Wastewater pump clog resistance cannot be determined by throughlet size

A wastewater pump's throughlet size is frequently used to specify clog resistance, despite data that demonstrates the irrelevance of this measurement. Clogging is a critical and highly undesirable operational problem in wastewater pumping, which results in increased operational costs and emergency calls from the end user. Clogging drastically reduces pump efficiency and causes pump tripping.

The number one requirement of a wastewater pump is its ability to pump wastewater without clogging. This paper will describe the importance of a pump's wet-end design for achieving clog-free operation. This paper will also establish how a pump's throughlet size is a misleading parameter in specifying clog resistance.

Historical perspective

The traditional definition of throughlet size refers to the free passage of matter through a pump impeller. Throughlet size is determined by the largest diameter of a hard, solid, spherical object that can pass through the pump. The concept is old, dating back to 1915, and was developed at a time when energy costs were not of significant importance. Pump manufacturers intuitively believed that pump clogging could be avoided simply by having an internal pump throughlet equal to or larger than what the toilet of the day could pass.

Pump manufactures believed objects would pass through the pump as easily as they did through the pipes. This design is called a large or maximized throughlet size design. The expectation was that large throughlets would increase reliability and reduce unplanned service calls. These hydraulic designs are referred to as *traditional designs* in this paper.

The last few decades of research and development, and experience from hundreds of thousands of pump installations, have proven that the simplistic logic of throughlet size is incorrect and misleading yet prevalent in wastewater pump procurement specifications.

How did manufacturers achieve large throughlet sizes?

The smallest section in a pump is the passage through the impeller.

There are two possible main impeller-design options to maximize the throughlet size:

1. Single-vane impellers (open or closed, valid especially for small pumps)
2. Vortex impellers (also known as recessed impeller or torque-flow impeller)

Figure 1: Example of a single-vane impeller

Figure 2: Example of a vortex impeller

These designs suffer from the following drawbacks:

Single-vane impeller:

- Relatively low efficiency (with more impeller vanes, higher efficiencies can be achieved)
- Significant rotating radial forces (this causes high shaft and bearing loads as well as increased vibration and noise)
- Difficulty in balancing (the impeller is water-filled during operation)
- Impeller trimming leads to further imbalance

Vortex impeller:

- Very low efficiency

Modern wastewater

Investigations and studies of modern wastewater have shown that it rarely contains hard, solid, spherical objects with a diameter as large as the inner diameter of the piping system. Objects that are truly solid and hard, such as stone, brick, or steel are also rare, and these items rarely reach the pump because they will be trapped on a flat horizontal surface where the liquid is stagnant or the carrying velocity is low. By far, the most common solids found in municipal wastewater are organic and often consist of long and stringy shapes, such as fibers.

Modern wastewaters also contain a higher amount of synthetic cloth and artificial fibers than before. The vast new array of household cleaning products, such as tissues, wipes, and dishcloths, are to blame. These products should be disposed of in the trash or compost, but many consumers flush these products down the toilet, thus adding synthetic fibers to the wastewater stream.

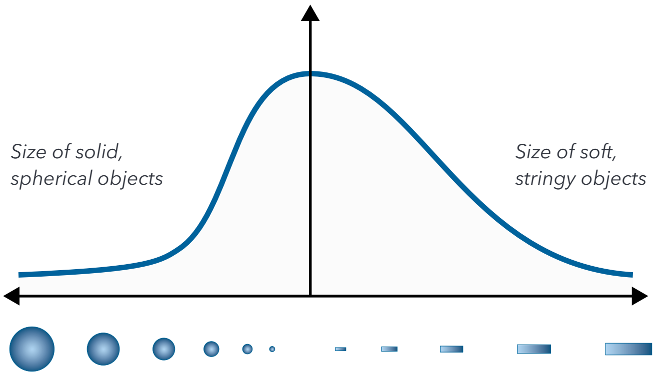

Figure 3

Figure 3 is conceptual and shows the probability of finding different types of solids in wastewater. The left side shows hard spherical objects (stone, gravel, sand, grit, silt, etc.) and the right side shows objects of various sizes and shapes, from circular to very large and elongated. The distribution curve shows that there is a very low probability of finding large, hard objects compared to small, hard particles and various small and large soft and stringy organic objects.

