BEAM PUMPING SYSTEMS BY VIBRATION ANALYSIS IN OPERATING

ANALIZA VIBRAŢIILOR IN EXPLOATAREA UNITATILOR DE POMPARE CU BALANSIER

Marius STAN[1], Nicolae Napoleon ANTONESCU, Lazăr AVRAM[1]

Abstract: *The operating condition of an implement can be found by the analysis mechanical vibrations produced by changing functional parameters. Method of analysis shall be based on the determination of parameter of vibration and its interpretation. Each fault or fault can be discovered and corrected without the need for installation has been shut down. The work is a way for the application of this method of diagnosis for the installation of delivery of crude oil. The work will be presented detailed rules for the implementation of an extraction of petroleum and how to interpret the results obtained.*

Keywords: analysis, process, pump unit, vibration, vibrotest.

Rezumat: *Starea de funcționare a unui utilaj poate fi găsită prin analiza vibrațiilor mecanice produse prin schimbarea parametrilor funcționali. Metoda de analiză se bazează pe determinarea parametrului vibrației și interpretarea acestuia. Fiecare defecțiune sau defecțiune poate fi descoperită și corectată fără a fi necesară instalarea. Lucrarea este o modalitate de aplicare a acestei metode de diagnostic pentru instalarea livrării de țiței. Vor fi prezentate reguli detaliate pentru implementarea unei extracții de petrol și modul de interpretare a rezultatelor obținute.*

Cuvinte cheie: analiza, proces, unitate de pompare, vibraţie, vibrotest

1. Introduction

Diagnosis by vibrations of the operating status of the plant, plant and machinery is based on the fact that in the process of energy transfer, oriented toward achieving a functions data, other than component, situated on the route of this transfer, may be excited mechanically, shall thereupon enter into vibration.

The concrete manifestation of this vibrations appreciated by, its various features (such as movement, speed, acceleration, production over time, frequency spectrum or the amplitude, etc.) it is promised in terms of both structure and the

[1] Prof., The Petroleum-Gas University of Ploiesti, e-mail: mstan@upg-ploiesti-ro; nnantonescu@upg-ploiesti-ro; lavram@upg-ploiesti-ro

special notes on constructive and functional of the system, established by project and carried out by execution, as well as in connection with the operating status, performance, but also any faults

As long as the process is carried out and the vibration constant components excited occurs constantly. Indeed, any change in the status of operation change default dynamic conditions of the system, the conditions of propagation of elastic waves and of course vibration characteristics valued in one way or another.

Sent to the outside, on the waveform components mobile-supports-fixed components, variation forces, specific operation, shall be recorded, as a general rule on the outside, as well as vibration and is measured as either relative movement of certain components, either as absolute motion.

As a matter of principle, the vibration can be considered as the result report:

FORCE/IMPEDANCE MECHANICAL=VIBRATION

Of course, that in changing vibration as a result of the amended the operating status, it is essential variation in force. At the same time, although it is considered that factor impedance is more stable, it is to be noted that and this resistance depends on the structure of the specific features and system components.

Thus, for a shaft movement in a concentration camp, impedance is dominated by they didn't have money or time properties of lubricant, while same motion measured on the outside surface of the bearings also depends on dynamic properties of the film, but to a greater extent and those of rigid construction of the body of the bearing.

The vibration, measured at the level of the surface outer bearings, it would be a few times (2-4) less than the vibration assessed directly, by moving the shaft journal.

As the function of a machine does not act only one force as a source of vibration and how rubber wave transfer may be made in several ways, it is clear that the answer to vibrate at the various requests can become extremely complicated. Interpretation requires not only experience, data and information with regard to satisfactory particulars vibration of the machine, but also application of selection criteria and assessing its calculation - experiment.

2. Paper contents

Diagnostics operation and machinery in operation by process parameters specific operation, vibration, temperature, etc. , is recognized as an important way to increase the reliability, efficiency of operation, to reduce production costs and operating.

