Vibration Signature Analysis-A Case Study On "Oil Whirl" Problem In Turbine Bearings

C G Porwal.
Monitoring & Diagnostics Center
National Thermal Power Corporation Limited

Abstract: *Maintenance has become a major cost factor in thermal industry. For optimizing maintenance cost and making considerable saving, a number of advanced techniques are available among which signature analysis is a powerful and widely used technique in Condition Monitoring of rotating machinery. During the time of commissioning and acceptance trials of the machinery, vibration signature assumes greater significance as these results determine the soundness of assembly of a various components. At the same time, these signatures form the basic reference or base-line for future monitoring and maintenance. Keeping these aspects in view, a typical case study highlights the existence of oil whirl experienced during periodic monitoring of turbine bearings by the author. Vibration signature was useful in identifying the probable cause of trouble which was confirmed on opening of the equipment.*

1.0 Introduction:

Vibration analysis is probably most widely used technique for the determination of health of a machine in Condition Monitoring. Each characteristics of vibration gives significant information about the machinery condition. Amplitude of vibration indicates how good or bad its health may be and an increase in the amplitude value signifies deteriorating condition. The determination of the discrete frequencies in the complex vibration signature and comparison with excitation frequencies permits identification of the vibrational sources. The various frequencies on the vibration spectrum of a rotating equipment can be related to many factors such rotating unbalance, misalignment, bent shaft, mechanical looseness, damage to the bearings, bad belt, gear drive, structural resonance and oil whirl. The physical interpretation of frequency spectra to correlate the vibrational source with the fault helps to predict the impending problem much before the occurrence of actual failures.

The present paper highlights a typical vibration problem encountered during the periodic Condition Monitoring of major equipment of NTPC Super Thermal Power Station. An experience with a problem due to oil whirl, its systematic analysis and corrective measures taken are described here.

2.0 History

The turbine generator (210 MW) comprises of seven pressure-lubricated bearings. Vibration levels on these bearings since commissioning were normal and did not indicate any vibration problem until end of June'1986. Although the vibration level was only 54 microns pk-pk. - within the limit of 70 microns pk-pk – there was a rising trend, which was matter of concern Subsequently, the unit was shut down to open the bearing no 3 for inspection and no abnormality was noticed. Bearing top and side oil clearances were within the limits. Hammer test did not reveal of any loose contact of babbitt. The unit was re-synchronized and further measurements were recorded on all the bearings of turbine at various loads and speeds. Vibration of bearing no 3 was fluctuating with frequency.

