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Computer Aided Pump Selection to Increase Rotary Pump Lifetime

Two-shaft rotary lobe pumps are often used for pumping suspensions with coarse matter, i.e. in liquid manure, biogas and sewage treatment plants. Pump characteristics change considerably with increasing wear. Based on a mathematical model for wear-caused internal leakage [1], a new calculation programme for „Computer Aided Pump Selection" was developed, which combined with the well known programme for calculating pressure drop in pipes [2], makes it possible for the user to design a complex agricultural pumping system.

Typical rotary lobe pumps have defined clearances between lobes and houses so that the lobes are running non-contacting. Therefore a gap leakage is created which stands for a loss of flow rate. Being small in new pumps those flow rate losses increase during the operation period caused by friction and fluid flow wear caused by abrasive coarse matters. That is why pump characteristic curves are changing during the pump's service life.

The effect of increasing gaps on the pump behaviour is generally depending on the flow characteristics of fluids. Therefore it is helpful for design engineers if they are able to calculate the pump's characteristics in dependence of relevant factors of influence with a calculation model. Then the design engineers are able to estimate flow rates and efficiency under the condition of certain wear behaviour.

The required calculation program helps a service engineer to reveal causes of failure and last but not least the rotary pump manufacturer is able to calculate the service live and hence avoid inefficient installation of pump parts.

Program basics

The mathematic basics for calculating the characteristic curves are described in detail [1, 3, 4, 5]. For calculating the effective flow rate of a rotary lobe pumps one must be able to calculate the gap flow through the lobe clearance of tips, middle part and front sides in dependence of the flow characteristics of the fluid considering the constructive circumstances too.

Rotary lobes coated with elastomers have proved successfully if suspensions with solids have to be pumped. Small clearances are regularly built-in in new pumps but the lobes don't touch neither itself nor the housing. The gaps are increasing during operation caused by the abrasive particles of the fluid. Regarding the abrasion the size of the abrasive particles is decisive. The research tests are carried-out at the Institute of Agricultural Engineering, Bornim (ATB) [3]. The results are integrated in a calculation model [1]. Based on this basis the calculation program CAPS (Computer Aided Pump Selection) was developed at the company Hugo Vogelsang, Maschinenbau GmbH and has been applied successfully.

Pipe diameters for agricultural-borne

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Keywords

Software, rotary lobe pumps, planning, pumping time, abrasive pump wear, gap leakage

Literature

Literature references can be called up under LT 04606 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

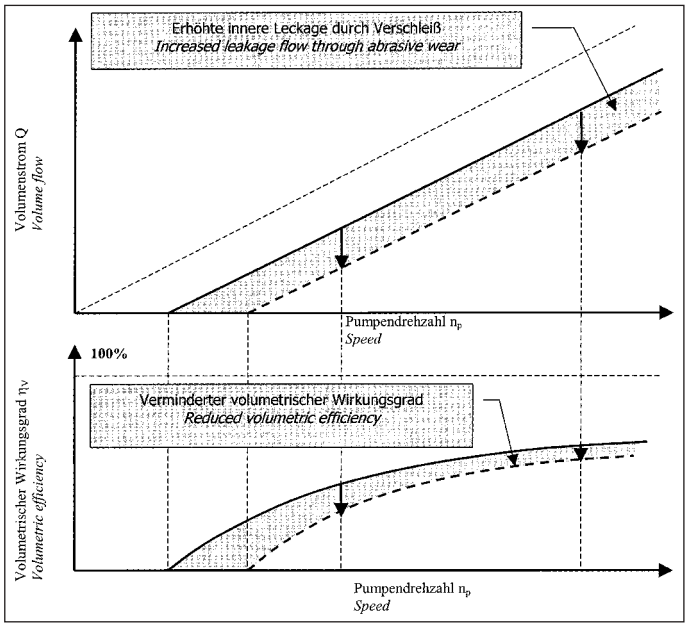

Fig. 1: Change of characteristic curves of rotary lobe pumps with abrasive wear

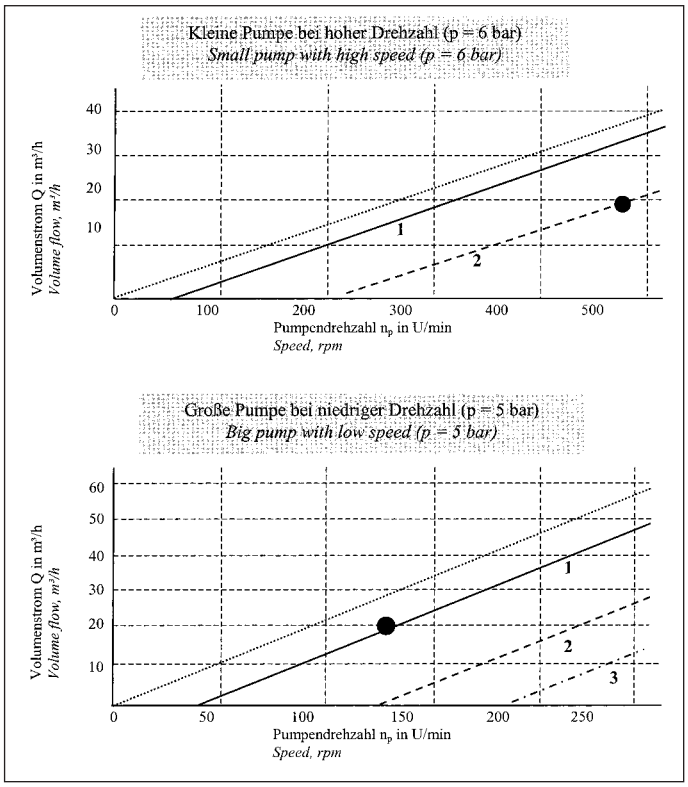

Fig. 2: Effect of speed on volume flow of rotary lobe pumps with abrasive wear (application example)

