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DYNAMIC BEHAVIOR SIMULATION OF AN HYDRO DYNAMIC AGGREGATE

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Abstracts:
The paper presents a stand that allows the simulation of a hydro power aggregate dynamic conduct, using exploiting conditions [5,6,7].
As a result of the measurement and studying by similitude the influence of the disturbing factors, we may also predict the systems operating in another condition than the initial ones, including the real conditions of hydro power aggregate operating.[1 ÷ 4].

1. GENERALITIES

The hydro - energetic equipments, as great complexity units, have rotate movement elements like: shafts, armatures, couplers, disks that characterized through large dimensions (diameters, length) and masses.

All these elements are caught in sliding and rolling bearings inside them lasting existing luboil necessary for lubrication.

Relative movement between shafts and bearings can dare in longtime at installation of ware process with certain velocity. That process is finished with diameters and mandrels alteration through increase values of clearances and position deviation, increase disequilibrium and therefore at appearing possibilities that components to be mechanically excitation, following such in vibration [1 ÷ 4].

2. THE STRUCTURE OF EXPERIMENTAL STALL

2.1. Stall components

The structure of stall for radial and axial hydrodynamic bearings attempt is shown in figure number 1 and it was conceived and realized in Hydraulic Laboratory of Oradea University for experimental studied of vibrations regimes which driving in elastic system from different conditions of operation.

The stall allow generating the variation of elastic forces by assembly exciting, to weight disequilibrium and that producing by out of axes deviations (in horizontal and vertical plan), should that producing by radial and axial rapping or that producing by ware for the sliding and rolling bearings.

For shaft lunge is used an electric engine by continuous current with variable voltage controller that content a tachogenerator for rotative speed measuring.

The charge of bearings is mechanical realized with help of bolt – nut mechanism with role feed-finger and all system is mounted on rotate plate sled (PR) that allow modify the position with 90 degree for radial and axial charging. Charging subassembly is envisaged by an elastic element (arc helical compression limb), which producing, through deformation, a variable charging force its value is proportionally with linear deforming of the limb.

Bearing corps are fixed inside their bearings (bearing boxes) what sustained the rotate movement shaft. That corps is fixed on cross sledge (S.T.), with the help of that may realize a different deviation by axes, in horizontal and vertical plan or another axial deviation.

This stall for tries of a radial sliding bearings, has the possibility to function in two variants:

- For sliding bearings with self-supporting effect of lubricant film;
- For sliding bearings with controlling hydrostatic pressure.

In that last type, the film of luboil it is obtain by the hydraulic plant for an gear wheels pump (R.D.) which aspire the oil from a reservoir by unique sense valve. The oil that was jumping-up by pump is assignment into the two bearings. The oil evacuate tubes from bearings are joins through common pipe which have a tap situated before reservoir entrance. Through the variation of this tap for oil evacuating from bearings it could control value to pressure of luboil film. That value may be correlated with different levels of vibrations from bearings and it could study so the problem of the hydrodynamic stability to small perturbances providing by vibrations.

