Pak. J. Sci. Ind. Res. 2003 **46** (4) 225-229

Vibration Monitoring and Fault Diagnosis of an I.D.Fan at a Cement Plant

Tariq Hafeez*, Afzaal Ahmed, G Yasin Chohan and M Amir

Dr A Q Khan Research Labs, P O Box-502, Rawalpindi, Pakistan

(Received 5 June 2002; accepted 12 September 2002)

I.D.fan (Kiln) of a Cement plant consisting of a motor, two mechanical couplings, a hydraulic coupling and a heavy fan (approx. two tons) was giving high vibrations at some locations. This was monitored at all the bearing locations and its vibration symptoms were recorded for analysis purpose. Frequency domain and phase analysis were made to diagnose the root cause of vibrations. On the basis of this analysis, fault observed was mainly with the fluid coupling. The vibration spectra and phase data are presented in this paper.

Key words: Vibration monitoring, Cement plant, Mechanical coupling, Rotating machinery.

Introduction

In the rotating machinery, vibrations have been adopted as a prime indicator of machine condition. During operation all machines are subjected to fatigue, wear and deformation which lead to the different faults like increase in the clearances between machine parts, shaft misalignment, cracks initiation and unbalances in rotors. All this leads to increase in vibration, which causes an additional dynamic load on bearings. The increasing vibration levels with time lead to the failure or breakdown of the machine. It is therefore, essential to get the vibration data and interpret it to determine the mechanical condition of a machine and pinpoint, any specific mechanical or operational defect (Ralph 1979; Edison 1994).

The vibration analysis of the I.D. fan (Kiln) of an Askri Cement plant at Nizampur NWFP is based on its time-to-time vibration monitoring. The vibration velocity is recorded along with phase in loaded condition at 1000-rpm fan speed. The collected data is analyzed by phase analysis technique. A data collector is used for frequency domain spectrum analysis.

Both the techniques are utilized to diagnose the problem. A brief introduction of the I.D.fan is given for understanding the system. Finally the problems in different machine components are diagnosed and discussed in detail.

Materials and Methods

The induced draught (I.D.) fan of the Cement plant is shown in Fig 1. The points 1,2,3,4,5 are the bearing locations, where the vibration data were collected in different directions, vertical, horizontal and axial with the help of a data collector. The whole system consists of a motor, two mechanical couplings a hydraulic coupling and a big fan.

*Author for correspondence

The I.D.fan drags high temperature air and dust to the Kiln with full load capacity of 375000 m^3/h at 350°C and 800mm of H_2O. It has 1200 kW motor driving the fan at the speed of 1000 rpm. The hydraulic coupling can control the fan speed from 200 to 1000 rpm.

The variable speed fluid coupling is hydraulic power transmission, which transmits power through fluid medium and releases stepless speed regulation. It consists of an impeller connecting with an input shaft, a turbine connecting with the output shaft and a rotating housing enclosing the turbine.

Vibration analysis. The system was monitored and diagnosed the fault on the basis of vibration spectra and phase analysis. It is discussed here.

Frequency spectrum analysis. The analysis of vibrations is said to be in the frequency domain and displays vibration amplitude along y-axis and frequency along x-axis in the spectrum. On the other hand, a plot of vibration amplitude against time, a waveform plot is said to be in the time domain. Energy in a vibration signal is distributed over a range of frequencies consisting of the fundamental frequency and complexities of the harmonics (Ralph 1979).

The presence of mechanical problems like misalignment of couplings, imbalance of shafts, worn damaged or locked coupling, bent shaft condition, bearing conditions and gear problems may be analyzed on the basis of vibration magnitude of different frequency peaks available in the frequency domain spectrum of the machine. The frequency spectrum may be analyzed on the following basis (Ralph 1979; Edison 1994; SKF 1995)

The presence of 2X peaks that is high in the radial direction is an indication of parallel misalignment. In almost 80% cases of misalignment there exist 1X symptom. 2X appears in case of severe misalignment. The presence of high 1X and 2X peaks in the axial plane is the reason of angular misalignment.

A bent shaft problem is possible if vibration levels are relatively high in the axial plane across the component. The 1X peak will exist in the axial plane at two ends of a component.

If there exists a 1X peak in the axial plane and 1X,2X peak in the radial direction of a component, it will be an indication of worn, damaged or locked coupling.

The presence of high 1X frequency component in both the horizontal and vertical planes and readings differ from each other by a factor of 2. It is an indication of imbalance, possibly an eccentric rotor.

