369. Comparable analysis of vibrodiagnostic results of rotary components with different type bearings

V. Vekteris[1], A. Čereška[2], M. Jurevičius[3]
Vilnius Gediminas Technical University,
Basanavičiaus str. 28, LT-03324 Vilnius, Lithuania
E-mail: [1]*vekteris@ me.vgtu.lt,*
[2]*audrius@me.vgtu.lt,*
[3]*mindaugas.jurevičius@me.vgtu.lt*

(Received 5 February 2008; accepted 13 June 2008)

Abstract. Comparable vibrodiagnostic results of rotor components of technological machines with bearings of tilting-pad journal bearing, sleeve liquid-friction and of roll are given in this work. Sliding of roll of researching technological machines are described; the main characteristics of work and photo are given.

Experimental comparable vibrodiagnostics measurements are done. Primary signals of measurement are gotten doing vibrodiagnostic measurements, using different programmable pockets they are transformed to other formats of data. Getting results of measurement are systematized and its analysis is done. Comparison of getting results is done and dependence of work characteristics between rotary systems with bearings of sledding friction and of roll is ascertained.

Generalization of results of vibrodiagnostic researches is done and conclusions are formulated in the end of this work.

Keywords: comparable**,** vibrodiagnostics, technological machine, rotor components, bearings, rotor, amplitude, frequency

1. Introduction

To verify the quality of any produced rotor components technological machines the latter are generally subjected to examination or test measurements [1, 2]. With the increase in the operating rate and precision of machines it is advisable to periodically diagnose their functional quality [2, 3, 4]. It involves evaluation of the machine's technical state. Machine diagnostics [5, 6, 7] is a diverse process and depends on the purpose of a particular machine. In case of power machines (i.e. turbines, generators, etc.) an early detection of trouble symptoms is of utter importance seeking to avoid heavy losses and gruesome ecological outcome. To this end various diagnostic and monitoring systems are created [5]. In case of technological machines it is important to evaluate the functional quality of their components [1, 2, 3, 8]. Such evaluation, however, requires laboratory conditions and special equipment notwithstanding a good many methods and means that have been created for this purpose [2, 3, 8].

An original computer-aided diagnostic measurement system based on standard transducers and statistical software packages [9, 10] has been created and successfully tested at the diagnostics research laboratory.

This paper is aimed at determining the reliability of measurements taken in the course of diagnostics of the accuracy of a machine or its components.

2. Research objects

Different rotor components of technological machines are used in different ranges of industry and are worked with different characteristics being different conditions of work. Parameters of work of technological machines are depended from different factors: from frequency of rotor rotation, from temperature of work, from vibrations and so on. Subject to type of using bearings are depended vibrations of rotor, accuracy of rotor rotation and so on. Researches of accuracy of rotor rotation are done using rotors components (Fig. 1a, 1c) with rolling, tilting-pad journal and sleeve liquid-friction bearings [8]. Bearings are one of the primary elements of technological machines, they are kept rotor and are pervaded in different systems of rotor.

Bearings of roll are used in little and mean power machines: in electric motors, in generations, in centrifugal pumps, in ventilators and so on. Bearings of sliding friction are used: in turbines of vapour of large power, in compressors, in pumps, in generators of internal-combustion, in generators and similarly.

In diagnostically transducers of measuring except are lay out 90° corners of phases in one plane of shafts transverse (Fig. 1b). Such exposition of transducers lets to measure the position of shafts neck sliding bearing of rotor revolution including and zero. Orientation of transducers its not necessary has to be vertical or horizontal. Transducers of non-contact improvement strengthen in holder specially making fixing to frame of rotor. It's choosing most comfortable position of mechanism position.

Such defects, as damage, deflection of coaxially of rotor system (non coincidence of axis with a common rotation axis), increased gaps in sliding bearing for wear or other reasons, cracks in a shaft or graze to carapace parts may be defined by using two laser or other transducer.