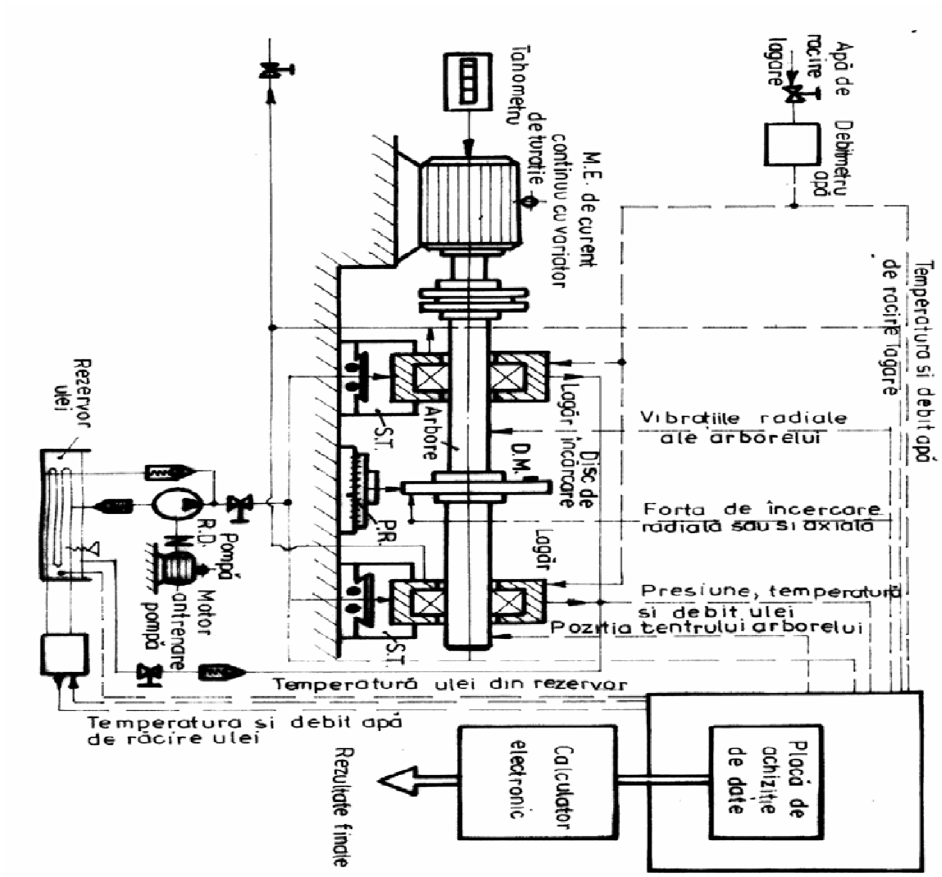
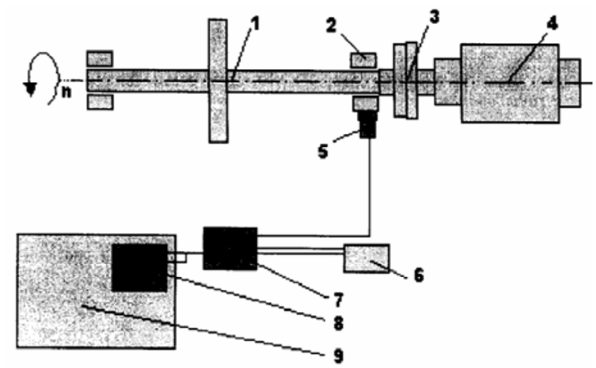


Fig. 1. Structure of experimental stall

2.2. Device from vibrations measure

Measure equipment for vibrations that utilized from experiences laboratory, is presented in the figure number 2



1. shaft;
2. bearing;
3. coupler;
4. lunge engine ;
5. piezoelectric transducer;
6. amplificatory supply;
7. amplifier;
8. capture slab;
9. computer system

Fig. 2. Measuring vibration device

3. TECHNIQUE OF MEASUREMENT, COLLECTION AND PROCESSING SIGNALS

3.1. Block scheme

Measuring and analyses of vibrations in the scope of technical diagnosis, involve used of basic schemes winch content next components: signal transducer, conditioned signals apparatus, analyzer, computing recording (figure 3).

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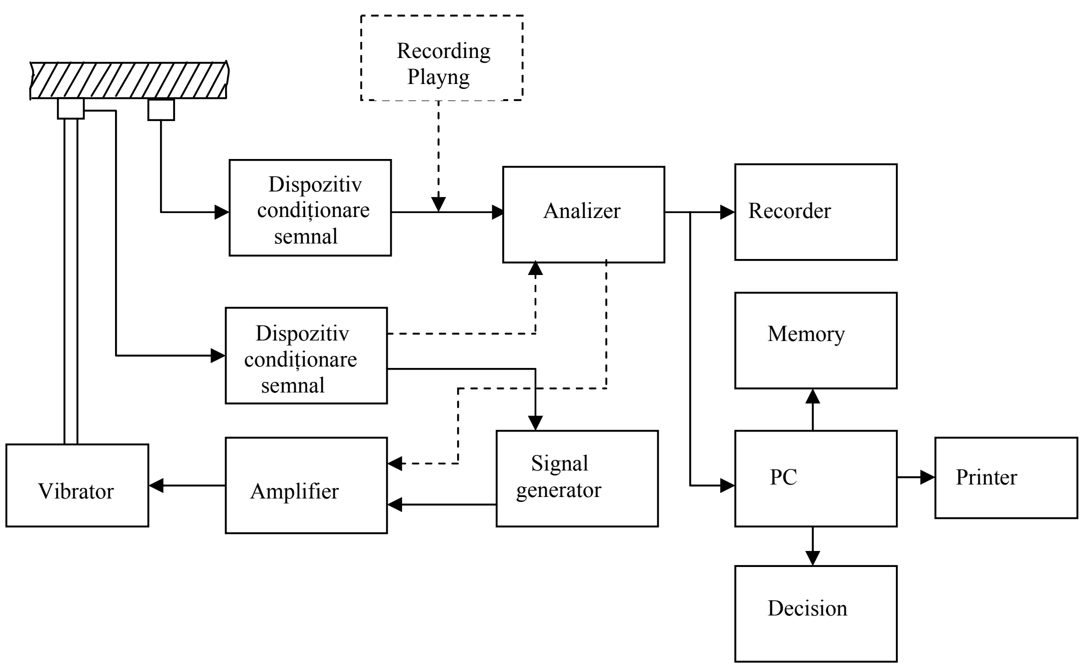