Intended use installations or systems for monitoring is to check the normality operation, to detect evenualele deviations or "problems" and to provide information and support for decisions and operation of a disconnect or shutdown, and for fault finding.

A suite of possible failures in operation of installations of petroleum extraction, falling within the scope monitoring, is indicated in table 1. connection and their development over time or with changes in the entire plant failure and cut-off.

It should be noted that the separation methodological failures in sudden and gradual failures depend not only objective of time, but also on the conditions under which processing of data for monitoring, in accordance with the conditions of supaveghere by man of the system, etc.

Thus, a sudden failure can occur in seconds, but also in hours; a failure mode in minutes but also in months.

Table 1 - *Possible failures in operation of the machinery and equipment*

Gradual Failures	Sudden Failures
Wear - changing wear leveling - changing alignment bearings wear - an increase in play in the bearings and bushings; operation with vibrations; - gears, operation and vibration; - for Leaks in seals fixed; - consequences opening seals by contact (pistons...) cracks with slow rate of change in the elements in rotation.	The rubbing parts; axial bearing failure; lack of lubricant in the camps; interruption of the circulation of cooling; failure of the turbine or vane compressor; dynamic instability; foreign objects; escaping fluid in fixed seals.

In addition to the other criteria for classification, depending on the position in the course of time in relation to durability machine, monitoring may be placed:

- during the process technology, after installing, in connection with the accuracy of execution of the components, with the accuracy of fitting; monitoring may be "warm" - under operating conditions - or "cold" - driven from the outside;

- during the initial break-in - to the operating conditions in empty or under load, in connection with the verification process parameters is reached, with the accuracy of execution or the workbench, for the detection of project or faults with the improvement;

- new machinery at the start or repaired, on the place of final placement; diversity sites, of the conditions concrete makes That such monitoring to the

highest claims in respect of staff training or equipment used; on the other hand in addition to fault finding as soon as possible of any damage or malfunction, monitoring allows you to check the starting design, leveling, transitional demands, as well as the start of the program routine monitoring apart by general data; in addition, the methodology to start presents a particularly important, watching for example, in steps (to 30' to 60 '), increase in speed, in accordance with the recommendations by the firm etc;

- during operation; during this period, monitoring includes all, or the most important variables of the process, the temperature in the camps or in the circuits of lubrication and cooling, vibration, and relative position of the elements of machine with the indication that, except the process parameters, the most developed methods of analysis and interpretation refers to vibration..

3. Sources of vibrations and noise to gears

Usually, gears are the most important sources of noise and vibrations in the structure mechanical machinery and equipment, having a significant weight in determining the level of overall noise and vibration.

Significantly increase the power and control to modern machines, at the same time as the cutting jig, may cause a deterioration of behavior of the driveshafts vibroacustice by gears, especially when in the design phase, execution and fitting have not been pursued criteria to optimize from this point of view.

For the adoption of appropriate measures to combat the vibration and noise of the drives by gears must be that the analysis acoustic behavior to be made at the same time with the analysis behavior to vibration.

Priority path to combat in vibration and noise a constitutive application of the protective measures active, as in the case of a low dynamic response, increase the durability of the constituents (reduces wear items located in relative motion and fatigue of materials or destruction to dynamic overloading) and at the same time increases effectiveness of passive protection.

