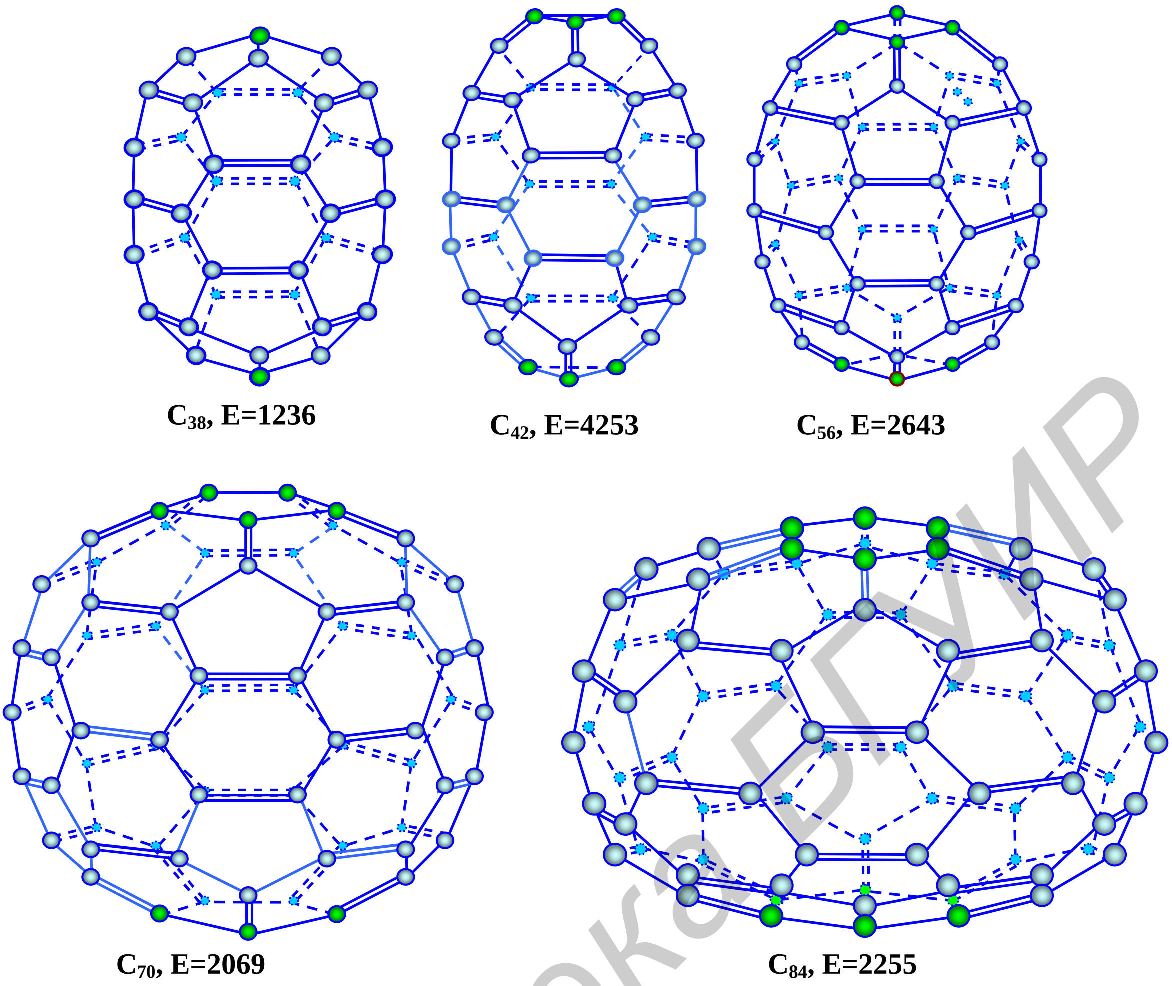

Figure 6 – Structure of the Δn=14 series fullerenes with single and double bonds. Energy in kJ/mol

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ON OPTIMIZATION OF HYDROGENERATOR THRUST BEARING CHARACTERISTICS

O. Antonova, A. Borovkov, U. Boldyrev, I. Voynov
Peter the Great St. Petersburg Polytechnic University, Saint Petersburg, Russia

I. INTRODUCTION

In conditions of the world hydropower dynamic development and construction of a large number of hydro power plants in developing economics: Brazil, China, India, etc. it is important to ensure reliable trouble-free operation of the key structural elements of the plant.

One of the most important structural elements is the hydro generator thrust bearing perceiving a major part of load. Generally, the load on the thrust bearing consists of the weight of the rotor, the impeller and the turbine shaft and also the water pressure on the impeller [1]. The important operating parameter, characterizing the efficiency of the bearing is the load capacity of the oil wedge, which is a nonlinear function of the magnitude of the gap, where the main role performs the minimum oil film thickness – the thinner the layer of oil is, the higher is the bearing load capacity. On the other hand, reduction of the oil film thickness leads to the decrease of bearing stability under dynamic loads.

By design the bearings are classified in various ways, in particular, by geometric characteristics, perceived load, number and type of supports and the kind of mounting. By the surface type realization bearings can be one-piece and segmented. One-piece bearing carrier surface is a surface coated with a terrain profile. Such bearings are called profiled.

