Application of vibration diagnostics methods and programs to assess the remaining lifetime of oil equipment

L Z Zainagalina

Ufa State Petroleum Technological University, Branch of the University in the City of Oktyabrsky, 54a, Devonskaya St., Oktyabrsky, Republic of Bashkortostan, 452607, Russian Federation

E-mail: zlz11@mail.ru

Abstract. The article deals with the method of evaluating oil equipment remaining lifetime by vibration diagnostics. The advantages of machine maintenance according to its technical condition, compared with planned-preventive repairs, are given. The technical conditions of the wellhead stuffing box of a beam pumping unit and a centrifugal pump machine were studied by Corsair vibration analyzer and Aurora software product, providing the evaluation of the current machine condition for planning a repair period. While analyzing the results of the equipment vibration diagnostics, the conclusions on faults were made and the dates of predictive maintenance were determined: the date for the next measurement (condition control) and the date for repair. The vibration diagnostics significance was confirmed in experiments as the most universal parameter which provides accurate information on equipment condition, making it possible to evaluate equipment technical condition in operation and predict its reliability.

1. Introduction

So far, the oil industry in Russia has been a predominant and fast growing industry [1–4]. Oilfield equipment experiences heavy workloads under changes in temperature and pressure, being exposed to toxic chemicals and explosive materials, as well as significant wear due to corrosion and mechanical impurities. Shutdown and failure in oilfield equipment lead to accidents, with negative consequences for staff and ecology. Moreover, it requires substantial material resources in eliminating equipment failure and damages [2].

The evaluation of equipment remaining lifetime is important as in the machine industry, as well in the oil industry. Vibration diagnostics provides data on the technical condition of a machine without disassembling it [4, 5].

Vibration diagnostics can be described as activities aimed at evaluating the remaining lifetime of equipment and avoiding faults which can cause the machine shutdown and damage in the operating conditions [6].

2. Materials and methods

To diagnose vibration of a centrifugal pump machine and the wellhead stuffing box of a beam pumping unit, “Corsair +” vibration analyzer has been used.

Vibration sensors, which detect oscillation, are attached to the diagnosed equipment. A piezoeaccelerometer, connected by a cable to the vibration analyzer, registers signals in vibration displacement, velocity (in the range from 10 to 1000 Hz) and vibration acceleration [7]. The accelerometer
measures the form of the vibration signal and analyzes its spectrum. It makes possible to monitor the condition of the machine in operation and detect emerging or developing faults, such as, unbalance or misalignment, which occurs mostly in rotating equipment [3, 8].

Aurora System aims to determine the mean value of the technical condition of rotating equipment, detecting emerging and developing faults, as well as to evaluate the machine utilization for further operation without repairs, i.e. to predict intervals between repairs.

3. Results and Discussion
The method of vibration diagnostics enables us to assess the technical condition of the wellhead stuffing box of a beam pumping unit which has become damaged due to the excess wear by friction against the polished rod carrier. The technical condition of the wellhead stuffing box before maintenance is shown in Fig. 1 and 2.

Fig. 3 and 4 demonstrate the signal of frequencies (vibration displacement), the period is 0.4 sec and the spectral components in the range from 0 to 1000 Hz (after maintaining the wellhead stuffing box).

![Figure 1](image1.png)

**Figure 1.** Vibration signal (vibration displacement, in mkm), period 0.4 sec (before maintaining the wellhead stuffing box).

![Figure 2](image2.png)

**Figure 2.** Spectrum components of frequencies in the range from 0 to 1000 Hz (before maintaining the wellhead stuffing box).
Before the wellhead stuffing box was maintained, it showed higher frequencies and the spectral components of frequencies also demonstrated the high amplitude, indicating the surface wear of the wellhead stuffing box due to the friction between disruptively worn rubber and the polished cylindrical rod carrier surface of a beam pumping unit.

