Why the time is now for the S-tube® impeller
How Grundfos S-tube® deals with new wastewater challenges

By Justyn Barnes

The rising price of water plus a range of new environmental and political factors must be accounted for when planning a modern wastewater system. The Grundfos S-tube® impeller is designed to help to meet these diverse challenges.

The fundamentals of the revolutionary S-tube® impeller, introduced to the market by Grundfos in 2012, have actually been on pump designers' drawing boards for decades. It's just that for many years no wastewater pump manufacturer was able to make this impeller design work successfully. The volume and diversity of waste material to be transported was relatively low, and therefore details such as the water and energy usage were barely considered by utility providers.

Image: The Grundfos S-tube® impeller is designed to transport an increased volume and diversity of wastewater over longer distances while using less energy and transportation fluid.

It is only in the past two decades that a variety of factors have all collided to make the S-tube® design relevant. These include: increased environmental awareness, new government legislation and directives, and the rising cost of water, energy and waste transport.

The challenges facing modern utilities

The main – and interlinked – challenges facing utility companies today in relation to the transport of waste may be summarised as follows:

- Rising cost of water and energy and stricter government controls (e.g. green taxes on water and energy for consumers)
- Lower water consumption – and energy usage,
- Less fluid mix of modern wastewater.

A core reason for utility companies to change their approach to wastewater management, then, has been the rising cost of water (see Figure 1). Consequently, consumers have cut down their consumption, which has meant a change in the composition of wastewater, with a higher proportion of dry solid content than before.

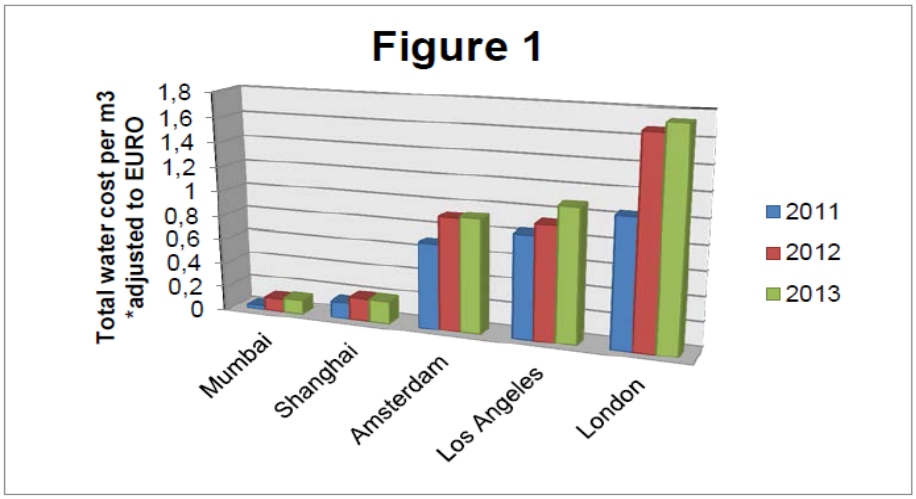

Figure 1: Rising total wastewater costs have been a significant factor in forcing utility companies worldwide to rethink their approach to wastewater management.
Source: GWI Water Tariff Survey – 2013 Update

Government regulations, standards and directives have added further layers of complication. For instance, clause five of the European standard on pumping installations EN 752-6:2008 states that pumping installations should "be planned and designed taking into account" such factors as "energy usage," "operations and maintenance requirements" and "environmental impact."

Aside from stricter controls on usage, the rising cost of energy has increased the incentive to find more efficient methods of transporting wastewater. Water-saving innovations have created new problems. For example, more efficient toilets use less transportation fluid, thus increasing the risk of clogging farther down the line. Traditional wastewater pumps add to this clogging risk rather than solve it because of the following design issues:

- Leading edges on which waste material easily catches,
- Bends in the pipework,
- Cutting mechanisms,
- Reduced free passages.

"We see two major and global challenges when it comes to wastewater transportation," says Maurice Martaud, Technical Support Engineer of leading French water company Lyonnaise des Eaux, part of the multinational Suez Environnement Group. "The first challenge centres on the changing social behaviour of the consumers. On one hand, this is driving the installation of water-reducing measures to reduce water consumption to a minimum, and on the other, an increase of fibrous material discarded to the collection systems. These changes challenge both wastewater pump hydraulics and pipe works as the solid stream conveyed by the wastewater becomes thicker and tougher to transport.

