

Energy efficiency

Energy savings begin at pump

Sophisticated controls, VSD drives, efficient motors – but don't forget the pump! Paul Davis looks at how design fundamentals and the effects of pump wear impact directly on energy costs. Can seal-less pumps lead the way to more efficient systems?

It is unusual these days to open a magazine, click on a web site, visit a trade show, or listen to a salesman and not be told how this product, that design or the other 'approach' will save you energy. Governments are involved, applauding, rewarding, penalising. Society approves – and rightly so, because concern is global.

Pump manufacturers and their customers have a special interest in energy issues. A report by US government department the Office of Energy Efficiency, cited in *World Pumps* last September, put the industrial sector's share of all energy consumed in the USA as high as 33%, while pumping systems account for 27% to 33% of all energy used in industry. Figures may vary internationally, but the USA is not alone.

So it would be surprising if pump and system suppliers were not only striving to improve the energy efficiency of their product, but also devoting considerable attention to publicising these efforts. The cumulative effect has been an ongoing outburst of energy conservation claims that may well leave the customer a little confused.

VSD developments

Over the last decade, one of the more significant steps towards the reduction of energy consumption in pumping systems has been the development and availability of smaller, cheaper and more efficient variable speed drives (VSDs). Controlling

system flow by altering pump speed, rather than diverting output via a by-pass valve or using simple on/off controls, makes it possible to operate the pump closer to the fluctuating flow/pressure demands of the system, thereby avoiding what may be considerable wastage of power.

The relative efficiency of the motor must be taken into account, and some pumps are easier to control than others. But in any case, no matter how good the motor and how sophisticated the control system, two underlying factors directly affect the baseline energy costs of running a pump: the efficiency of the pump itself at the required pressure, and the extent and rate at which performance degrades through pump wear in a given application. Both these factors vary widely with the type of

pump in use, and can have a dramatic effect on energy costs, measured through time.

Underlying efficiency

The first factor, determined arithmetically, was one of the elements used by Dr.-Ing F-W Hennecke in 2006 when the former BASF pump chief published the results of a comparative enquiry into the Life Cycle Costs (LCC) of a representative selection of five types of pump used in the process industries. A leading proponent of the LCC concept (he co-edited the jointly published by Europump and the Hydraulic Institute) and a member of the Pump Working Group of the VCI in Germany, he was well placed to conduct a survey based entirely on data

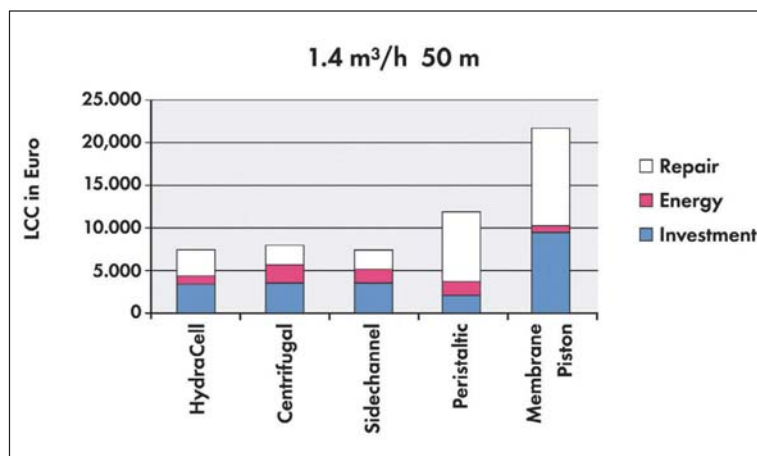


Figure 1. LCCs for pumps delivering 1.4 m³/hr at 5 bar. (F-W Hennecke).

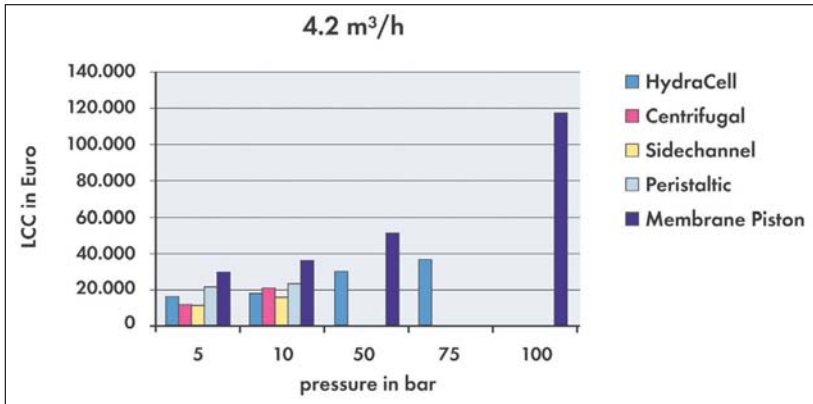


Figure 2. LCCs for pumps delivering 4.2 m³/hr at various pressures. (F-W Hennecke).

supplied by the manufacturers themselves – five companies, each chosen as a leading producer of a particular type of pump.

