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Sensitivity of Bearings to Vibration: Its Effect on Ultrasonic Waves, Its Effect on Bearing Life

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Abstract

High vibrations caused by various factors in the bearing of a car is a common problem in the automotive industry. Nowadays, the issue of reducing excess vibrations that cause bearing failure in industry has been considered by engineers and industry owners. By examining these vibrations and controlling the vibrations in the cars, it will increase the bearing life and reduce the number of out-of-program stops. The experiments were performed using experiments and technologies such as ultrasound, each of which, depending on its inherent characteristics, will have a variety of effects on all components tested. In this paper, by performing various calculations and tests on bearings used in automobiles and investigations such as the effects of vibrations on bearings, the effect of oil viscosity on bearings vibrations, the effect of ultrasonic waves on bearings. And then, using a relative graph, discuss their effects on the bearings. Calculations and tests performed on the bearing were performed by applying the effect of weight and without the effect of weight, the amount of vibration and oscillation was obtained according to the diagram. Then, the effect of increasing the oil temperature for vibrations was presented by a diagram, according to which we can find an increase or decrease in vibrations in the bearing. With the help of these tests, it saves a lot of costs in repairing and maintaining machines, and increases the reliability of machines, and the use of this test reduces noise pollution and increases the quality of bearings in the industry.

Keywords: Bearings, vibrations, ultrasound, oil viscosity effect, relative graph, bear life extension

INTRODUCTION

Vibration is one of the key parameters in determining the health of rotary or linear machines; Which has been used in recent years as a powerful tool in diagnosing defects. Vibration measurement in industry is a specialized field and is used as the main method (cm) [1, 2]. There are many reasons for vibration in an industrial device or system. So that each rotating or linear part or mechanism has a vibration rate; By investigating this issue and timely detection of this phenomenon in the system, we can prevent component failure and even device failure. One of the methods to diagnose the defect of these parts is through vibration analysis. The Experimental Modes Analysis (EMD) method is a new method for processing nonlinear and non-static signals, which was developed by Huang in 1998 [3]. Also, in 2014, Ben Ali et al. In a practical article, examined the method of

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experimental analysis of fashion and artificial neural shape in bearing fault diagnosis based on vibration signals. In this paper, according to the experimental mode of mode analysis, the desired signal is decomposed into 12 intrinsic and remaining mode functions. Ten properties in the time domain are extracted from the selected functions [4]. Ultrasound is not unaffected by the subject of this paper, as researchers have concluded that the effect of ultrasound on vibrations is to reduce yield stress, reduce internal friction, reduce ductility, and increase elongation in the tensile test; In 1966, Langenkers studied the effect of ultrasonic vibrations on the mechanical properties of metals such as aluminum and zinc, and concluded that ultrasonic vibrations significantly reduced the yield strength of metals. This reduction in yield stress was introduced directly by ultrasonic energy [5]. Adverse effects of vibration on machinery can reduce the life of the part, create noise, and reduce occupant comfort. Bearings are one of the vital components that change against vibrations. Proper design of bearings and the correct use of materials in the manufacture of bearings and the use of lubricant (oil or grease) by considering the correct viscosity to reduce friction and damping vibrations can prevent damage to this part; on the effect of oil viscosity change on the vibrations. Harigaya et al. obtained the cylinder bush according to the amount of temperature and cutting rate in oil [6–8]. In this paper, first vibrations were investigated by ultrasonic and then the effect of vibration with weight and without weight was investigated. Then the vibration frequency at each engine speed was calculated. We examined the graphs and clearly showed their effect in the obtained figures. Then, the effect of oil viscosity on vibrations was studied and its results were presented in a relative graph. The effect of ultrasonic waves on the bearing was investigated, which was important for the industry, and then the effect of ultrasonic vibrations on the bearing was categorized. These tests were performed with high reproducibility.

Effects of Vibrations on Bearings and Components

The industry tries to install and maintain parts with proper principles to prevent the transmission of shock and vibration. Vibrations on parts such as bearings cause the following:

- Short life of bearings and components involved in vibration
- Frequent failure of gaskets
- Disintegration of ball bearings and roller bearings
- Lubrication due to protrusion of the bowl
- Fracture of the warping axis (unbalance), defect of the part (bearing).