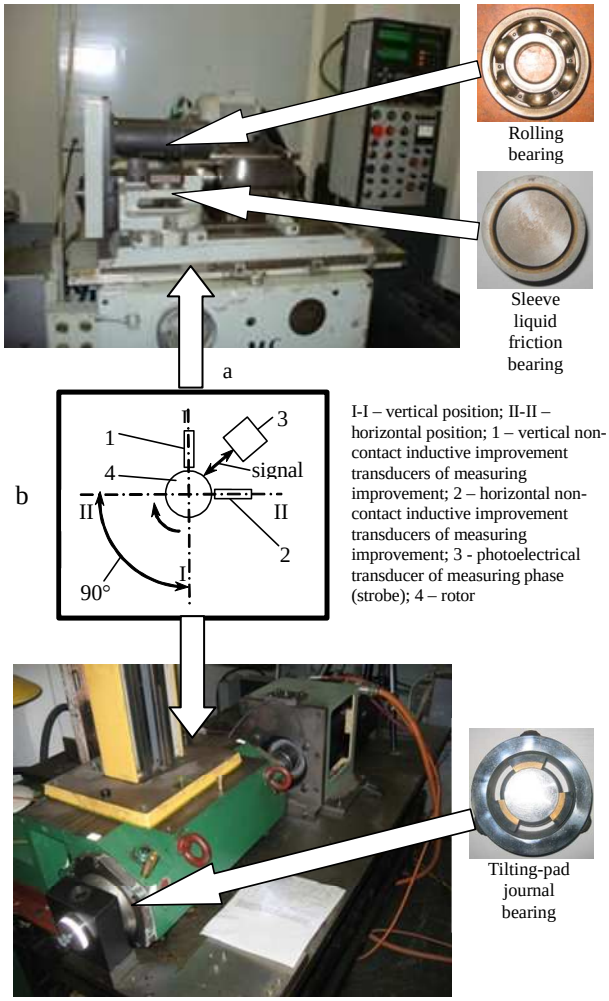


Fig. 1. Rotor components of technological machines: a – with rolling and sleeve liquid-friction bearings, b - principal scheme of transducer of measuring exposition to measure c – with tilting-pad journal bearings

3. Vibromeasurements system

The system of measuring form: non-contact transducers of measuring improvement, photoelectrical transducer of measuring phase, amplifiers and computer (Fig. 2).

For measuring of rotors rotation defections rotor systems had applied firm Germany Hettinger Baldwin Messtechnik CMBH transducers of non-contact inductive improvement mod. Tr. 102.

Transducer of improvement 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.

To establish phase is used photoelectrical phase's transducers of original construction. The system of photoelectrical phase's transducers effecting is present. The strop at foundation of rotor's frame is in the specially controlling holder.

Special plate DDAD1210 is installed in computer. The plate of input-output DAD1210 of universal electric signals are used for transmissions information to computer, for strengthen of transducers signals and for government of experiment.

The 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;

Doing measurements it is getting primary signals, that are getting with different disturbances and with biases for

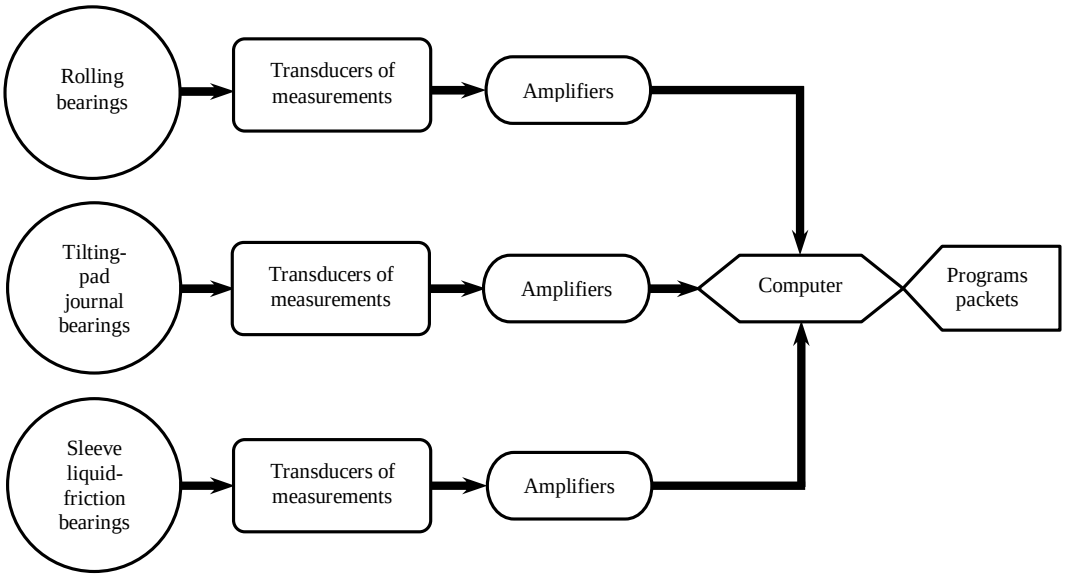


Fig. 2. Vibromeasurements system

different factors that is operating on system. So primary signals must be filtrate before doing further analyzed.
Doing filtration primary signals are analyzing, when are getting different formats of data, that showing technical state of researching system, breakdowns and its reasons of coming.

