290. The evaluation of resonant frequencies of rotary system with adaptive segmental sliding bearings by orbits of rotor rotation axis

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Abstract. This paper is based on research of work parameters of rotary systems with segmental sliding bearings, working system in the resonant regime. Primary signals are given doing experimental researches, they are analyzed with special programmable pockets and different formats of data are given. Evaluation of work state of rotary system is done in the resonant and in the normal regime by getting orbits of rotor rotation.

The principal scheme of researching system is given in this work and its technical characteristics and principle of working are described. Methodology of experimental researches is given.

The gained results are described in graphs and a comparison of obtaining results and its discussion.

Keywords: rotor system, resonance, frequency, adaptive segmental sliding bearing, axis, orbit.

1. Introduction

Sliding bearings are one of the primary elements of construction of rotary machines of big power. Bearings hold the rotor together and rotate in the turbines of vapour of big power, in the compressors, in the pumps abroad. Marks to EEI (Edison Electrical Institute) statistical data, breakdowns of sliding bearings form 23 % causes of breakdown of all the system. Analogical research of thermo power stations done by EPRI (Electrical Power Research Institute) is show that outages are happening mostly because of problems of these bearings.

One unacceptable phenomenon that occur in rotary systems is work in the resonant regime. The resonant regime is attributed to the crash bearing work regime, because working bearing in the resonant regime, could be damages during snatch all mechanism us, in which is embed bearing.

Sliding bearings are stocks of rotors and being some workloads and frequencies of revolution they are characterized with unstable work which is differed with its nature from unstable regime of roll bearings work. If those instabilities are asserted in the elastic (limp) rotor, that working to critic, resonant frequency of revolution, then breakdown of machine is necessary. Such breakdown is sudden, therefore catastrophic. Some mechanisms can excite phenomenon of instability.

A substantial difference is spotted between vibrations of rotor that raises unstable work of sliding bearings of friction and between other vibrations that raises the rotor, for example a disbalance of rotor, deflections of truths of rotors, rubs of turning parts over bodies and so on.
Vibrations that raise lubricant of sliding friction are shown with spontaneous cross vibrations of rotor. In the case system of rotor – it raises vibrations in itself, when energy of vibrations of vapour or gas, of liquid, of lubricant carried to the rotor. These vibrations results for lubricant, sucks and agitation and for raising impact in the sliding bearing.

Dynamic parameters of the “rotor-lubricant-bearings” system and parameters of liquid taken together show step of stability of rotary system that is expressed with frequency of revolution of rotor [1]. When this frequency of revolution of rotary system have secured and have exceeded, causes spontaneous cross vibrations of sub-synchronic frequency of rotor, that is started by whirls of lubricant in the clearance of bearing. It forms whirls of lubricant in the clearance of bearing that raises procession of rotor with much less frequency than its side of frequency of revolution [2, 3]. There is characteristic instability for whirls of lubricant, because they enlarge dynamic powers, and these enlarge whirls. The rotor becomes unstable then, when the lubricant cannot remain in its axle or when frequency of whirls is coincident with frequency of vibrations of axle. The result of the above-mentioned phenomenon is a raised cross vibration of the rotor of steady frequency [3, 4, 5].

However spontaneous cross vibrations spring up in different frequencies of rotor revolution, than simple slide bearings [6]. Lines of self-contained vibrations with segmental sliding bearings in the rotary systems are determinate (Fig. 1).

Additional researches are necessary to determinate formats of work parameters of rotary systems that are worked in the resonant regime [7, 8, 9].

This work is based on research of work parameters of rotary systems with segmental sliding bearings that are worked in the resonant regime. The mechanism of research and the methodology of research are described. The discussion of getting research results is done and conclusions are given.