One of the influential factors on vibrations is the effect of weight. To obtain the results of the effect of weight on vibration must be compared in two ways. Case 1: The system must be considered by applying the weight effect. In the second case: the system should be considered without applying the weight effect. In the first case, the rotation speed ratio (engine speed) is selected as the control parameter. To ensure the test is performed at different speeds, the vibration frequency is proportional to the engine speed. Special tools such as time history, contractor and maximum Lyapanov view are also used to identify the dynamic behavior of the system. The vibration frequency must also be calculated at each engine speed.

$$f = \frac{n}{60000} \tag{1}$$

In formula (1) f is equal to the vibrational frequency, n is the motor speed, to obtain the vibrational frequency. The motor speed must be divided by 60,000 to obtain the vibrational frequency in kHz.

$$f = \frac{1000}{60000} = 0.016\,kHz \tag{2}$$

$$f = \frac{2000}{60000} = 0.33\,kHz \tag{3}$$

Equation (1) is for calculating the vibration frequency. In this formula, we considered the motor speed to be 1000 and 2000, and according to it, the vibration frequency was examined by the diagram. The graph shows that at 1000 rpm we will reach the frequency value of 0.016, and this value will reach 0.33 at the 2000 rpm which results in the calculations being done correctly. As you can see in Figure 1, the vibrational frequency also increases with increasing motor speed.

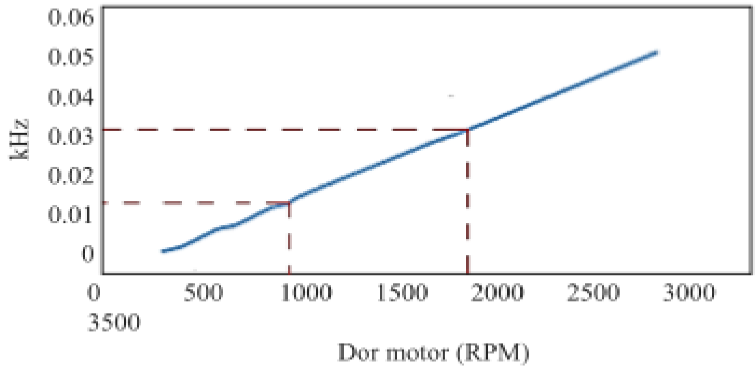

Figure 1. Graph of weight application.

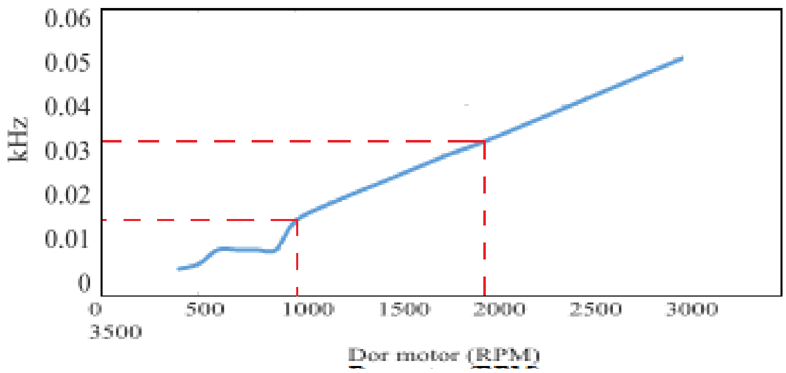

Figure 2. Graph without applying weight effect.

As you can see in Figure 1, with the calculations and tests performed on the bearing, we concluded that by applying the weight effect, the vibration rate is somewhat ineffective and has a slight oscillation, and the vibration turbulence is delayed, but within a longer range. The engine rises and suddenly increases. In the second case, in the diagram of Figure 2, it increases without applying the weight effect to the engine speed system; And the vibrational frequency also increases. In the low-speed mode, it has a constant or so-called periodic state; But as the engine speed increases, it goes out of periodic mode and the trend increases.

THE EFFECT OF OIL VISCOSITY ON VIBRATIONS

Numerous factors cause the engine to vibrate, including engine combustion, the movement of moving engine components such as reciprocating masses, crankshaft imbalance, mechanical looseness, as well as the type of oil and its temperature. To detect vibrations and vibrations in the motor, it is necessary to consider the operation of the motor, which all components of the motor can have a specific vibration and vibration. First, we examine the operating mechanism of the engine and then the forces that are applied to the engine through the components. We obtain the effect of oil viscosity on the motor vibration and the motor itself in the vertical direction. First, the motor vibrations are measured by compensatory motion and then by reverse motion. Then, by disconnecting the piston and connecting rod from the crankshaft, the engine vibrations from the crankshaft period only are obtained. Therefore, by the difference between these two measurements, the amount of vibration due to the movement of reciprocating masses and the effect of oil viscosity can be determined [1]. It should be noted that the results of the engine vibration are in the vertical direction and to regulate the engine oil temperature, the oil temperature and pressure regulator should be used. The test for SAE 20 W 50 oil at 35 and 90°C at different engine speeds is presented. As shown in Figure 3, the motor vibration does not decrease in the vertical direction with increasing oil temperature. Rather, it can be said that one of the reasons for increasing the vibration of the engine due to the increase in temperature can be that with the dilution of the oil, the force behind the rims increases and increases the vibration [9–11].

