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Bearing Shaft Misalignment Estimation using Acoustic Signal Processing

P. Gopal[1], T. Senthilkumar[2], N. Raja Sekar[2,*], Pon. Azhagiri[1]

[1]Department of Automobile Engineering, University College of Engineering, BIT Campus, Tiruchirappalli, India
[2]Department of Mechanical Engineering, University College of Engineering, BIT Campus, Tiruchirappalli, India

*Corresponding author email: sekarnakkeeran@hotmail.com

ABSTRACT

The main aim is to estimate the misalignment in bearing shaft by signal processing of acoustic signal. There are many signal processing technique such as Fast Fourier Transformation (FFT) function, Discrete wavelet transform, Morlet wavelets, and Wavelet transform among them Fast Fourier Transformation (FFT) function is used for analysis purpose. Acoustic Emission (AE) is being extensively used as a Non Destructive Technique (NDT) for diagnosis of rotating components or bearing systems. Design and fabrication has been done for experimental set up to generate the acoustic signals. Three different shafts are used such as Aluminium 6061, Mild Steel, and Stainless Steel 304 for analysis purpose. Fast Fourier Transformation (FFT) function is used to represent the Acoustic signal at different levels of misalignment by using MATLAB software. By calculating the energy values and angle of contact for corresponding acoustic signals and compare the results among different shafts.

Keywords-.

1. INTRODUCTION

Vibration analysis is widely used in diagnostics of faults in machinery. There are many analytical techniques such as Resonance demodulation, Instantaneous power spectrum distribution and Conditional moment’s analysis etc. which have been developed for processing vibration signals to obtain useful diagnostic information about processing gear faults. Number of signal processing techniques like by using Discrete wavelet transform, Morlet wavelets, and Wavelet transform etc. have been developed to diagnose the faults in bearing and removal of noise from the signal in other industrial and research applications. Fast Fourier Transformation (FFT) function is widely used in diagnostics of faults in machinery which is one of the signal processing technique. It is very simple and easily understandable.

2. MISALIGNMENT

Angular misalignment between the shaft and housing occurs when the shaft defects (bends) under the operating load. Misalignment can also occur when the bearings are too far apart. Rigid bearing and cylindrical roller bearing can accommodate only a few minutes of angular misalignment without damaging the bearing. Self – aligning bearing, spherical roller bearing, toroidal roller bearing and spherical roller thrust bearing. Can accommodate shaft defection as well as initial misalignment resulting from machining is mounting error.

3. SIGNAL PROCESSING TOOLBOX

Signal processing toolbox provides functions and apps to generate, measure, transform, filter and visualize signals. The toolbox includes algorithms for resampling, smoothing and synchronizing signals, designing and analysing filters, estimating power spectra, and measuring peaks, bandwidth, and distortion. The toolbox also includes parametric and linear predictive modelling algorithms.

4. STAINLESS STEEL 304

Stainless steel has less hardness than mild steel and more hardness when compared to aluminium 6061. It can withstand the loads next to mild steel and more when compared to aluminium. In this material, corrosion occurs slowly when compared to mid steel and slightly rapid than the aluminium. This material may also use in the place of corrosion occurs. While using of this material, vibration is more compared to mild steel and less compared to aluminium

6061.Misalignment of the material increases when vibration increases. By using of this material, vibration is more compared to mild steel and less compared to aluminium 6061. In this material occurring of misalignment is more.

5. METHODOLOGY

Experiment setup is designed and the fabrication is made. Aluminium, Stainless steel Mild steel are used as shafts. Different weights are added and the acoustics signals are recorded from the recorder. The following graph is plotted using MATLAB software and the energy value and the angle of contact is calculated. Estimate the misalignment in the bearing shaft.