The types considered were the centrifugal pump, the sidechannel pump, the peristaltic pump, the membrane piston pump and the Hydra-Cell pump – each of these being generically different from other types of pump.

Measuring LCC

LCC, accepted as the true cost of owning and operating a pump, must historically include every element from purchase to

scrapping, but in a general comparison of costs for pump types, some factors must be excluded as less useful, being common to all types or dependent on individual circumstances. The significant elements for purposes of type comparison in this survey were purchase cost, maintenance/repair costs and the cost of energy.

Operating values were invited for each pump type to match specified flow rates from 1 m³/hr to 8 m³/hr and an assumed duty cycle of 4000 hrs/yr. In each case, LCC was calculated for working at specific pressures from 5 to 100 bar. For higher pressure applications,

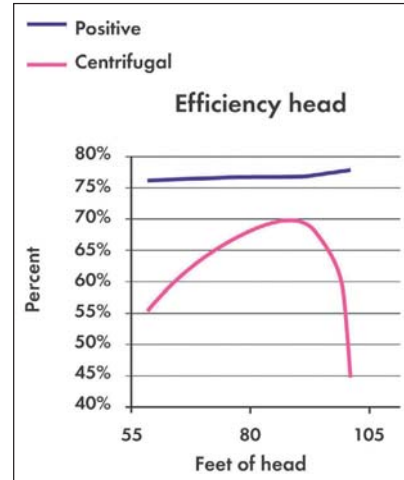


Figure 3. Pump type comparison example – the effect of pressure variation.

Dr Hennecke took into account only the membrane piston pump and the Hydra-Cell, both of which could be classified more generally as reciprocating positive displacement pumps – though with distinct differences. The other types in the cost survey ‘could not usefully be considered’ for working at pressures above 10 bar. He also noted that in practice not all the pump types were suited for operation in all circumstances. Limiting factors would include temperature, solid content,



Figure 4. Seal leaks lower efficiency and waste power. (Water treatment plant, Seonam).



Figure 5. Installing seal-less Hydra-Cell pumps removed leak problem and halved energy use at Seonam.

hazardous fluids and pump pulsation – all excluded for purposes of the survey.

The bar chart in Figure 1 summarises the LCC comparison costs for pumps delivering 1.4 m³/hr at 50 m head (5 bar), while Figure 2 shows the overall LCC findings for the same pump types delivering 4.2 m³/hr.

Energy costs in the Hennecke survey were based on manufacturers' pump specifications, related to horsepower requirements at specific operating levels. They therefore reflect pump efficiencies. It will be seen that at low pressure and flow, the LCCs for centrifugal, side-channel and Hydra-Cell pumps were broadly similar, though the energy cost figures indicated that the latter had some advantage in mechanical efficiency. Hennecke's results for higher flows at the same low pressure bore this out. But at all flow rates, the effect of operating at higher pressures was to increase energy cost differentials.

The investigation confirmed an important principle: namely that the life cycle costs of pump ownership, and within that the energy cost, do vary significantly with the type of pump used. That still applies in 2010, when energy is a bigger factor than ever before.

Pump comparisons

In broad terms, positive displacement pumps are capable of higher efficiency levels than are centrifugal pumps. They are also more flexible, being relatively unaffected by changes in fluid viscosity or operating pressure (see Figure 3). The typical efficiency curve for a centrifugal pump shows why, to restrict energy consumption, it is important to avoid deviation to left or right and restrict operation to the centre section of the curve. In practice this may be difficult to achieve.

Dr Hennecke was concerned with LCC (not just energy cost) and his sampling leaves out several types of positive displacement indus-

trial pump for which high efficiencies may be claimed, in greater or lesser degree. Piston/plunger pumps, gear pumps, twin-screw pumps and progressing cavity pumps are examples. But at pressures above 30-40 bar, power requirement differentials between one efficient pump and another can be significant (see Table 1).

Seal-less benefits

What none of the foregoing takes into account is the potential loss of efficiency through time. New is compared with new, using power requirements as revealed by manufacturers' data sheets – and the liquid pumped is generally assumed to be clean. Real life is not always like that.

The most common cause of loss of performance through time is wear – of seals and close tolerance moving parts. The faster the wear in a vulnerable part and the longer it continues, the higher the electricity bill through the letterbox. Even clean cold water is not a good seal-lubricant. Recycled liquids, dirty liquids, hot liquids, corrosives, very thin liquids or liquids carrying abrasive particles are potentially more damaging.