Table 2 - *The construction parameters influence on the level of noise*

Parameter analyzed	ANALYZED values range	Increase value of the parameter influence on the level of noise
Tooth Tilt	$0^o \div 40^o$	↓20 dB
The stiffness of material	÷	↑12 dB
Tooth flank	(0 ÷ 0,02) mm	↓6 dB
Degree of coverage	1 ÷ 2,2	↓3 dB
The module	(1 ÷ 12) mm	↑2 dB

Number of teeth	z ÷ 2z	↑3 dB
Specific movement profile	0,092 ÷ 0,883	↓1 dB
Tooth width	-	↓ Reduced Effects
Tooth Bomb	-	↓ Large errors in the direction of the tooth
The rigidity and the chassis earth	-	

In table 2 are sintetizati constructivi parameters of gears and housing which have an effect on the level of noise and vibration. With regard to the selection geometric elemntelor difficulties is to accommodate a simultaneous resistance requirements and those vibroacusti

4. Bearing Diagnostics

For bearings, it can be considered separately, the level of vibration and noise is one of global indicators of quality, reflecting specific technologies efficiency finishing and fitting. On the other hand, the level of noise vibratiisi bearing fit in a machine or implement influence to a significant degree, along with other high-performance product competitiveness in numerous applications (domestic appliances, office and information technology equipment with high precision kinematic).

In operation, the level of noise and vibration of bearings fit correlates with their status of a failure, indicating the presence, possibly increasing faults and allowing operation of such a nature as to avoid costly accidents.

In fig. 1. a is represented possible failure rates of the bearings, and in fig. 1. b and 1. c are examples of faults.

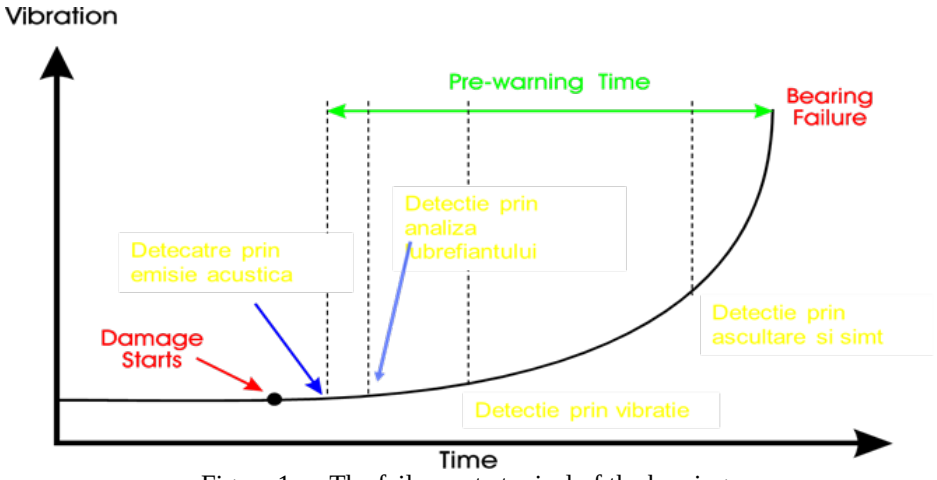
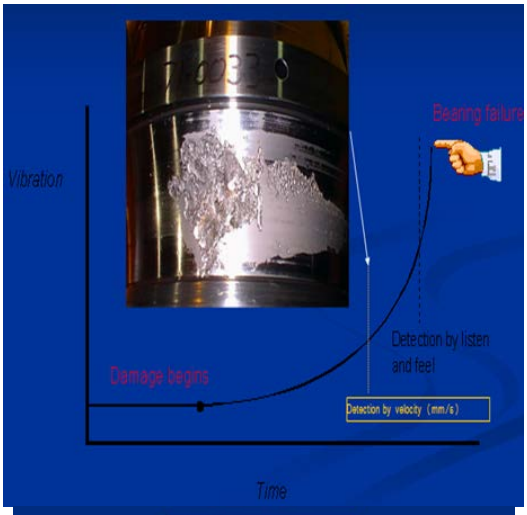


Figure 1.a.. The failure rate typical of the bearings.