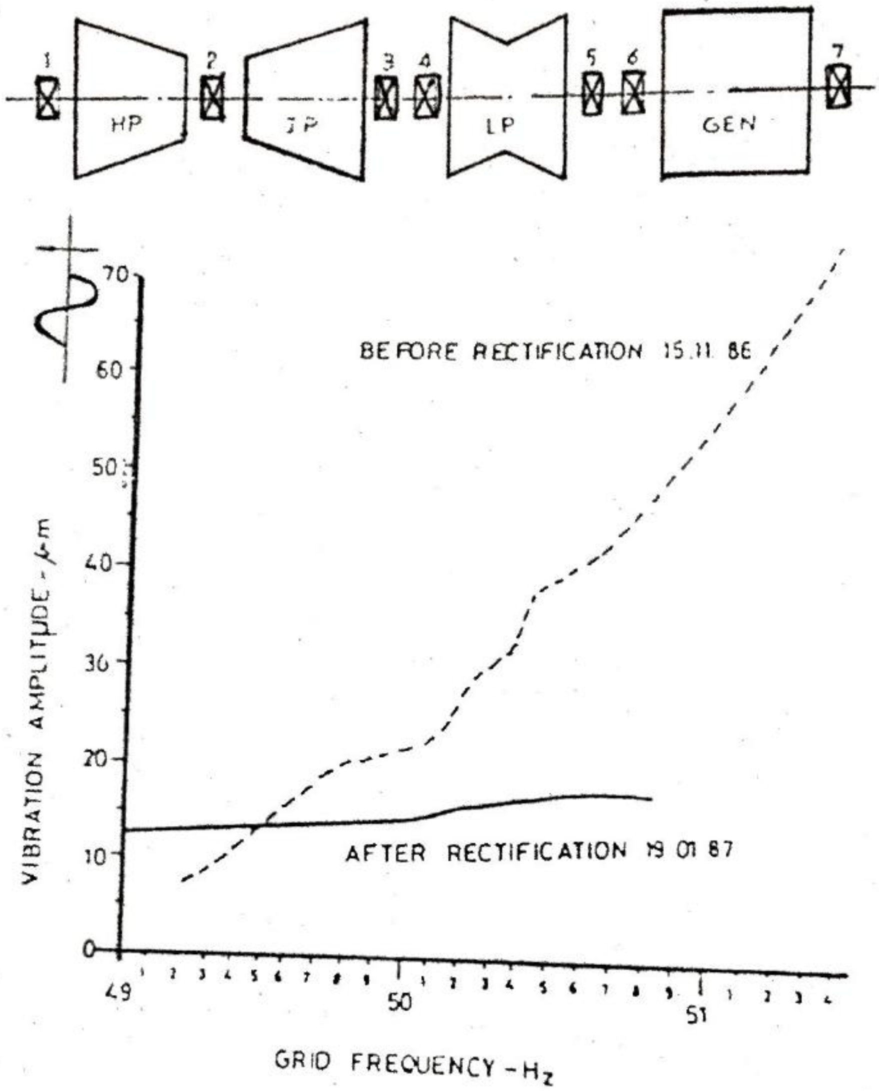

Fig no. 1

3.0 Observations

A knocking type of sound was heard from the bearing no 3, especially at higher grid frequencies and gradually vanished when the grid frequencies came down to below 50 Hz. This knocking was imparting high vibration to the bearing. Bearing metal temperature was 65° C and the axial shift (-) 0.56 mm.

To understand the nature of vibration, it was necessary to establish the dependency of vibration i.e. whether vibration was load-dependent or speed dependent or both. For this, vibration measurements on bearing no 3 were recorded when the grid frequency was fluctuating between "49 to 51.3 Hz" and the vibration signature was also recorded. Predominant vibration was seen on the bearing no 3, not on foundation or associated piping.

4.0 Vibration Analysis

The amplitude of vibration had an increasing tendency with grid frequency irrespective of load, as brought out in Fig No1.

4.1 Interpretation of Discrete Frequencies

Vibration at discrete frequencies (Fig No 2) are analyzed as follows:

1400 cpm: Vibrations at this frequency is maximum in vertical direction and occurs at 45.2% of rotational speed (3000 rpm). It has been established that vibration occurring at 42- 48% of speed will be due to oil whirl: Oil whirl phenomena is described later.

2800 cpm: This is the 2nd harmonic 2 x rpm of 1400 cpm of the fundamental. Elimination of 1400 cpm vibration will automatically eliminate this.

3000 cpm: This is the vibration produced at the rotational speed of the turbine speed.

4200 cpm: This is the 3rd third order harmonic (3x1400cpm).

4400 cpm: This is the modulated signal with 1400 cpm and 3000 cpm vibration and will automatically vanish when 1400 cpm is eliminated.

5600 cpm: This is the 4th order harmonic vibration produced by (4 x 1400 cpm).

6000 cpm: This is the 2nd order harmonic (2x3000 cpm) of vibration produced by the rotational frequency.

From the above analysis of discrete frequencies, it will be seen that the culprit is the 1400 cpm vibration component due to oil whirl.