Generalisations are to be treated with caution, and every pump application is different. However, commonsense suggests (all other things being equal!) that pumps that do not rely on seals, or on closely meshing metallic surfaces, will be less prone to wear and its potential consequences. Case files at Wanner International record numerous situations where savings in energy costs were directly traceable to sustained efficiency resulting from seal-less pump design – energy savings often being accompanied by parallel reductions in maintenance and repair expenses.

At the Seonam water treatment plant in South Korea, engineers scored a double success when they replaced leaking screw pumps with the seal-less G25. Though working pressure

Table 1. Example of energy-use differences between PD pumps at higher pressures, screw pump v. Hydra-Cell.

Flow rate (l/min)	Discharge pressure (bar)	kW power used		% Saving in energy
		Screw pump	Hydra-Cell pump	
29	70	8.3	4.2	49%
4	80	2.8	0.7	75%
118	80	34.5	19.5	43%

Efficiencies are from manufacturer's published data sheets. Efficiencies are stated for emulsions, kinematic viscosity of 1 mm²/s.

Table 2. Reducing energy costs by pump selection. Centrifugal pumps v. Hydra-Cell.

Flow rate (l/min)	Discharge pressure (bar)	kW power used		% Saving in energy
		Centrifugal pump	Reciprocating PD pump (Hydra-Cell)	
10	20	1.13	0.48	57%
20	20	1.51	0.96	36%
70	20	3.83	3.1	19%
10	30	3	0.67	77%
20	30	3.84	1.35	65%
25	42	5.31	2.27	57%

The sustainable high efficiency (c.85%) of the Hydra-Cell pump is partly explained by its compact design. Compared with traditional metering pumps or large centrifugal pumps of equivalent performance, the build of the Hydra-Cell is less complex and its footprint is smaller. Multiple hydraulically balanced diaphragms, in most models 3 or 5, are combined in a single head, flexing in sequence to provide a smooth low-pulse flow. Frictional energy losses through the pump are minimal as the drive components operate immersed in lubricant.

The Hydra-Cell pump can handle difficult wear-threatening liquids without premature loss of performance. Isolated from the drive end by the diaphragms, the pumped liquid is 100% contained within the wetted end of the pump. There are no dynamic seals in the pump, so no seal wear. There is also no possibility of wear at meshing surfaces (cf. gear or vane type pumps). Valve and seats are available in resistant materials to suit the medium, and are replaceable in-situ within minutes.

on a disinfection system was only 8 bar, the screw pumps could not satisfactorily handle the MgO₂ abrasives in the liquid. Premature seal wear caused external leakage (Figure 4) and cumulative energy wastage as efficiency

declined and wear increased. Since installing the replacement pumps (Figure 5) there have been no more leaks and energy costs have been reduced by 50%.

Meanwhile, a French chemical manufacturer reported 'huge' energy savings when a G25 with 11 kW motor replaced a centrifugal pump driven by a 37 kW motor on a central pumping system feeding tank washers and lances with 'not necessarily clean' water at 60°C. The working pressure was 66 bar.

In another example, piston pumps feeding raw turpentine to burner units at a Swedish plant, and others of the same type transferring pitch oil, were breaking down as often as 10 times a year. Low lubricity of both liquids and ash content in the pitch oil caused severe wear – leading to loss of performance and ultimate pump failure. When seal-less pumps replaced the piston pumps, annual cost savings in power consumption and mechanical repairs were estimated at SEK 170,00 (18,000 Euros).

In Germany, a chemical processor had been using a magnetic drive centrifugal pump with 55kW motor to transfer polystyrol into a process line over a distance of 5.8 km. The original pump was successfully replaced with a Hydra-Cell G35 fitted with 13.2 kW motor. Other units in contention had included a 4-stage centrifugal pump with

double axial face seal, and a multi-stage canned motor pump. The G35 had a clear price advantage and a pumping efficiency double that of the alternatives.

Systems control

On many applications there is also the issue of control. A major machine tool manufacturer wanted accurate control of coolant pressure and flow rate (20-30 bar, 10-20 l/min) in order to vary conditions and optimise performance and energy use as different tools were selected. This was attempted by means of a centrifugal pump controlled by an inverter. But with this type of pump, flow rate is significantly affected by the discharge pressure – making control difficult and complicated. By contrast, the flow rate of a reciprocating PD pump is independent of discharge pressure, so all the relevant variables are easily controlled. Moreover, as can be seen in Table 2, at the required flows and operating pressures the PD pump offers substantial savings in energy costs. ■

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