Mechanical looseness can take many forms in rotating machinery. The classic spectral signature is the string of harmonics of the running speed, with peaks ranging from 1 X to 10 X. These peaks can be accompanied by 1/2and 1/3 harmonics (i.e. peaks at 2. ½ X , 3 .1/3 X etc.). A looseness caused by structural defects (i.e.weakness in the machine feet, foundation or grouting) will more likely to have vibration signal with relatively higher peaks at 1X and 2X frequency condition. A looseness exhibited by relatively higher amplitudes in the upper harmonics (3X to 10X) is more likely to be the bearing related (given that machine has rolling element type bearings).

The presence of a peak in the approximate area of inner and outer race on a rolling element bearing of unknown configuration may indicate bearing wear. The non-synchronous peaks between 3X and 6X show the bearing problem.

The presence of sub-synchronous and low band symptoms on both ends of the shaft or machine component is a possible indication of structural resonance.

*Phase analysis.*The ability to determine the relative motion between various parts of a machine structure using phase measurements can be a very valuable analysis tool. For example high amplitudes of axial vibration may be caused by coupling misalignment, bearing misalignment and Bent shaft or unbalance of an over hung rotor (Ralph 1979).

The vibration signal at 1X and 2X can be obtained along with phase for detailed analysis.The first step is to select a convenient location on the machine where phase reading can be observed with the help of a photo pickup/strobe light. The objective of a phase analysis is to distinguish among imbalance, eccentricity, misalignment, bent shaft and mechanical looseness. The phase reference measurement accuracy lies within 30° (Bulk Kruger and SKF 1998). To analyze the imbalance, it is essential that 1X must be the dominant frequency of the spectrum. If this condition of frequency peaks along with the phase information is available, then it is better to segregate the problem by phase analysis. Following will be the conditions of phase relationship for evaluating a particular problem:

There will be a 90° phase shift, if the vibration sensor is moved from horizontal to vertical position on a machine. No radial phase shift may be observed across the machine or coupling. This will be the case of mass unbalance in the rotor.

If 180° phase shift is observed in the axial direction across the machine with no phase shift in the radial direction, this exhibits the bend shaft condition.

A phase shift of 180° in the axial direction will exist across the coupling in case of angular misalignment.

If 180° phase shift exists in radial direction across the coupling and 0° or 180° phase shift exists from horizontal to vertical position on the same bearing, this may be due to parallel misalignment.

The problem of both angular and parallel misalignment may appear, if phase shift acrosses the coupling in radial and axial direction which is about 180°.

Results and Discussion

The frequency spectrum analysis and diagnosis. The vibration velocity (mm/sec, peak value) was measured using a data collector (Microlog by SKF) with the help of a hand held accelerometer (4370 by B&K). The motor of the I.D.fan was monitored, while uncoupled. The levels of 1X rpm peaks were very much low.

The vibration measurements were made at point no.2, 3, 4, and 5 of the I.D. fan in vertical, horizontal and axial position, respectively in the loaded condition. The frequency spectrums obtained at all points were analyzed on the basis of theoretical background as discussed in article 3(a). The problems diagnosed are given below.

The high 1X peaks level along with 2X peaks in radial direction across the points 2 and 3 (Fig 2 and 3) is the indication of parallel misalignment in rigid coupling 1.

The high 1X peaks along with 2X peaks in the radial as well as in axial direction across the flexible coupling at point 3 and 4 (Fig 3 and 4) is an indication of misaligned, worn, ceased or locked coupling.

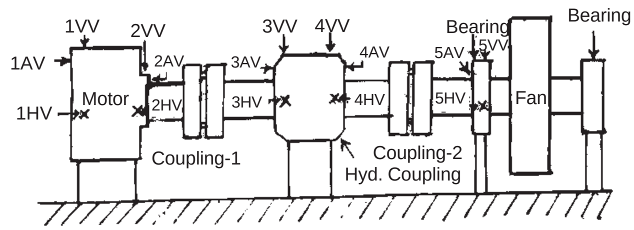

Fig 1. I.D.Fan (Kiln)

