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EXPERIMENTAL AND THEORETICAL RESEARCH OF ROTOR SYSTEMS WITH ADAPTIVE LIQUID-FRICTION BEARINGS

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ABSTRACT
A set of adaptive liquid-friction bearings is designed to ensure a reliable and qualitative operation of rotor systems under intensive operating conditions.
Therefore, a field of application for such bearings is broad and ranges from the standard semi-automatic machines with a constant grinding wheel rotational speed to the flexible modules with an adaptive control system.
Work specifics of rotor systems with adaptive liquid-friction bearings of a new design analysed in the paper. Experimental research equipment and principle at its work are described. Experimental researches and computer calculations of rotor systems with adaptive liquid-friction bearings are performed with purpose to define the influence of different factors on work quality of these systems.
Keywords: rotor system, adaptive liquid-friction bearings, parameters, diagnostics measurements.

1. INTRODUCTION

The wear of the bearing reveals itself at a starting up and stoppage at the moment when the speed changes in time, i.e. the acceleration takes place. At bearing wear the gap between the rotor neck and the bearing increases and when in further exploitation of the system this gap becomes abnormal, the work of lubrication wedge disturbs, the friction increases, other parameters change also [1-3].
It is defined by experiments that [4, 5] the increasing gap excites the polyharmonical oscillations which frequency is multiple to the half rotor rotation frequency. So the half harmonics of the revolving frequency exceed the level of the noise hum by 20-25 dB.
It is recommended to [6, 7] differentiate the nature of a defect arising in a sliding bearing for exact definition of the frequency of a newly arose component which is less than the rotor revolving frequency. If the arisen frequency comes to 42-48% (not exactly 50%) of the rotor revolving frequency it indicates the non-stability of rotor oscillations in the lubricant film, the vortices are forming in the lubricant layer and it greatly decreases functioning quality of the bearing.

2. TESTING SYSTEM

The functional diagram is presented in Fig. 1.

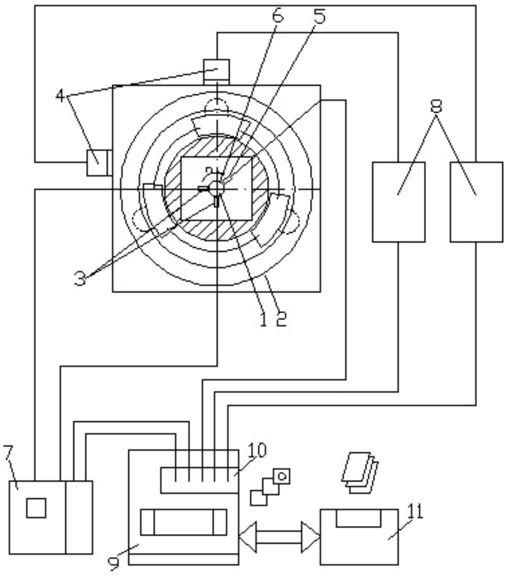


Figure 1. Testing system of rotor system with adaptive liquid-friction bearings
1-rotor; 2-spindle head, 3-non-contact induction displacement converters, 4-accelerometers, 5-photoelectric phase converters, 6-mark, 7- amplifier, 8- primary amplifiers, 9-computer, 10-measurement signal input/output board, 11-printer

Relative body wise displacements of the rotor (1) see (Fig. 1) are measured by non-contact induction displacement converters (3). The direction of rotation and rotary velocity of the rotor are measured from the mark (6) by a photoelectric phase converter (5). The phase converter synchronizes signals of the displacement converters (3). Absolute vibrations of the rotor's body are measured by accelerometers (4) whereof signals amplified by the primary amplifiers (8) are sent to the measurement signal input/output board (10) of the computer (9). Signals of induction displacement converters (3) and the phase converter (5) are also sent to the board. The computer (9) processes the signals registered with the versatile board (10) by using Origin, Data Master and Statistika, Excel or other software packages. Non-contact induction displacement converters have been selected to determine deviation (beating) of the rotary motion of the rotor. Two converters mounted at 90° angle are used to determine the rotary trajectory (orbit) of the rotor's pivot.

