Abstract

„Method for determining the height of the circumferential gap in external gear pumps”

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Due to their numerous advantages, hydrostatic drive systems are widely used in construction and agricultural machinery, aerospace applications, and industrial automation. In response to rising energy costs, designers are increasingly focused on improving the energy efficiency of hydrostatic drives by, for example, increasing operating pressures and system efficiency.

Hydraulic systems, commonly applied in working machinery and industrial equipment, rely on the operation of positive displacement pumps, which convert mechanical energy into hydraulic energy. Among them, external gear pumps have gained significant popularity due to their simple design, high durability, and low cost. A critical factor determining their performance is internal tightness—particularly the axial and circumferential gaps, which significantly affect pump efficiency and volumetric performance. Accurate knowledge of these clearances is essential for predicting the performance of designed units.

While axial clearances are well understood and effectively compensated for, a notable research gap remains in the study of circumferential clearances. Direct measurement of this clearance is technically challenging due to the extreme operating conditions during working conditions. Existing methods for estimating this clearance often neglect the deformation of the pump housing, which significantly affects measurement accuracy—especially in pumps operating at pressures exceeding 25 MPa.

To address this issue, the present study introduces a novel method for determining the circumferential clearance in external gear pumps under operational conditions, taking into account the structural deformation of pump components. The research enabled the determination of circumferential gap height using the proposed approach, both for a conventional gear pump and for an innovative design incorporating circumferential gap compensation. The investigation involved advanced numerical simulations using the Finite Element Method (FEM). The results of the numerical calculations were compared with the experimental data. Comparative studies of the deformations of the tested units were carried out using strain gauges.

The hydraulic performance tests confirmed the effectiveness of the proposed compensation method implemented in the novel external gear pump design. A noticeable improvement in volumetric efficiency was observed in comparison to the conventional unit. The developed design, due to its implemented compensation mechanism, was able

to maintain satisfactory performance at operating pressures up to 40 MPa. This is a range of working pressures that has so far been reserved for much more expensive multi-piston pumps.

Given the growing development of pumps with circumferential clearance compensation, a need has emerged for tools supporting the design of such units. In response, this work presents a new analytical model of circumferential compensation with a composite structure, along with novel criteria for selecting the thickness of the compensating element. These solutions allow for the precise design of displacement of compensation, thereby enabling the shaping of the circumferential gap which is a significant advantage over existing models, which focus primarily on structural strength aspects.

This study thus provides a comprehensive approach for determining height of circumferential gap in external gear pumps and delivers design tools that enable engineers to control the geometry of this clearance in order to enhance the energy efficiency of such units.