"The second challenge focuses on the increasing need for monitoring collection systems to prevent clogging of gravity sewers, pumps, and force mains," he says. "Clogging caused by the mixing of fats, sediments and macro-debris is an increasing problem that places a great demand on service resources. Hence, any clogging trend must be anticipated as much as possible."

Different impellers, different problems

The industry response to these changes and pressures has been a general trend towards centralized waste management systems where possible. Variable-speed pumping has also become commonplace as a means to save energy, but with reduced-flow velocity comes greater risks of clogging in the system, which affects both efficiency and longevity.

Altogether this presents a difficult problem for wastewater pump designers: how to move more waste than ever before, over longer distances, using less water and less energy, and with little or no maintenance required after installation.

Various types of wastewater impellers have been developed over the years in search of greater reliability and higher hydraulic efficiency – vortex types, semi-open or closed impeller solutions or hybrid variations on these themes.

“Customers have also been asked to purchase costly add-on assemblies,” says Mikael Nedergaard, Global Product Manager at Grundfos. “These are intended to lead, cut or treat wastewater as it passes through, but deliver no noticeable improvements in long-term reliability.”

The S-tube® Impeller: no trade-off

EN 752-6:2008 identifies both “optimising efficiency” and “the ability to pass permitted solids without clogging” as vital attributes of a pump. However, according to Mikael Nedergaard, “customers have often been led to believe that they must accept a trade-off between the two”. The S-tube® impeller, which features in Grundfos wastewater pumps, dispels this notion, offering both excellent hydraulic efficiency and free passage, which prevents the pump from clogging.

“The key advantage of the smooth S-tube® design over impellers with leading edges is that there is nowhere waste matter can catch and cause clogging,” explains Flemming Lykholt-Ustrup, Head of Global WW Fluid & Mechanics at Grundfos. “Special features at the front and back plate of the closed S-tube® also optimise the leak flow into the cavities between the rotating impeller and the stationary pump housing.

Because the non-compromised inner diameter of the S-tube® is uniform (see Figure 2), there is less likelihood of clogging, even with a relatively low volume of transportation fluid as found in modern-day wastewater.

“Consequent hydraulic efficiency gains drive down energy costs for the end-user,” says Flemming Lykholt-Ustrup. “Furthermore, the lack of a leading edge has the benefit of significantly lowering NPSH inside the centrifugal pump where the hydraulic system is most prone to cavitation.”

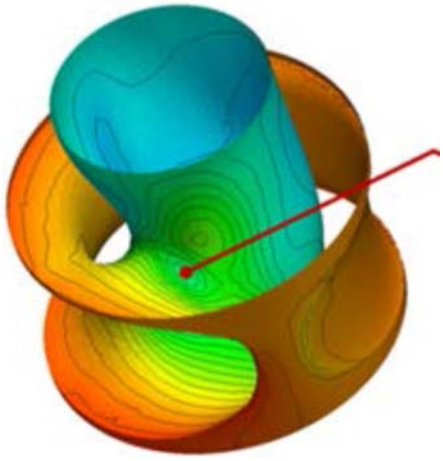

Figure 2: This colour-coded image shows how pressure acts on the surface of a typical hydraulic S-tube® surface (no material added). Blue marks the lowest pressure, increasing through green and then yellow to red, the highest pressure as the fluid leaves the impeller. This build-up pressure indicates promising efficiency and no backflow to start the accumulation of solids. At the point marked, where the tube is bent most, it is still almost impossible for solids to get stuck inside the S-tube® as there is no leading edge in the impeller concept.

The holistic approach

Research published in the book *Pump Life Cycle Costs: A Guide to LCC Analysis for Pumping Systems* by the Europump and Hydraulic Institute, shows the initial purchase price rarely accounts for more than five per cent of a pump's total cost over its lifetime. Power consumption is by far the most significant factor at 85 per cent of total expenses, while service costs are likely to be approximately ten per cent.
It is understandable then, that some of the leading players in market have recognised that a holistic approach is required to optimise a pump system. Grundfos's *modus operandi* is rooted in its iSolutions [Intelligent solutions] philosophy, which embraces the entire lifecycle of a pump, from design and development to production, installation and maintenance, scrap and recycling.

