Pressure on pumping

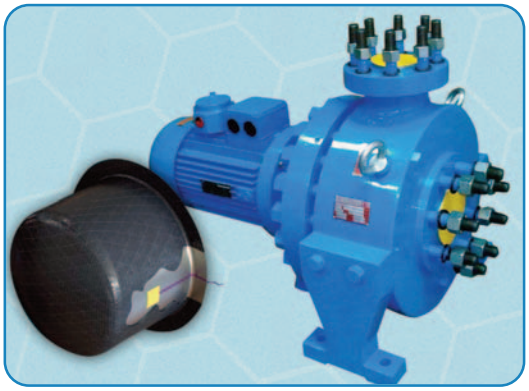
Pump designs may be evolving only slowly, but that's far from the whole story. Brian Tinham examines developments and some cautionary tales around selection, installation and commissioning

Although some in the water industry are talking about new impeller designs, from the likes of Grundfos, Flygt (now Xylem) and ABS, designed to broaden and improve efficiency curves on submersible pumps, little else appears to have changed in recent months. Yes, such units are now being offered with IE3 (premium efficiency, higher than the old Eff1 on CEMEP) electric motors built in, to reduce energy consumption over the pump lifetime, but that's it.

Or is it? Dig deeper and you quickly find that change is always ongoing – in pumps as elsewhere – at the very least, in response to the requirements of more demanding plant types and processes. Look at high temperature fluids, pumping reaction products or others that are solids or semi-solids at ambient, for example. Problems generally stem from differential thermal expansion, causing fit problems with bearings, bushes and dynamic seals, and there can be corrosion issues, too.

One solution is Hydra-Cell pumps, from US-based Wanner, which can handle liquids at up to 120°C, because of their multi-diaphragm design, with no dynamic seals and no bearings or bushes wetted by the pumped liquid. The latter is also always isolated from the lubricated pump drive end and, where even higher operating temperatures are encountered, the manufacturer offers to supply compatible oil coolers to maintain the pump's hydraulic liquid at optimum viscosity.

Another interesting design – this one improving on seal-less, magnetically-driven pumps and enabling direct temperature measurement of the process fluid



Steps to consider before selecting a pump

It is essential to establish a full definition of the process outline and main process parameters, such as flow, pressure and temperature. The following advice, from maintenance, repair and overhaul specialist Brammer, covers most of the points to consider.

1 Determine the required pumping services
2 Get a complete description of the fluid to be handled in each pumping operation (type, temperature, density, viscosity, vapour pressure, solids in suspension, toxicity, volatility)
3 Review the general layout of the plant and available space in three dimensions
4 Look at the arrangement and dimension of the piping, according to the recommended velocities for each fluid and type of pipe
5 Determine elevation for the suction and discharge points of vessels, relative to the centre line of the pump
6 Perform a preliminary calculation of friction losses and plot system characteristic curves
7 Define the working parameters of the pump, namely capacity, head, suction and discharge pressures, taking into account any possibility of variations in pressure or temperature at different pumping conditions
8 Determine any exceptional start, stop or running conditions
9 Check the available NPSH (net positive suction head).

– involves what M Pumps (formerly 3M Pumps) describes as a breakthrough. Beyond the established benefits of leak-free, low-maintenance and reliable pumping, including with aggressive and corrosive fluids, these units overcome the problem of eddy current losses in the containment shell, caused by rotation of the magnetic field.

Instead of the usual zirconium oxide, borosilicate glass and PEEK matrix composite shell materials, M Pumps has developed a hybrid rear shell design, using an inner made from Hastelloy C and an outer comprising a carbon filament wrap. According to distributor Pump Engineering, the result is a composite rear shell with the properties of a non-metallic material, plus good mechanical and chemical resistance.

One more seal-less design – this involving a micropump and inverter, supplied by Michael Smith Engineers – recently met demanding production process requirements at Specialist Glass Products, where mechanically sealed pumps had failed. The Huddersfield firm manufactures reinforced laminated double-glazed panel sections, in sizes up to five metres. The interior sandwich is filled with UV-sensitive, urethane-based acrylic monomer via a batching pump and metering system.

Sticky business

Flow rate has to be adjusted during the process to ensure that the UV resin is introduced at the right speed. If the flow is fractionally too fast, the mix picks up air bubbles caused by drag on the glass surface and the surface tension of the liquid resin. So the design brief was: provide a pumping system to deliver a smooth and accurate output; and incorporate a seal-less magnetic coupling, so that the resin is not exposed to air. The pump also had to be easy for the operator to use and provide automatic slowing at batch end, to prevent overfil.