4. Methodology of vibromeasurements

Preparative works of regulation and coordination and calibration were done before doing vibrodiagnostically measurements. Experimental vibromeasurements were done such method (for all rotary components):

- It is calibrating transducers of measuring;
- It is coordinating all separate systems;
- It is testing provided clearance between neck of rotor and tilting-pad journal bearings (50 μm), (sleeve liquid friction bearings is not regulated);
- It is testing due frequency of rotor rotation (500 rpm);
- It is coordinating several components and boosters of transducers of measuring;
- It is connecting-up computer;
- It is doing experimental vibromeasurements;
- Data are incorporating into made-up data and informative files;
- Data are inscribing in made – up files of data and inform acing files;
- Results of measuring are analyzing with different program packets.

5. Results of experimental tests and its analysis

Researches of accuracy of rotor rotation of technological machines with sliding friction and bearing of roll are given in graphs (Fig. 3, 4, 5, 6, 7, 8).

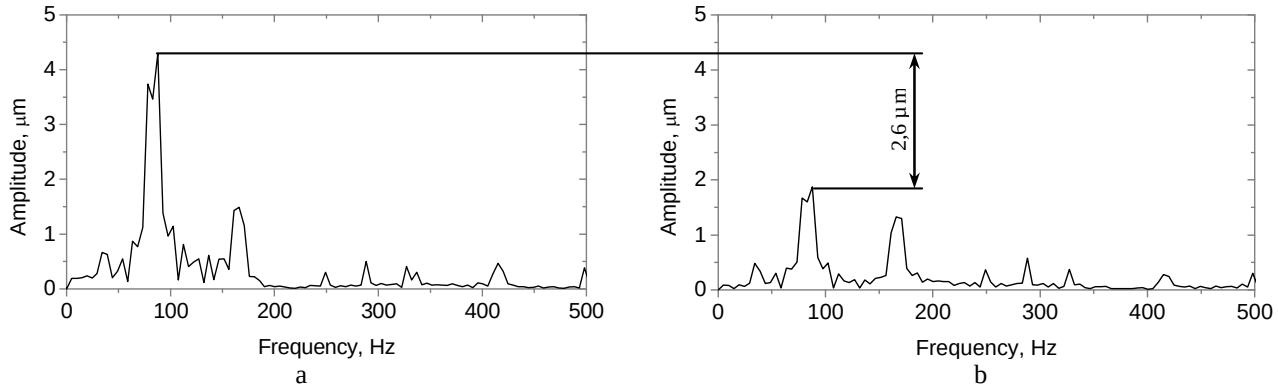


Fig. 3. Rotor with rolling bearings spectrums: a – horizontal position, b - vertical position

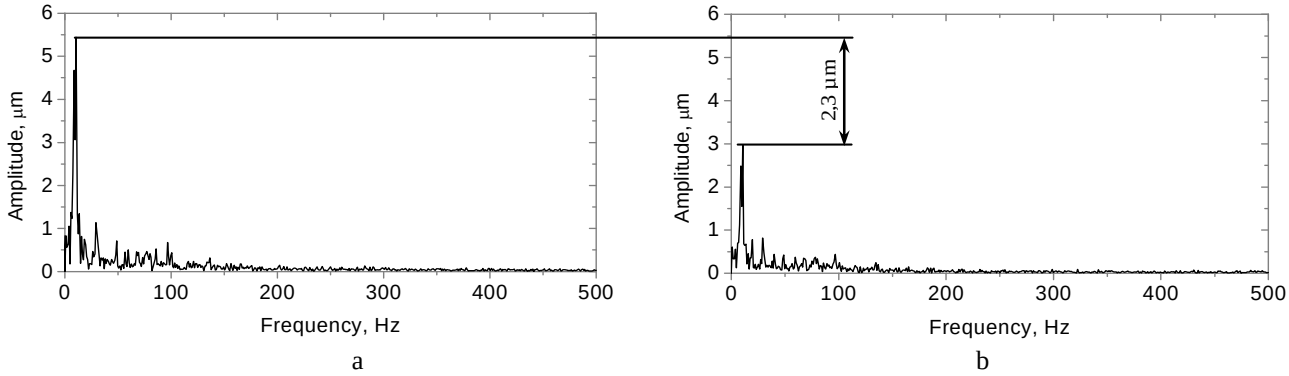


Fig. 4. Rotor with tilting-pad journal bearings spectrums: a – horizontal position, b - vertical position