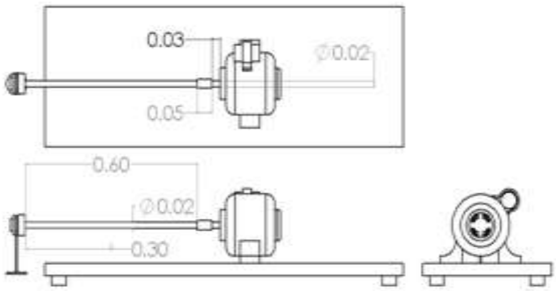

Fig 1 2D diagram of experimental setup

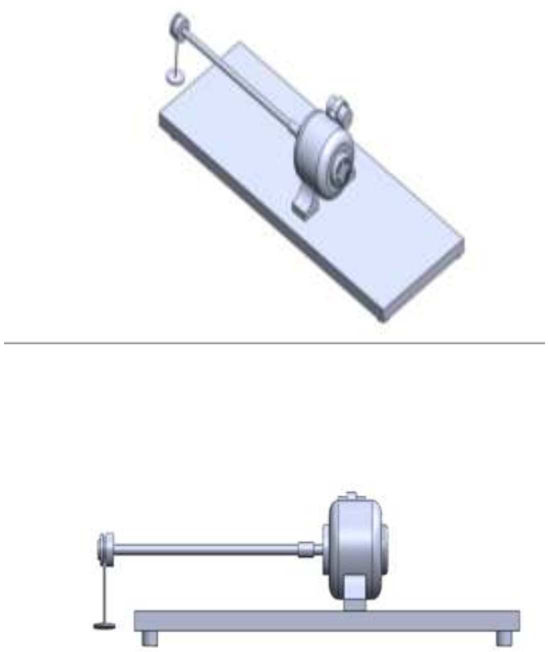

Fig. 2 3D diagram of experimental setup (front view)

6. RESULTS

6.1 Raw Signal for Stainless Steel 304 Shaft

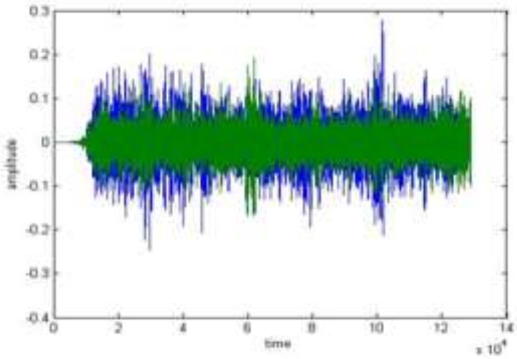

Fig. 3 Raw signal of without misalignment at 1460 rpm

6.2 FFT of Stainless Steel 304 Shaft with Misalignment of its Own Weight with Pulley

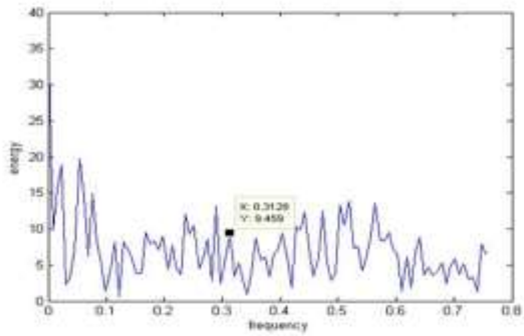

Fig. 4 FFT of the signal with misalignment at 1460 rpm

6.3 FFT of Stainless Steel 304 Shaft with Misalignment with 1kg Additional Load at 1460 rpm

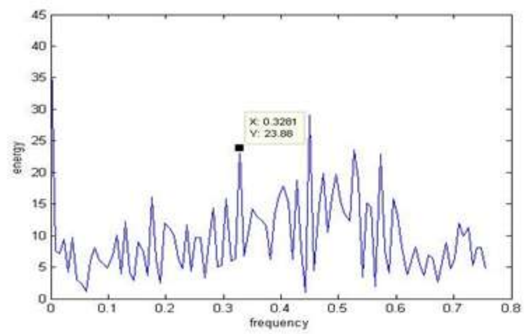

Fig. 5 FFT of the signal having misalignment because of its own weight and additional1Kg point load at 1460 rpm

6.4 FFT of Stainless Steel 304 Shaft with Misalignment with 2kg Additional Load at 1460 rpm

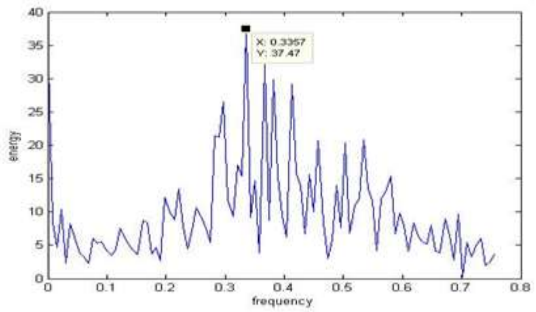

Fig. 6 FFT of the signal having misalignment because of its own weight and additional 2Kg point load at 1460 rpm

