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Noise Analysis of An Industrial Fan Bearing- A Case Study

Vikas Sharma[a, *], Ankur Saxena[b], Naresh K. Raghuwanshi[c]
[a]*Department of Mechanical and AerospaceEngineering,Seoul National University, Seoul 08826, Korea Republic*
[b]*Department of Automobile Engineering,D. Y. PatilSchool of Engineering Academy,Pune, Maharashtra, India*
[c]*Department of Mechanical Engineering,Madhav Institute of Technology and Science, Gwalior,Madhya Pradesh, India*
**Corresponding Author: s.vikasiiti@gmail.com*

Abstract: Fan and blowers are one of the most common industrial appliances. The present manuscript presents a case study on the diagnosis of fault based on noise analysis of the industrial fan. A clicking noise was observed from the fan causing discomfort to the worker. Noise both of high amplitude and frequency is unacceptable, as it could lead to failure of component as well as can increase the human fatigue. The noise signals were recorded by an iNVH application devised by the Bosch Engineering Solutions. The noise signals were recorded and were further processed in Matlab to study the fault occurred in the fan. This paper presents a study on diagnosis of faulty component present in the fan causing severe noise. It was found that a fault was occurred the ball of the bearing located in stator-rotor assembly. Due to long hours of operation, a spallwas developed in the ball bearing.

Keywords: bearing, ball fault, fault diagnosis, industrial fan, noise analysis

1. INTRODUCTION

Noise from the fans are one of the major issues causing human discomfort. In a workshop floor of an industry, the noise level is usually high due to the operation of machines. Such noise caused by the machines is of low frequency and gets distributed. On the other hand the noises generated by the fan are always uncomfortable in nature and can generate human fatigue.High levels of clicking noise were observed causing fatigue to a worker. In a month three operatorsreported the issue of fatigue and the productivity of the machine was reduced.

This case study presents the diagnosis of fault in an industrial fan used at the shop floor. It was observed that the noise caused by the fan was responsible for reducing the efficiency of the workers. Such an observation was noticed by a workshop-in-charge of a manufacturing unit.The author was then appointed by the company to analyze the causes of such noise and to suggest the remedial measures to reduce the noise emission. Noise analysis of rotating machines for fault diagnosis is one of the most acceptable techniques used by researchers [[1]]. In this study, noise measurement were taken and analyzed for reducing the noise level and identifying fault such that corrective measures can be taken of.Figure 1, shows the location of fan and machine.

2. DETAILS OF FAN

The fan is a product of a renowned company of air circulators having power features of 100W, 230V and 50Hz. The fan makes an air delivery of 150cmm at a speed of 1440rpm. It operates at the noise level of 60dB-65dB with a 3 blade arrangement. The motor hangs inclined at the end of the vertical column with the help of wall mount arrangement. It uses a double shielding ball bearing at both the ends of the motor winding. The structure of ball bearing is presented in Figure 2 and the details of ball bearing used are listed in Table 1

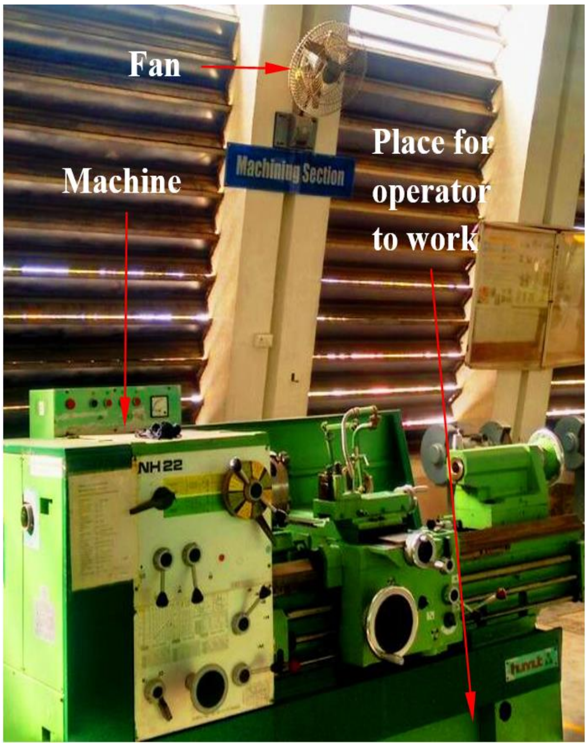

Figure 1. Location of a fan and machine

Table 1. Specification of bearings of fan

Parameter	Values
ID/OD (mm)	10/30
Width (mm)	09
Limiting speed (rpm)	2500
Fillet (mm)	0.6