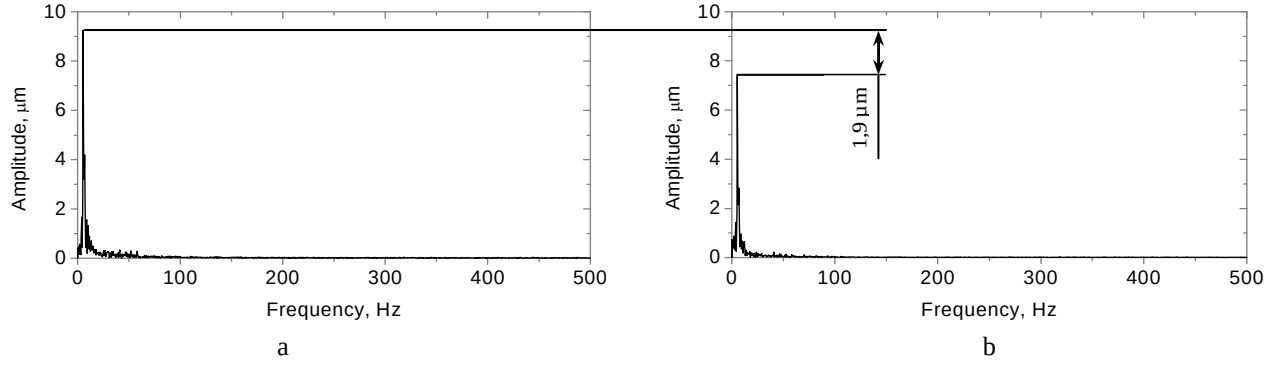
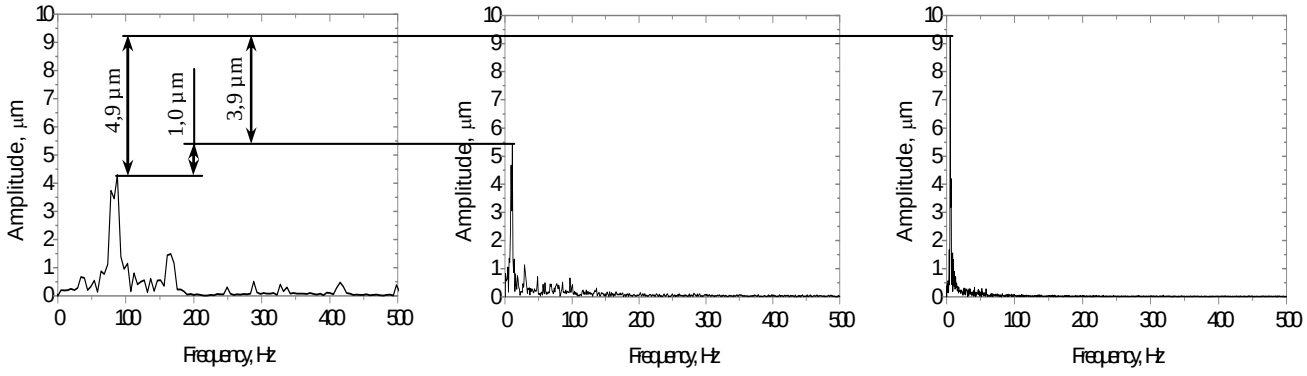
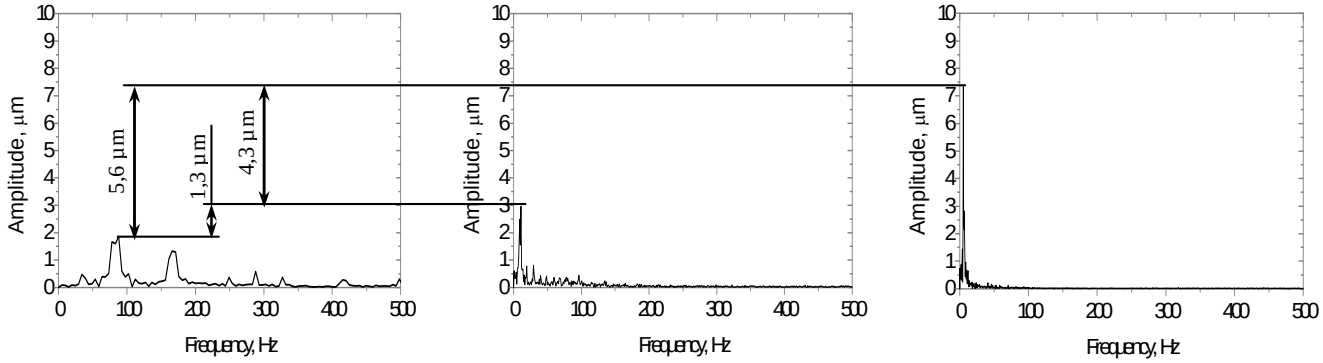