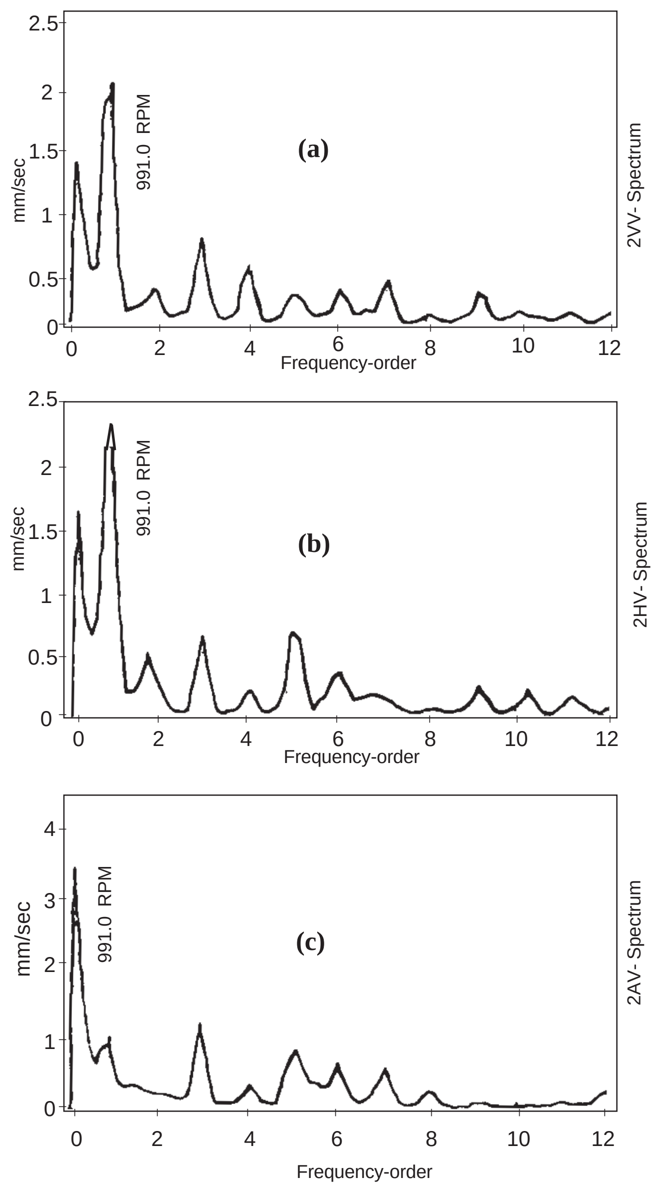

Fig 2 (a,b,c). Frequency domain spectrums at point 2 of I.D. fan.

The high 1X peaks along with 2X peaks in the radial as well as in axial direction across the points 4 and 5 (Fig 4 and 5) is indication of both parallel & angular misalignment in rigid coupling-2

