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TYPES OF FAULTS AND THEIR INFLUENCE ON THE CHOICE OF VIBRATION DIAGNOSTICS STRATEGY

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ABSTRACT
Selection of suitable strategy in the process of mechanical system's vibration diagnostic (especially rotating machines) is very important task dependant on the level of knowledge and recognition of faults during working process of machines and structures.
Data base for various kinds or irregularities in different phases of machine and structure's life cycle was presented in this paper.
Detail description and research of faults on rotating machines and rotating assemblies is focused on determining fault coefficients which are used to make correction of the load relevant for the choice of vibration isolation system still during machine and structure's designing phase.
Keywords: faults, diagnostics, vibration isolation

1. INTRODUCTION
Very demanding and complex task of analytic evaluation for mechanical system's technical state under working conditions would have been impossible to solve without using adequate methods from domain of mechanical engineering vibrations, methods influenced by inclination of technical condition parameters in comparison to standard conditions. The importance and efficiency of using such methods is conditioned by the established relation between defined information contained inside vibration signal and dynamic process of excitation and vibration spreading through the structure of mechanical system, as well as with the possibility to automate and organize the system of tracking, monitoring and processing multidimensional high frequency measuring information with the application of modern computational technique based on mathematical instrument of cognitive theory. Therefore, it is necessary to select the correct strategy of diagnostic process presuming determining basic tasks of vibration analyses, impulse conditions and vibration spreading throughout the structure of a mechanical system with the goal to detect faults at the early stages in due time, in order to install these information into the system before its functional realisation.[1,2]
Successful selection of diagnostic strategy mostly depends on correct choice of diagnostic model of rotating system and its linear and nonlinear features i.e. at the correct selection of vibration signal model and its components, especially while diagnosing faults at its genesis.

2. BASIC CHARACTERISTICS OF VIBRATION DIAGNOSTICS
When designing the engine parts on rotating machines it is necessary to compose computational model with the aim to ensure precise evaluation of their impulse frequencies and custom vibration frequencies in order to evaluate probabilities of working in resonance regimes.
To ensure conditions of strength it is needed to apply the highest quality materials and technology. Mismatch in parts manufacture technology and inadequate assembly system usually bring to basic vibration sources, which are:

- Imbalance of rotating machine parts;

- Inaxial alignment of arbor and supports;
- Disruption of elements geometry relations, so called mechanical clearances.

Since it occurs as an important component of solving the problem of vibration processes inside a machine, the task of identification and localization of the impulse source is, at the same time, one of the components for diagnostic solution to overall technical condition of a machine. For example, even though there is an increase of a frequency component close to a spinning frequency, showing up on a vibration spectrum, it does not mean that certain and clear reason of such behaviour was explained. Increase of amplitude under turning speed, at the turning frequency, can be caused for more reasons, such as: rotor imbalance; inclination from arbor axis (inaxial alignment); increase of clearance in torque supports; increased deflection or rotor (e.g. due to inner cracks) etc.

Inside the machine containing either denticular or pulley transmission other reasons can appear such as; faults in gear manufacture; defected racks on dentil band; too large side clearance or denticular free play; wear out of racks, overload on dentil band; warn out, loose or unsuitable pulley; inaxial alignment between turning axis of pulleys; pulley resonance etc, of for example on a turbine machine the causes can be: erosion and corrosion throughout a vane span etc.

If an analyst is focused only on a fact that the reason for the increased vibrations is an imbalance of rotating components, than, it would be possible to make mistakes in analyses. At the same time, if the solution of the problem of vibration source identification is focused on the speed of rotation (as the basic frequency), and a task is much more extensive i.e. it is necessary to evaluate an overall technical condition of the entire machine, than, it is necessary to determine diagnostic signals which will enable identification of faults.

Extensive alterations of machine's technical parameters, which usually point to catastrophic condition or close to it, often lower the level of vibrations at basic impulse frequencies. In such cases nonlinear vibrations emerge, causing division of energy between combined or complex components of vibration signal. Analogy example for such case is the influence of assembly mistakes (faults), which lead to reassignment of vibration energy in the zone of higher harmonics of basic impulse frequency.

At the selection of diagnostic strategy and system of diagnostic signs it is essential *to establish functional relation* between basic diagnostic parameter of machine's technical condition and its alteration in changed characteristics of vibration signal. Thereof, specific experiment was undertaken to create specific alteration of machine's technical condition parameters simulating the most important irregularities. [3,4]

3. RESEARCH OF FAULTS ON ROTATING MACHINES

Selection of correct strategy and diagnostic method for the machines are mostly dependant on a diagnostic goal, which is largely influenced by the life cycle phase at the moment of evaluation: phase of manufacture, exploitation, or phase of remount.

At the manufacture phase the goal is to provide an optimal designing and construction, created by the increase of security and decrease of vibration activity on mechanical system's assemblies. Eliminating certain kind of irregularities is an attempt to achieve security; for designers, the most important ones are kinematic faults on assemblies, but also there are faults in the process of assembling such as imbalance, inaxial alignment, inclination, mechanical clearances, inadequate and unsuitable greasing, etc. In the phase of exploitation, considering the natural process of deterioration during time, it comes to changes of structural parameters, which can be the cause of break. The speed of parameters alterations, in this phase, is divided on two types: fast developing faults, which lead to unpredicted failures and slower developing faults which gradually lead to failures. Considering the fact that mechanical system's life cycle is divided on three mentioned phases, it can be concluded that vibroacoustic diagnostic is mainly justifiable at the exploitation phase and that, under correct organisation of this phase, faults can be early predicted, enough before critical condition of mechanical system, so that diagnostics at the remount phase would be lowered only on control of technical condition after remount. In order that vibroacoustic diagnostics would have meaning during this phase, diagnostic procedure for evaluation of technical condition should be conducted before remount works.

