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Failure Analysis of Rolling Contact Bearing for Cold Drawing Machine Using Vibration Signal Processing[1]

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Abstract

In rotating machineries, rolling contact bearings are commonly used. Their failure mostly causes down time in plant. In current work ball bearing chrome steel and phosphors bronze material is carried out defects are identified using FFT analyzer in frequency domain. Signal processing is done to simulate the vibration signal obtained from ball bearing. The simulation results are validated with experimental results.

Keywords

BALL Bearing, Signal Processing, FFT Analyzer.

1. Introduction

Vibration analysis is used to determine the operating and mechanical condition of equipment is very importance. A major advantage is that failure analysis can be identify developing problems before they become too serious and cause unscheduled downtime. The conducting regular monitoring of machine vibrations either on continuous basis or at scheduled intervals can be achieved. can be detect defective bearings with the help of vibration monitoring, mechanical looseness and worn or broken gears. Vibration analysis can also detect misalignment and unbalance before these conditions result in bearing or shaft deterioration. Reducing vibration levels can identify poor maintenance practices, such as obtain bearing installation and replacement for inaccurate shaft alignment or imprecise rotor balancing conditions. At high speeds the bearing loads are due in large part to dynamic forces-inertia and centrifugal forces [1].

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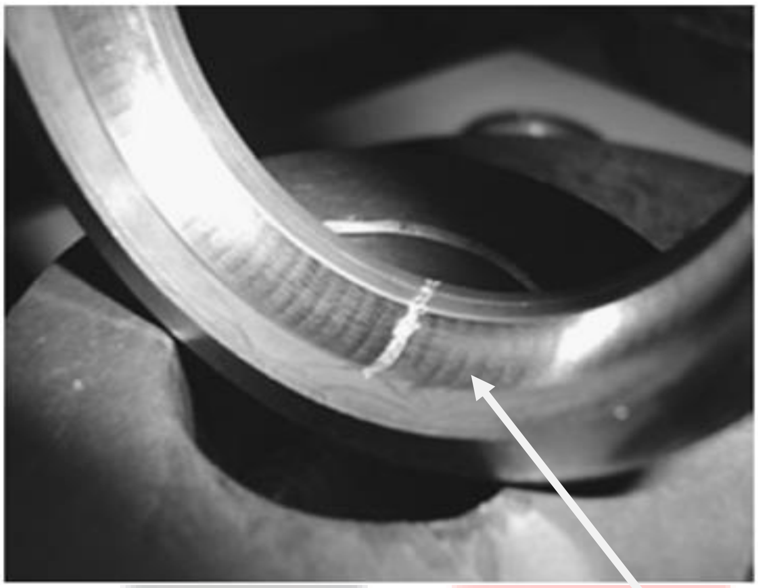
Rolling Element Bearings (REB) are the most used in the rotating machine most common machine elements and find out failure is the cause of down time in plant machinery. Commonly occurring REB defects are cracks and pits located at outer race, inner race and on the rolling element. These defects generate a sequence of impacts with each passage of rolling element over the defect due to the metal to metal contact. The ensuing vibration is distinguished by sharp peaks. It is not easy to identify the defect frequency in the spectrum as these impact vibrations disseminate their energy over broad range of frequencies, thus the bearing's defect frequency contains low energy and hence can be easily masked by noise and other low frequency effects. [2]

To find out solution this problem two methods time domain and frequency domain have been developed. Also indices that are sensitive to impulsive oscillations time domain methods usually involved, such as peak level, Root Mean Square (RMS) value, crest factor analysis, kurtosis and shock pulse counting Since it is difficult to identify incipient bearing defects in the frequency spectrum , many specialized techniques have been developed over the years the bearing fault diagnosis, such as, Bi-spectrum coherence, spectral entropy , autoregressive models , envelope spectrum wavelet transform and more Artificial Neural Network (ANN) to machinery fault diagnosis. In practice, it is quite difficult to obtain vibration signal from bearing having incipient defects.