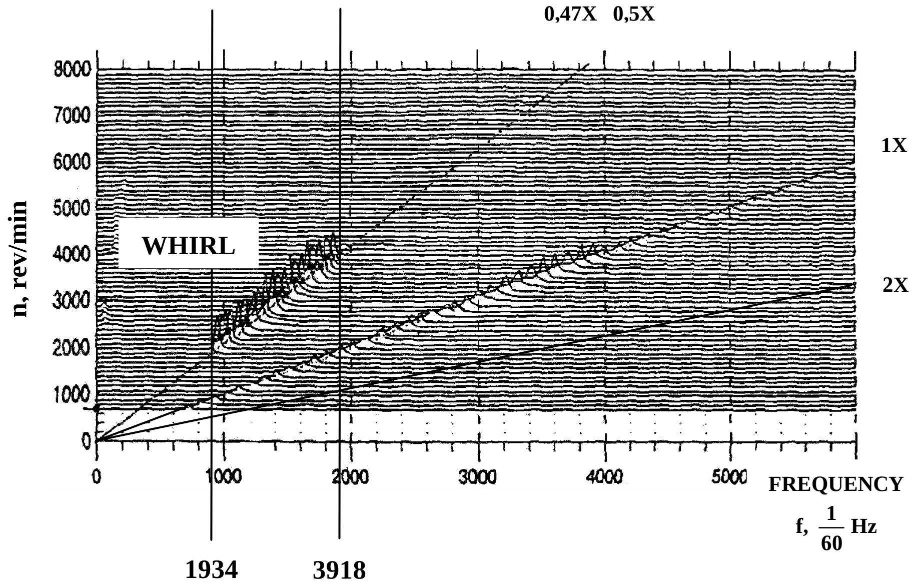

Fig. 1. Resonant frequencies of rotary system with segmental sliding bearing

2. Testing system

All researched system (stand of research) consist of four several subsystems (Fig.2):

- the researched system (rotary system with segmental sliding bearings) (Fig. 2b);
- the step less system of regulation of rotor revolution frequency (Fig. 2c);
- lubrication system of rotary system (Fig. 2a);
- analyses system (Fig. 2d; 2e; 2f; 2g; 2h) of measurement and measurements results.

*Researching system (rotary system with segmental sliding bearings)***.** Research system is rotary system with segmental sliding bearings (Fig. 2b).

The system of regulation of rotor revolution frequency. The step less system of regulation of revolution frequency of Germany firm “INDRAMAT” (Fig. 2c) is used for rotation of rotary system with bearings of sliding frequency, that primary technical data:

- The pressure of system 380 V;
- The power of electricity engine 6.5 kW;
- Frequency of revolution of step less regulation 0-8000 rev/min.

The step less system of regulation of rotor revolution frequency consist of asynchronous three-phase electricity engine and its block of control, with its help it allows the start and stop of the electricity engine, settings of fixed or step less frequencies of revolutions.

Programmable module AS31 is installed to regularize block of control with mechanic of asynchronous engine. The module is done function of transducer constructional; it has a programmable supply and it keeps necessary parameters of compatibility in the memory.

The lubrication system of rotary system. The lubrication system of the rotary system deals with functions of lubrication and refrigeration of the rotary system (Fig. 2a).

Lubricant from special reservoir with the help of hidropump through filter is got into rotary head, where is researching object (Fig. 2b). Lubricant from rotary head is got to reservoir again. Lubricant that is coursed around like so and is lubricated and is refrigerated the system rotor-bearing together.

Analyses of measurement and results of measurement. The system of analyses of measurement and results of measurement consist of: different transducers of measurement, its boosters and supply units, and computer with special plate DAD 1210 (Fig. 2d) that is installed in the computer. Transducers: no contact displacement transducers Tr.102 (Fig. 3g) and transducers of Denmark firm Bruel & Kjaer accelerometers 4370 (Fig. 2h) were used for measurements.

Transducer of no contact displacement is consisting two large sensitiveness inductive reels installed in one frame scheme. Reel of measurement is strengthening in the part of lost cylindrical frame and compensatory reel is inside of frame. Carrying frequency is 5 kHz or 50 kHz.

Characteristics of accelerometer are: sensitiveness according to change 10...10,12 pC/ms^{-2}, or 99,0...99,4 pl/g; sensitiveness according to voltage 8,84 mV/ms^{-2}, or 86,9 mV/g; capaciousness in common with hook is 1144 pF; resistively – 2000 MΩ min in room temperature.

