

Impeller selection for wastewater pumps

By Majid Hadavi

Single-stage centrifugal pumps are the reliable workhorses of the water and wastewater industry. However, while their versatility makes these pumps the logical choice for many applications, specifying the right impeller for the job can have an important impact on how well they perform in the field.

The problems

Pumps in sewage treatment plants and other wastewater management facilities have a tough job to do. Not only do they have to move huge volumes of wastewater, efficiently and reliably, but they must also cope with a wide variety of solids and other contaminants that find their way into the waste stream. These can include chunks of plastic, rubber, wood or other materials; fibres (e.g. pieces of cloth or sanitary products); and sand. When they show up in the waste stream, problems can arise! Solid chunks block passages or even jam the impellers. Fibrous materials can build up around the throat of the impeller, blocking the flow. Sand and other abrasive materials act over time, eroding impeller vanes and degrading the efficiency of the pumps.

Operators are finding that these problems are getting more serious. Low-flow toilets and other water-efficient appliances are helping to reduce the per-capita water consumption, but with higher solids content in the remaining flow. (In Europe, per-capita water consumption has gone down 40% in the past 15 years.)



Solids and fibres can cause serious problems.

From the operator's point of view, blockages or pump failures can cause serious and costly interruptions. Clearing blockages or swapping out damaged components is dirty, time-consuming

due to fibres in the waste stream. This tends to take place in two areas: at the leading edge of the impeller, and in the narrow gap between the outer surface of the impeller and the inner surface of the

	<i>Closed vane</i>	<i>Open vane</i>	<i>Free-flow (vortex)</i>
<i>Pumping efficiency</i>	✓ ✓	✓	
<i>Solids (in chunks)</i>	✓	✓ ✓	✓ ✓
<i>Fibrous solids</i>		✓ ✓	✓ ✓
<i>Sand and abrasive solids</i>	✓		✓ ✓

work. At the same time though, energy costs are a significant (and growing) part of most plant budgets, so that pumping efficiency remains an important consideration.

Impeller options

Major pump manufacturers offer a variety of impeller designs. Choosing the 'right' impeller for the job depends on having a clear understanding of the operating environment, the nature of the waste stream and the relative strengths of the various designs.

There are broadly three types of centrifugal pump impellers on the market: closed impellers, with single, double or multiple vanes; open impellers, again with one or more vanes; and specialized designs.

Closed or shrouded impeller designs

Closed impellers offer very good energy efficiency, especially with multi-vane designs. What's also important, closed impellers still deliver good efficiency while operating under low-flow conditions or when operating with an enlarged sealing gap (due to wear). Single vane closed impellers typically provide large clear passages, which reduces the danger of blockage due to large objects in the waste stream.

Unfortunately though, closed impeller designs can be more prone to clogging

volute casing. Accumulation of fibrous waste in these areas will reduce flows or even stall the pump.

Open impeller designs

There are several open impeller designs on the market that promise greatly reduced sensitivity to clogging with fibres, thanks to specially contoured leading edge shapes and the elimination of the troublesome gap between the impeller shroud and the volute casing. These impellers typically have generous clear passages, so that they can pass reasonably large chunks of solid materials without blocking. The principal disadvantage of this type of impeller is that their pumping efficiency is lower than the best closed-vane designs, especially under low flow conditions. These types of impeller are also less than ideal when pumping wastewater with significant sand content, since erosion of the vanes(s) will increase tip clearances and reduce pumping efficiency.

Specialized designs

Several pump manufacturers offer special free-flow or vortex type impellers. These impellers have much shorter vanes than conventional open-type impellers and work by inducing a vortex in the pump casing. Pumping action depends on the difference between the low pressure at the centre of the vor-



Closed or shrouded impeller.

tex and the relatively high pressure around the outer edge. Because of the stubby vanes and large clearances, this type of impeller is extremely resistant to blocking or clogging. Since there is only limited contact between the impellers and the pumped fluid, these work well with waste streams that contain significant amounts of sand or other abrasive materials. They also work well when there is gas in the fluid.

The principal drawback to free-flow impellers is their relatively poor pumping efficiency. These designs typically have efficiencies in the 40 to 50% range, compared to 75 to 80% efficiency for the closed-vane impellers.

Some pump manufacturers also offer so-called cutter impellers. These have special blades or shearing elements that



Free-flow or vortex type impeller.



KSB 'D-Impeller' – single-vane, open type of impeller for high-fibre wastewater.

are designed to cut long fibrous objects (sticks, pieces of cloth, etc.) into smaller pieces. These impellers are optimized for specific types of solid debris and, as with the free-flow impellers, pumping efficiency may be compromised.

And the winner is...

What's the best pump/impeller combination for your application? The answer is, of course, "it depends". The recommended approach here is to consider the full life-cycle cost of the pump installation. Different impeller designs typically don't change the purchase price of the pumps very much, so initial cost is not a major concern. However, the cost of energy to drive the pumps can be a significant part of the equation, and here the superior pumping efficiency of closed-vane designs makes them a good choice – at least when fibrous solids are not a significant concern.

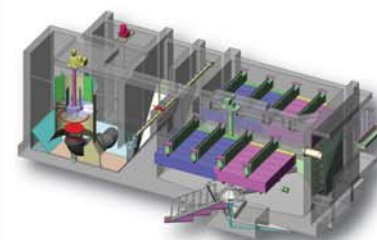
As the quality of the waste stream deteriorates, reliability becomes the driving force. Experienced plant operators know that the cost of correcting unexpected blockages or equipment failures can be very high – higher perhaps than the initial cost of the equipment. When fibrous solids can cause problems, the more clog-resistant open-vane designs emerge as a better choice. And, when things get really ugly, the so-called free-flow or vortex impellers might fill the bill.

Working closely with a specialist from your pump supplier can help make sure that you get the pump/impeller combination that is best for your application.

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