Shelke et al. (2016**),** presented adaptive spectral kurtosis (ASK) for multi-fault in single row ball bearing detection. A theoretical model of multiple bearing faults was developed. They showed that their method could more effectively extract a feature of multiple bearing faults in the presence of strong background noise compared with the kurtogram and preprogram techniques. Patel et al. (2015**),** reported that local defects, such as spalls, pits and cracks on mating components of bearings are generated due to fatigue. Rajewari et al. (2014**),** developed a ball bearing fault model that is based on dynamic load analysis of the rotor bearing system. They investigated rotor bearing vibration model combined with both dynamic response and fault signal expression of ball bearing. The experimental results verified with the signal model simulation result. Khan et al. (2014**),** employed singular spectrum analysis for fault detection of single row ball bearings. The effects of operating parameters such as load and speed on the indicator are studied. Their results showed that the indicator defined is less sensitive than the RMS value, a traditional vibratory indicator. Kankar et al. (2014**),** used continuous wavelet transform (CWT) for a single row ball bearing fault diagnosis. They used SVM and self-organizing maps (SOM) for faults classifications and reported that the SVM gave a better diagnosis performance as compared to the ANN and SOM. Abu-Zeid and Abdel-Rahman **(**2013) studied damaged bearings and reported they generated high amplitude of vibration at high frequencies and consumed higher energy. Bearing faults can increase vibration level up to 85%, increase power consumption 10- 14% and decrease pump efficiency up to 18%. Different researchers have used different parameters of vibration signal to study bearing fault

For the current cold draw bench machine there are frequent failures of rolling contact bearing of motor. Cracks are observed at the outer race of the rolling contact bearing. Failure of Bering is due to unacceptable level of vibration during cold draw process. Sources and reasons for the vibration are to be studied for the failure of rolling contact bearing.



