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A quiet revolution

Dennis Heath details how an ingenious seal-less pump is gaining fans across a wide range of process applications

LET us begin with a tale of three pumps – call them X, Y and Z.

pump X – cat litter manufacture

A manufacturer of cat litter in the US installed piston pumps working at 28 bar to deliver a proprietary solution (20% sodium hydroxide, 2% boric acid, dye, perfumed water) to a spray system over a conveyor carrying fuller's earth. Crystallisation of the solution made it abrasive as well as corrosive and despite their stainless steel construction, the pumps failed rapidly.

Compromising on pressure, the plant tried air-operated diaphragm pumps. Heavily pulsing flow and low pressure created inconsistent spray coverage. Stainless steel gear pumps, tried next, raised pressure to 14 bar and gave a more even flow. But abrasion destroyed their mechanical seals, leaking chemicals over the pump-room floor.

Finally, pump X was installed and ran successfully. It combined seal-less design with smooth, even flow, and pressure capability up to at least 70 bar – comfortably above the optimum level for the process. There were no dynamic seals in the pump – so no risk of seal wear. In fact very few components were in direct contact with the pumped medium.

pump Y – metering Celite

The specification for a system to dose a 5% suspension of Celite (viscosity 750 cps) into a slurry line at a Belgian chemical plant originally called for a traditional, hydraulic diaphragm, metering pump. But the pump eventually installed and successfully operated was pump Y. Both pumps met relevant standards of accuracy. Pump Y however gave lower pulsation.

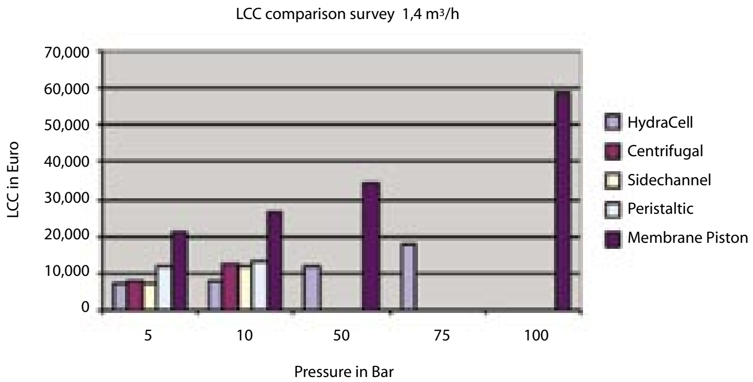


Figure 1: Pump lifecycle costs (LCC) – comparison example (pumps recommended for 1.4 m^3/h flow rate) F-W Hennecke March 2006

It was more compact, simpler in construction and about half the price.

pump Z – foaming chemicals

Dosing accuracy, within ±1.5%, is also essential in the production of polyurethane foam. But here the pumping challenges were different because foaming chemicals such as pentane are highly volatile, flammable and toxic. They have very low viscosity. To handle these thin, non-lubricating liquids at 8 bar, with no leaks tolerated, an Italian manufacturer of foam production equipment standardised on pump Z – having rejected all alternative types of pump.

In these random examples, pumps X, Y and Z had to satisfy three quite different sets of requirements – in terms of flow, operating pressure and liquid media – and any one of the combinations might have stretched the capabilities of many process pumps. In fact however, pumps X, Y and Z are all of the unique type and model, a seal-less hydraulic cell pump also known as a Hydra-Cell pump.

Their flexibility has helped these pumps quietly gain market share ever since their conception more than 30 years ago. The concept is still unique, and defines these positive displacement pumps not just as a brand name but as a generic type.

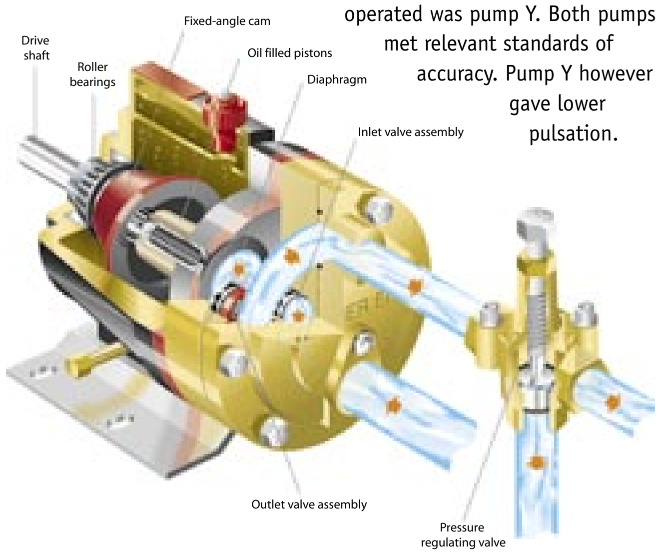
The pumps are characterised by low energy consumption, high pressure capability, minimal maintenance requirements and a record of long-term reliability even when handling liquids and conditions that can cause severe technical difficulties for many types of pump.