Fig. 3. Block scheme from vibration measuring

Signal transducers transform the energy of mechanical waves into electric signal which after ulterior briefing, provide necessary data for technical diagnosis.

Signal conditioner realized next primal functions: pre - amplification, adapting impedances, integration, filtering and time averaged.

Analyzer can work in frequency domain, amplitude domain or time domain. The Evolution of analyses techniques in real time and in special evolution of technique data control, offer superior possibilities to increase the velocity and precision of analyze with higher efficiency from point of view of necessary time for diagnose.

Signals stockage following later processing or to realized analyze in frequency domain that maybe obtain through recording upon strip into magnetic memory with digital indent. Using a PC allow the automatic processing of signal with a increaser precision and work speed, admitting so much continuous recording of signals and their reproducing, such as the multiple possibilities by comparison.

Vibrators are dedicated for realizing by excitation systems that characterized through large forces and displacements. The most utilized types are the mechanicals and electrodynamics which are many possibilities for utilization in simulation schemes.

Power amplifier assured the amplification of signal, without distortions, in dynamics and frequency domains so large is possible, at exit impedance as low is necessary.

The quality of measurement system and briefing of vibration signals is determined by qualities indicators of subsystems that compose and which knowledge is necessary to remove the measuring and processing data failures.

3.2. Analysis of vibration signals

The signals necessary for dynamic analyze of hydro-unit contents data about technical condition at time moment of this and for his degradation state.

In all cases, indifferent by physical measurement, the diagnosis signals are functions with depending by time. These content a continuous element $\bar{x}(t)$ and a fluctuant component $x'(t)$, that is:

$$x(t) = \bar{x}(t) + x'(t) \qquad (1)$$

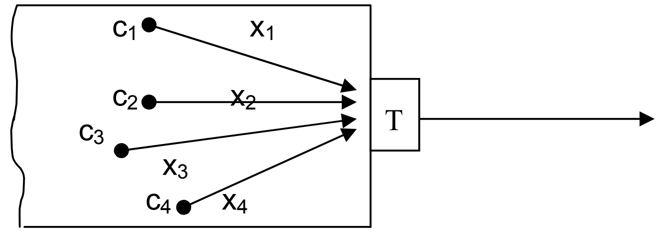
where:

$$\bar{x}(t) = \frac{1}{T}\int_0^T x(t)dt\,, \qquad (2)$$

T – Time interval of analyses.

In signal analyses interested both components: that which continuous one $\bar{x}(t)$ that named momentary average value, and the fluctuant one: $x'(t)$. Measurement and assessment of information's content of them presuppose particular methods for solved.

Measured signal from transducer has a structure formatted by many signals emitted to object in cause, fig.4.



T - Transducer; c_i – conduction factors; x_i – emitted signals.
Fig. 4. Signals propagation from piece to transducer

Characteristic measures of vibration signals its scalar types, appearing to the time variation of measured values.

The characteristics of dynamics signals:

- *Average value* $\bar{x}$:

$$\bar{x} = \frac{1}{T}\int_0^T x(t)\cdot dt \tag{3}$$

or depend by number N of measured values:

$$\bar{x} = \frac{1}{N}\cdot\sum_{i=1}^{N} x_i \tag{4}$$

where: x_i is the value of discrete function at time moment t_i, N – measured number values from time domain (0,T).