Crack

Fig .1, Outer race defect

2. Causes of Ball bearing Failure

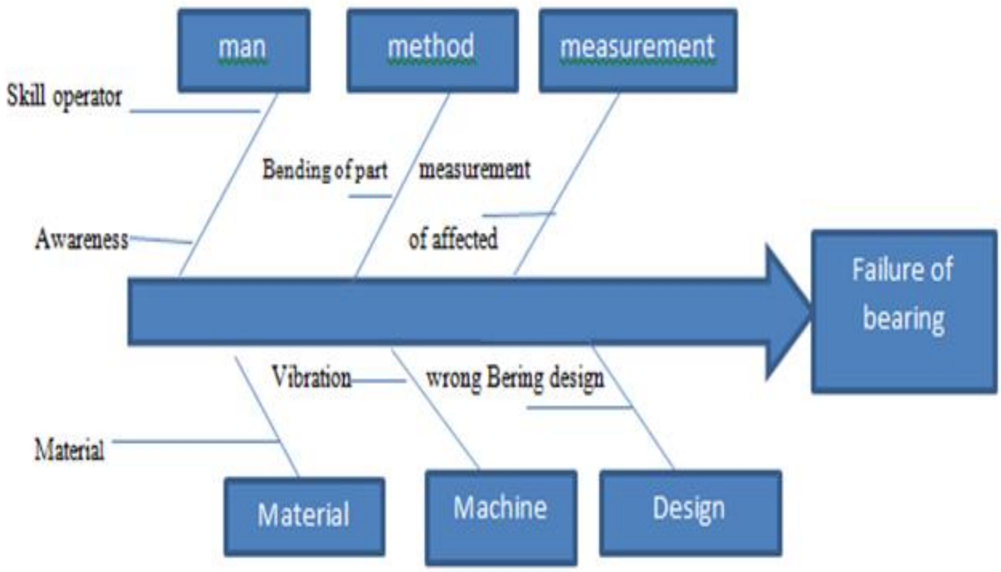


Fig.2, Cause and effect diagram for bearing failure

3. Experimentation

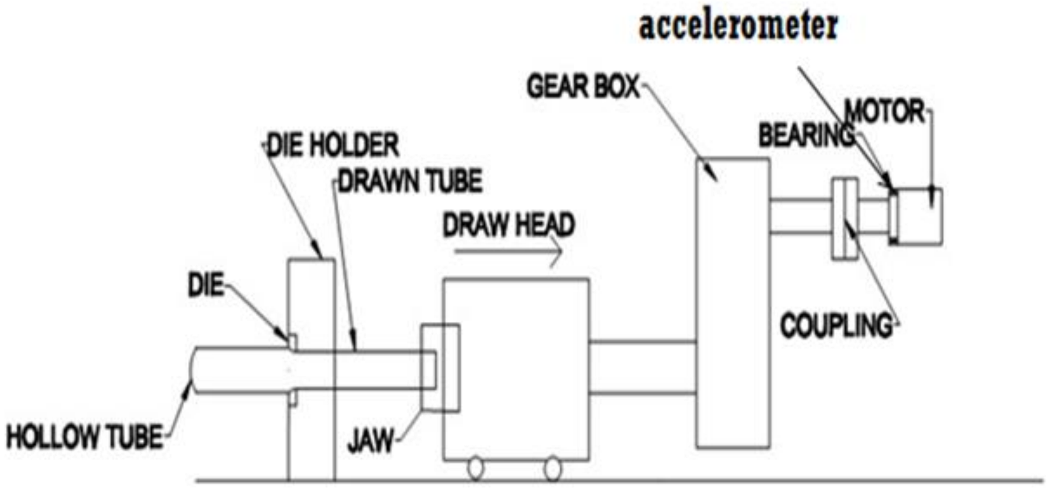


Fig.3 Experimental setup of cold draw bench

Fig 3 shows the experimental set up of working condition of the bearing. The FFT analyzer is used to measure the displacement, velocity, acceleration, vibrations of the existing bearing system . The FFT analyzer is held in vertical, horizontal, axial directions of bearing as shown in fig to measure the a below parameters.

4. Results and Discussion

A. Results for Old Bearing

Vibration response of old bearing (Material: Phosphor Bronze) with load The graphs given below are of Phosphor bronze bearing in load condition-

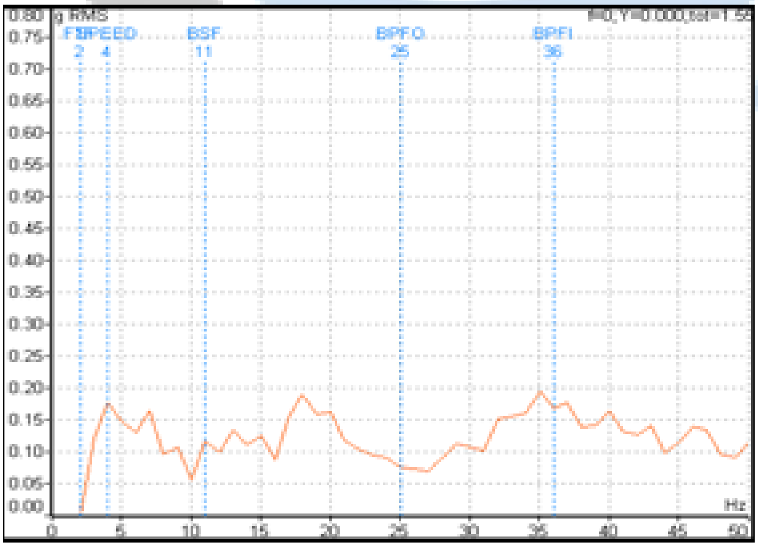


Fig.4, FFT of bearing with load in vertical direction

Fig.5 shows that envelope spectrum of phosphor bronze in vertical direction. In this fig., the values of

FTF, ball pass frequency Ball pass outer frequency and Ball pass inner frequency are indicated clearly .The overall acceleration – rms value for the vertical direction is 0.955.

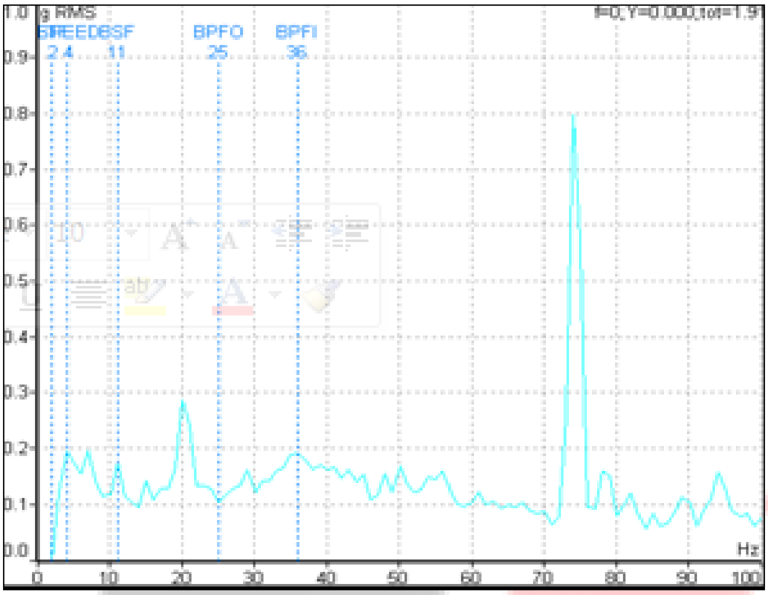


Fig.6, FFT of bearing with load in horizontal direction

Fig.5, shows that envelope spectrum of phosphor bronze in Horizontal direction. In this fig., the values of FTF, BSF, BPFO and BPFI are indicated clearly. The overall acceleration – rms value for the vertical direction is1.91.