All results of measurement are given and cumulated in the computer with the help of special plate DAD 1210. The special plate of input-output of universal electric signals is realized:

- Input-output function of programming of universal information;
- Function of time intervals formatting of programming length;
- Exchange of numerical signal to analogue function;
- Function of strength of programming analogical signal;
- Exchange of analogical signal to function of numerical code.

The results of measurement are analyzed with the help of different programming batches.

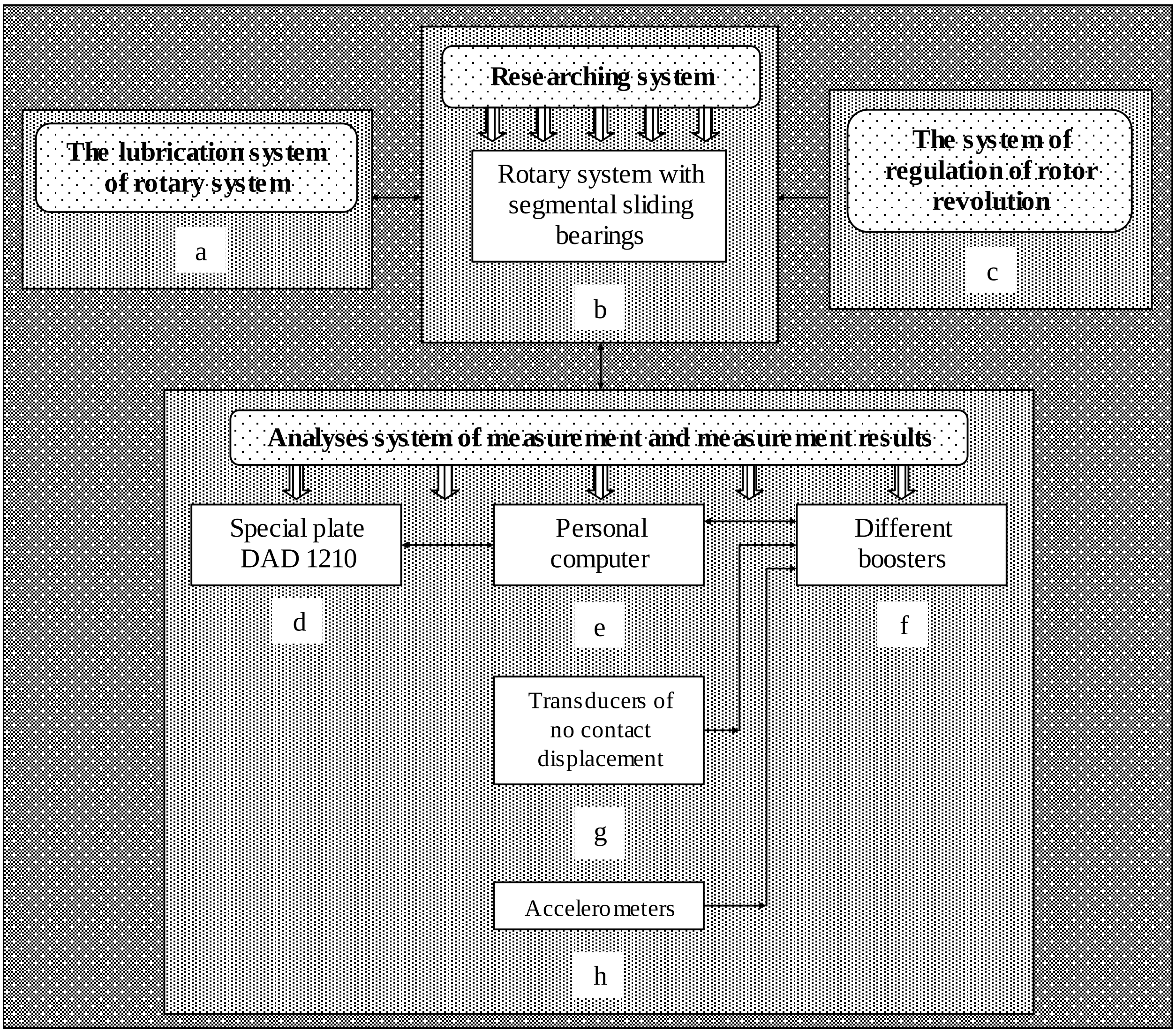

Fig. 2. Principal scheme of testing system: a - The lubrication system of rotary system;, b - Researching system; c – The system of regulation of rotor revolution frequency; d – special plate DAD 1210; t – computer; g - no contact displacement transducers; h - accelerometer

3. Methodology of experimental measurements

Experimental measurements of test of resonant frequencies of rotary system with segmental sliding bearings are done using describing system (Fig. 2).

