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Experimental Study of ParallelMisalignment in Shaft Rotor System using Vibration Signature Analysis

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Abstract

The paper deals with the analysis of shaft-rotor system which is under parallel misalignment. Misalignment is one of the most commonly observed faults in rotating machines. Misalignment is the second common mechanical fault in rotating machine applications after unbalance. The aim of the paper is to investigate the misalignment problem in rotating system using its vibration signature analysis. Parallel misalignment was given to the well aligned shaft-rotor system.Experimental studies were performed on a shaft-rotor system at to predict the misalignment in system. Analysis of shaft-rotor system with parallelmisalignment is done by using FFT (Fast Fourier Transform) analyser. In experimental results acceleration pick occurs which shows misalignment in system. Vibration analysis therefore helps to detect misalignment in the system.

Keywords: *Misalignment, Shaft, FFT, Vibration*

1. Introduction

"Misalignment" means that the components of an object are not co-axial. Particularly in industrial process electric motors experience a wide range of mechanical problems. It causes over the 70% of rotating machinery vibration problems. Misalignment causes a decrease in motor efficiency, and misaligned machinery is more prone to failure due to increased loads on bearings and couplings. Misalignment is the second common mechanical fault in induction machine applications after unbalance. Misalignment may be present due to various factors such as improper assembly of machines, thermal distortion of machines, asymmetry in applied loads, unequal settlement of foundation, etc. Practically misalignment is always present in the machine thus perfect alignment between rotors shafts cannot be achieved.

However, it will be within an acceptable range. Hence, proper study and good knowledge on the vibration characteristics will be very helpful in diagnosis and analysis of the misalignment to avoid any damage or failure that may occur.

The paper deals with the experimental analysis of shaft-rotor system which is under parallel misalignment.

1.1 Types of Misalignments

Misalignment in a motor drive system is a condition where the centerlines of coupled shafts do not coincide. This is one of the severe conditions that occurs very frequently in motor drive systems and are most of the time responsible for drive failure. Shaft misalignment effects negatively influence on the rolling, sealing, and coupling parts and can also produce eccentricity in the air-gap.

The misalignment conditions are broadly classified as angular (offset) and parallel and combination of these two. Offset misalignment, is sometimes referred as parallel misalignment. This is typically measured at the coupling center.

Angular misalignment is sometimes referred as gap or face, is the difference in the slope of one shaft, and usually occurs in the moveable machine, as compared to the slope of the shaft of the other machine, usually in the stationary machine. Almost all misalignment conditions of motor drive systems seen in practice are a combination of these two basic types.

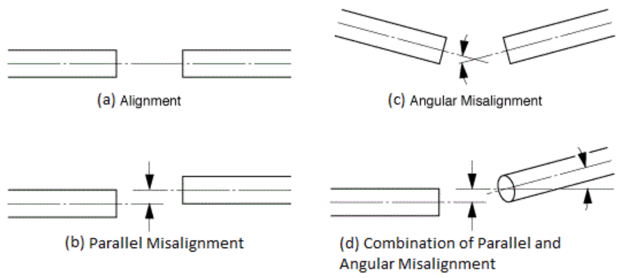

Fig. 1 (a) alignment,
(b) Parallel misalignment,
(c) Angular misalignment,
(d) Combination of parallel and angular misalignments.

2. Experimental setup

Experimental set up is as shown in following figure. It consist of 1 HP 3 phase A.C. induction motor. Motor shaft is connected to rotor shaft by using rigid coupling. There are two bearings are used Plummer block 1 (PB1) and Plummer block 2 (PB2). Variable Frequency Drive (VFD) was used of speed range 0 to 3000 rpm.

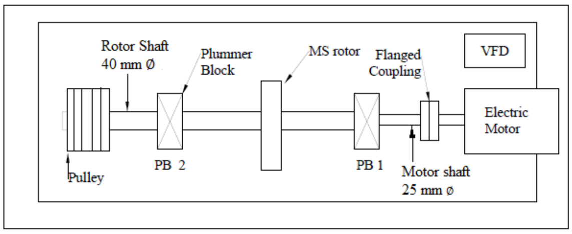

Fig 2.Line diagram, top view of experimental setup

Table 1. Dimensions and features of all the components

Sr. No.	Component	Feature
1	Motor	1 H.P. 3 phase A.C.
2	Rotor Shaft	Ø 40 mm
3	Motor Shaft	Ø 25 mm
4	VFD (Variable Frequency Drive)	from 0 to 3000 rpm
5	Rigid coupling	3 inch
6	MS rotor	O.D.= 212 mm , I.D.= 40 mm
7	Plummer blocks (PB 1 & PB 2)	Ø 40 mm

3. Experimental procedure

Experimental setup was as shown in fig.1. This set up was used for measuring vibrations in terms of acceleration. Vibration analysis was done for two working conditions of shaft rotor system i.e. well aligned shaft rotor system and misaligned shaft rotor system. For both the conditions vibration analysis was done at a speed 1500 rpm. Alignment between motor shaft and rotor shaft was checked by using SKF shaft alignment tool TKSA 20. We make a provision to give a parallel misalignment to shaft rotor system. For second condition parallel misalignment of 0.25 mm was given and then vibration analysis was done.

Vibration signals at Plummer block no. 1 and motor were measured by FFT analyzer with the help of uniaxial accelerometer in radial direction.Accelerometer were installed above the motor and bearing block in radial direction.The accelerometers were connected to FFT analyzer which was connected with computer having RT Pro software for the analysis of vibration signature. Therefore on RT Pro software we observed the vibration signature i.e. Acceleration vs. Frequency graph.