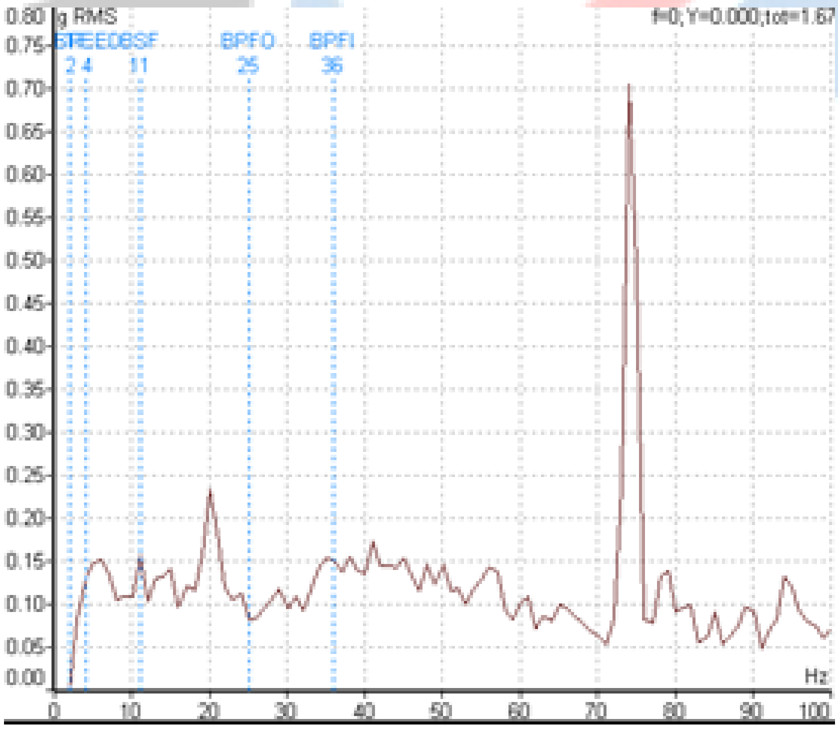


Fig.6 FFT of bearing with load in axial direction

Fig.6 shows that envelope spectrum of phosphor or bronze in axial direction. In this fig., the values of FTF, BSF, BPFO and BPFI are indicated clearly which are tabulated below in with load condition. The overall acceleration – rms value for the axial direction is1.37.From the above graphs, the values of the fault frequencies such FTF, BSF,BPFO, BPFI are tabulated below for the phosphor bronze bearing
The overall-rms acceleration Level in vertical, horizontal and axial direction is 0.955 g, 1.91 g and 1.37 g respectively for the Phosphor bronze bearing.

B. RESULTS FOR NEW BEARING

Vibration response of new bearing (material: chrome steel) with load. The graphs given below are chrome steel bearing in load condition-

Figs. 7, 8 and 9 shows envelope spectrum of new bearing with load in vertical, horizontal and axial direction respectively. The overall-rms acceleration level in vertical, horizontal and axial direction is 0.4g, 0.394 g and 0.258 g respectively.