3. DIAGNOSTIC MEASUREMENTS

Diagnostic measurements of hydrodynamic bearings are performed as follows: after mounting bearings of the adequate structure on the spindle head and connecting a drive motor, converters are mounted, amplification of the measuring channels is adjusted and calibration is performed. The rotor's driver is switched on and the desired rotary velocity of the rotor is set. The rotary velocity regulation range is as follows: 0.5...8000 rpm. When the rotor reaches a stable preset rotary velocity the Experiment application is run in the computer.

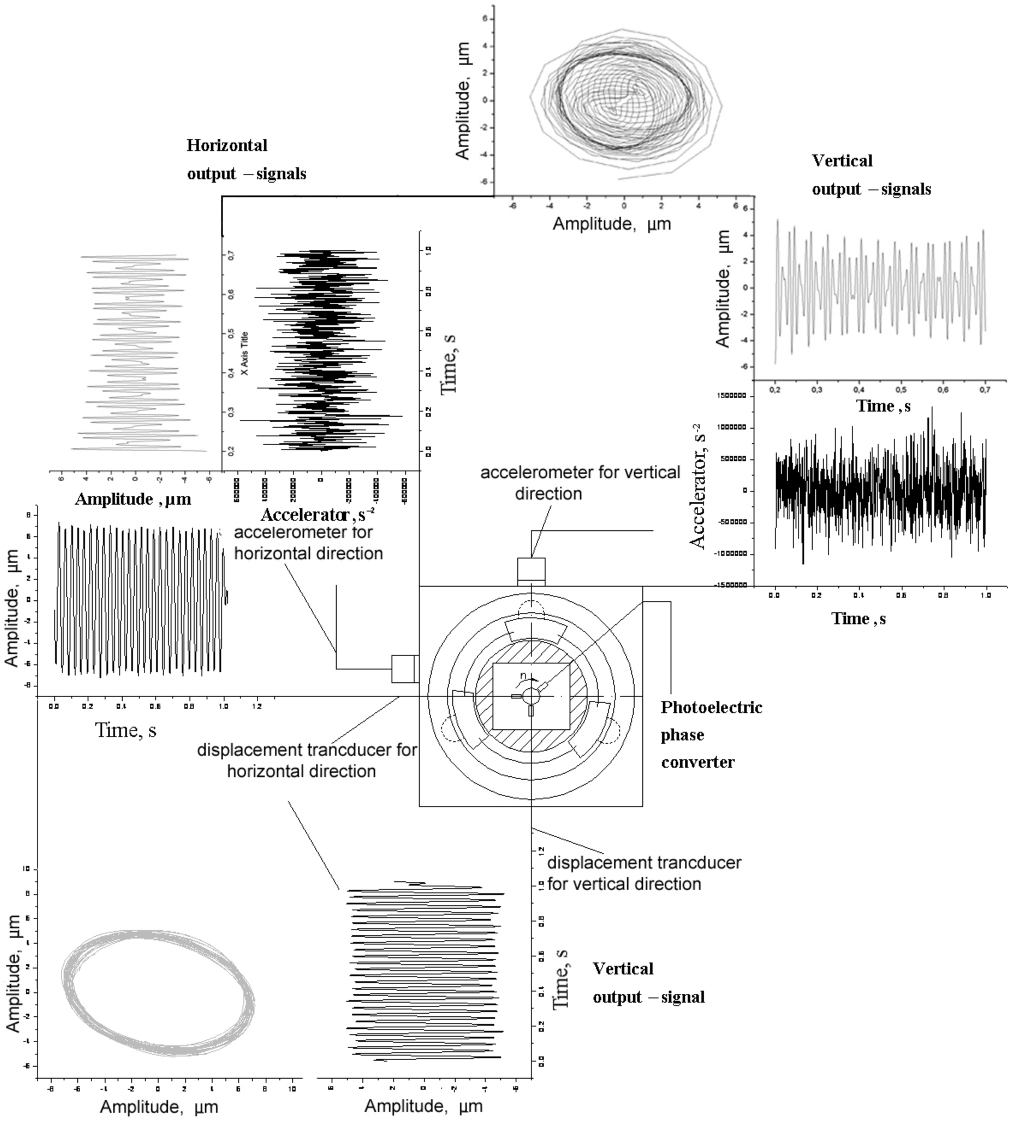


Figure 2. Results of measurements

Measurement signals from both displacement converters, accelerometers and the strobe converter are registered within 10000...15000 interval limits. The data is recorded into the created data file and information files. A text file with a specified file name is created from these files in the computer which text file is further processed by means of Origin, Statistika or other software packages in accordance with respective methods. By varying the rotary velocity of the rotor it is possible to take readings at various rotary velocities of the rotor and to analyse the interrelation of the rotor's orbits at various rotary velocities and types of hydrodynamic bearings, and the absolute vibrations of the spindle head body in various directions and at various locations. The obtained results are presented in Fig. 2.