1 - new pump; 2 - worn pump (s = 0.7 mm); 3 - worn pump (s = 0.9 mm); • - working point

thick matters and suspensions (manure, biosuspensions and sewage sludge) can be selected with help of the program ROHRWIN [2]. This program is helpful if designing rotary lobe pumping stations for difficult conveying problems.

The software CAPS enables the user:

1) *To design a rotary lobe pump on the basis of given operating conditions*: The program selects a sum of suitable pumps. An experts system chooses the optimum pump regarding a couple of aspects such as application field, efficiency and price. The priority of each aspect can be separately adjusted. A suitable driving motor will be chosen too.
2) *To calculate a selected pump*: The data sheet and different characteristic curves are calculated. The best speed range can be predetermined. The wear condition of the pump can be simulated as an all-around wear (both tip and front gap) by a variable input of an average particle size value.
3) *To simulate wear scenarios*: All kind of gaps, which can be changed by the design engineer, can be predetermined separately. Even a lobe undersize can be put in. So also pumps fitted with steel lobes - the lobes of those pumps ought to run absolutely non-contacting - can be calculated.

The program creates Excel tables and diagrams. Besides the actual specifications like flow rate, motor capacity and efficiency the program can retrieve technical details like coupling, pipe connectors, gap motor and base plate as a single drawing or as assembly drawing. The aim of the software is that the user is able to print a complete set of tender documents.

Application

A lasting problem of rotary lobe pumps was the question of optimum speed under increasing wear conditions. The engineers refer to the experiences with eccentric helical rotor pumps. Permanent friction wear in eccentric helical rotor pumps requires always low rotational speed, because the flexible rotor is bearing in the stator [6].

Rotors inside of the housing of a rotary lobe pumps don't touch the housing so that mainly fluid flow abrasion occurs. Thus the rotor speed has only a marginal effect on the wear. That is why much higher rotor speeds are possible. Only recently the original equipment manufactures and rotary pump operators realise the advantage of longer lifetimes if they set up smaller units with higher speed. The assumption that a slow running pump with perhaps less wear has a longer lifetime is false. Fig. 1 reveals the basic relationship between wear and the volumetric efficiency η_V. A fast running new pump with a better efficiency at the beginning has also a better efficiency under wear conditions. The consequences of wear on the volumetric efficiency are noticeable less if a pump is operating at high speed. This fact has been confirmed over and over again by practice (*Fig. 2*).

The rotary lobe pump of a pump station in a food processing plant has to pumpQ = 20 m^3/h potato wastes at a pressure of $p_D = 5$ to 6 bars. First they fit in a slow running R210 HD with a displacement volume of 3.8 l/rev. The pump is operating at 130 rpm. The service life between the lobe changes was too short. Only when they changed the pump into a smaller one (R 70 HD) with a displacement volume of 1.27 l/rev and run the pump with 475 rpm they were able to double the service life.

If we check the example with the program CAPS we will get curves as they are printed in *Fig. 2*. The smaller pump - still achieves its operation requirement at 0.7 mm wear.

The tests show that the backflow caused by fluid flow abrasion will be increased by nearly the same factor under the condition that the pumps are running at a similar operational situation and are delivering the same flow rate.

If the pump's efficiency factor η_V is known from both an unused pump and a worn-out pump, one is able to estimate the wear behaviour of an other pump. The average size of solids is adjusted by using CAPS in such a way that both pumps show a same wear factor F_V. The wear factor comes to the quotient of the gap flows of the worn-out pump and the gap flow of the new pump and can be calculated as:

$$F_V = \frac{1 - \eta_{V\ Verschleiß}}{1 - \eta_{V\ Neu}} = \frac{Q_{S\ Verschleiß}}{Q_{S\ Neu}}$$

From these considerations follows a general pumps recommendation that - under the condition of fluid flow wear - it is always the best solution if one selects in case of doubt between two new pumps the pump with the better volumetric efficiency.

Conclusion

On the basis of large-scale experimental and theoretical research calculation models for computation of pump characteristics of rotary lobe pumps had been developed considering wear and flow characteristic of the fluid. The software named CAPS are now used for designing rotary lobe pumps. In addition with the well known program for designing pipe networks (ROHRWIN) the program enables the user to calculate complex pumping equipment. With help of the program the quality and the accuracy for design and operation of pumping stations is improved decisively. With optimal pump selection under actual wear scenarios one is able to double the service life of rotary lobe pumps particularly when designing a pumping station for fluids from farms, biogas plants and sewage treatment plants with exceptionally high wear condition.