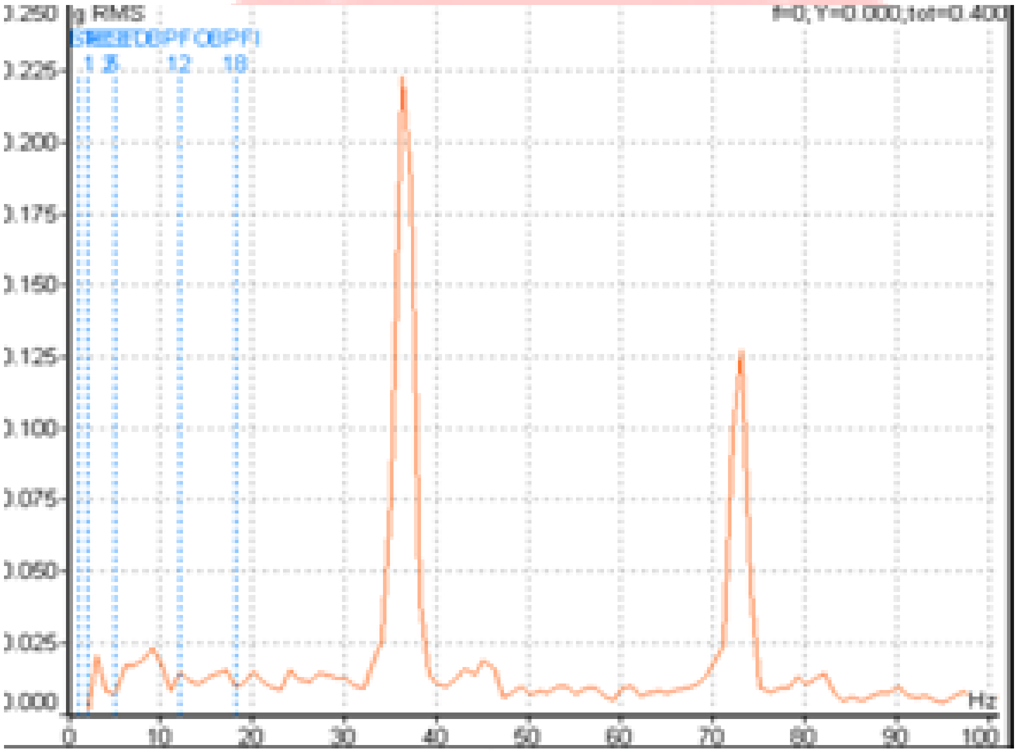


Fig.7 FFT of bearing with load in vertical direction

Fig.7 shows that envelope spectrum of Chrome steel in vertical direction. In this fig., the values of FTF, BSF, BPFO and BPFI are indicated clearly which are tabulate below in with load condition. The overall acceleration–rms value for the vertical direction is0.4

Fig.8, shows that envelope spectrum of Chrome steel in horizontal direction. In this fig., the values of FTF, BSF, BPFO and BPFI are indicated clearly which are tabulated below in with load condition. The overall acceleration – rms value for the horizontal direction is0.398