Segmented or self-aligning acting bearings – the bearings whose fixed part consists of separate parts, segments, mounted on special supports, which allow each segment to turn in the flow of liquid lubricant, forming an angle with the rotating disk surface. In order to provide greater load capacity support is moved relative to the segment axis by a certain value in the direction of rotation, creating eccentricity. Typically, the value of the eccentricity is 5-8 % of the segment length. Such bearings are called irreversible because they provide the load capacity only in one direction of rotation. For example, in hydropower, they are used for a wide range of devices on the majority of the existing hydropower plants.

However, in some cases, for example for devices with changing rotation direction of the turbine generators, it is necessary to set zero segments eccentricity, which ensures their durability in different directions of rotation. Such bearings are called reversible. Currently, thrust bearing of this type installed on Zagorskaya GAES – unique and Russia's only pumped storage power station.

In this work, with the aim of optimal design of the hydrodynamic bearing characteristics, we consider the problem of lubricant layer microgeometry profiling based on the conditions of a load capacity maximum

II. OPTIMIZATION PROBLEM STATEMENT

Let us consider the optimization problem of the thrust sector bearing microgeometry [2] An example of such a bearing is shown in Fig. 1. All sectors are assumed to be identical, having an angle Δφ = 2π / N, where N is the number of sectors.

Figure 1 – Michell thrust bearing [3]

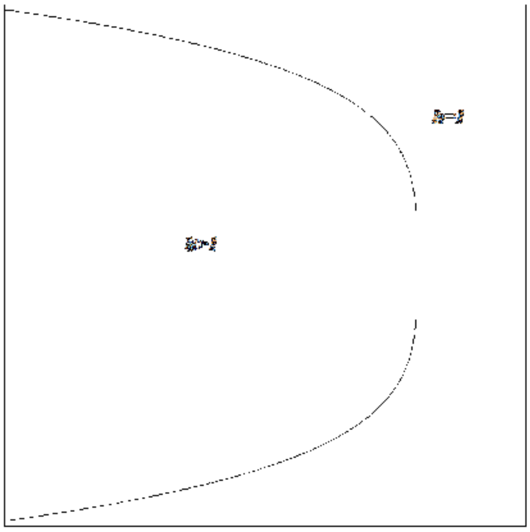

Figure 2 – Microgeometry shape for rectangular region

We assume that a region Ω with boundary ∂Ω, corresponding at one thrust bearing sector, is located in (r,φ) plane of cylindrical coordinates (r,φ). Plane (r,φ) moves in the φ direction with constant angular velocity ω. Let us assume that the profile shape of the lubricating layer is determined by piecewise-smooth function h(r,φ) with the minimum specified value of the profile hmin. We describethe pressure field p(r,φ) in lubricant layer by a linear Reynolds equation, which write in the following dimensionless form

An example of rectangular region with parabolic profile is shown on Fig. 2

$$div(h^3\,\nabla p - h\boldsymbol{V}) = 0 \qquad (1)$$

Here, the dimensionless pressure p and the coordinates r and φ are normalized by the ambient pressure pa and the corresponding dimensional values Lr and Lφ, characterizing segment dimensions. Note that the critical parameter γ=Lr/Lφ, which characterizes the elongation of the region Ω, in equation (1) and throughout what follows is put equal to 1 to simplify calculations. The profile function h is normalized by hmin. The velocity vector Vφ=(1,0) is normalized by the magnitude of |Vφ|. Boundary conditions for equation (1) correspond to the equality to zero pressure on the boundary $\partial\Omega$ of the region Ω

$$p|\partial\Omega = 0 \qquad (2)$$

Note that the equation (1) is for the excess pressure p(r,φ) in lubricant layer in region Ω. Profile function of lubricant layer h(r,φ) according to shown above character of normalization should satisfy a restriction

$$h \geq 1 \qquad (3)$$

According the last inequality, let us specify hmin is selected. Its value, corresponding to equilibrium stationary mode of thrust bearing operation is specified, generally of technological considerations.
The aim is construction of lubricant layer profile h(r,φ), which provides maximum sector load capacity.
Thereby, normalized by LrLφpa value of the lubricant laeyr lifting force should be considered as functional in a variational problem .The value supposed to be negative, by tradition rules of the calculus of variations, to search for a functional minimum)

$$W = -\int_{\Omega} p\,d\Omega \qquad (4)$$

III. CONCLUSIONS

Historically the first formulation of the considered problem in one-dimensional case goes back to the work of Rayleigh, published in 1918 [4]. The Rayleigh results, much ahead of his time, were repeated S. Y. Maday in 1967 [5]. In 1975 one of the authors together with V. A. Troitsky considered the Rayleigh theory of lubrication to spatial variational problem – the problem of the optimal profile shape for the rectangular form of gap region [2]. For the sectoral bearings considered here, one of the authors together with Yu. V. Borisov obtained the first results in [6]. Here we develop the results of our works [2,6] in relation to the hydrogenerator sectoral thrust bearings based on advanced computing technologies until the transition from the model of Reynold to the model of Navier-Stokes. Also note the fact that over the years unique technologies of desired shape surface micro-geometry generation were developed, making optimization work relevant. Based on procedures described problems were solved in [2,6] as well as the results obtained for one-dimensional problem in the case of gas lubrication.

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