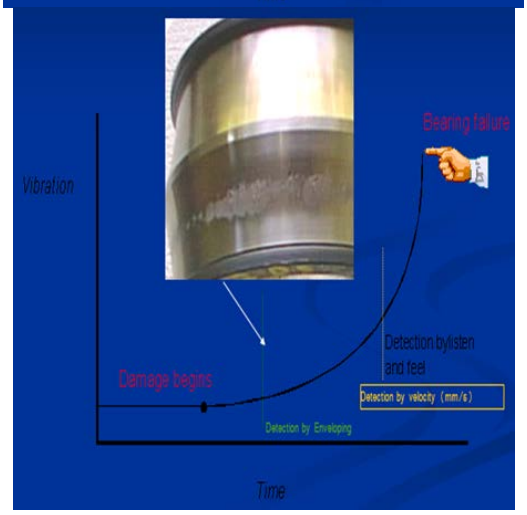


Figure 1.b. Faults due to vibrations Figure 1.c.

Vibration and noise produced by bearings acting either through direct effects, acoustic radiation or vibration, or by indirect effects. Direct effects (fig 1. , (a) it is found in indistinguishable under conditions of technological research or testing, on the stands. Fit bearings are used in the machines or implements, in a whole; in these conditions, it is found that both direct effects, and, to a greater extent, indirect effects (fig. 1. ,b), on the other components (trees, cases, etc.)or kinematic couplings, excited by the vibration bearings, on the waveform source receiver.

In the category of vibration, bearings, has recently introduced and non-uniformity of rotation of the bearings, parameter that is of interest particularly in the equipment operational accuracy, for low speed or very low.

In the bearings, generate vibrations and noise is caused by the following:

- Change the position of the driving bodies in the area charged, unload respectively of bearing, in connection with the dimensions and the number of the driving bodies, altered according the spring contact and working clearance;at the same time, changing the position of contacts, determine the modification of regular contacts and rigidity system, with favoring the occurrence of vibration type parametric;

Uneven movement of the rolling bodies, as a result of different requests depending on the position; this movement lead to uneven wear and dings of bodies when driving with O-rings or the cage;

- Achieving your contacts with rolling on surfaces with dimensional tolerances of form and position: differences in diameters, warpage or eccentricity of the taxiways, eccentricity, hairless, poligonalitate, waves, roughness; moving

the bodies when driving over impurities placed on the contact surfaces or over faults or damage located (pinched type Peeling or pitting, wear abrasive, fingerprints, etc.);

5. Vibration measurements in main bearings of the pump unit UP 5T

Apparatus used for Vibration measurements on the pump unit UP 5T 1500 - 1000C is called VIBROTEST 60, Brüel & Kjaer, Schenck (fig.3.1.1) is specially designed for the purposes of the measurements of vibration, spectra, the process value and variable data over time, is designed to last level technology solutions and have a high operating safety.

Brings you a modular concept, a number of ways, namely:

• analysis vibration

• instrument in the field leveling manifold rotors

• data to authenticate VIBROTEST 60 represents a measuring instrument designed to evaluate technical status and operation of the plant, the diagnostics with accuracy of damage and themal functioning

Modular concept the VIBROTEST 60 allows individualized combinations of measuring function and thereby diversify their number of applications.

Functional modules of the tool may be extended indefinitely, so that subsequent developments in respect of types of measurements can be easily carried out.

Advantages VIBROTEST 60:

- the analysis in frequency with Fast Fourier Transform (FFT), initial equilibration of rotors, the collection of data with a single tool easy to handle.