- *Square Average value* $\bar{x}^2$ *:*

$$\bar{x}^2(t) = \frac{1}{T}\int_0^T x^2(t)\cdot dt \tag{5}$$

Or, by function of measured number values:

$$\bar{x}^2 = \frac{1}{N}\cdot\sum_{i=1}^{N} x_i^2 \tag{6}$$

- *Effective value* x_{ef};

$$x_{ef} = \sqrt{\bar{x}^2}(t) = \sqrt{\frac{1}{T}\int_0^t x^2(t)}\ . \tag{7}$$

- *Peak value* which maybe positive or negative:
    - positive peak value: $\hat{x} = \max x(t)$; (8)
    - negative peak value: $\check{x} = \min x(t)$ (9)

Peak value indicated the extreme magnitude and make suggestion about extreme forces.

- *Dispersion* σ^2 *:*

$$\sigma^2 = \lim_{T\to\infty}\frac{1}{T}\int_0^T \left[x(t) - \bar{x}\ \right]^2 \cdot dt \tag{10}$$

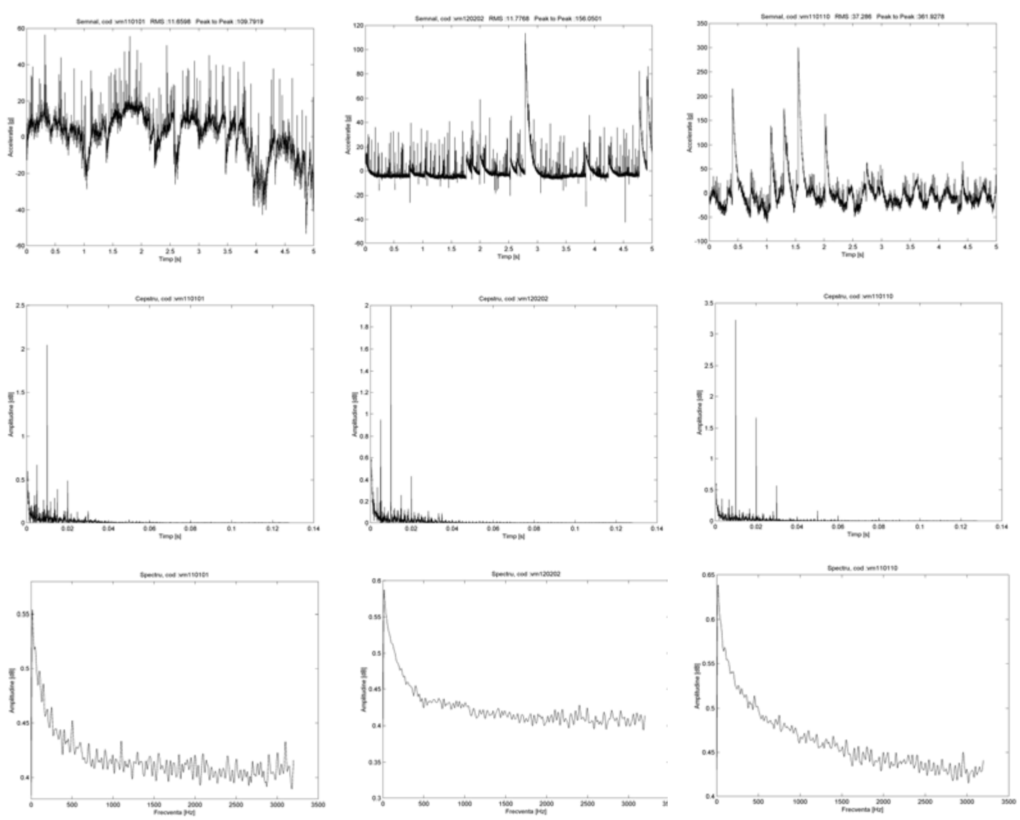
$$\sigma^2 = \frac{1}{N} \cdot \sum_{i=1}^{N} \left(x_i - \overline{x} \right)^2 \qquad (11)$$

where, σ is square average deviation. The Dispersion defining the medium deviation of the signal comparative with average value of that.

4. EXPERIMENTAL TRIES

Upon experimental laboratory stall we made determination regarding dynamic behavior of rotor - shaft - bearings assembly at strains that generating by coaxes deviation, weight disequilibrium and depreciation at different grades of loading, finally determining the vibrations spectrums which their corresponding [5,6,7].