3.1. Experimental research of potential faults as vibration sources

To create significant argument for presentation of faults, experimental installation modelling was conducted, composed of large number of different rotating machines, where all of them were monitored, their vibration processes were analyzed and diagnostic of technical state conducted based on appearance of alarming values of vibration characteristics. Monitoring and analyses of vibration processes preceded creation of diagnostic system for several rotating machine model types (one of them is displayed on fig. 1.a.b), i.e. researches were conducted to select out all week assemblies on rotating machines suitable, or sometimes needed, to be diagnosed.

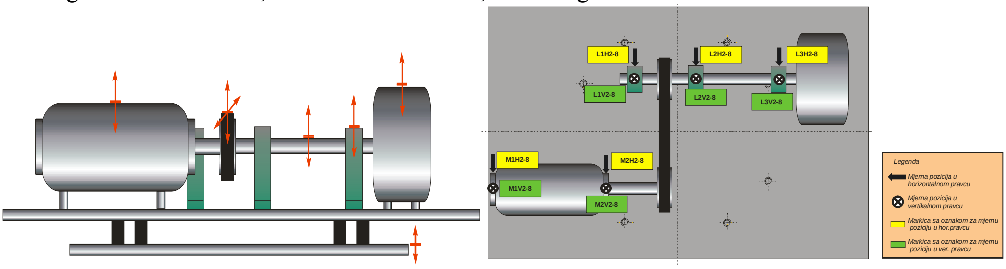

Figure 1. a. Experiment scheme EXM4/SV8 with marked impulse vibration motions;
b. measuring positions on experimental model

After applied methods for vibration tracking and conducted analyses based on performed experiments, identification of vibration parameters followed, i.e. it's expressed components (increased amplitudes) on spectrums, which are also used as diagnostic parameters if positively related to the component of rotation speed or its suitable frequency (1xrpm) (Fig. 2b). During vibration spectrum analyses on rotating machines single appearance of some kind of fault is rarely alone. Therefore, it is necessary to conduct process of interpretation of vibration spectrums and their indicators very carefully, because different faults can be the cause of spectral components on equal frequencies. Faults are selected by its importance, but as well by the assemblies of rotating machines on which they have appeared.

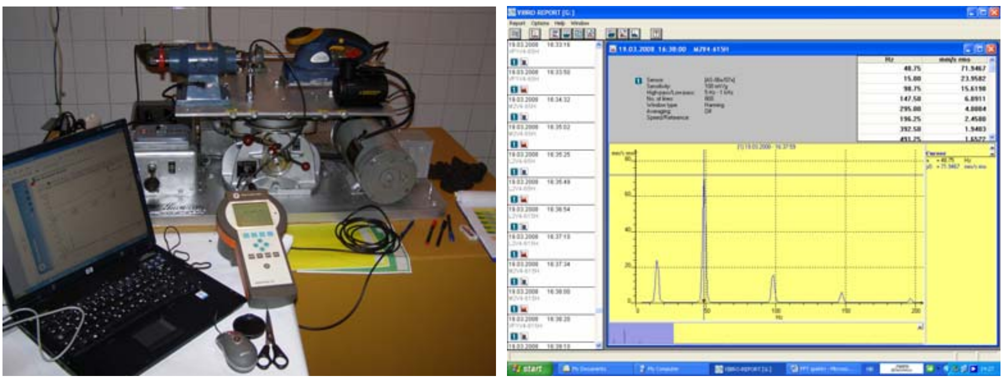

Figure 2. a. Photo of the equipment for measuring of EXM4/SV8; b. FFT spectrum of measured position

After defining and describing of each fault which can become the cause of vibration, based on measuring results in relation to selected parameters of mechanical system (software xms-eXtended Monitoring System) and relating parameters from vibration research equipment (Vibrotest 60) (Fig.2a.b), the correct order of faults is established, selected by its negative effect and its frequency, which is very important in order to determine coefficient of fault influence (k_N), i.e. intensity of dynamic force used to correct the load proper for selection of vibration isolation system still during phase of designing and construction.

3.2. Composing the vibroisolation system

Vibroisolation system (SV) is based on a distribution of the load on each isolator, and it is corrected using fault coefficient (k_N) applied on mechanical model using vibroisolators in certain combination between vibration platform and additional board containing positioned elements of a model. Selection of vibroisolation system followed steps of designing optimal vibroisolator as it is shown on the following scheme Fig.3 [5,6]

Figure 3. Designing procedure of vibration isolation

4. CONCLUSION

Selection of vibration diagnostic strategy is based on dynamic parameters, which appear as the result of interactive action on rotating machine assemblies and can be presented as parameters of position, speed, acceleration or pressure pulse. Changes on rotating machine in such state are conditioned by fast changes of vibration signal, dependant on wide frequency and dynamic area of vibration process and high spreading speed of sound waves throughout the structure of the machine, relevant in the case of failure when diagnosing speed is very important to prevent cases of total shutdown or breakdown.
Considering that experimental researches were based on theoretical explanation of resonance diagrams which represent functions of transmission dependent on relations between impulse and custom frequency, but dependent on other characteristics as well, transmission can be influenced by change of distribution parameters of mechanical system, i.e. change of elasticity parameters (stiffness), system's mass or damping. Selection of experimental model variants, determination of priorities and coefficient of fault influence (which have been priority of this paper), using the correct kind and disposition of vibroisolation system proved to be the best way to influence results of vibration response on mechanical system in function of security and isolation of vibrations. Each fault with its characteristics, but also their interaction, dictates selection of the type of vibration isolation and the task of a designer is to point out to the optimal one for its role.

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