Alternative seal-less pump technologies

Dennis Heath, Wanner International, explains why a pump of unconventional design may offer an increasingly interesting alternative.

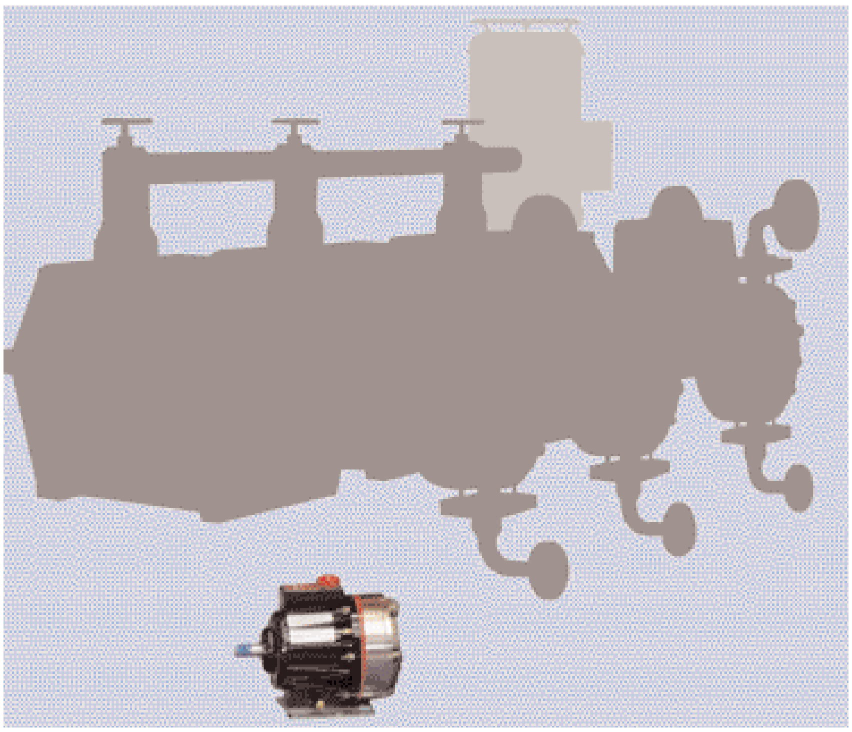


Fig.1: Size comparison example: Hydra-Cell G10 pump with typical API 675 pump. Each pump has max flow of 1500lph, max pressures 70/80 bar respectively, motor spec. (G10) 5kW, API 675 pump 15kW.

Many pump specifiers in the process industries and elsewhere have difficulty in finding a good solution for a particular application because the combination of features they seek is not easily found in one and the same pump. Such difficulties are currently intensified by safety concerns, new environmental regulations and the need to contain costs. This article reviews some of the strengths and limitations of pump types commonly used in non-straightforward applications, and explains why a pump of unconventional design may offer an increasingly interesting alternative.

In a document released to the press by DECHEMA for the opening of Achema 2003, its authors made a prediction. “Visitors to the fair will be asking one key question: how can operators of a process technology facility handle material safely without emissions and, above all, what is the most cost-effective way of doing this?” One conclusion reached in DECHEMA’s Trend Report No.2: pumps/fittings/seals, was the increasing importance of seal-less pumps. “The focus is back on units that do not leak,” said the authors. Reporting on actual and projected pump sales (in this case for centrifugal units) they noted that “it is not surprising that seal-less pumps show the highest growth rates.” Commenting on the potential for magnetic drive pumps, and recognising present limitations, the report mentioned that many observers were expecting ‘quantum leaps’ in innovation in the not too distant future.