For exampling we had shown partial spectrums of vibrations which are result from the tries and the conclusions of experiences.



a) out of axis - 1mm ***b) out of axis- 2mm*** ***c)out of axis- 3mm***

Fig. 5. Vibrations spectrum at coaxial deviation of shaft

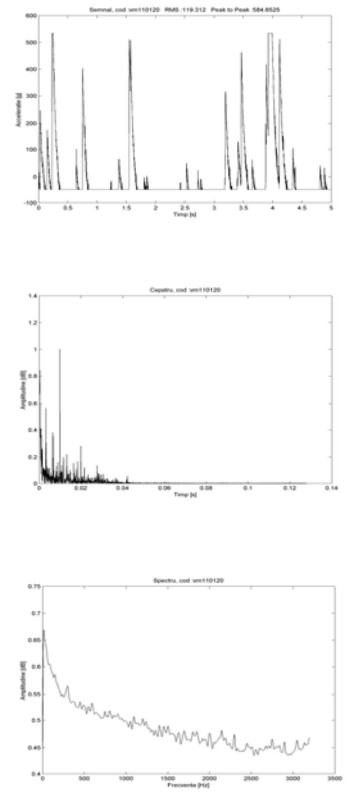


Fig. 6. Vibrations spectrum at disequilibrium of weight

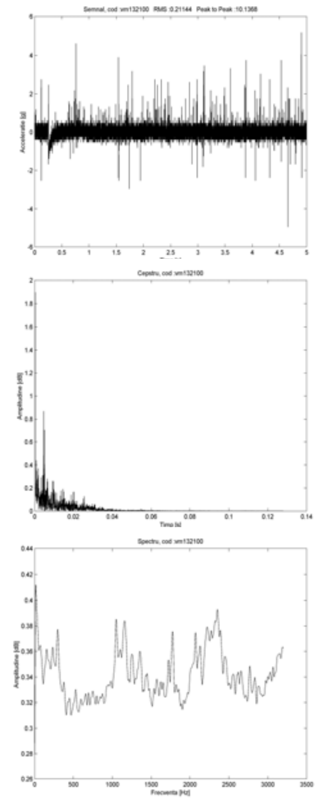


Fig. 7. Vibrations spectrum generate by uneven wear of bearing

5. CONCLUSIONS

1. Experimental research of the dynamic phenomena specific to rotor –shaft – bearings assembly through stalls utilization, which reproduce to lessen scale, into laboratory, the real condition from exploitation of hydro - energetic units, allow sources identification and characterized the level of vibrations.

2. For experimental tests is necessary, preliminary to delimit of investigation domain and set the principles, make care to specify hydrodynamic processes of axial and radial bearings from hydro-energetic unit.

3. The experimental tests involve conception and realization to the adequate stall. The structure who recommended for that stall, because it is proved viable and adequate our follow scope, it was shown in fig.1.

4. After vibrations analysis challenging by non-axes deviation, we established:

- In frequency spectrum exist three harmonics of basic frequency, amplitude of vibrations increase with alignment degree.;
- If value of the second harmony is bigger to the first and the threes, than its produce an effect by shaft curving, and the flexion is proportional with nonalignment degree;
- Increase the bearing clearance, after wear of shaft mandrel and bearing boxes, be in charge to decrease of vibrations amplitude because luboil film development help the hydrodynamics phenomena of pressure distribution and to increase of slimy damping value.

5. The effected registrations regarding the vibrations that generating by weight disequilibrium admits to formulate follower conclusions:

- weight disequilibrium is present of every rotate with the same intensity;
- the value of vibration amplitude is change direct proportional with value of disequilibrium;
- weight disequilibrium's to big values be in charge to shafts curved when in frequency spectrum is implicate especially the second harmony which have the highest value;
- when the vibrations into the both bearings are in same phase and its have an sinusoidal time signal with the same frequency to basic harmony it is install the static disequilibrium and when the phase difference is de 180^0 is install the dynamic disequilibrium.

6. From analyze of common sliding bearings it was established that:

- bearing function is conditioned by mechanical abrasion and hydro – dynamic phenomena that forming and keeping the self – supporting luboil film between shaft and bearing boxes;
- the Abrasion from sliding bearings is manifesting into frequency spectrum through spectral lines spacing itself with shaft rotate frequency and the vibration amplitude that measuring in horizontal plan is bigger than vibrations amplitude measured in vertical plan;
- if the contact about pieces have place on every rotation, then appear an impulse with frequency equal with rotation frequency of the piece;
- magnitude of impulse is determinates by intensity of the contacts, by the slimy amortization and by the baring charge;
- the ware of the shafts mandrels or a bearing boxes facilitated the decrease of vibration magnitude because luboil film development and pressure assignment which increase the value of capacity by damping of the vibrations; this variable phenomenon appear only to specify ware degree after them appear coaxes deviation with specific manifestations.

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