4. Experimental Observations

I) Aligned Condition

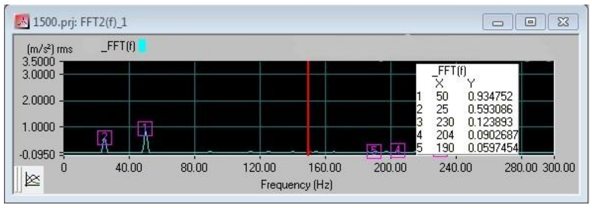

Fig. 3. Vibration signature at Motor Radial (MR) direction

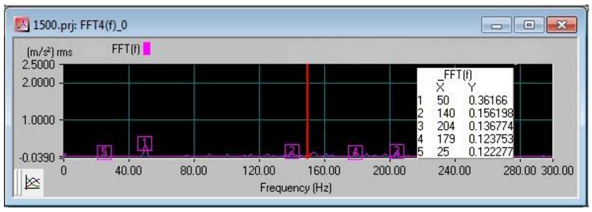

Fig. 4. Vibration signature at Bearing Block Radial (BBR) direction

II) Misaligned Condition

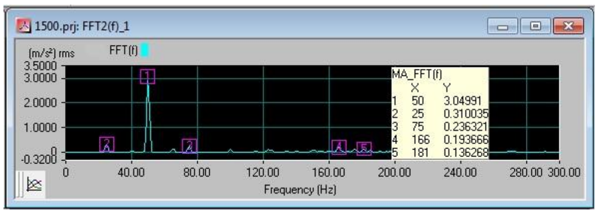

Fig. 5. Vibration signature at Motor Radial (MR) direction

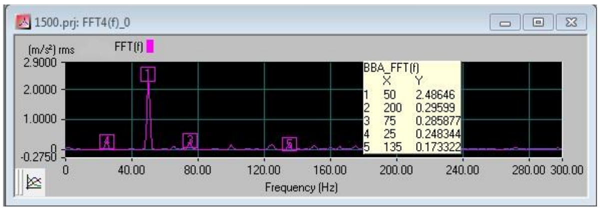

Fig. 6. Vibration signature at Bearing Block Radial (BBR) direction

5. Results and Discussion

I. Comparison of vibration readings at Location 1 (Motor Radial)

Table 2. Vibration readings at Location 1

Location 1 : Motor Radial		
	Aligned condition	Misaligned condition
1X	0.5931	0.31
2X	0.9347	3.0499
3X	0.0241	0.2363
4X	0.0322	0.1011
5X	0.0449	0.0742
6X	0.0146	0.0776

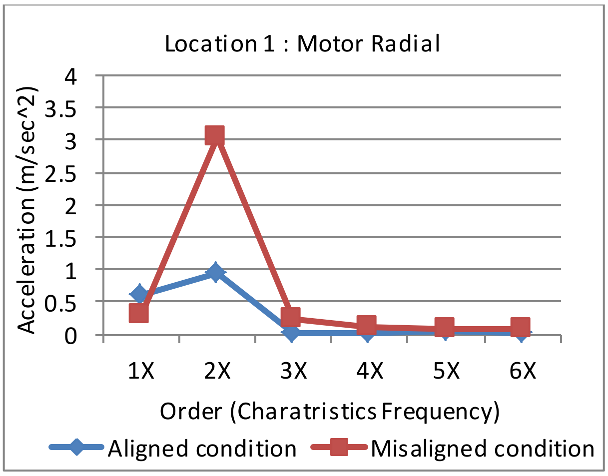

Fig. 7. Graph for comparison of Aligned and Misaligned condition

II. Comparison of vibration readings at Location 2 (Bearing Block Radial)

Table 2. Vibration readings at Location 2

Location 2 : Bearing Block Radial		
	Aligned condition	Misaligned condition
1X	0.1223	0.2483
2X	0.3616	2.4865
3X	0.0463	0.2859
4X	0.0581	0.1583
5X	0.0745	0.1497
6X	0.0176	0.1093

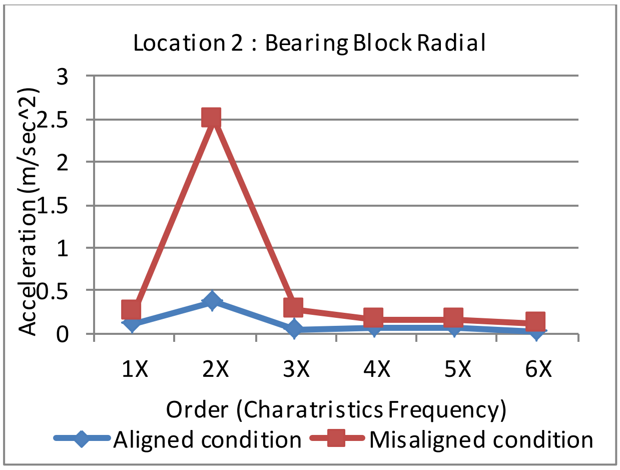

Fig. 8. Graph for comparison of Aligned and Misaligned condition

Conclusions

The experimental model for vibration analysis of misaligned shaft rotor system was prepared. Then vibration analysis for well aligned condition and misaligned condition was done by using FFT analyzer. Vibration signatures were observed in RT Pro software. By observing vibration signatures we can conclude that

1) Vibration analysis can be used for detecting misalignment in the system.
2) Vibration signature for aligned and misaligned conditions were compared in Fig. 7 and Fig. 8 for motor radial and bearing block radial direction respectively.
3) For aligned condition, the acceleration value was found very low with respect to order or characteristics frequencies.
4) For misaligned condition, there is sudden increase in acceleration value at 2x characteristic frequency.
5) This increase in acceleration value for misaligned condition shows the effect of misalignment in the system.
6) More detail investigation is still required with different parameters and working conditions.

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