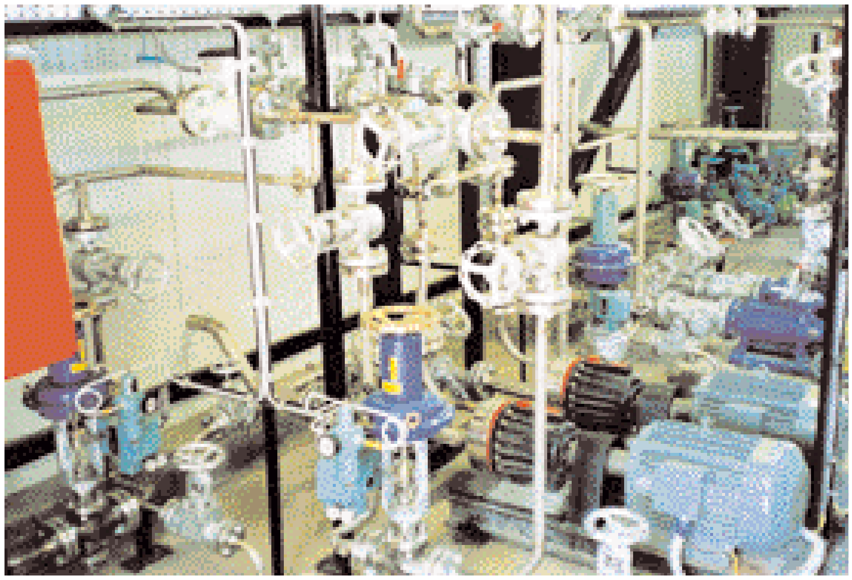
Dale Moore, of Dow Chemical-Midland, in a paper for Seal Forum, reprinted in Pump Engineer, August 2003, puts forward a rather different view. “Why has the use of seal-less pumps levelled off?” he asks. “Why don’t we expect to specify a major increase of this design versus conventionally sealed pumps?” For his company the answers are apparent: comparative total life cycle costing and product reliability. He goes on to explain why seal-less pumps, though giving excellent service when properly applied, have not been a cure-all.

Hydraulic diaphragm pumps

In the terminology of many pump users, a ‘seal-less’ pump is taken to be a magnetic drive or canned motor pump. The merits and limitations of these types of pump are generally known. Their popularity has tended to increase alongside growing concern with industrial safety and the imposition of more stringent environmental regulations. However, in their present state of development, such pumps are more commonly successful on applications where they do not have to contend with non-lubricating fluids, suspended particles or crystal formation, and are never allowed to run dry. If problems do occur, repairs and downtime can be significant.

If service conditions preclude the use of mag drive/canned motor types, does this effectively oblige the pump user to choose a pump with seals and accept the likelihood of wear, leading to possible problems of leakage, seal replacement costs, downtime and maybe even replacement of the whole pump? Not necessarily, because there is, of course, another form of high performance sealless pump - the hydraulic diaphragm type. In these pumps, hydraulically actuated diaphragms pump the liquid, and also isolate it from the drive mechanism. As compared with mag drive pumps, hydraulic diaphragm pumps can safely handle a wider range of difficult media, including non-lubricating liquids and those with suspended solids. They have higher pressure capability and superior linearity; while of course they share with the mag drive type the advantage that they are not subject to the consequences of seal wear.

In fact though, 'hydraulic diaphragm' is a broad label that can be applied to two quite different types of pump. In varying degree, all the features mentioned in the previous paragraph apply to both, but there the similarity ends. On the one hand are the slow-running, elaborately engineered pumps manufactured in conformity with API 675 requirements for metering pumps. (In practice the pumps have a wider field of application and are often used on other duties.) They are made to tight specifications and must incorporate extra safeguards such as double diaphragm construction and built-in leak detection systems. In consequence, even models in the flow ranges below 10m³/hr tend to be massive in construction. Size, combined with sophistication and a high specification, makes them expensive to buy. They can also be costly to repair if problems do occur. Pumps of this type are available over a wide flow range, with some models capable of 50m³/hr or more.

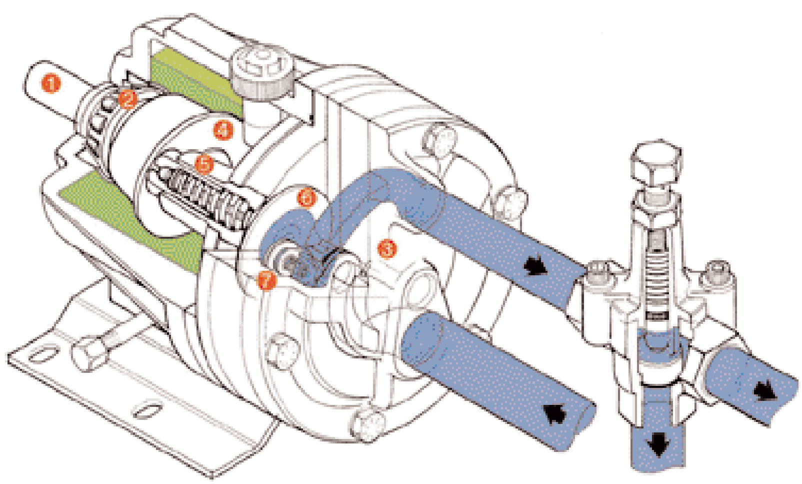


Nitrogen plant with Hydra-Cell G25 pumps (right foreground) pumping ammonia/methanol solution 55 bar, (50 lpm each pump) at 76°C.

