "other efficiencies" we need to review are as follows:

- Non-clogging Efficiency
- Un-clogging Efficiency
- Maintenance efficiency

Non-clogging efficiency

It is important – no, critical for a sewage pump to resist clogging. It will otherwise be a maintenance nightmare for operators. Having impellers with large passages and few vanes (1 or 2) is important here, but we need to remember that pumps capable of handling the "standard" 80mm sphere are rarely blocked/clogged by 85mm spheres. It is normally long stringy materials that cause a blockage.

The "Pump Handbook," Karassik et al, 1989, Second Edition, p9.29, states ... "Actually, no pump has been developed that cannot clog, either in the pump or at its appurtenances. Experience shows that rope, long stringy rags, sticks, cans, rubber, plastic goods, and grease are objects most conducive to clogging."

Therefore a sewage pump that resists clogging from stringy rag type materials should be considered to be very efficient in the "non-clogging efficiency" area.

Apart from how well a pump resists clogging when all clearances are "tight", it must also be considered that a pump relying on radial clearances will eventually be more susceptible to clogging when these clearances start to "open up". The "TPC Training Systems, Trainee's Guide, Centrifugal Pumps, 1975, p.45" says of this.......................... "It should be remembered, however, that wearing rings are subject to wear from gritty or abrasive materials and eventually have to be replaced. This replacement may be necessary in 6 months, a year, or longer, depending upon the application and the material being pumped."

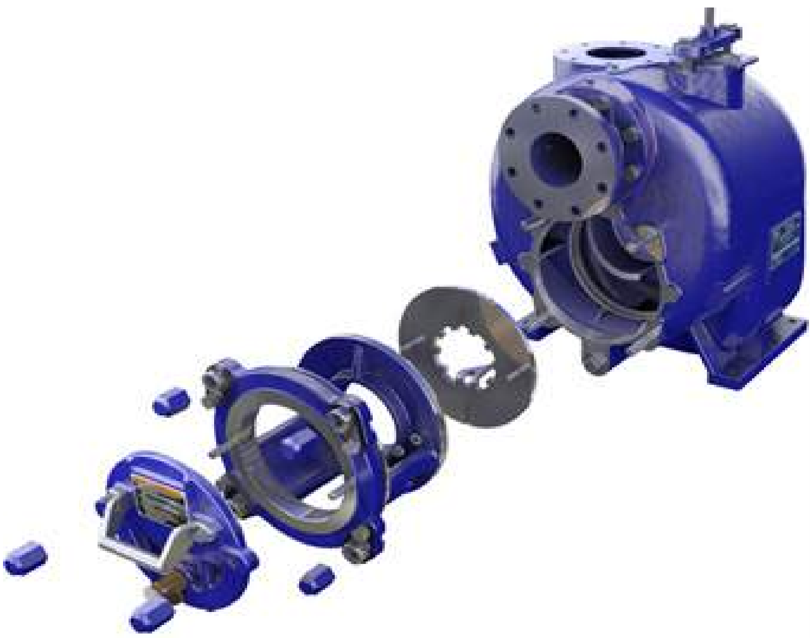
Therefore a sewage pump that not only resists clogging by stringy materials, but is also able to maintain its [tight] clearances will be the most efficient pump in the "non-clogging efficiency" area.

Submersible pumps that rely on radial clearances can be considered the most inefficient in this regard. This is because the only way to change the wearing rings is to open the wet well lids (exposing operators to height and confined spaces dangers), hoist the pumps from the pit, then [most of the time] they will need to be sent to the workshop. At the workshop the wearing rings are chiselled out or possibly need the casing to be heated and wear rings cooled to get them off. Because this is an arduous and drawn-out process, it is often left till choking becomes so frequent, that something has to be done.

Slightly more efficient than these, are submersibles that use axial clearances. The pumps still need to be pulled from the pit and cleaned, but instead of needing their wearing rings changed, clearances can be adjusted via jacking screws. Yes, more efficient, but operators need to be prepared to open the lids, pull back the safety screens, get the hoist out then perform the adjustments.