Preparative works of regulation and coordination and calibration of special thermometers were done before doing diagnostically researches.

Diagnostically researches were done such method:

1. Coordination of system and calibration of measurement are done;

2. Transducers of measurement are fixed on stand (Fig. 2g,; 2h);

3. Provided clearance between neck of rotor and segment of sliding bearing (50 μm clearance is tested during experiment) is tested;

4. Lubrication system is actuated, which is given lubricant to chambers of segmental sliding bearings (Fig. 2a);

5. Motor of electricity is actuated, which is turned rotary system, provided frequency of rotor rotation is ascertained (Fig. 2c);

6. Boosters of measurement are actuated and proportionated (Fig. 2f);

7. Computer is connected-up (Fig. 2e);

8. Special computer program is operated;

9. Data of measurement results are incorporated into made-up data and informative files;

10. Analysis of all getting results during measurement is done.

Frequency of rotor rotation was changed during experiment. Frequency was changed 50 rev./min on step and from 0 to 8000 rev./min. on limits though the system of regulation of rotor revolution frequency is let to change frequency of rotor rotation and sleeplessness. Results of measurement were fixed changing frequency of rotor rotation on every moment.

4. Results of measurement and its discussion

Graph of resonant frequencies of rotary system with segmental sliding bearings is made doing analysis of experimental results of measurement (Fig. 3; 4; 5; 6).

It can see by given graph (Fig. 1), that the system beginning to work from 0 to 1934 rev/min system is worked keel and exceeding 1934 rev/min it starts spontaneous vibrations of rotor, that continue until 2921 rev/min. Obtained frequency of rotor revolution 2921 rev/min spontaneous vibrations decrease and that are gone when the rotor rotates to 3918 rev/min. Working rotor from 3918 rev/min to 5500 rev/min spontaneous vibrations are not again.

Primary signals of measurement are got doing measurements of work parameters of rotary system with segmental sliding bearing, they are analyzed with special programmable pockets and different formats of data are got.

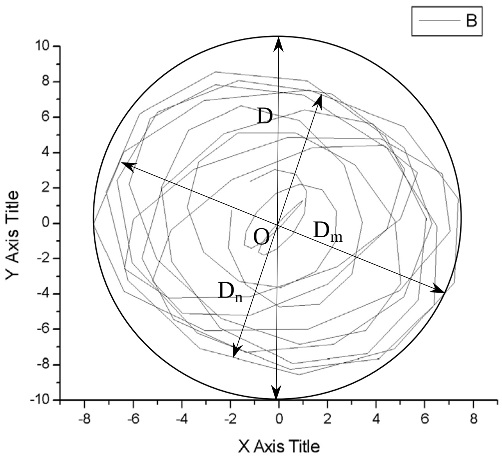

Fig. 3. Rotor rotation orbit, rotation frequency 2070 rev/min: O – centre of rotor rotation; D – diameter of ideal orbit; D_m – diameter of orbit, in the horizontal direction; D_n – diameter of orbit, in the vertical direction

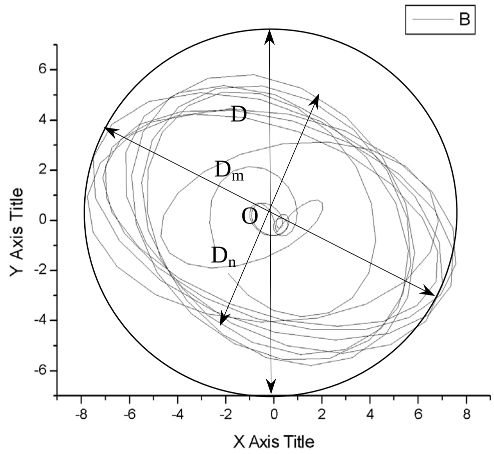

Fig. 4. Rotor rotation orbit, rotation frequency 3092 rev/min: O – centre of rotor rotation; D – diameter of ideal orbit; D_m – diameter of orbit, in the horizontal direction; D_n – diameter of orbit, in the vertical direction