6.5 FFT of Stainless Steel 304 Shaft With Misalignment with 3kg Additional Load at 1460 rpm

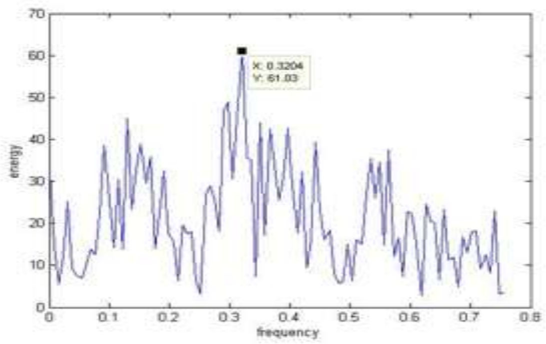

Fig. 7 FFT of the signal having misalignment because of its own weight and additional 1Kg point load at 1460 rpm

Table 1 Energy values for Stainless Steel 304 shaft

Sl.No.	Case	Respective height in mm	Angle of contact	Energy values
1	Without misalignment	155.00	0°	9.459
2	Misalignment by 1Kg additional load	154.26	0.005°	23.88
3	Misalignment by 2Kg additional load	153.10	0.0065°	37.47
4	Misalignment by 3Kg additional load	152.36	0.019°	61.03

The peaks are coming at the multiple of 24.3Hz which are the harmonics of fundamental frequency of rotation.

This can be calculated by

1460 / 60= 24.3 rotation per second (Hz)

We have marked the energy values corresponding to 4th consecutive peak on each FFT graph and their respective values are measured as 9.459, 23.88, 37.47, and 61.03 for the Case2, Case3,Case4 and Case5 respectively, which are described (Graph between Energy of 4th consecutive peak of rotational frequency vs Angle of contact). Angle is measured by using angle decker.

The trend shown by energy level (4th harmonic of 24.3Hz) frequency in FFT graph is the clear indication of misalignment, as misalignment increases energy level increases. So the 4th consecutive peak of rotational frequency must be observed very precisely to avoid the damages caused by the misalignment.

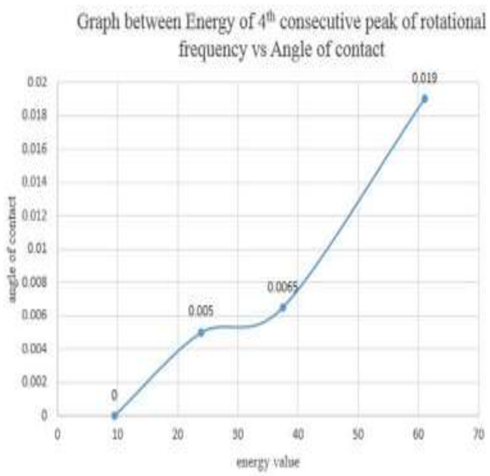

Fig. 8 FFT graph for Stainless Steel 304 shaft

7. CONCLUSION

The bearing shaft arrangement with motor is fabricated and acoustic signals by using recorder is recorded.The graphs by using FFT function in MATLAB software are drawn and the energy values and angle of contacts are calculated.The results among different shafts are compared.Finally, the misalignment in the bearing shaft is estimated among different shafts.

Among these different shafts,misalignment rapidly occurs in aluminium 6061(194.56 J) than stainless steel 304 (61.03 J) and mild steel (772 J). Mild steel is better than 0.96% aluminium and 0.85% stainless steel.So,it can make damage on material rapidly and neglect it.

Mild steel can withstand heavy load without misalignment when compared with aluminium 6061 and stainless steel 304. So,misalignment occurs slowly in mild steel shaft.

FFT graph is the clear indication of misalignment, as misalignment increases energy level increases.Preventing the damage from material by detection of misalignment.In an automated machines, FFT function of MATLAB is more applicable.

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