ABSTRACT

The dewatering pumps operating in the deep level mines show the problems of volumetric losses and wear that are caused by the wear of thrust axial disk. The pumped fluid, contaminated with the hard mineral particles, flows through the gap between the rotating disk and stationary relieving disk and it causes the wear of both elements.

The paper describes the grounds and the design of the modernized thrust node of multistage centrifugal pump. This node fulfills the function of axial hydrostatic bearing supplied with the working fluid and transmitting high axial load. The suggested node design consists of relieving disk with flat carrying surface and stationary thrust ring supported elastically on the polymer layer. The disk and ring are separated by the thin water film.

INTRODUCTION

In the mining and power industry the multistage centrifugal pumps have a special relieving disks that carry a large axial forces [1,2]. These axial hydrostatic bearings are lubricated by the pumped fluid from the first stage of pump. The operation of these axial bearings affects in large the volumetric efficiency of pump. The operation of pump relieving disk, particularly at the pumping process is characterized by strongly, mechanically contaminated mining water. It generates fast erosion process of the wear of this design node of pump. As result, there is fast increase in the volumetric losses during the pump exploitation.

One of the reasons of accelerated wear of relieving disk is the lack of the self compensation of pump shaft in such way to keep the constant thickness of flat clearance on the full peripheral of disk [3-5]. Elastic support of relieving disk gives the possibility of its self adjusting to the variable operating conditions of pump. The authors have designed the heavy duty node of pump by the mounting of pump thrust disk on the elastomer layer [4,5].

On the assumption that the flow of fluid in the bearing gap is laminar, the engineering method of calculation of fluid pressure, before reaching the bearing gap, was developed. The method allows the calculation of equivalent axial force magnitude, the value of the mean width of bearing face clearance and it supports the design changes that were required for achieving the proper performances of pump operating with elastically supported thrust disk [4,5]. Based on the theoretical calculations, the pump with elastically supported relieving disk was manufactured and experimentally investigated.

The modernized shaft of new design shows the advantages which come to light particularly in case of pumping the polluted mining water [4,5]. An increase in the volumetric efficiency of pump and the decrease in the wear vulnerability to the erosion wear of the elements of relieving node have been obtained. The considered node design also allows to reduce the pumped fluid pressure. It operates as a high pressure sealing on the delivery side of the pump housing.

The results of experimental investigation [5] have proved that the flow of contaminated fluid, particularly at hard contaminants (e.g. mineral particles, sand, oxides as wear particles, etc.) intensifies the wear. This wear becomes the combination of erosion and abrasion one. An increase in the surface layer hardness or application of elastomer support of meshing elements counteracts the wear process. In considered node of pump, the hydro-erosion can be expected.

In the paper, the design solution of the relieving node designed for the pump operating in the system of the dewatering deep level pumps was analysed and described. The results of experimental measurements of relieving node parameters in the centrifugal multistage mining pump have certified the method of its calculations.

NOMENCLATURE

\( a_{0} \) thickness of transverse flat gap
\( A_{0} \) face surface of pump rotor
\( A_{c}, A_{2} \) thrust relieve disk surface and internal surface
\( r_{1}, r_{2}, r_{m} \) inlet, outlet radius of relieving disk and the mean one
\( q \) the flux of fluid through the gap
T  axial force acting on the rotors
F  axial force generated by the pressure

AXIAL FORCES IN THE PUMP

In one stage of multistage centrifugal pump, an axial force that acts on the rotor, has the values 10-40 kN. This force is the basis that is required for the design calculations of relieving disk. For the analysis of this disk and hydrostatic thrust bearing, the axial force equalizing the disk should be determined [2].

In the steady operating conditions the total axial force $T$ that is applied to the rotor equals the axial force $F$ that acts on the relieving disk. Axial force $F$ can be defined by Eqn (1) (Fig. 1).

$$F = (p_2 - p_3)A_2 - 0.5(p_2 - p_3)c$$  \hspace{1cm} (1)

It results from Eqn. (1) that for the relieve disk calculation, the pressure $p_2$ is of great importance. This pressure can be determined on the base of axial gap [1-2]. The value of axial force generated by the pressure acting on the disk and determined from Eqn. (1) has the value of 107517 N for the 4 stages pump.

In new design of thrust node (Fig.2) this force acts on the thrust disk supported by the elastomer layer, i.e. this layer should feature proper compression stresses.

The permissible compression stress of elastomer layer restricts the load of thrust ring that is caused by the pressure in the face clearance.

Inner diameter of elastomer ring has to fulfill the following condition:

$$r = p_2 - k$$  \hspace{1cm} (2)

Registered parameters of pump operation with the relieving disk and elastic support are given in Fig. 3 [5]. All parameters do not show sharp variations what certifies good properties of applied solution and should affect in the decrease of the wear of axial thrust bearing elements.

Figure 1 Basic dimensions and denotation of centrifugal pump

In the experimental investigation the decrease in the pressure drop has generated the decrease in the volumetric losses. The decrease of the flux of mechanically contaminated water has decreased the erosion wear of relieving disk.

REFERENCES