They are also cost-effective. In March 2006, Friedrich-Wilhelm Hennecke, an independent authority on process pumps, presented the results of a comparative study of pump lifecycle costs (LCC). The LCC of a pump is its total cost from purchase to scrapping, including elements such as repairs and energy consumption. It is a special interest for Hennecke, the chairman of the pump working group of the German chemical industry and a member of the German pump standardisation committee.

Using data supplied by the pump manufacturers, he compared the Hydra-Cell with centrifugal, side-channel, peristaltic and membrane-piston pumps. Within the "considered range", which covered flow rates of 1.4, 4.2 and 8.4 m^3/h and pressures of 5, 10, 50, 75 and 100 bar (see Figure 1) the Hydra-Cell emerged as the most economic pump overall. And it was not restricted by pressure considerations or the type of fluid it could handle.

When in the 1970s William F Wanner Snr built his first seal-less pumps and joined with Bill Wanner (his son and current ceo) in founding Wanner Engineering – the company that to this day remains the sole producer of Hydra-Cell pumps – he had in mind the agricultural machinery business, reverse osmosis and the expanding car-wash market. They called for a pump of simple design that could handle chemicals, work dependably and would need little maintenance. Success in these areas attracted users in other markets. Chemical plants were early users, though the Hydra-Cell had to prove its merit case-by-case, by showing incontestable advantages over more familiar types of pump. This has particularly been true in respect of

Figure 2: Hydra-Cell pump – simple construction



metering and dosing – a field in which there are long-established ideas of what constitutes a 'proper' metering pump.

Though the pump range is continually being expanded and its technology developed, the basic Hydra-Cell concept still applies to all models. The pump (Figure 2) works on the principle of hydraulically-balanced diaphragms (in most models three or five in a single compact head). They have a dual function, flexing in sequence to provide a smooth, almost pulse-free, pumping action and acting as a barrier, totally isolating the pumped medium from the hydraulic fluid in the drive end of the pump. Facing only a 2 psi pressure differential between the two fluids, the diaphragms operate without stress, even at high working pressures. Wanner's patented Kel-Cell technology has lately added an extra safeguard – diaphragm protection under adverse inlet conditions, such as vacuum that might result from a blocked suction filter or accidental closure of a valve. The pump can run dry without damage.

Its seal-less design allows the pump to handle virtually any liquid, including corrosives, abrasives, recycled liquids, non-lubricating liquids and those carrying solids in suspension. Absence of dynamic mechanical seals and other vulnerable wearing parts avoids problems that account for a high proportion of all maintenance and repair work done on process pumps, especially when the medium is something other than clean water.

The drive mechanism is submerged in a reservoir of oil, which keeps it permanently lubricated and allows power to be transmitted through the drive train with minimal frictional losses; helping to achieve pumping efficiencies as high as 85% and reducing required energy input. This compares with around 45% for a typical multi-stage centrifugal pump, for example, and it means that on many applications a Hydra-Cell pump can be fitted with a smaller motor than would be needed by another type of pump for the same work output. It is not uncommon for a plant to recover the cost of the pump within a year on energy savings alone.

A practical example of this was seen at a German chemical plant where a magnetic drive centrifugal pump with 55 kW motor was replaced with a Hydra-Cell G35 pump fitted with 13.2 kW motor. The duty was transfer of polystyrol over a distance of 5.8 km from a remote storage tank into a process line. The G35 was less expensive than alternatives, but with twice their pumping efficiency. And a crucial factor in this case, since polystyrol tends to flocculate if liquid temperature rises above 60 °C, was that the pump's input of heat into the process was only half of that of any of the centrifugal pumps on offer.

Hydra-Cell pumps have been used in spray drying, reverse osmosis, gas conditioning and cooling, feeding of waste product to burner nozzles, pressure cleaning of filters, tanks and mixing vessels, and of course transfer.