However, many pumping applications in the process industries call for relatively modest flow capability. It is at these levels, where the flow requirement from a single pump is no more than about 7m³/hr, that a second category of hydraulic diaphragm pump comes into the reckoning and can offer an increasingly interesting alternative, not only to the bigger diaphragm pumps, but to many other types of sealed and seal-less pump. These alternative diaphragm pumps are from one manufacturer, Wanner Engineering. They must be considered as a separate category because they are not properly classifiable under any regular type. Table 1 gives a general indication of their characteristics in relation to some other types of commonly used pump.

HYDRA-CELL PUMP

Visually, the immediately obvious thing about a Wanner Hydra-Cell pump is its



Hydra-Cell pump (operation) Drive shaft Cam with Timken roller bearings Pump head Drive mechanism submerged in oil Oil-filled pistons 6/7 Diaphragms and valves.

Features	Sealed pumps Centrifugal, Multi-stage	Piston plunger	Seal-less pumps Mag-drive Gear or vane	Hydraulic diaphragm, API 675	Hydraulic diaphragm, 'Hydra-Cell'
Resistance to wear from suspended particles or crystals	Poor	Poor	Poor	Good	Good
Resistance to thin, and non-lubricating fluids	Poor	Poor	Poor	Very good	Very good
Can run dry without damage	No	No	No	Yes	Yes
Initial purchase cost	Low	Low-Medium	Medium	High	Medium
Energy consumption	High	Medium	Medium	Medium-High	Low
Cost of repairs-spare parts	Med-High	Med-High	High	High	Low
Down-time for repairs when required	Med-High	Med-High	High	High	Low-Medium
Output characteristics	Non-linear	Linear	Near-linear	Linear	Linear
Pulsation	Very low	High (Triplex)	Medium	High (Triplex)	Medium (Triplex)
Effect on flow of change in discharge pressure	Large	Small	Large	Small	Small
Physical space required for installation	Large	Medium	Medium	Large	Small

Table 1: For applications using a single pump, in the range of 7-70 bar discharge pressure, up to 7 m.cu/hr flow, with non-clean fluids at temperatures from 10-100 deg.C.

size in comparison with a typical API 675 unit of very similar flow and pressure rating. (See Figure 1, originally a photograph on which the larger pump has been converted to a silhouette) Compactly constructed, and not obliged to incorporate the extra devices built into pumps conforming to API 675, Hydra-Cell pumps are nevertheless well engineered, robust and of proven reliability over a wide range of applications. In the design, positive displacement pumping is provided by diaphragms flexed from behind by hydraulic fluid. Each diaphragm closes off a hydraulic cell (single-cell, 3-cell and 5-cell arrangements are used) and separates drive fluid from pumped fluid. The drive end operates in a lubricating oil bath. Liquid pressures on either side of the diaphragm are automatically held in balance, so that the diaphragms operate without stress, even at high pressure levels. Unlike API 675 type pumps, which are slow moving and deliver a large volume on each stroke, Hydra-Cell pumps work at high speed, delivering a small volume from each cell but at high frequency. As well as reducing pulsation, this is one reason why the pumps can be physically small in relation to flow capability. Another reason is their exceptional efficiency (80%) which also reduces power requirement and energy costs. These pumps are characterised by an unusual combination of features, namely seal-less design; isolation of pumped fluid; high flow and pressure capability in relation to size and energy input; ability to handle hot, cold, thick or thin liquids; whether non-lubricating or not; tolerance to solids in suspension and crystals; tolerance also to chemicals; and through the availability of optional materials for pump head and for diaphragms. Moreover they are positive displacement pumps. Flow is linear, that is, it relates directly to pump speed and is little affected by changes in pressure.