Michael Smith Engineers' system comprises a micropump with an inverter-controlled motor, having an integral dual-channel encoder for operating at speeds up to 2,100 rpm. Following installation, filling accuracy was measured at +/-1% of batched volume and the problems of entrained bubbles were eliminated.

But significant developments are also being witnessed at the other extreme of operations and on different pump types – and some of them relate to the detail of associated plant issues. Take the 400 million euro, 700,000 tonnes per year Artlant MegaPTA (purified terephthalic acid) plant, which recently started full-scale operations in Sines, Portugal. A total of 40 centrifugal process pumps, worth in excess of 2 million euros, was ordered by Artenius UK and Tanton Technology for duties including low NPSH (net positive suction head), high-temperature, high-speed, low-flow, high-head and slurry pumping, in power ranges of 5.5–315kW.

Amarinth won the project and says development was driven by stringent hydraulic requirements for most of the pumps. On the high temperature side, for example, thermal expansion of pipework was deemed likely to mean large stresses, but conventional mitigation methods, such as expansion joints and bellows, were not options. The solution in this case: a sliding baseplate that allows versions of its A Series API 610 OH2 and C Series ISO 5199 pumps to move, so reducing the risk of leaks. Plan 54 double mechanical seals were also provided by Kytola, of Finland, with an innovative seal support system, which was significantly cost-reduced against conventional approaches.

Finally, another interesting project – also involving Amarinth – that sheds light on the importance of accurate specification involves the Ineos 500,000 tonnes per annum vinyl acetate monomer (VAM) plant at Saltend, near Hull. Back in 1999, when the plant was under BP ownership, three new acetic acid pumps started having problems, with the shafts regularly braking at the impeller joint and causing significant downtime. Over a decade, BP tried a range of maintenance interventions, including changing the impeller fixing design to increase MTTF (mean time

Top left: the 700,000 tonnes per year Artlant MegaPTA plant, in Sines, Portugal, which required 40 centrifugal process pumps, worth over 2 million euros Centre left: Hydra-Cell pumps, from US-based Wanner

Guidelines for optimal pump selection

The following guidelines, also put together by Brammer, will assist in final selection of most centrifugal pumps.

1 Select the pump based on rated conditions, as per the data sheet
2 Ideally, the pump should have a suction-specific speed of less than 11,000
3 .The BEP should be between the rated point and the normal operating point
4 Remember that hydraulic efficiency is high at specific speed 2,000 and 3,000, but low if the speed drops below 500. Higher efficiency means less vibration and noise
5 Do not select a pump with maximum diameter impeller. The pump should be capable of a head increase at rated conditions by installing a larger impeller
6 The head/capacity characteristic curve should rise continuously to shut-off
7 Minimum continuous flow should be based on hydraulic stability, not temperature rise. Furthermore, the pump should not be operated below minimum continuous flow rate
8 Select a driver that allows operation to the end of the curve
9 For safe operation, NPSHA (net positive suction head available) should exceed NPSHR (net positive suction head required) by more than 1m at the rated condition. As the NPSHR varies, depending on the head and flow, it is safer to select the margin at the end of the curve
10 Consider how the pump will be driven, particularly with reference to energy efficiency. A high-efficiency motor should always be specified, while fitting a variable speed drive may also be advisable.

Specialist Amarinth pumping equipment

between failures), but to no avail. The problem of cavitation causing catastrophic failure just continued.

Amarinth was called in after Ineos acquired the plant and the firm says that, on stripping down the pumps, it quickly discovered that their design integrity had indeed been compromised. However, having reviewed the original datasheet, Amarinth's engineers agreed the pump design should indeed have been adequate for the duty. Then came the 'Aha' moment. Reviewing the pump installation with the VAM plant mechanical and operations engineers revealed a subtle, but crucial, discrepancy between the original datasheets and the real operating conditions.

The supply temperature into the pump was 133°C, while the datasheet requested 125°C. That mattered, because, at the process pressure involved, acetic acid starts to vaporise at 125°C – and hence the cavitation and the regular failures.

Armed with this knowledge, Amarinth engineers reassessed the existing pumps and associated systems, and decided that replacement wasn't necessary. They could be modified and the rate of recirculation on the plant increased to cool the acid at the pump inlet and so eliminate the problem at source. That change would also allow the pump to operate closer to its BEP (best efficiency point) than previously had been the case.

Amarinth also modified one of the plant's spare pump casings to ensure that it was interchangeable with the installed runner and standby pumps. Job done. PE