Rotary lobe pumps, like eccentric screw pumps, are positive displacement pumps that are often used for pumping highly viscous, sludge-type media. With respect to operational characteristics, both are used in similar pressure ranges and have a volumetric flow rate that is relatively pressure-independent and proportional to the rotational speed, making them easy to regulate. Also the pumping efficiency at an identical pressure differential is comparable. As the stroke volume increases, the specific advantages of rotary lobe pumps become more evident when compared to other positive displacement pump types. Large volume, rotary lobe pumps can attain flow rates of over 900 m³/hr and are known for their extreme durability when running dry, which enables them to be employed as self-priming pumps. Unlike eccentric screw pumps, rotary lobe pumps require minimal installation space, maintenance and servicing (Figure 1).

Incorrect pump selection

The concept of a rotary lobe pump with elastomer-coated lobes is relatively new. Because rotary and screw pumps are used for similar applications, designers often employ the selection criteria without modification and without giving consideration to the distinct differences between the two pump types. As a result, selections are made that fail to consider the advantages of the excellent characteristics of rotary lobe pumps.

One example is the rotary speed requirement. Eccentric screw pumps, due to their design, have a greater imbalance and are subject to high levels of wear. To counter the effects of wear, a low rotational speed is often specified. For rotary lobe pumps there is a specified gap during operation, meaning that they work without contact. Furthermore, the rotary lobes are symmetrically designed, so vibration cannot be a cause of imbalance.

At one time rotary lobe pumps, particularly those with three or more vanes, had problems with strong pulsations. Now, as a result of advanced HiFlo technology, problems with pulsation in rotary lobe pumps no longer exist.

Applying theory

Doubts concerning the use of rotary lobe pumps at high rotational speeds still persist, even though their recommendation is based on test results already outlined and proven experience in other areas.

It is often feared that high rotational speeds, as is the case with eccentric screw pumps, will also lead to increased wear in a rotary lobe pump. However, the test results are indisputable and demonstrate that the volumetric efficiency of a rotary lobe pump increases as the rotational speed increases. Using reverse logic, it is only at high rotational speeds that it is possible to attain optimum levels of efficiency, particularly in respect of advanced wear.

In practice this means it is better to use a small pump at high rotational speeds than to use a large pump at slow rotational speeds. For identical flow volumes, a small pump with high rotational speeds is generally more efficient, which means that it operates more effectively. At the same time investment and operational costs are significantly lower as a result of reduced parts wear.

Field trials

Having conducted laboratory tests, pump designers looked for an environment in which to conduct field tests under realistic conditions to support their claims. The chosen site was a sewage treatment facility where three centrifugal pumps were pumping statically thickened primary sewage from pre-acidifying concentrators to a sludge digestion vessel.

Figure 1: Size comparison
The existing application involved pumping a media with a solid material content of 4% at a flow rate of about 55 m³/hr and at 3 bar. Variations in the solid material content unavoidably led to fluctuations in volumetric flow rates. Regulation was possible, but only with considerable difficulty. Efforts were also made to pump media containing a higher solid material content previously not possible using the centrifugal pumps. Eventually, it was decided to employ positive displacement pumps.

A medium-sized rotary lobe pump (pump 1) operating at the relatively slow rotational speed of 272 rpm was used. On average a solid material content of 9% could be pumped, where peak values of 12% were reached. In general, the rotary lobe pump performed well, but from the beginning satisfaction with the pump's operational lifetime was a concern.

The result.

This application provided the ideal setting for a field trial. Three rotary lobe pumps were installed one after the other. One large-size pump (5 l/rev) with a low rotational speed of 218 rpm was used. On average a solid material content of 9% could be pumped, where peak values of 12% were reached. In general, the rotary lobe pump performed well, but from the beginning satisfaction with the pump's operational lifetime was a concern.

The smaller the pump size selected, the smaller the investment costs and the higher the rotational speed, the longer the operational lifetime of the pump. Using the standard requirements of pump No.1, the smallest pump with the highest rotational speed, this being pump No.4, attained a lifetime that was 1.4 times the standard lifetime (Figure No.2) and represented the least investment.

This advantage becomes even more pronounced when consideration is given to the spare parts costs for a typical repair and replacement of worn parts. At a cost difference of between 56% and 115%, pump No.4 performed the best (see Figure 3, yellow bars).

Ignoring the investment costs, but correlating the average spare parts costs in relation to the attained service life, the operator can also realise enhanced financial advantages when considering the costs of wear per hour of operation, or per cubic meter of pumped medium. Here, the difference ranges from 40% to 115% (see Figure 3, red bars). The smallest pumps not only represent the lowest investment and worn component costs, but also give the longest operating lives.

Theoretical simplification

A very interesting factor for the operator is provided by a simple theoretical simplification. This takes as its basis the investment costs and the costs of repairing and replacing worn parts for the first three pumps. These operating costs are compared as a function with service lifetime. Using these reported figures pump No.4 clearly performed the best with 52%. If one adds up the investment cost and the costs of replacing worn parts for three jobs calculated with respect to running time, the total costs for pump No.4 are just over half of those when compared against pump No. 1, which was selected according to the standard prescribed requirements. As can be seen in Figure 4, pump No.4 is far superior to pump No.1.

Viscosity

Under actual operating circumstances, the decision was taken to opt for pump No.3 and this was done for other reasons. This pump is to be operated with an even higher solid material content and where an under-pressure of 0.5 bar is needed in order to draw the medium into the pump. If the rotational speed is too high, there is a possibility that the chamber may not become completely filled, which would lead to a drastic drop in efficiency.

Figure 2: Operational lifetime and investment costs.

Figure 3: Costs of worn parts and repairs.

Figure 4: Costs of worn parts and repairs.
A high viscosity medium is significantly more effective in closing the gaps inside the pump. As a result, the efficiency of the pump increases as the viscosity of the medium increases until the chamber, depending on the rotational speed, is no longer filled completely. This means that selection of the pump must always give consideration to the viscosity of the medium. In other words: the optimum rotational speed is very much dependent on the viscosity of the medium. As a general rule, as viscosity increases, the rotational speed must be reduced accordingly.

**Elastomers**

In other trials, various elastomeric materials for coating the rotary lobes were tested. Developments in this area have yielded significant progress. However, the rule that should be applied is that the cheapest solutions are not always the most economical. For example, by using an elastomeric material that is 20% more expensive, a service lifetime in this case could be increased by 70%.

**Summary**

The figures given in this report do not of course apply one hundred per cent for every case. The trials, however, do confirm the scientific trial results and clearly indicate that the pump type should be selected according to its specific characteristics. For elastomer-coated rotary lobe pumps, this means that running at high rotational speeds provides the best efficiency and the longest working life, which in turns leads to the most economic operation. However, all relevant factors must be taken into consideration, which is why installation designers and operators are advised to seek the guidance of specialists when selecting pumps.

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**Figure 4: Theoretical operating costs of 3 repair jobs.**