COST-SAVING APPLICATION

The effect of combining so many features in one pump is to make it more versatile, and enable it to replace more conventional units over a considerable range of applications. For example, when a Swedish paper mill installed a Hydra-Cell G25 pump on a filter cleaning system that had previously relied on a multi-stage centrifugal pump, the mill began to save energy costs calculated at EUR 6500 per year. Multi-stage centrifugal units are commonly used in the industry on this type of work which involves the removal of residual lime mud from the filters, using re-circulated water. However, high energy consumption and maintenance costs, mainly through problems with seals and bearings, had prompted mill engineers to re-assess the situation when planning the replacement of the previous pump 4 years ago. With power consumption of 30kW and assuming energy costs of SEK 2,500 per kW per year, the cost of running a centrifugal pump for one year worked out at SEK 75,000 (EUR 7800). That was for energy alone. By contrast, the Hydra-Cell G25 unit draws only 3kW of power, and in every respect is more than equal to needs of the mill on this application. The initial cost of the pump was some 25% to 50% less than multi-stage centrifugal pumps originally under consideration. Energy consumption has been reduced by 90% and ongoing service costs have been reduced. Performance is also improved. Mill engineers were able to raise the pressure of the cleaning water to 50bar, and so increase filter capability.

In a German chemical plant a similar Hydra-Cell G25 pump replaced a hydraulic diaphragm pump of the API 675 type on a spray drying system, delivering a suspension with 40% solids content to the spray nozzles at a working pressure of 70bar and flow rate of $5m^3$/hr. Service life of the larger pump had been only 'modest' on this application. Taking into account its procurement cost (about three times higher than the Hydra-Cell pump) along with relatively high energy and maintenance expenses, total life cycle costs of the original pump were considerable and well above those of its replacement.

Checked after two years of service on another chemical process in a German plant, a larger Hydra-Cell pump (G35) showed no discernible wear at the valves or diaphragms. No spare parts had been fitted in that period. The unit's function is to transfer chemical products from a storage tank to a production line over a distance of several kilometres, a task complicated by the tendency of the chemical to coagulate at temperatures above 60°C. Other pumps considered for this duty included a hermetically sealed canned motor centrifugal pump, over which the Hydra-Cell unit had a clear price advantage. Other points in its favour against multi-stage centrifugals were higher efficiency, smaller motor and a notably lower drag-in of energy to the medium when the system operates in bypass mode. It was also noted that the linear characteristics of the pump made it easy to control in process. Flow rates (up to $7.5m^3$/hr) could be reproduced at will.

A specialised, but very well established, application for Hydra-Cell pumps is in the metal manufacturing industry, where the pumps are used to deliver coolant at 70bar pressure to the workface during high-speed machining and grinding operations. The introduction of high pressure in place of gravity feed cooling systems allowed faster feed and cutting speeds, reduced tool wear and boosted productivity. But recycled coolant carries swarf and other abrasive particles and needs ultra-fine filtration before it can be handled by the piston pumps at first favoured for this work. Hydra-Cell pumps combine the necessary pressure capability with the ability to handle small particles. They do not need expensive ultra-fine filtration. One early customer, a component manufacturer in the UK, was able to save GBP 10,000 on filtration costs when equipping two CNC lathes with a high pressure coolant system.

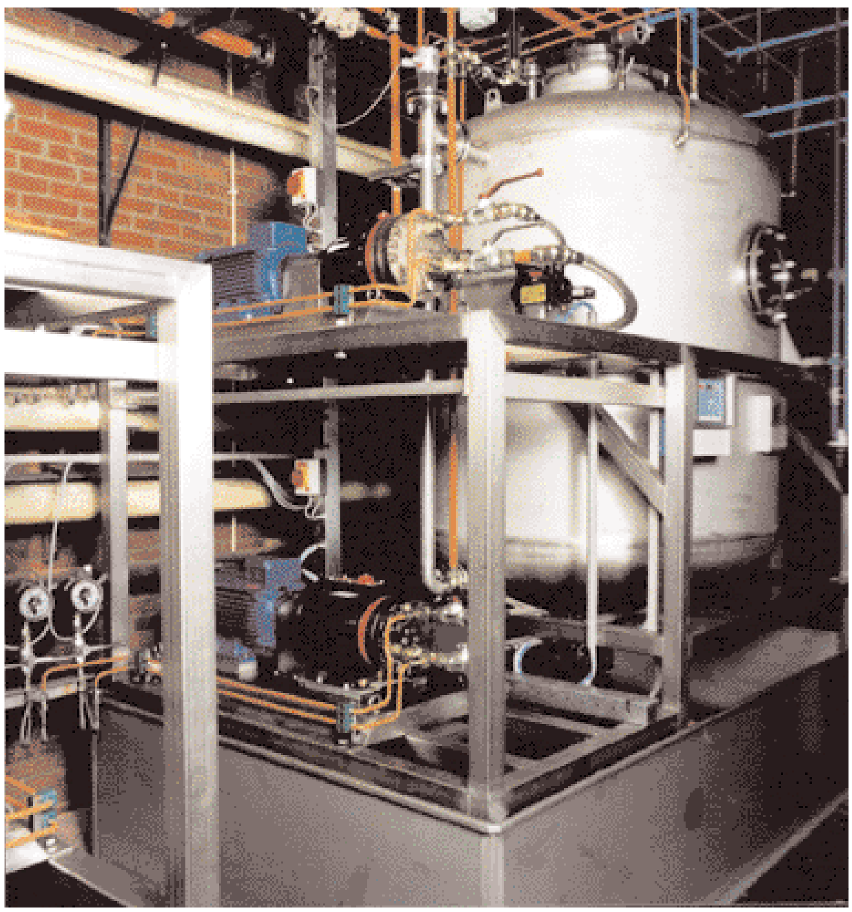
Another unpromising candidate for pumping is Xylene, produced as a by-product from coal processing and used as liquid fuel in cement plants. It is non-lubricating, toxic and contains particles. It must be delivered to injector nozzles at 25bar pressure. In one plant, a gear pump, with seals of good quality, lasted 1 week on this duty. Piston pumps are not suitable, peristaltic pumps cannot deliver enough pressure. A big hydraulic diaphragm pump could do the job, but is ruled out on economic grounds by its initial cost. Hydra-Cell G25 pumps are now performing this operation in plants in Belgium, France, Switzerland and the Czech Republic, with no reported problems.