Standard non-clog centrifugals with radial clearances are more efficient again, because they are easier accessed, but they still need to be virtually pulled apart to change the wearing rings.A "standard" non-clog centrifugal with axial clearances can be considered to be a very efficient "non-clogger", but the cost of building the wet well/ dry well pump station needed to house them can usually count them out on cost efficiency.

Sitting at the head of the non-clogging efficiency table are the Gorman-Rupp self priming centrifugal sewage pumps. A very modern design which features "Eradicator" solids management technology to resist clogging by stringy rag type materials [wet wipes etc].



The Eradicator™ system features an aggressive self-cleaning wear-plate incorporating a number of notches and grooves, as well as a patent pending lacerating tooth that helps break up stringy materials, scrape them off the impeller vanes and pass them through the pump - all without impacting performance or interrupting service. A special cover plate with the system includes a patented lightweight inspection cover that can easily be removed if necessary to inspect pump internals.

Gorman-Rupp wastewater pumps also utilise an axial clearance system which allows internal pump clearances to be adjusted in less than five minutes by one (1) operator with two spanners. No lids to be opened and not one drop of sewage needs to be touched. This is much safer and cleaner for the operators and, for this reason, much more likely to be done. Clearances can then be maintained for the life of the pump, greatly minimising the chances of clogging occurring.

Unclogging efficiency

Having a pump that displays good non-clogging efficiency is ideal, but as we have discussed “no pump has been developed that will not clog”. Therefore, when a pump does clog, having a pump that is “un-clogging efficient” will make life a lot easier for operators. Conversely, a pump that takes time and effort to remove a choke or clog can be said to be inefficient in this area.

A submersible pump located in a sewage pumping station wet well can be considered inefficient in this area. It will require:

- A minimum of two persons in attendance (possibly 3, depending on local regulations and rules about confined spaces)
- Access lids need to be un-locked and opened and the safety screen pulled back. (This now exposes operators to a 6-7 metre fall).
- The pump then needs to be hauled to the surface, using either a permanently installed crane or lifting hoist with block and tackle or a vehicle fitted with a lifting hoist.
- It is then possibly cleaned down (maybe using a pressure cleaner – consuming energy and cost) and the clog/choke re moved.
- The pump is then lowered back into place, the safety screen re-positioned, lids closed and the hoist can go back to the store.

A conventional centrifugal or dry pit submersible pump is a more efficient option for removing clogs/chokes, but it will still require:

- Going down two sets of stairs or ladders, which are often steep and narrow.
- Entering the “pump room” which is generally in quite a small room, often requiring operators to turn sideways and press themselves up against the pump room wall to get past the first pump.
- At the pump, they need to isolate the pump through the suction gate valve. Then the access to the pump is generally through a small cover-plate built into the suction elbow. If the clog cannot be accessed through this small area, the pump motor may have to be removed in the case of the dry mounted submersible (possibly needing a lifting device) to access the pump casing.
- Re-fit motor and cover-plate.
- Ensure pump is primed, because an air-bound submersible or standard centrifugal cannot evacuate the air in the system.

These styles of pumps can be considered to be moderately efficient in the un-clogging area.

A Gorman-Rupp self priming centrifugal sewage pump is much easier to remove a clog/choke from and can be considered the most efficient pump in this area. A clog is removed this way:

- Access the pump at ground level, because the pumps can lift from 7.5m above the wet well. No ladders to descend and the wet will lids do not need to be opened. (no need to expose operators to the dangers of open wet well lid covers)
- Drain the casing quickly through the casing drain.
- Access and remove the blockage through the large removable cover-plate.
- Close the cover-plate.
- Re-fill the pump and turn it on.
- Job done.

An operator easily removes a blockage from a Gorman-Rupp Pump

Maintenance Efficiency

The last component of overall efficiency we will review is that of maintenance efficiency. As the "dry well" is very rarely considered these days because of the very high cost, we will compare the maintenance efficiency of only submersible pumps and Gorman-Rupp self priming sewage pumps. The areas we will look at here are as follows:

- Ease of monitoring
- Ease of troubleshooting
- Ease of adjusting clearances
- Accessing valves
- Conducting major overhauls
- Any "type specific" additional work that needs to be done

Ease of Monitoring

To inspect a submersible pump, you need to raise it. Open lids, pull back screen, get the lifting device out etc. This of course, will not be done. No operator will want to go to all that trouble to inspect impellers, check oil levels, and perform a general "once over".

