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ScienceDirect

Procedia Engineering 152 (2016) 406 – 411

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Oil and Gas Engineering, OGE-2016

# Fractal approach for the "teeth ends - footstep" friction couple loads estimation of the long - stroke low - speed compressors cooling system pump

Aistov I.P.[a], Svishchev A.V.[a]*

[a]*Omsk State Technical University, 11, Mira Pr., Omsk 644050, Russian Federation*

**Abstract**

The paper deals with the "teeth ends - footstep" friction couple operating conditions of the gear pump applied in the long - stroke low - speed compressors cylinders cooling systems. The NSh-32K gear pump "teeth ends - footstep" friction couple operating conditions are considered in the paper. The fundamental principles and calculation data on the basis of "classical" theory and using the fractal approach for rough friction surfaces describing of the sliding friction couple are represented. The results show the principal results agreement of the friction couple operating conditions estimation on both theories. It was concluded that the fractal approach of the friction couple rough surfaces representation is the most appropriate one for the tight fixed joints describing under the saturated contact of the interacting rough surfaces microroughnesses at the rough surfaces relative contact area high values.



Peer-review under responsibility of the Omsk State Technical University

*Keywords*: long - stroke compressor; cylinders cooling system; gear pump; "teeth ends - footstep" friction couple; rough surface; elastic contact; fractal dimension

## 1. Introduction

In refining and petrochemical industries the gear pumps applied for quickly solidifying viscous fluids, liquid gases, drilling fluids, different working fluids pumping at the high discharge pressures find wider application [1]. The use of displacement pumps in the long-stroke low-speed compressors cylinders cooling systems [2-6], where the centrifugal pumps application is difficult as a result of comparatively low coolant consumption and high

* Corresponding author. Tel.: +7-913-660-3828.
*E-mail address:* alsvishev@mail.ru


Peer-review under responsibility of the Omsk State Technical University
doi:10.1016/j.proeng.2016.07.606

hydraulic resistances of the cooling system flow passage, is of particularly current interest. The gear pump failures analysis showed that the main reason of premature failures is the unit actual loaded condition mainly depending on the design features and actual relative position of parts assembling the unit, i.e., combination of their manufacturing and mounting errors. It is showed in the paper [7] that the most gear pump failures are related to the "teeth ends - footstep" friction couple operating conditions, the main one is the gear pump footstep wear (Fig. 1.)

## 2. Gear pump

Friction forces of the "teeth ends - footstep" couple are determined by the fact that the footsteps serving as gear pump end seals are accurately constructively oriented on gears teeth ends and prevent gear rotation at the mounting twist angle $\delta_i$, and, as a consequence, the additional axial forces acting upon the footsteps end face develop (Fig. 2). In paper [7] the "teeth ends - footstep" friction couple operating conditions estimation was conducted by the authors. The footsteps additional axial force value depends on the gear teeth and footsteps end faces obtained "approach" one:

$$h = r \cdot \delta - S_{e.c.} \tag{1}$$

where $h$ is the maximum value of gear teeth ends embedding into the footstep; $\delta$ is the gear skew as a result of mounting errors; $r$ is the maximum distance from the gear shaft to the action line of emerged axial force; $S_{e.c.}$ is the end clearance value between gears teeth ends and footstep end surface.

End clearances $S_{e.c.}$ between gear teeth and a footstep are not constant values but regularly vary as a result of gear ends beating, nonparallelism and roughnesses of gears and bearing contacting surfaces, elastic deformation of sliding surfaces in the contact area etc. Therefore, the end clearance value $S_{e.c.}$ is generally higher than minimum acceptable value of $S_{e.c.}$ = 3 μm and varies depending on the gear turning angle $\delta_i$ within the range from 5 to 15μm.

When calculating the "approach" $h$, gears twist angle $\delta$ is taken equal to the following: $\delta = \min \{\delta_i = 1, \delta_i = 2\}$, where indexes ($i = 1$)and ($i = 2$) relate to the twist angles for drive and idle gears correspondingly (Fig. 2).

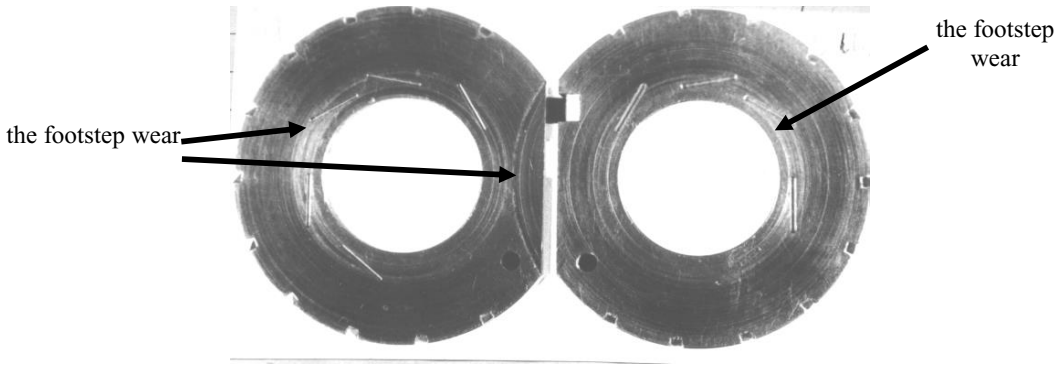


Fig. 1. The footstep wear of the gear pump "gears teeth ends - footstep" friction couple.