Figure 2. Vibration analysis at the pump unit technical pilot using VIBROTEST 60

Two meter channels and a channel for the rotation speed.
The latest technology in the collection of data with:
High speed measurement and simultaneous processing of up to 5 different types of measurements;

$$x(t) = \sum_{n=0}^{\infty} An \cdot \sin(\omega_n \cdot t + \theta_n) \quad (1)$$

We can measure all implements dynamic range: electric motors; fans, suction units ; pumps, bellows ; reduction gears, multipliers, gearboxes; die, rafinoare ; compressors, turbines; drum, cylinders of drying; press, to guide me." laminating; sortizoare ;mulcher ; site vibrators; agitators, mixers, mixers ; rotating filters; conveioare, blankets to the rollers, auger assemblies; saws cutter ghilotine; and support studs electrobrose of machine tools; crushers ; couplings

Rules relating to the measurement correct with VBROTEST :
- always on the bearings;
- shall be measured on the three directions (H, V, A), fig. 3;
- With the sensor firmly attached from the bearing;

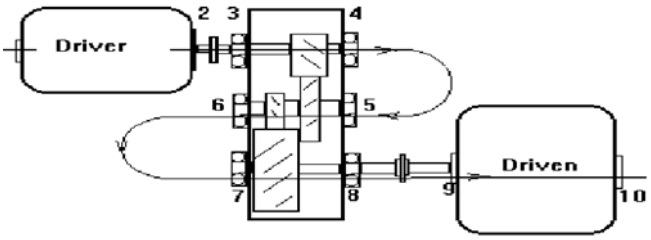


Figure 3. Using the same numbering system on the bearings on all machines measured

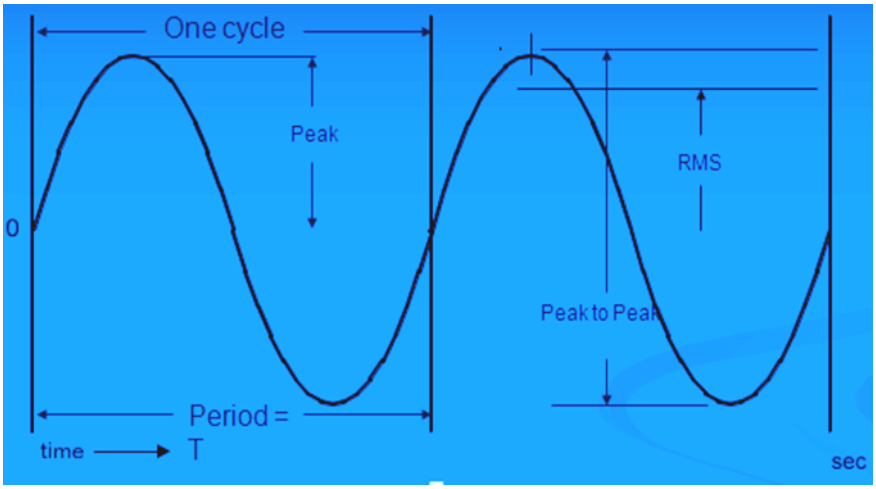


Figure 4. RMS – Root Mean Square (RMS) a) The vibration RMS wave definition

The following tables list the vibration values recorded in various positions near gear bearings (L), center bearing (LC), and driven electrical engine (M).

Table 3.1 - *Vibrations from the UP main bearings , fig.5 a*

	Input Speed rpm	Vibrations - V RMS(m/s)	Vibrations – H RMS(m/s)
L1	490	0,121	0,074
L2	490	0,185	0,105

L3	490	0,145	-
L4	490	0,162	-
L5	490	0,117	0,125
L6	490	0,128	0,124
LC	490	0,107	0,135
M	490	1,109	1,080

Table 3.2 - *Vibration when braking of main bearings of UP fig 5 b.*

	Input Speed rpm	Vibrations - V RMS (m/s)
L1	110	0,035
L2	127	0,031
L3	204	0,033
L4	137	0,110
L5	148	0,106
L6	182	0,080

a) LEFT view L5 b) RIGHT VIEW l.6

Figure 5. Layout of location of the vibration sensors L5 and L6 on the bearings respectively speeed on the bearings

6. Conclusions

Can be drawn by comparing the values of vibration measured Table. 3.1 and Table 3.2 with the values accepted in accordance with Table 4, we can see the vibrations are within the limits allowed. At the time when it is found that the vibration has been reached in the field "still allowable" is warned of maintenance team should be ready for operation at any time.When the vibration has exceeded maximum permissible value is required stopping the machine, its removal to determine the reasons for any vibration and then, repair of faults.