How traditional hydraulic designs are affected

Stringy objects tend to get caught in traditional impeller types even if the throughlet size is large.

As shown below, the problem point is the leading edge of the impeller vanes. All impeller designs have one or more leading edges.

Figure 4: Accumulation in a single-vane impeller

Figure 5: Accumulation in a single-vane impeller

Figure 6: Accumulation in a vortex impeller

Figure 7: Accumulation in a vortex impeller

Soft, strong, and elongated objects in wastewater are continuously fed into the pump; some of these will meet a leading edge on one of the impeller vanes. The fibers tend to wrap around the edge and fold over on both sides of the vane. On straight and moderately curved leading edges, the debris will not dislodge, instead debris will continue to build up. These accumulations will create big lumps or bundles of solid organic material (sometimes called rag balls). As these objects accumulate in a traditional impeller design, the following become likely:

1. The flow rate of the pump decreases as the solid objects start to constrict the free passage of liquid. This usually leads to decreased efficiency. This phenomenon is called soft or partial clogging because the pump continues to operate. It will take longer to pump down the sump with a constricted impeller that with a non-constricted impeller.

2. The input power increases when the accumulated objects make contact with the volute and create drag. Drag leads to lower efficiency and to the risk of a stop due to motor overloading. The solids act as a brake which increases the required input power. Once the running current exceeds the trip current, the pump is shut off due to hard clogging.

With decreased pump efficiency, the operational cost for the end user is increased because the pump has to operate for a longer time to handle the inflow. A motor overload or pump trip also adds cost for the end user because it requires a service technician to visit the pumping station in order to clean and restart the pump.

For pumps operating intermittently, back flushing will occur naturally every time the pump is turned off. This cleans the leading edges of the impeller and flushes the accumulated solids through the pump's suction opening back into the pump sump. This flushing phenomenon occurs in systems with and without check valves.

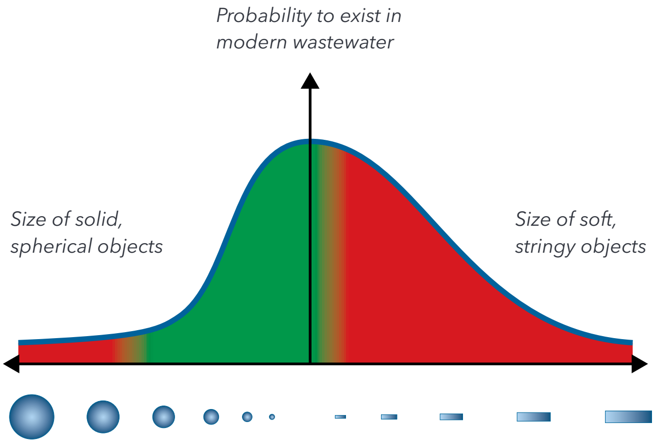

Figure 8

Figure 8 shows the types of solids that can pass through a traditional impeller with a large throughlet. The green area indicates objects with a high probability to pass through the pump. The red area indicates a higher probability of clogging.

Some hydraulic designers claim that vortex impellers are self-cleaning because after back flushing, the impeller is free of solids. In practice, this has not been the case. Even if the back flushing frees the impeller from the stringy objects, they return during normal operation, leading to a significant decrease in efficiency and higher energy bills.

Modern pump hydraulic designs

Today there are better and more advanced hydraulic designs available to increase a wastewater pump's clog resistance and to maintain pump efficiency over time. A state-of-the art self-cleaning design, with substantially backswept leading edges and a relief groove, has proven to be the answer to most clogging problems.

Figure 9: Modern self-cleaning hydraulic design

A standardized clog test was developed by Flygt in the late 1990s and has been used to test many existing hydraulic designs as well as new and innovative ideas. This development, carried out for over 15 years, has resulted in refined wastewater pumps that vastly outperform all traditional wastewater pump designs.

The company's knowledge from the large installed base of wastewater pumps has provided data necessary to develop self-cleaning impeller capability that works for all duty points and for reduced rotational speeds. The function of transporting liquid has been separated from the function of transporting solids. This self-cleaning hydraulic design does not accumulate the typical contaminants present in modern wastewater.