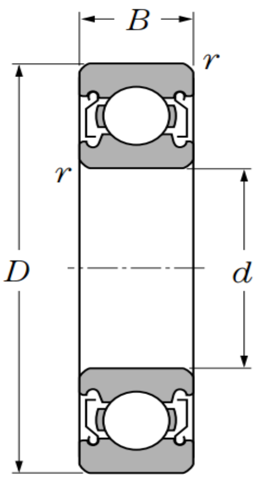

Figure 2. Cross sectional view of bearing

Figure 3illustrates typical modulation patterns for unidirectional (vertical) load on the bearing, at shaft speed for innerrace faults, and cage speed for rolling element faults. The formulae for the various frequencies shown in Figure 3are as follows[[2]]:

Ballpass frequency, outer race:

$$BPFO = \frac{nf_r}{2}\left\{1 - \frac{d}{D}\cos\emptyset\right\}$$

Ballpass frequency, inner race:

$$BPFO = \frac{nf_r}{2}\left\{1 + \frac{d}{D}\cos\emptyset\right\}$$

Fundamental train frequency (cage speed):

$$FTF = \frac{f_r}{2}\left\{1 - \frac{d}{D}\cos\emptyset\right\}$$

Ball (roller) spin frequency:

$$BSF\ (RSF) = \frac{D}{2d}\left\{1 - \left(\frac{d}{D}\cos\emptyset\right)^2\right\}$$

where $f_r$is the shaft speed, n is the number of rolling elements, and $\phi$is the angle of the load from the radial plane. Notethat the ballspin frequency (BSF) is the frequency with which the fault strikes the same race (inner or outer), so that ingeneral there are two shocks per basic period. Thus the even harmonics of BSF are often dominant, in particular in envelopespectra.

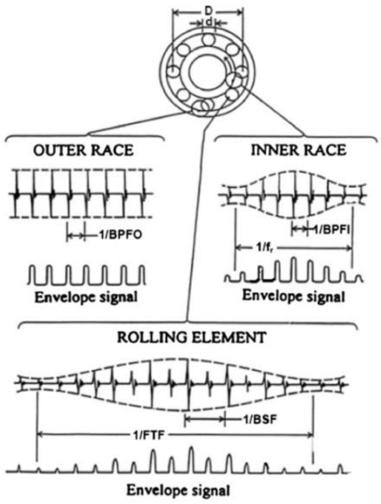

Figure 3. Typical signals and envelope signals from local faults in rolling element bearings [[2]].

3. METHODOLOGY

The objective is to analyse the effectiveness of the developed mobile application for examining noise and vibrationsfrom a component. A mobile application known as *iNVH* developed by ***Bosch*** has been used to acquire the noise signals of the fan. For acquisition purposes, the microphone of the smartphone becomes the sensor to aid the acquisition. These signals were processed in Matlab to identify the fault transients appearing and then verified by the results obtained by the mobile application iNVH.Total five data sets of noise signals were acquired by the author for this analysis.

4. DATA ACQUISITION AND PROCESSING

The signals were acquired under the real time conditions, i.e. under the operation of both machine and fan (as shown in Figure 1). The signals were acquired at a sampling rate of 4 kHz for a period of 20seconds.For a close observation, noisy signal of one second has been presented in the study. Figure 4 shows the acquired noise signal for a span of one second. From the raw time domain noise signal, it is very difficult to observe the transients peaks generated by the faulty component present in the fan. Wavelet based denoising has been to perform to extract the transients [[3]]. Figure 5 shows the transients appearing in the time domain signal. In one second of signal, the peaks are clearly visible, however some of then still buried in the signals. To deal with issue, envelop of the denoised signal is developed using Hilbert transform [[4]]. The enveloping technique has a potential to reveal all the transients engulfed [[5]]. Figure 6 shows envelop of the wavelet based denoised signal. From Figure 6 the trasients peaks which were masked earlier were now extracted. Both denoised signal and envelop are shown in Figure 6.