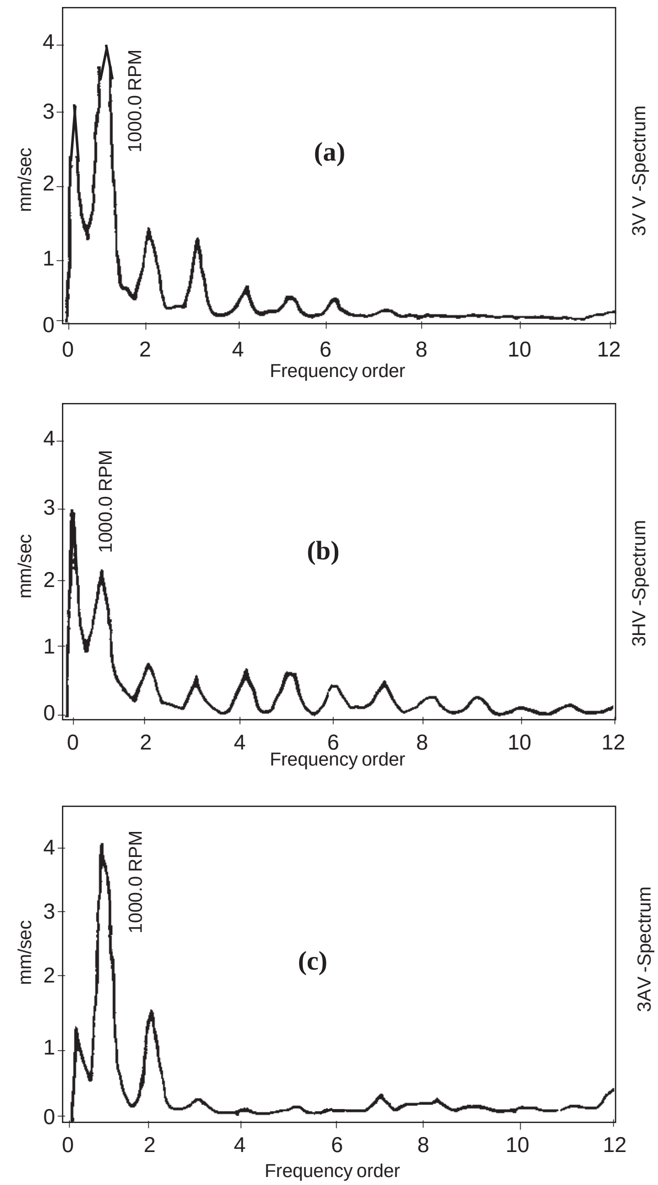

Fig 3 (a,b,c). Frequency domain spectrums at point 3 of I.D.fan.

The string of peaks at 1X, 1.5X, 2X, 2.5X and so on, almost in all points spectrum is the clear indication of mechanical looseness in all machine components or its foundations.

The subsynchronous peak observed in all spectrums is the indication of structural resonance. This may be the frequency of any part in the machine system or may be due to vibration in the nearby machine. These low frequency peak remain even if the system is made OFF. This rules out the possibility of outer race problem in the bearings

The high 1X peaks in both radial and axial planes at about all points may also be due to imbalance and bent shaft condition in the three coupling.

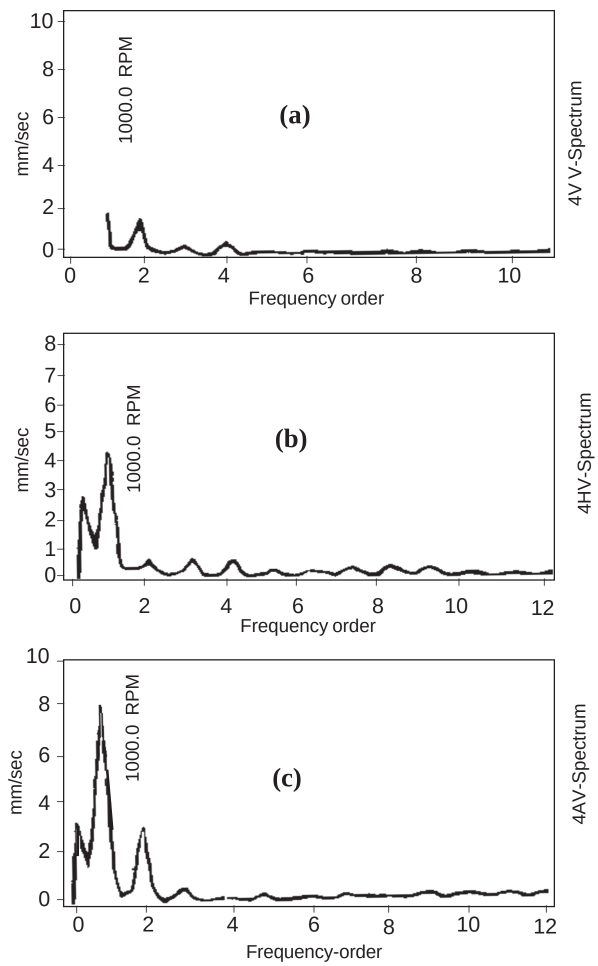

Fig 4 (a,b,c). Frequency domain spectrums at point 4 of I.D.fan.