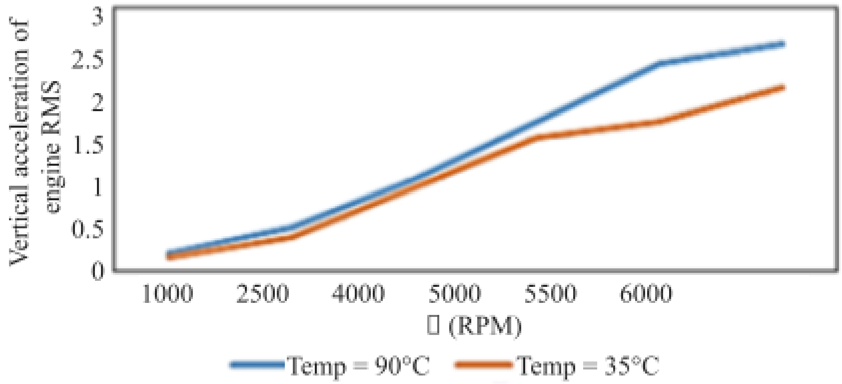

Figure 3. R.M.S. diagram of engine vibrational acceleration at different speeds.

THE EFFECT OF ULTRASONIC WAVES ON THE BEARING

Ultrasound is produced by friction, impact, turbulence, and electrical discharge. Friction and impact are by-products of mechanical equipment. For example, a roller bearing will produce friction when the shafts and balls rotate around an axis. But if there is a lot of friction, problems occur due to imbalance in the equipment or the bearing may stop, thus the equipment will fail. When the bearing begins to erode, the ultrasonic waves will produce many spikes in the signal due to flat spots or scratches on the wall (bearing frame). Spikes are heard through the headset, like the sound of an explosion or explosion. When ultrasound is generated by the bearing, it begins to show these features, and bearing displacement can be planned during normal production failure. Discovering erosion is instantaneous. It is not necessary to consider the bearings from several points of contact along the different axes and send them for analysis. Phenomena such as ultrasound have different effects on all or some materials, both metallic and non-metallic, depending on their inherent properties. Ultrasonic waves generate local heat in heterogeneous and discontinuous positions, and therefore in places where the dislocations are normally locked, due to the local heat, it is possible for the dislocations to move and penetrate from one crystal to another and from grain to grain. The merging of bipolar dislocations reduces the amount of dislocations. The effect of ultrasonic vibrations on materials, such as increasing temperature, reduces the strength and shortens the life of the metal [12]. Also, by applying ultrasonic vibrations, the stress is immediately reduced, while the increase in sample temperature occurs with a time delay. Components such as bearings are no exception, as bearings also change state against ultrasound and temperature depending on their sex and molecular structure [10]. The use of ultrasound technology to monitor the situation should not be complicated. High-frequency ultrasound components are ultra-shortwave in nature. A shortwave signal should be relatively directional. Therefore, it is relatively easy to discover its exact position by separating these signals from the noise of operational equipment and context. In addition, when changes begin in mechanical equipment, the directional nature of the ultrasound allows these potential warning signals to be detected before the actual fault, often before they are detected by vibration or ultraviolet light [12]. In this test, the effect of ultrasound on the bearing defects was found that we were able to observe these defects with the A scanning device, but the effect of ultrasonic vibration on the results was done, some of which are mentioned below. In general, the most important observations in the tests related to the effect of ultrasonic vibrations on the bearing can be categorized as follows. These tests are performed with high reproducibility.

- Decreased bearing yield strength of bearings when ultrasonic vibrations are applied to it.
- When vibrations enter the bearings, a lot of residual stresses will remain on the bearings.
- Vibrations are observed at very high pressures, both at high powers and at high powers, and cracks and cracks are observed in the bearing surface.
- Increasing the bearing temperature at high ultrasonic powers leads to grain fall and reduced friction between the bearing surfaces and the thickness of the oil layer during deformation.
- Local heat generation by absorbing ultrasonic energy in defects such as cracking and porosity and wear of bearings [12].
- Ultrasonic energy will facilitate the movement of misalignments.

CONCLUSION

By assessing the causes of vibration and the effect of vibration on bearings and helping to eliminate these factors, it is possible to reduce the life of the bearing as well as financial and human losses. Practical and flawless bearing design that can be used as an example of this material design and the weight of the bearing and its components are designed and then made so that with increasing engine speed (1000 and 2000 rpm) we will see that less weight will be applied and can prevent the vibration frequency from rising and using the desired material for the bearing so that the bearing material resists inhomogeneous vibrations; And neutralize the blows to some extent. Using the right oil with the desired viscosity can prevent vibration and damping of impacts to the bearing, and can also prevent insulation or coating to protect the bearing from ultrasonic waves that increase the bearing temperature and reduce the strength of the part.

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