Preventive maintenance involves periodic measurements of vibration and noise on the bearings and When comparing measured values with those prescribed by the manufacturer machine or with the standards in force.

Table 4 - *Alarm fields*

Enveloping Severity	Shaft Diameter and Speed		
gE Peak-to-Peak	Diameter Between 200mm and 500mm and Speed < 500 RPM	Diameter Between 50mm and 300mm and Speed Between 500 RPM and 1800 RPM	Diameter Between 20mm and 150mm and Speed Between 1800 RPM and 3600 RPM
0.10	Good	Good	Good
0.50			
0.75	Satisfactory		
1		Satisfactory	
2	Unsatisfactory (Alert)		Satisfactory
4	Unacceptable (Danger)	Unsatisfactory (Alert)	Unsatisfactory (Alert)
10		Unacceptable (Danger)	Unacceptable (Danger)

Predictive Maintenance by vibrations analisys represents a qualitative leap upper in a modern system of maintenance, regardless of industry or of the specific nature of the production, since it provides all the information necessary for the purpose of detection of the time of the appearance of faults;

In addition to these aspects of vibration monitoring and lead us to the following advantages:Reduces costs related to the shut-off time of the plant and increase profits through an increase in production times;reduce or eliminate costly technical incidents or serious damage; reduce maintenance costs, reduce or eliminate the cost of unplanned maintenance, repairs can be carried out with minimal loss for production; reduce excessive consumption of electricity;

Reduce demand for equipment and the costs related to the phase of "standby" reduce the capital investment, machinery may be used for much longer;

reduce the risk of unsuccessful repair and eliminate extra time and costs incurred in restoring its appearance and reboot and conditions necessary for safe operation; increase safety at work;

If the formation fluid has a high content of sand, it is necessary to prevent the operation of the pump on the depth of the top of the velocity field. For highly abrasive fluids will consult manufacturers for such equipment.Do not start the machine again without fluid in the pump probe. Usually it is good to follow for such pumps a minimum of approximately optimal submergence.

A dominant feature of gear unit pumps that should never be skipped when using this extraction system, is the compatibility of the materials used in the construction of wells pump circulating fluids. Work are presented in a series of

articles comprising the pump gear unit and indicate the type of application they can be used.

R E F E R E N C E S

[1] *S. Andreason*, "Load distribution in a taper roller bearing arrangement considering misalignment, " Tribology, 6 (3) (1973), pp. 84–92

[2] *Lebold, M.; McClintic, K.; Campbell, R.; Byington, C.; Maynard, K.*, "Review of Vibration Analysis , Methods for Gearbox Diagnostics and Prognostics, Proceedings of the 54th Meeting of the Society for, Machinery Failure Prevention Technology, " Virginia Beach, VA, May 1-4, 2000

[3] *Stan, M* "Metode avansate de proiectare a utilajului petrolier," Editura Universitatii Petrol Gaze din Ploiesti, 2006

[4] *Stan, M* "Fiabilitatea si diagnoza utilajului petrolier de schela," Editura Universitatii Petrol Gaze din Ploiesti, 2016

[5] *N.W. Sachs* "Understanding the surface features of fatigue fractures: how they describe the failure cause and the failure history Journal of Failure Analysis and Prevention," 5 (2) (2005),

[6] Volume 11: failure analysis and prevention; metals handbook ® ninth edition, ASM Metals Park, Ohio, United States of America (1986),

[7] ******* Environmental Protection for Onshore Oil and Gas Production Operations and Leases**, API RECOMMENDED PRACTICE 51R** FIRST EDITION, http://www.api.org/~/media/Files/Policy/Exploration/API_RP_51R.pdf**,** JULY 2009