Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 206 (2017) 334–339

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering, ICIE 2017

Experimental Study of Foil Gas-Dynamic Bearing Elastic Elements Deformation

A. Sytin, A. Rodichev, A. Babin*

Orel State University named after I.S. Turgenev, 95, Komsomolskaya st., Orel 302026, Russia

Abstract

The paper considers the questions of experimental research of deformation of elastic elements regarding the foil gas dynamic bearings. This research is required to check the adequacy of developed theoretical basics and the applicability to the real operation of a high-speed rotor. The paper presents the description of a test rig, the choice of the controlled and measured parameters, the experimental set up of the systems of control and measurement; and identifies the range of controlled parameters deviation. The paper also features schemes and photos of original measurement system, which include a mechanical part and the data acquisition system. The data acquisition system is based on an ADC by National Instruments and inductive proximity sensors. The software developed in LabVIEW is used as an instrument of experimental data registration. The test results have been compared to the numerical results of the mathematical modeling.

Peer-review under responsibility of the scientific committee of the International Conference on Industrial Engineering

Keywords: experimental complex; foil gas-dynamic bearing; elastic elements; deformation of the elastic elements; rotor system; displacement of the rotor.

1. Task formulation and experimental planning

The developed theoretical assumptions have to be proven adequate to the real operation of the high-speed rotor. For this, the results of the theoretical study was compared with the experimental results, obtained by independent means: directly by the author, the results were obtained with the use of the developed test rig; and the results obtained by other researchers. In [1] the maximum load capacity of the journal foil gas-dynamic bearing is determined when the temperature rises rapidly at the moment of contact with the rotor surface. To acquire the

* Corresponding author. Tel.: +7-929-060-6012.
E-mail address: alex.mech.espc@gmail.com

1877-7058
Peer-review under responsibility of the scientific committee of the International Conference on Industrial Engineering.
10.1016/j.proeng.2017.10.482

temperature of the foil the holes in the bearing's housing and in some foil elements are made in order to connect the thermocouple to the main part of the foil. So, to determine the parameters of the bearing, laborious preparations have to be made to carry out the experiment. To study the specific phenomena in a rotor-bearing system it is necessary first to rationally simplify the system. Due to the fact, that the stiffness of the elastic elements (here the circular corrugated element) is the basic parameter, which characterizes the workability of the foil gas-dynamic bearing; it was decided to apply static load study [2]. The rotor, supported by the foil gas-dynamic bearings is a complex multifactor system with a large number of the controlling factors. Given the objective complexity of the experimental study of all the factors influencing the system, the aim of the present research is to acquire and analyze the data on the influence of the static load on the deformation of the elastic elements of the foil gas-dynamic bearing [3].

When conducting the experiment the output parameters (response function) were radial rotor displacement in both bearings under various load, various thickness of the elastic elements and the mounting angles of the elastic elements independently in the left and right bearing. Based on the obtained data the graphs of the deformation were built in dependence on the load [4-6]. Acceptable range of the control parameters, which can be adjusted using the developed test rig, are shown in the table 1.

Table 1. Experiment settings.

Controlling parameter	Units	Range of change	No. of levels	Parameter type
Static load	N	18…72	6	Controlled
Bearing position angle (left bearing)	Degrees	0…-135°	4	Controlled
Bearing position angle (right bearing)	Degrees	0…135°	4	Controlled
Thickness of the elastic elements	mm	0.1…0.15	2	Not controlled

If we go through all the acceptable levels, we get a set of different states of the given object, which defines the number of possible experiments. In reality, the experiments which imply every possible test have to be omitted. To determine, how many and which tests to include in the experiment, experimental planning is used. Experimental planning followed the instructions in accordance to [7], the main goal of which was to minimize the time consumption of the experiment, its cost and the imprecision of the measurement, and getting as much data as possible at the same time. The results of the experimental planning were as follows: a necessary number of tests, their sequence, randomization method and the mathematical model for the response function. The test order was calculated using the randomization method in order to minimize the influence of some random nature, which can not be controlled during the experiment and which do not depend on the test conditions.

The adequacy check of the obtained results of the mathematical modeling was implemented by means of the experimental and measuring complex, developed by the authors of the paper. The complex consists of the mechanical part and the data acquisition system [8].

2. The description of the experimental complex

The whole series of experiments was implemented on the special experimental bench, which consists of the test rig (figure 1), modernization of which al-lowed modeling of the rotor-bearing system on the foil gas-dynamic bearings with the lowest number of constructional adjustments; and the data acquisition system, which allows experimental study of the elastic elements' deformation under the static load. Functionality of the rig and the data acquisition system must allow the determination of the physical parameters, which could prove the workability of the foil bearings and which could be compared with the calculation results. To study the influence of the static load on the deformation of the elastic elements of the foil gas-dynamic bearings the test rig (figure 1a) was designed and developed, the scheme of which can be seen in the figure 1b. The structure of the rig allows loading the rotor with the force symmetric in relation to the bearings, constant in value and direction.