Fig. 5. Rotor with sleeve liquid - friction bearings spectrums: a – horizontal position, b - vertical position



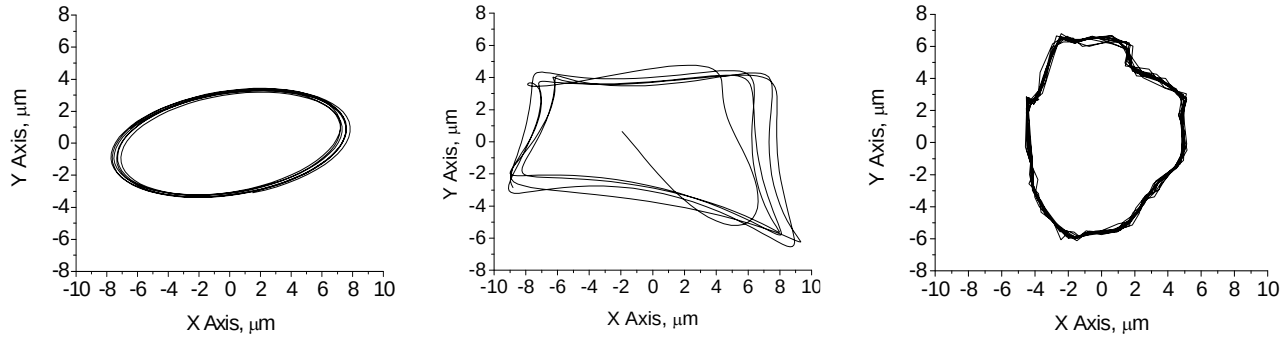
a b c

Fig. 6. Spectrums of vibrations rotors of horizontal position: a - with rolling bearings, b – with tilting-pad journal bearings, c – with sleeve liquid-friction bearings



a b c

Fig. 7. Spectrums of vibrations rotors of vertical position: a - with rolling bearings, b – with tilting-pad journal bearings, c – with sleeve liquid-friction bearings



a b c

Fig. 8. Orbits of vibrations rotors: a - with rolling bearings, b – with tilting-pad journal bearings, c – with sleeve liquid-friction bearings

It can see by given results of experimental measurement and its results of analysis (Fig. 3, 4, 5, 6, 7, 8). Being little frequencies of rotor rotation bearings of roll are worked more keel, because bearings of roll are worked in hard contact with rotor, and bearings of sliding friction – through liquid. Amplitude of spectrum of horizontal signal of roll bearing is 4,3 µm (Fig. 3a), amplitude of spectrum of horizontal signal of tilting-pad journal bearings is 5,4 µm (Fig. 4a), and sleeve bearings of amplitude of spectrum of horizontal signal is 9,2 µm even (Fig. 5a). Similar results are got and by signals of vertical measurement (Fig. 3b, 4b, 5b).

Amplitude of spectrum of vertical signal of roll bearing is 1,8 µm (Fig. 3b), amplitude of spectrum of horizontal signal of tilting-pad journal bearings is 3,1 µm (Fig. 4b), and sleeve

bearings of amplitude of spectrum of horizontal signal is 7,3 μm (Fig. 5b).

Differences of bearings vibromeasurements of amplitudes values of primary signals spectrums on horizontal and vertical directions are these: rolling bearings 2,6 μm (Fig. 3a, 3b) tilting pad-journal bearings 2,3 μm (Fig. 4a, 4b) and between sleeve liquid-friction bearings 1,9 μm (Fig. 5a, 5b) only.