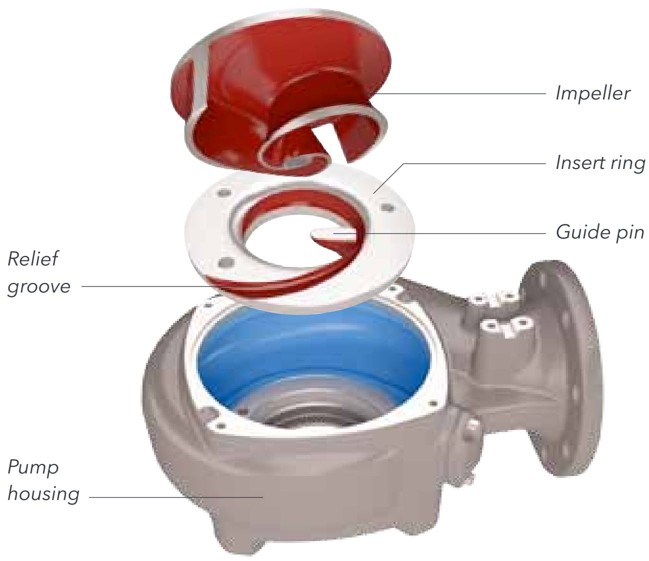

Figure 10

Solids that land on the leading edges of the impeller are continuously pushed towards the periphery and out through the pump discharge via the relief groove located in the insert ring.

Figure 11 shows what a modern, self-cleaning hydraulic design with backswept leading edges and a relief groove and can achieve. The green area indicates objects with a high probability to pass through the pump. The red area indicates a higher probability of clogging. The green area is much larger than for a traditional, large throughlet pump as shown in Figure 8.

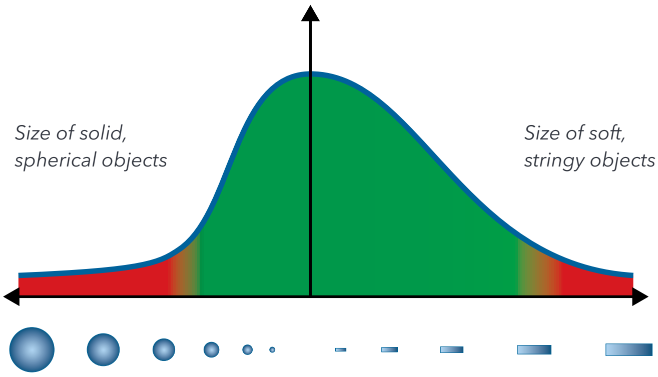

Figure 11: Capability of modern, self-cleaning hydraulic designs

A pump with self-cleaning hydraulics will not accumulate the solid objects that are likely to be found in modern wastewater. It delivers sustained efficiency and increased clog resistance, which results in minimized costs for operation, service, and maintenance.

Clogging significantly affects pump lifecycle costs
A good pumping solution results in a minimized total cost of ownership. The total cost can be broken down into three different parts:

- Investment costs: Costs associated with engineering, design, construction, equipment procurement, installation, and commissioning
- Operational costs: Costs associated with the pump station's energy, maintenance, and labor needs
- Unplanned costs: Costs associated with problems and downtime, such as pump failures, pump clogging, station flooding, emergency calls, sewer backups, overflows, basement flooding, or untreated effluent.

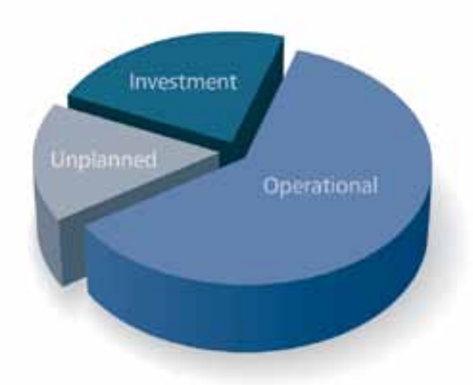

Figure 12

Because operational and unplanned costs represent the vast part of the total cost of ownership, the best solution for the end user isa well-designed pump station with modern pumps that are clog-free, reliable, and energy efficient.

Conclusion
A pump's throughlet size is not a useful parameter for specifying clog-free operation of a wastewater pump, especially for today's modern wastewater systems. The end user of a wastewater pump needs a pump that is reliable and efficient during both short and long duty cycles.

Using modern, continuously self-cleaning pump hydraulics will yield significant operational savings due to increased clog resistance and the ability to deliver sustained efficiency when pumping wastewater.