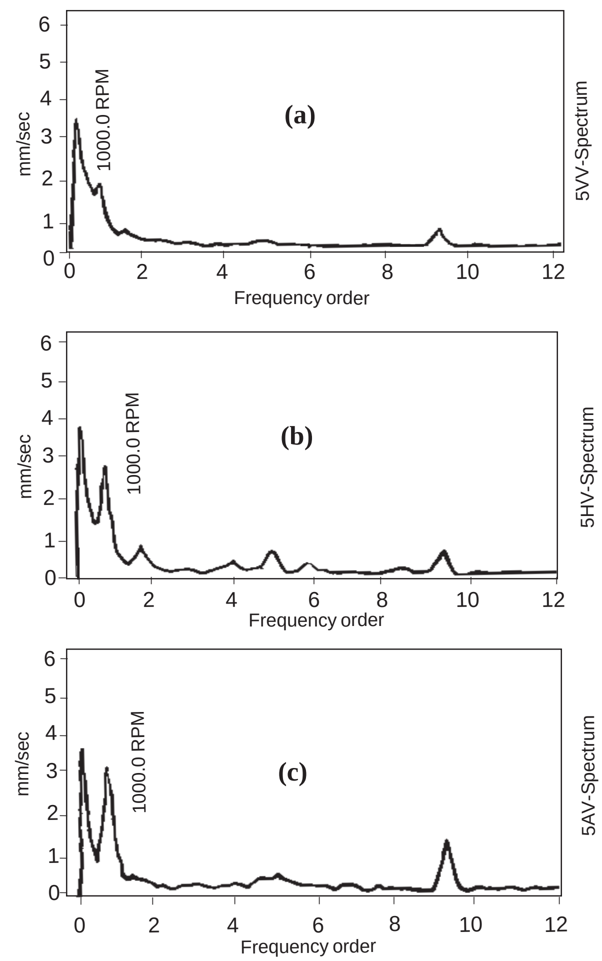

Fig 5 (a,b,c). Frequency domain spectrums at point 5 of I.D.fan.

Table I

The measurements of the vibration severity levels

S.No.	Pickup location	SUM mm/sec	1X RPM mm/sec with phase
	V	1.20	0.28/207°
1	H	1.70	1.00/216°
	A	3.70	0.15/330°
	V	2.00	1.50/207°
2	H	2.50	2.00/102°
	A	3.00	0.50/12°
	V	4.10	2.00/160°
3	H	5.10	2.20/299°
	A	9.80	4.10/200°
	V	6.00	1.30/146°
4	H	5.20	1.60/325°
	A	8.90	4.30/358°
	V	2.30	0.40/304°
5	H	2.50	0.10/394°
	A	4.40	0.90/325°
	V	0.95	0.78/129°
6	H	1.50	0.67/328°
	A	2.10	1.70/315°

*The phase analysis and diagnosis.*The vibration data of the I.D. fan was collected by another vibroport(Vibrometer by Schenck) with the help of a hand held velocity sensor by measuring vibration severity level (velocity in mm/sec, rms value) at all the located points in vertical, horizontal and axial direction as shown in Fig 1.The vibration data for overall and 1X frequency component along with phase were recorded for analysis purpose.

The vibration severity levels measured (Table 1) at all machine components of I.D.fan, except the hydraulic coupling, which is of low level and does not generate the symptom of any severe problem. The vibration signal across the two ends of hydraulic coupling and rigid coupling-I may be analyzed as under.

The 1X peak of moderate level along with the phase shift of 197° in horizontal direction across the rigid coupling-1 at point 2 and 3 is the indication of parallel misalignment in this coupling. This can be the problem of worn coupling which can be confirmed after its dis-assembling.

It may be noted that vibration levels obtained during phase measurement do not meet with the values of spectra. This is due to the use of another instrument on different date for phase analysis.

The high axial and moderate horizontal 1X peak at point 3 and 4 across the fluid coupling along with the phase shift of about 180°is an indication of parallel as well as angular misalignment in this coupling

Conclusion

On the basis of frequency spectrum and phase analysis, it is diagnosed that:

There is maximum chance that problems of misalignment or wear exist in the hydraulic coupling.

There is an indication of moderate misalignment in both the rigid couplings.

The 1X peak along with higher harmonics at about all machine components is due to mechanical looseness in most of the machine components or its foundation.

The subsynchronous component present in almost all spectrums is because of structural resonance. This may be due to vibration in the nearby system or the natural frequency of a part of any machine in the system.

Any loose mechanical component or foundation is to be checked and rectified. The rigid and hydraulic couplings require adequate rectification. The machine foundation and vibration isolators are also to be checked.

The vibration data of I.D.fan system may be taken again as the rectification work is completed.

References

Bull Kruger, SKF 1998 *Condition Monitoring Training Course, CM 103 Machinery Inspection and Evalution.* 21th July-24th July, Singapore- 629610.

Edison M 1994 *Vibration Analysis I, II Training Course.* conducted by Entek IRD International 1700.

Ralph AC 1979 *Vibration Monitoring and Dignosis*. George Godwin Ltd. London, UK, pp 175 - 329

SKF 1995 *Prism Pro-Software, Version 2.21 for Condition Monitoring and Diagnosis. Condition Monitoring Inc. Copyright 1995, 1996*. 4141 Ruffin Road, San Diego, CA 92123, USA.