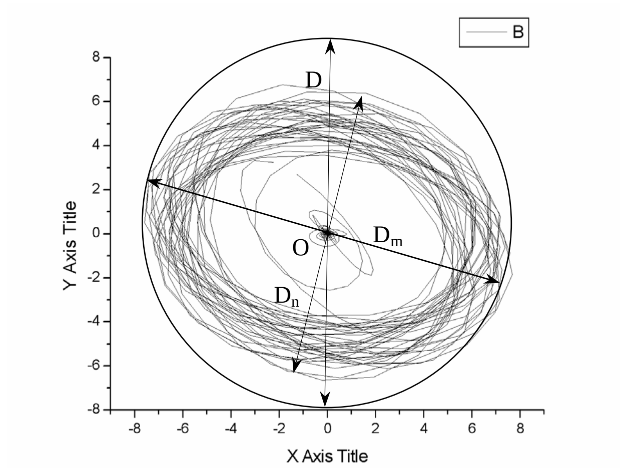

Fig. 5. Rotor rotation orbit, rotation frequency 3506 rev/min: O – centre of rotor rotation; D – diameter of ideal orbit; D_m – diameter of orbit, in the horizontal direction; D_n – diameter of orbit, in the vertical direction

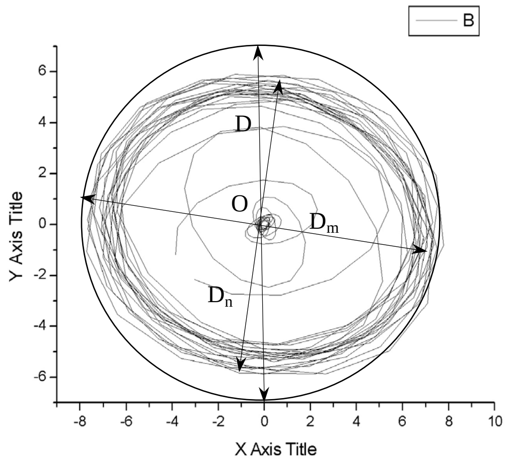

Fig. 6. Rotor rotation orbit, rotation frequency 4077 rev/min:

O – centre of rotor rotation; D – diameter of ideal orbit;
D_m – diameter of orbit, in the horizontal direction;
D_n – diameter of orbit, in the vertical direction

It can see by given orbits (Fig. 3, 4, 5), that when frequency of rotor rotation is on the limits of resonant bands of frequencies 1934 – 3918 rev/min orbits are on the broken forma and its several turns is not repeated each other, but are rotated chaotically, because the system is worked unstable.

When frequency of rotor rotation of researching rotary system is passed by line of resonant frequencies 4077 rev/min orbit is become more stable, more fixed again (Fig. 6), because and regime of system work is become stabile.

Diameter D of ideal orbit and real working orbit has two diameters D_m and D_n (Fig. 3, 4, 5, 6). The diameters D_m and D_n of orbits are the same; the form of orbit is the regular and the similar to orbit of regular form. It could solve about regime of rotary system by ratio of diameters D_m and D_n.

So by this format of data how rotation orbit of rotor axe it can determinate is the system worked in normal or in resonant frequency which is very unacceptable, because it can bee unacceptable results working the system in this regime.

5. Conclusions

1. Getting results are shown doing experimental measurements, that structure of orbits that are in resonant frequencies is unstable, chaotic (Fig. 3, 4, 5).
2. By orbit of rotor axe rotation it can determinate is the system worked in the normal or in the resonant frequency.
3. There are many data of formats to appreciate work state of rotary system, but rotation orbits of rotor axe are more picturesque.
4. It can see by getting results, that forms of orbits and structure are proved the graph of resonant frequencies of rotary system with segmental sliding bearings (Fig. 1).

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