4. ERROR ANALYZE

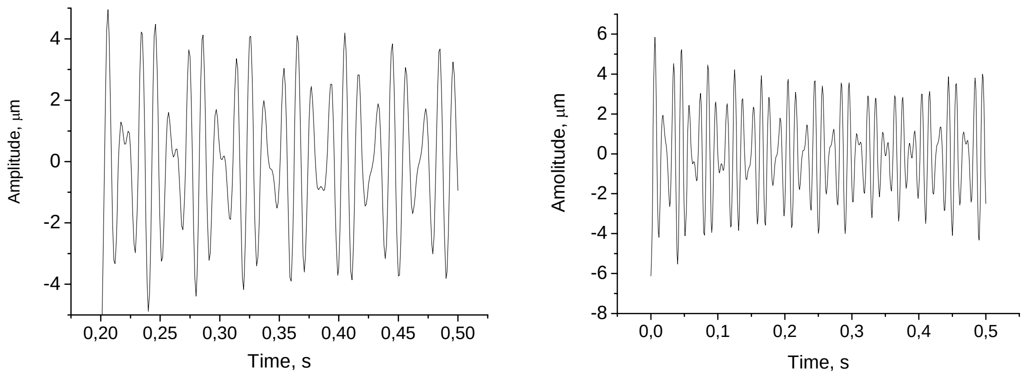
Rotary system with hydrodynamic articulate bearings is not strong straight but it could be linearised. In this case it is need to find such value of operator, hat function of error could be near zero [3].

$$\Delta_d(t) = Y(t) - A \cdot X(t) \qquad \ldots(1)$$

here $\Delta_d(t)$ - function of error; $X(t)$ - fluctuations of revolution of rotor (Input signal); $Y(t)$ - fluctuations of frame of rotor (Output signal); A – operator.

$$A = A(\sigma_x) = \frac{1}{\sigma_x^2} K_{yx}(0). \qquad \ldots(2)$$

Results of errors counts are giving in graphs (Fig. 3a and Fig. 3b). Results - graphs of counts of measurements transducers that are setting horizontally: error $\Delta_d(t)$ (Fig. 3a). Results - graphs of counts of measurements transducers that are setting vertically: error $\Delta_d(t)$ (Fig. 3b).



a b

Figure 3. Rotor rotation of frequency 4500 rpm, error $\Delta_d(t)$; a - horizontal converter, b - vertical converters

5. CONCLUSIONS

Dynamic error $\Delta_d(t)$ (Fig. 3a and Fig. 3b) is showing that practice of accelerometers is possible and expedient being confusing constructions of rotors systems.

Dynamic average square deflection of error $\Delta_d(t)$ between oscillations is making 2,15136 μm (Fig. 3a) and 2,3053 μm (Fig. 3b).

Rightness results of measurement are getting measuring non-contact induction displacement converters.

6. REFERENCES

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