After the worn wellhead stuffing box replacement, the situation has changed (figures 3 and 4). The vibration values have become optimal. The given example demonstrates that vibration diagnostics makes it possible to examine the technical conditions of a machine with a high degree of accuracy and rapidly. The measurement of oscillation parameters of a centrifugal pump machine, driven by the rotating electric motor, has been made in the laboratory of vibration diagnostics of UGNTU branch, Oktyabrsky city.

The root means square value of oscillation is measured in four dimensions that are vertical, horizontal, cross and axial directions. According to the value of the corresponding directions, it is possible to conclude on a fault. The vibration analyzer data are imported into the Aurora Program. All the parameters are introduced into tables and the analysis of vibration data provide approximate equipment maintenance date: the date for the next measurement (condition control) and the date for the next repair.

A report on the technical condition of the pump machine below gives vibration diagnostics data, obtained by Aurora 2000 Program. Figure 5 shows the location points of vibration analyzers.
Figure 5. Vibration measurement points on a vertical pump machine.

The diagnostic assessment of the machine demonstrates that the overall vibration condition of the pump is good, the remaining service of the machine is 84%; the evaluated date for the next measurement is 28.06.2019; the evaluated date for the next repair is 11.12.2019.

4. Conclusion
Thus, vibration diagnostics makes it possible to detect hidden faults, without disassembling the machine, and determine emerging faults. Vibration analyzers are inexpensive portable autonomous devices [9, 10]. For this reason, vibration measurement takes less time and less costly. This method provides high economic efficiency as the use of vibration diagnostics allows to increase the efficiency of enterprise repair services and reduce the number of repairs by 2-5 times.

References
[1] Mukhametshin V Sh, Kotenev Yu A and Sultanov Sh Kh 2018 Assessment of the need to stimulate the development of hard-to-recover reserves in carbonate reservoirs IOP C. Ser.: Earth Env. 194(8) 082027
[2] Chudinova D Yu, Kotenev Yu A, Sultanov Sh Kh and Mukhametshin V Sh 2018 The neural network for grouping wells of different facies zones of productive layer IOP C. Ser.: Earth Env. 194(8) 082008
[3] Mukhametshin V V 2018 Bottomhole formation zone treatment process modelling with the use geological and geophysical information IOP C. Ser.: Earth Env. 194(2) 022024
[4] Batalov D A, Mukhametshin V V, Dubinskiy G S and Andreev V E 2018 Laboratory grounding of waterproofing sealant based on acrylic polymers IOP C. Ser.: Earth Env. 194(4) 042003
[5] Zainagalina L Z, Suleimanov R I, Gabdrakhimov M S and Khabibullin M Ya 2018 Determining oscillating system dynamic parameters of a near-bit junk pulper Advances in Engineering Research (AER) (Int. conf. "Actual issues of mechanical engineering" (AIME 2018)) 157. 642–45
[6] Yagafarova Kh N, Arslanov I G and Teregulov R A 2018 Performance analysis of surface reducing gear of rod driven screw pump with involute gearing and Novikov gearing Advances in Engineering Research (AER) (Int. conf. "Actual issues of mechanical engineering" (AIME 2018)) 157 627–30
[7] Goryunova M V, Kuleshova L S and Khakimova A I 2017 Application of signal analysis for diagnostics Int. Conf. on Industrial Engineering, Applications and Manufacturing (ICIEAM) (Saint Petersburg: IEEE) pp 1-5
[8] Muhammed A and Childs D W 2016 Vibration modeling and experimental results of two-phase twin-screw pump J. Eng. Gas Turb. Power 38(9) 092601
[9] Macary S, Mohamed I, Rashad R, El-Noby M, Latif M A, Awni I and Khalek M A 2003 Downhole Permanent Monitoring Tackles Problematic Electrical Submersible Pumping Wells SPE Annual Technical Conf. and Exhibition pp 817–24
[10] Kozikhin R A, Daminov A M, Fattakhov I G, Kuleshova L S and Gabbasov A Kh 2018 Identifying the efficiency factors on the basis of evaluation of acidizing of carbonate reservoirs IOP C. Ser.: Earth Env. 194(6) 062013