Comparing amplitudes of vibrations spectrums in bearings of all rotors that are assembled rolling bearings, tilting-pad journal bearings, sleeve liquid-friction bearings, it is getting inconsiderable difference (Fig. 6, 7). Watching according spectrums of signals of horizontal direction (Fig. 6a, 6b, 6c) it can see, that between rolling and tilting-pad journal bearings peaks of spectrums are 1,0 μm, between tilting-pad journal bearings and sleeve liquid-friction 3,9 μm, and between rolling and sleeve liquid- friction 4,9 μm even. Analogous differences are gotten comparing spectrums that are gotten from signals.
Difference of peaks of spectrums amplitudes is 1,3 μm between rolling and tilting-pad journal bearings (Fig. 7a, 7b), difference of peaks of spectrums amplitudes is 4,3 μm between tilting-pad journal and sleeve liquid friction bearings (Fig. 7b, 7c), and difference of peaks of spectrums amplitudes between rolling and sleeve liquid friction bearings is 5,6 μm (Fig. 7a, 7c) even.

Bearings of roll are worked quite keel being little frequencies of rotor rotation, but when speeds are increased, then to use bearings of sliding frequencies are rather, because stability of these bearings is increased greatly now.

8a, b, c fig. are gotten orbits of rotor rotation with roll, tilting-pad journal and sleeve liquid friction bearings in rotary components.

Orbits are gotten rotors rotating in rotary components with tilting-pad journal (Fig. 8b) and sleeve liquid-friction (8c) in irregularly-shaped bearings, and the implication is that rotary component with the following bearings is worked instability and inaccuracy. Rotor revolution orbit in roll bearings is more correct form from getting orbits (Fig. 8a). That is proven and spectrums.

Conclusions

1. Rotor rotating with little frequencies of rotation is worked rotor components technological machines with bearings of roll precise (Fig. 3), but being major frequencies of rotor rotation, that rotor components of rotor components of technological machines are worked precise and security, its rotors are assembled in tilting-pad journal and sleeve liquid-friction bearings (Fig.4, 5).

2. Bearings of sliding friction are assembled in rotary components of technological machines, they are stable less being little frequencies of rotor rotation, because between rotor and bearing is liquid, that is decreased friction and is refrigerated zone of work between rotor and bearing, but stability of rotor rotation is decreased, and this have influence on quality of work of correct systems particularly, for example, rotary component of precision metal cutting technological machines.

3. Bearings of sliding friction are used in technological machines generally, those are worked in major frequencies of rotor rotation, because with liquid they are refrigerated and lubricated, and roll bearings for internecine friction of internal elements is heated more in that case and it could be different breakdowns therefore.

4. Orbits of rotor revolution are proven that components of technological machines with roll bearings are worked more stability and more accuracy rotor rotating with small revolution frequencies.

References

[1] **Vekteris V. J.** Precision Metal-Cutting Systems. Vilnius: Technika. P. 212. 1995.

[2] **Jurevičius M., Čereška A.** Use of laser transducers in diagnostics of tribological systems. Journal of Vibroengineering. 2000. No. 3 (4). P. 199–201.

[3] **Vekteris V., A. Čereška.** Diagnostics of Functioning Quality of the Systems with Sliding Bearings. Mechanika. No.2 (34) Kaunas: Technologija. 2002. P. 51-56.

[4] **Vekteris, V., Čereška A.** Diagnostic errors of rotating systems with sliding bearing. -Scientific Symposium: Metrology and Metrology Assurance.-Sozopol, Bulgaria, 2004. P.142-146.

[5] **Barzdaitis V., Chinikas G.** Monitoring and Diagnostics of Rotary Machines. Kaunas: Technologija. P. 364. 1998.

[6] **Bently D. E.** Rotating Machinery Measurements 101. – Orbit, June, 1994, Vol. 15, No. 2. Printed in USA. P. 4–6.

[7] **Bently, D.E., Hatch CH. T.** Fundamentals of Rotating Machinery Diagnostics. Bently Pressurized Bearing Company, printed in Canada, first printing. P. 726. 2002.

[8] **Vekteris V.J.** Adaptive Tribological Systems. Theory and application. Scientific publications. Vilnius: Technika. P. 203. 1996.

[9] **Vekteris V., Jurevichius M., Daktariunas A.** A Computer-Aided Diagnostic Measurement System. Measurements, № 2(11) 1999. P. 11-17.

[10] **Vekteris V., Jureviccius M., A.Čereška.** Diagnostic rotor System of Statistical Methods. Measurements. Kaunas. Technologija. No.1 (17) 2001. P. 36-40.