More recently Hydra-Cell pumps have made inroads into the field of accurate metering and in a surprising number of cases have won out over types of pump well established in that field of duty. Not all were traditional diaphragm metering pumps; Hydra-Cell pumps also replaced lobe pumps, peristaltic, piston, centrifugal pumps and progressing cavity pumps.

A metering pump in the broadest sense is one that can generate controlled liquid flow. But for precision chemical injection the preferred type has been the hydraulically balanced diaphragm piston pump built to conform with API 675, a standard developed for "controlled-volume positive displacement pumps".

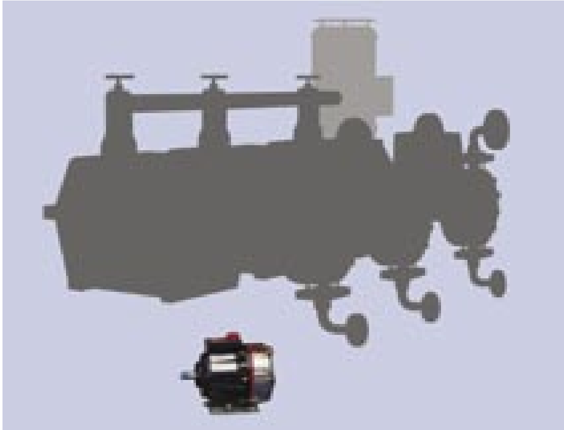
API 675 laid down standards of accuracy for metered flow and also defined the construction features and technology which at the time represented the best means of setting, sustaining, adjusting and re-adjusting flow rate within precise limits. However, technology has moved on, not only in pump design but in the control options now available to system builders, and this is making Hydra-Cell pumps a compact alternative.

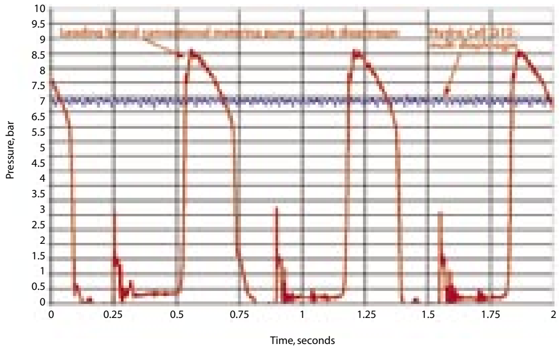
Like traditional metering pumps, they are seal-less hydraulically balanced diaphragm pumps. Both can handle difficult media and operate at low or high pressures. But there are major differences.

To vary flow, a traditional pump typically uses an internal mechanism to change the actual or effective length of the piston stroke. Automating the mechanism by attaching an actuator is expensive, while the rate of change is slow (typically 1 s/1% of stroke) resulting in pumping inaccuracies during adjustment. The flow range of any one size of pump is relatively narrow.

With only one diaphragm in a pump head, every stroke makes flow pulsate. Pulsation can only be reduced by installing dampeners or multiplexing – adding pump heads – neither of them cheap options.

Elaborately engineered and internally complex, traditional metering pumps are characteristically massive in construction





– models for high flows and pressures and multiplexed units even more so. The contrast between a traditional pump and a Hydra-Cell of identical flow/pressure rating is dramatic (see Figure 3).

Several factors contribute here. By incorporating several sequentially-acting diaphragms in a single compact pump head, Hydra-Cell pumps simultaneously save space, bulk and cost, while reducing pulsation to a level where dampeners may not be needed at all (see Figure 4).

Simply built, the pumps need neither stroke adjusters nor their controls. Flow rate is in direct linear proportion to pump speed and is easily varied electronically through VFD motor control. This arrangement, facilitated by advances in VFD technology, is not only less costly, it is more accurate and faster (0–max RPM in 0.3 s, against 0–100% stroke length in 45 s or longer).

The investment cost of a Hydra-Cell metering solutions pump, motor and controls package is perhaps 30% lower than that of a comparable system based on traditional metering pumps. Running costs are also low. And following an intensive programme of controlled tests over the last two years, the company now has formal evidence of Hydra-Cell accuracy in the three critical areas of performance required by API 675. In linearity, steady-state accuracy and repeatability, pump performance matched or bettered the standard – a claim Wanner is more than happy to document. **tce**

(top) Figure 3: Size comparison Hydra-Cell G10 vs traditional metering pump performance (both pumps) max flow: 1500 l/h max pressure: 80 bar

(bottom) Figure 4: Pulsation comparison. Hydra-Cell G10 vs traditional traditional metering pump

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