A Gorman-Rupp Super T or Ultra V self priming sewage pump though, can be easily accessed from ground level. Oil levels and clarity in both seal and bearing chambers can be easily inspected through the large sight glasses for each. Gauges are easily inspected as is general mechanical "health".

Ease of Troubleshooting

When something goes wrong at a submersible pump station, operators look to their amp meters. This may give some clues, but amps can be misleading. Motors "do" amps, pumps "do" pressure. Does an increase in amps mean a rubbing impeller, increased recirculation within the pump or maybe a badly leaking discharge elbow? All of these conditions can produce the amp increase. And what about an amp decrease? Blockage on suction, blockage on discharge, or worn pump?

Now what about a Gorman-Rupp self primer?

- Low discharge pressure and high suction vacuum = blockage on suction side
- High discharge pressure and low suction vacuum = blockage on discharge side
- Low suction vacuum and low discharge pressure = problem in the pump

Pumps do pressure, not amps. Troubleshooting a Gorman-Rupp is much easier for operators.

Ease of Adjusting Clearances

Some model submersibles have radial clearances that can only be adjusted by changing the wearing rings (which according to some “text books”, should be changed or repaired after clearances have doubled). This can only be done by raising the pump and going through routines already discussed.

Other types of submersibles have axial clearances. These are easier, but still require pumps to be raised, cleaned and adjusted, then lowered etc etc.
The Gorman-Rupp is vastly simpler. If clearances need adjusting, just:

Undo locking collar. Then rotate collar by two “notches”. Return it to line holes up, then re-fit locking collar screws. Job done!

Accessing Valves

Valves for the submersible pumps are located in a separate below ground valve vault under a locked lid. These vaults are known for being damp and un-inviting places to work and home to insects and vermin.

The valves in a Gorman-Rupp station are located with the pumps and generally “found” at chest level and easy for operators to access and exercise.

An example of what a below ground valve vault can look like.

It’s an old station, but notice how clean the valves are and how easy they are to access.

Major Overhauls

A major overhaul for a submersible pump could include a motor re-wind, seal change or impeller change. All these will naturally require pumps to be raised and mostly will require pumps to be sent to the workshop – possibly needing access to a standby pump to maintain a back-up at the station.

A major overhaul on a Gorman-Rupp can be done by replacing the rotating assembly and wear plate. Two skilled operators can have this done in an hour. There is no need for a back-up pump and the job is quicker, cheaper and easier.


The pump remains in the piping system and major components are easily replaced.

Type Specific "Extra" Work

Gorman-Rupp pumps are generally driven by belts to maximise flexibility, maintain maximum vacuum, and "hit" duties exactly. These belts will occasionally need changing (about every 4-6 years), but they are very cheap and good fitters can have the job done in under an hour.

Gorman-Rupp self primers are also fitted with internal flap valves to maintain prime between pump cycles (although they don't need them to actually prime). These may need replacing every 2-3 years, but again they are a cheap component, and even an un-skilled operator can change a "V series" flap valve in 10-15 minutes.

The "extras" for a submersible pump do not happen as frequently, but they are vastly more labour intensive. I refer to the need to replace discharge "duck foot bends" and submersible guide rails. When these major overhauls are necessary, they require confined spaces trained personnel (generally 3-4 persons), equipment to bypass the pump station during the works and the time, components and effort to retrofit these major items.

4. Is there an Optimum Design?

I believe the above is convincing argument that the Gorman-Rupp self priming centrifugal sewage pumps offer the best choice in the "other efficiencies" area. Designers and asset owners need to decide whether these "other efficiencies" outweigh any "wire to water" efficiency difference there may be with a submersible pump. In recent years, with the advent of Gorman-Rupp's Ultra V Series sewage pump, the wire to water efficiency has closed up and in some instances, crossed over.

We trust this paper has been thought provoking and of value to you.
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