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Compensating for Wear in Rotary Lobe Pumps

Rotary lobe pumps are often used for pumping slurry in manure, biogas and in sewage treatment facilities. Here wear occurs and backflow losses inside the pump increase with time. Wear can be reduced through the use of designed components. The effects of some technical solutions for wear compensation were studied and evaluated.

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Keywords

Rotary lobe pumps, abrasive pump wear, gap leakage, wear compensation

Double-shaft, rotary lobe pumps are self-sealing, displacement pumps which are often used for pumping abrasive, highly viscous liquids, slurries and heavy media. Here wear occurs and the backflow losses inside the pump increase with time. The resulting geometric changes to the lobes and housing lead to larger gap sizes and backflow inside the pumps, which leads to a net reduction in volumetric displacement [1]. The suction ability is also reduced when gases must be pumped [2]. Depending on the gaps that occur inside the pump, one distinguishes between [1]:

- Tip wear (the gap between the lobe tips and the housing, as well as the middle gap between the lobes), and
- frontal wear (frontal gap between the frontal surface of the lobes and the frontal side of the housing elements).

A critical step for preventing wear is selecting the optimum pump design with respect to the in-situ volumetric flow rate requirements. If the gaps inside the new pump are matched to the properties of the medium (viscosity, particle size), then wear can be significantly reduced [3].

Before worn out components, generally the rubber lobes, are replaced with new ones, all technical possibilities for extending the service lifetime should be considered. For doing this, the following measures can apply:

- Tip gap:
  1. Matching the housing's inside diameter to the reduced lobe diameter by using insert liner segments with different wall thicknesses (*Fig. 1*),
  2. Reducing the inside pumping space by vertically adjusting the housing,
  3. Deformation of the lobe tip (*Fig. 2*)
  4. Exchanging the lobe tips [4]
- Frontal gap:
  Using frontal wear plates of different thickness [1], or using offsets or adjustable elements for shifting the frontal plates [4].
- Operating parameters
  The volumetric flow rate can be increased by increasing the rotary speed.

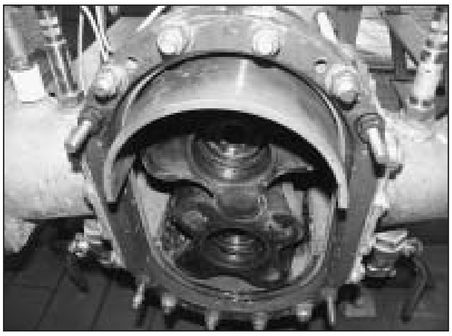

Fig. 1: Changeable insert liners of pump housing

Some solutions were tested in practical field trials and were evaluated.

Trial Results and Discussion

The measurement of pump characteristic curves took place on a pump test apparatus at the ATB in Bornim [1] using a special one-sided bearing trial pump of type VX 136-140 Q. Tip and frontal wear could be changed by using replaceable inserts such as frontal plates and housing inserts (*Fig. 1*), as well as rotary lobes milled off in increments from 0 to 2.5 mm. .

The effect of using different wear compensation methods are clearly visible for various wear conditions when one views the measured pump characteristic curves of *Figure 3*.

For investigating the effects of *replaceable insert liners* for wear compensation, the rotary lobes were milled off until the tip gap was 1.8 mm. By using the housing insert liners with smaller inner diameters (smaller than when new) the tip gap was once again compensated to 0.3 mm. To install the insert liners, the rotary lobes were disassembled and the housing insert liners were then attached to the housing using two retainer plates. The work needed for this installation

Fig. 2: Expander of lobe head

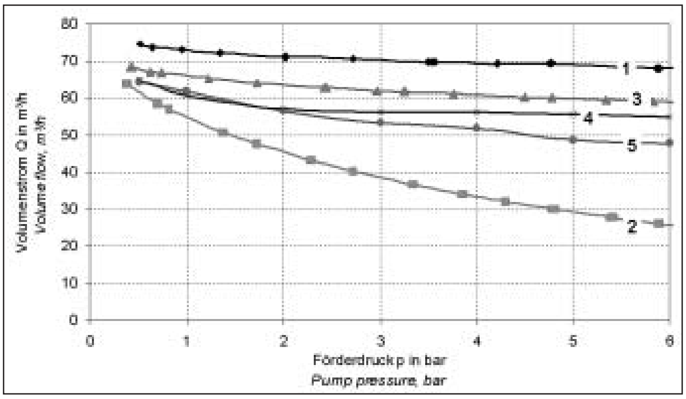

Fig. 3: Effect of abrasive wear compensation of head gap from s_K = 1.8 mm to 0.3 mm on pump characteristics (water pumping, nP = 500 rpm); 1 - new pump (s_K = 0.3 mm), 2 - worn pump (s_K = 1.8 mm), 3 - interchanged liners of housing (s_K = 0.3 mm), 4 - adjusted point of lobe (sK = 0.3 mm), 5 - vertical adjusted housing segments (s_K = 0.3 mm)

is minimal. Because the lobe diameter and thereby the chamber volume are reduced, the pump characteristic curve (3) in *Figure 3* is shifted downwards. By reducing the lobe diameter, the middle gap is increased as well.