Customer feedback is key to this approach, according to Mikael Nedergaard.

"End-customer involvement during the product development project ensures that the solutions in the final product meet customer demands," he says. But this is not the sole driver of design refinements, he adds. For instance, one issue that is often underappreciated by customers is air handling (see Figure 3). It is important to ensure that a pump is able to handle a certain amount of air in the fluid. Grundfos engineers conducted extensive CFD investigations to optimise the critical areas where air will accumulate in order to minimise the flow reduction through the S-tube® impeller when operating with gassy or air-filled media.

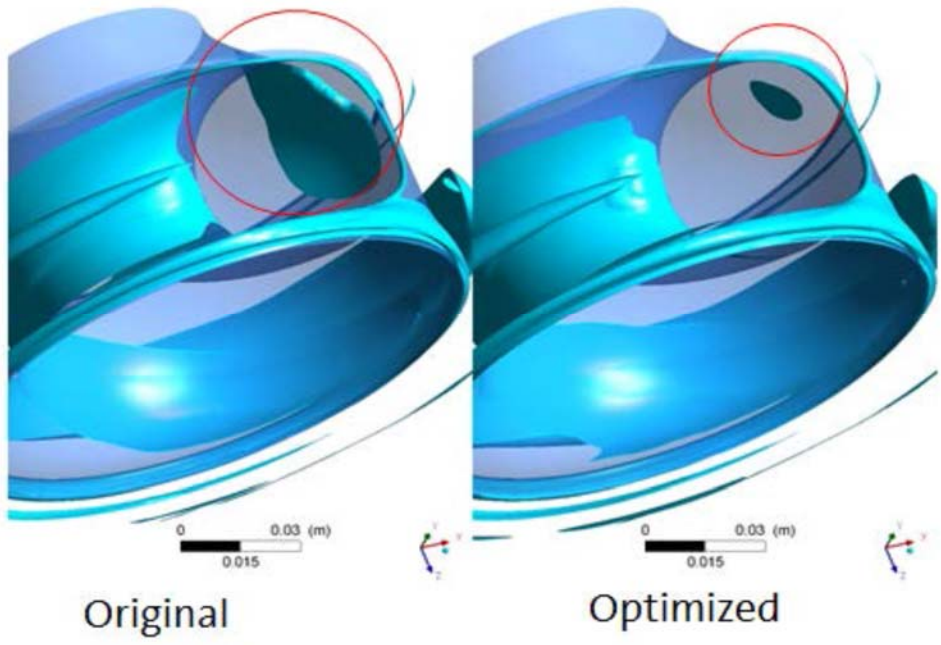

Figure 3: In this multiphase CFD simulation, the two impellers are of similar size but slight geometric difference (within a few millimetres) in shape. The fluid flow is the same for both impellers, with 8 per cent air continually added to the flow. The circled areas show the accumulated air bubbles in each and how air handling may be optimized by specific design.

Summary

Modern wastewater management systems must be able to transport an increased volume and diversity of waste over longer distances, but using less energy and transportation fluid. This requires a centrifugal pump that does not compromise on either clogging or hydraulic efficiency and offers extended life span with minimal maintenance. The age-old tube concept, refined by skilled 21st-century engineers and the feedback of end-users, is proving to be the most effective all-round solution.

'Wastewater now and in the future presents a difficult problem: how to move more waste than ever before, over longer distances, using less water and with little or no maintenance required after installation.'

'Water-saving innovations created new problems. For example, more efficient toilets use less transportation fluid, thus increasing the risk of clogging farther down the line.'

'Altogether this presents a difficult problem for wastewater pump designers: how to move more waste than ever before, over longer distances, using less water and less energy, and with little or no maintenance required after installation.'

'Many modern wastewater pumping solutions ask the customer to accept lower hydraulic efficiency in order to increase the non-clogging capability. With the S-**tube**® impeller the consumer does not need to compromise on either.'