Finally, another recycling story. Management at a small Czech converting mill, where recycled paper is made into toilet rolls, was struggling with problems of seal wear and frequent replacements on a multi-stage centrifugal pump delivering recycled water at 70bar pressure to spray manifolds for cleaning the transport belt. The manager liked the idea of using a Hydra-Cell G35 pump, but demurred at the cost.

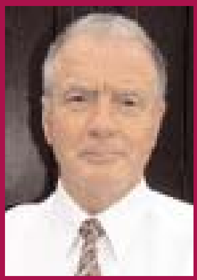
"Tell you what," said the pump salesman, "You can have the pump and motor for one Czech crown, but you must give me whatever you save in energy cost over the first year." The mill manager thought it over for a few seconds, then decided to pay the full price. Energy savings paid for the new pump unit within 6 months.

KEL-CELL

Hydra-Cell pumps have a good track record for reliability, but they have sometimes been damaged through sys-



Iso cyanate pumps, Hydra-Cell G15 dosing MDI at 120 bar (10-40 l/min) Hydra-Cell G25 re-circulating liquid within the tank at 50 bar (70 l/min) tem problems, poor system design, faulty installation or some operational incident that has not been allowed for. To protect the pumps in face of abnormal and adverse system conditions, the manufacturer is progressively introducing a new development, the Kel-Cell. Its introduction enables the company to further extend its areas of application. With patents pending, the technology is already incorporated on all 70bar rated pumps (G10, G12, G25 and G35 models) and in Slurry Duty pumps. Other Hydra-Cell models will benefit in due course. Kel-Cell DPC (diaphragm position control) technology involves subtle but far-reaching modifications on the drive side of the pump. It is an enhancement of the original Hydra-Cell concept. The Kel-Cell innovation safeguards the diaphragm in the event of abnormal or fault conditions that would cause the diaphragms to operate out of hydraulic balance. For example, an inlet valve shutting off, an inlet filter blocking, or continual operation of the pump at zero outlet pressure could upset the balance, with the effect that diaphragms gradually deform and may eventually rupture. Kel-Cell DPC is designed to stabilise the diaphragms in all such conditions and so prevent incidental failure. Not a substitute for good system design (standard installation guidelines still apply) Kel-Cell is a significant advance for the extra protection it gives, especially on critical applications. ●



About the Author

Dennis Heath is managing director of UK-based Wanner International, a subsidiary of Wanner Engineering, the privately owned American company that manufactures Hydra-Cell pumps. Trained originally in the machine tool industry, Dennis is a Chartered Engineer and a Member of the Institute of Mechanical Engineers. He joined Wanner International in 1989, originally as European sales manager, and was appointed managing director 7 years ago. In this role he is responsible for sales, marketing and technical support services for Hydra-Cell pumps throughout West and East Europe, the Middle East and the Indian sub-continent. At Wanner International he has worked to develop the trust and long-term relationships with a, currently 22-strong, network of 'sales partners' - distributors and representatives - which he regards as fundamental to the growth of the business.