This, however, has a relatively minimal effect on volumetric backflow [1].

The *housing segments* of built-up pumps (no modular housings) may be shifted vertically. To do this the flange fastenings on the housing must be loosened. Here the tip gap is fully compensated in the vertical lobe position. At other lobe positions, the gap height changes and becomes smaller as the lobe moves from the transverse position to the vertical position. The pump characteristic curve shows a partial improvement as a result (curve 5 in Figure 3). This adjustment possibility is not undertaken by all pump operators because of the work involved. Users with good technical skills, for example agricultural contractors, successfully use this readjustment method to extend the service life of heavily used liquid manure pumps.

Another technical solution for tip gap compensation is the *elastic deformation of the rubber lobe tip* for straight toothed rotary pumps as in *Figure 2*. A large diameter displacement element (a so-called expander) is placed inside a guiding bore-hole. This causes the lobe diameter to increase, thereby reducing the tip gap. However, the resulting backflow can be only partially compensated (curve 4 in *Figure 3*). The original contour of the lobe cannot be re-attained by adjustment. Only a small strip may be deformed. The service life of a re-adjusted lobe is therefore less than of an original lobe. The expander creates material stresses and causes an uneven surface on the lobe head. Handling during normal operation is impractical. Only minimal information is known concerning long term effects. If the lobe wear is caused by coarse foreign particles in the medium, then compensation by re-adjustment of the lobes is not possible. Analogue solutions using integrated adjustment mechanisms in the lobe tips are known [4] and have similar effects.

Another method for tip wear compensation is to replace each individual rotary lobe tip [4]. This solution however requires time-consuming lobe cores, which must be changed after the lobe tips have been replaced several times. Each pump operator must decide for himself, with regards the actual pumping application, what the most economical approach is.

Wear occurring on the frontal sides was compensated by using *replaceable frontal wear* plates with heavy wall thicknesses [1]. For this a cover gap and gearbox-side frontal gap of 2 mm was set and systematically reduced using frontal wear plates. The other gaps were also reduced in these trials. The pump is thus returned to its original geometric state and the pump losses can be fully compensated. It is also currently possible to reduce the frontal gap by installing compensation disks. Adjustable spring loaded wear plates are also known [4]. However, they entail great technical expense.

In general pump design must be done while considering the medium to be pumped and the explicit pumping requirements. To do this, a pump design program is of great assistance [3]. Involved in this task is the selection of material.

For pumping at high operational pressures, it has been proven advantageous to equip single-side bearing rotary lobe pumps with a *removable pump cover* that is equipped shaft bearings (*Fig. 4*) [5]. This leads to reduced shaft deflection, smaller gaps and thus reduced backflow losses, and less wear arising from contact between the lobe tips and the housing during the "breaking in" phase of the pump [1]. The easy accessibility to the pump interior is also maintained.

To reduce shaft deflection inside single-side bearing pumps, the largest possible shaft diameter should be selected.

For larger pressure magnitudes, two-stage pumps may be advantageously used [5]. Reducing the pressure difference in each pump chamber by 50% leads to a reduction in wear. Also increasing the number of lobe vanes adds to the number of contact surfaces, and as a result leads to longer operational lifetimes. When the pump volume is significantly reduced because of wear, then this can be compensated through simple adjustment of the rotary speed. Using variable speed pump-drives for adapting to the various stages of wear is always advantageous.

Summary

Rotary lobe pumps are often subjected to highly abrasive loads. As a result, it is necessary and economical to extend the pump service life through either readjustment, or using replaceable or adjustable compensation elements. The use of adaptable housing insert liners and frontal plates have proven to be technically effective and easy to do. These insert liners must be available in various standard sizes and may be used multiple times. For adjustable housing segments, a certain technical expertise is required. In this case, no components for compensation need to be kept or purchased. Adjustable components for rotary lobe pumps are time-consuming and require considerable skill, and therefore are rarely used for normal operation. In general, the service lifetime of the pump can be considerably extended by optimising the pump design, using a greater number of lobes, using larger shaft diameters or adding a second bearing.

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Fig. 4: Additional shaft bearing in the pump cap