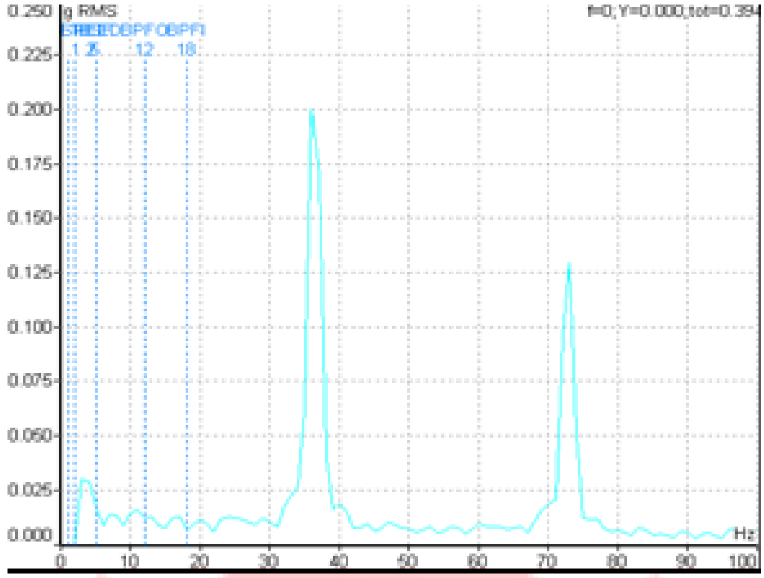


Fig.8, FFT of bearing with load in horizontal direction

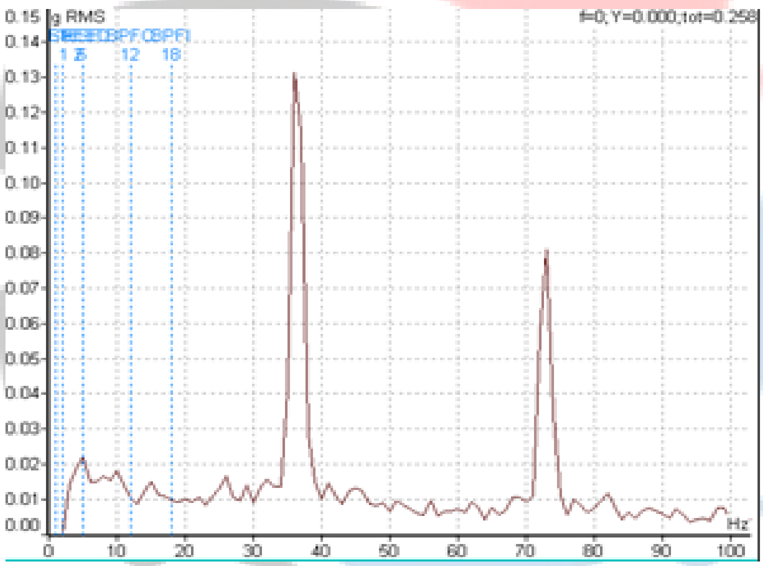


Fig.9, FFT of bearing with load in axial direction

Fig.9, shows that envelope spectrum of Chrome steel in axial direction. In this fig., the values of FTF ,BSF ,BPFO and BPFI are in dictated clearly which are tabulated below in with load condition. The overall acceleration–rms value for the vertical direction is 0.2.From the above graphs, the values of the fault frequencies such FTF,BSF,BPFO, BPFI are tabulated below for the chrome steel bearing

Table.3 FFT result for bearing

Direction	Rms value of old bearing	Rms value of new bearing
Vertical	0.92	0.41
Horizontal	1.91	0.3
Axial	1.31	0.2

From the fig, the overall rms – acceleration values are as. For Phosphor bronze 0.955, 1.91 and 1.37 in vertical, horizontal and axial direction respectively. For chrome steel 0.4, 0.394, and 0.2 in vertical, horizontal and axial direction respectively. From the above values, chrome steel is having less rms – acceleration. From the graphs, we tabulated the values of fault frequencies for both the bearings as in fig From the table, say that the frequency of outer race (BPFO)and inner race (BPFI) is having high value of phosphor bronze as compared to the chrome steel. From the FFT results the acceleration-rms of old bearing phosphor bronze is more as compared to new bearing chrome steel.

B. Vibration Signal Processing

FFT functions are used for spectral analysis. A common use of FFT's is to find the frequency domain of a signal buried in a noisy time domain signal, to find the value of kurtosis, standared deviation and mean

$$\text{Mean } (\mu) = \sum fixi/\sum f \quad \text{----------(1)}$$

$$\text{Standard deviation } (\partial) = 1/2(\sum f(xi-\mu)^2/ \sum f) \quad \text{---------- (2)}$$

$$\text{Kurtosis} = 1/N \sum((xi- \mu)/\partial) \quad \text{--------------- (3)}$$

Table 3, Signal Processing results for bearing

Parameter	Old bearing			New bearing		
	vertical	horizontal	axial	vertical	Horizontal	axial
Kurtosis	52.8	31.1	46.1	28.1	28.1	26.78
Standard deviation	0.87	1.70	0.90	0.34	0.33	0.154
Mean	0.19	0.61	0.61	0.23	0.21	0.156
Rms	0.89	1.80	0.91	0.41	0.39	0.158

From the table, the kurtosis values are as. For Phosphor bronze 52.82, 31.13 and 46.1369 in vertical, horizontal and axial direction respectively. For chrome steel 28.9369, 28.13, and 26.789 in vertical, horizontal and axial direction respectively. From the above values chrome steel is having less kurtosis. Same as the value of standard deviation and mean in vertical, horizontal, axial direction of chrome steel is less than phosphor bronze.

kurtosis in vertical, horizontal & axial position for new bearing are 82.53% ,10%, 72.25% more than that of old bearing. Standard deviation in vertical, horizontal and axial position for new bearing are 60.57% ,80.61%, 81.8% more than that of old bearing. mean in vertical, horizontal & axial position for new bearing are 66.2% ,71.4%, 86.9% more than that of old bearing

From frequencies and acceleration – rms, it is clear that the chrome steel is better material than phosphor bronze for ball bearing of cold draw bench motor. The results of experimentation are validated with Matlab.

5. Conclusion

The work done on the bearing of cold draw bench motor is carried out on the FFT and validated with the matlab. The study of the bearing of cold draw bench motor for the Phosphor bronze and Chrome steel is done. From the result the following conclusions are drawn.

- From the FFT results the acceleration-rms of old bearing phosphor bronze is more as compared to new bearing chrome steel.
- From the signal processing results the kurtosis, standard deviation, mean and acceleration-rms of old bearing is more as compared to new bearing. From the result % of kurtosis, standard deviation and mean for new bearing is more than that of old bearing
- It is clear that the Chrome steel is the better than the Phosphor bronze for the cold draw bench motor.

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