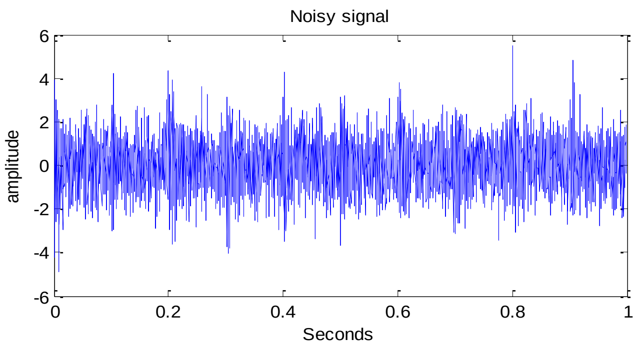

Figure 4. Noisy signal of fan acquired by Bosch iNVH app

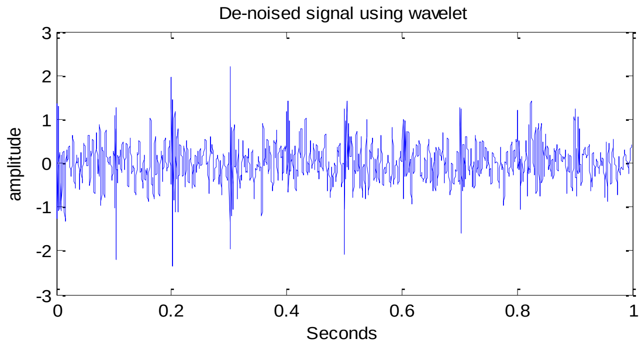

Figure 5. Denoised signal using Wavelet in matlab

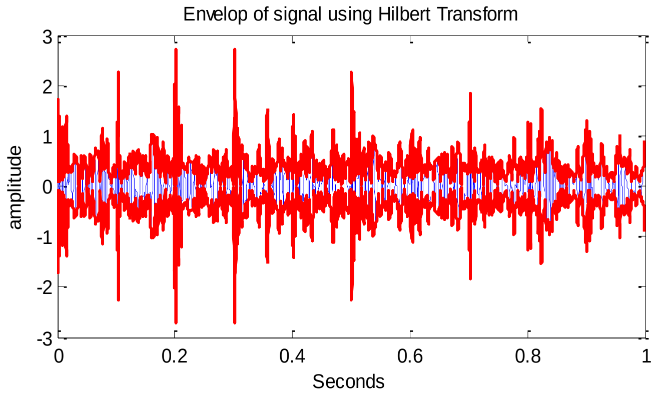

Figure 6. Envelop of the denoised signal

5. RESULT AND DISCUSSION

The noisy signals acquired by the microphone of the smartphone were processed by both using matlab and the iNVH mobile application. The matlab based analysis clearly highlights the bearing fault characteristics.

The iNVH based results are shown inFigure 7 and Figure 8. Figure 7 clearly highlights the overall noise levels with *A* weighting. Figure 8 presents FFT versus Time plots of the acquired vibration signals. Both the plots clearly highlights the fault present in the bearing.

To find out the actual fault, the fan was opened and checked for the bearing fault. It was found that the bearing located in stator-rotor assembly was having a ball fault and it was making a clicking noise (Figure 9). It was found that the mobile application devised by Bosch Engineering Solutions really works well.

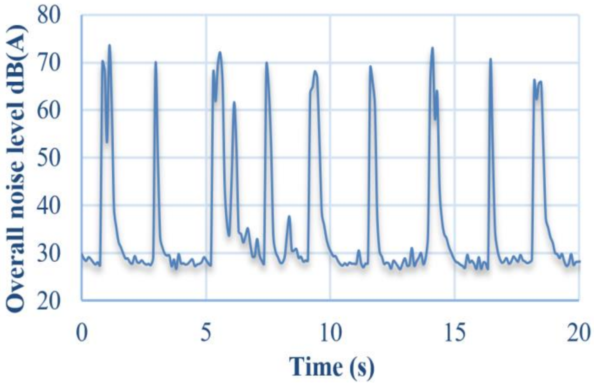

Figure 7. Overall noise analysis

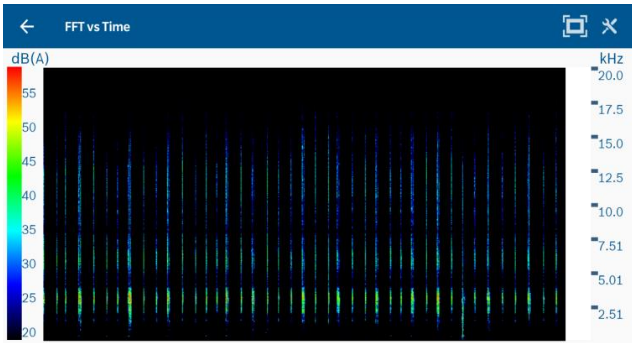

Figure 8. FFT vs time plot by Bosch iNVH app

Figure 9. Ball fault in a ball bearing

6. CONCLUSION

The case study on the diagnosis of fault based on noise analysis of the industrial fan. Noisy signal from the fan was used to investigate the fault component. The noise signals were recorded by an iNVH application devised by the Bosch Engineering Solutions. The noise signals were recorded and were further processed in Matlab to study the fault occurred in the fan. The analysis to find out the fault from the noisy signal were first denoise using wavelet and then later enveloping was performed to find out the bearing characteristics. The similar results were observed from the iNVH mobile application. Later, it was found that a spall was occurred in the ball of the bearing located in stator-rotor assembly due to long hours of operation.

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