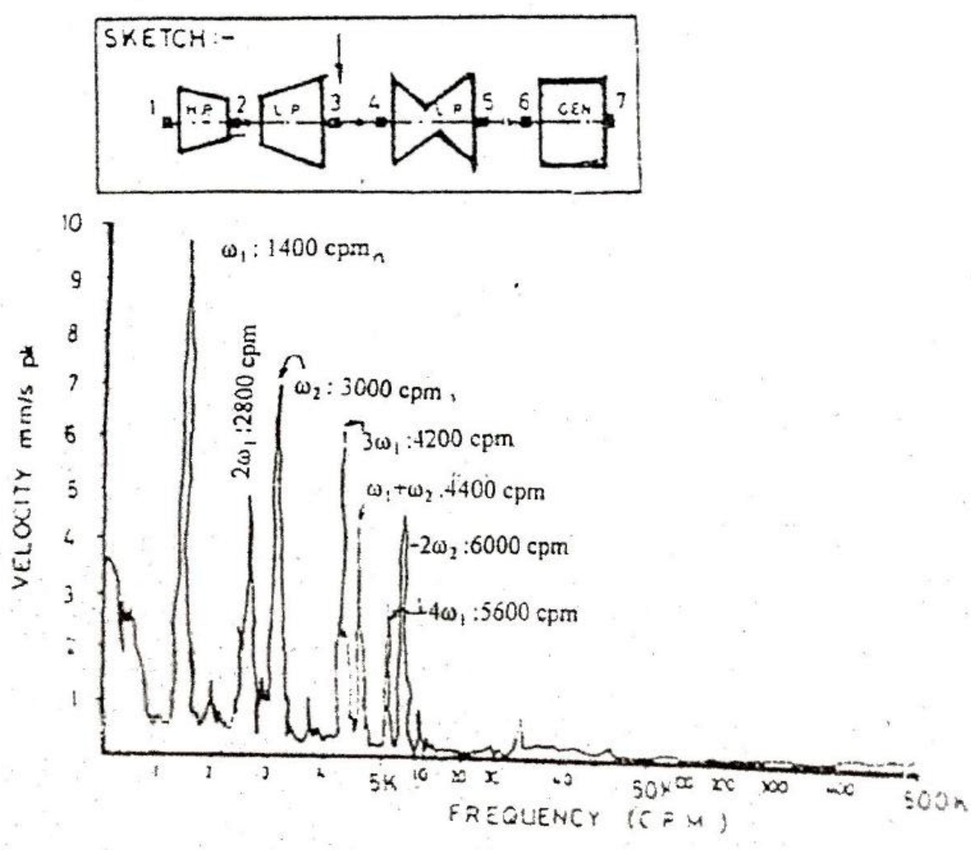

Fig. No 2

4.2 Oil Whirl

The mechanism of oil whirl is explained in figure no. 14 at page no. 22 of this book

As per the observations made, no vibration at 1400 cpm was seen predominantly on the associated lube-oil piping or foundation. Therefore, vibration due to external excitation is ruled out.

5.0 Recommendations

Following line of action was recommended to resolve the vibration problem.

a) Bearing no 3 to be inspected for the following
- Healthiness of its white metal
- Oil clearances (side and top Oil clearances)
- Tightening of parting plane bolts
- Matching of support pads housing
- Contact area of journal with the bearing

b) Bearing no 4 should also be checked for oil clearances and journal contact area

6.0 Rectification

Following jobs were carried out on bearing No 3 and bearing No.4 by field personnel during the shutdown.

- Bearing no 3 was raised by 0.15 mm by providing shims.
- Bearing no 4-bottom pad was scraped and matched for 90 % contact area.
- The healthiness of white metal of both the bearing No 3 and 4 were checked and found in good condition

7.0 Results

The unit after rectification of bearings no 3 and bearing No. 4 was brought back the vibration measurements were recorded on bearing no 3 and the results were encouraging. The vibration at different grid frequencies indicated that maximum level of vibration now at 50.8 Hz is only 16 microns pk-pk, which is acceptable for smooth operation of the turbine. Comparison of vibration data and spectrum before and after rectification is represented in Table 1 and Fig. No. 3.

TABLE 1

Grid Frequency Hz	Direction of vibration	Before rectification	After rectification Microns pk-pk
49.0 hz	H	8	12
	V	7	12
50.0 hz	H	12	14
	V	22	14
50.5 hz	H	25	16
	V	42	16
50.8 hz	H	27	14
	V	50	16

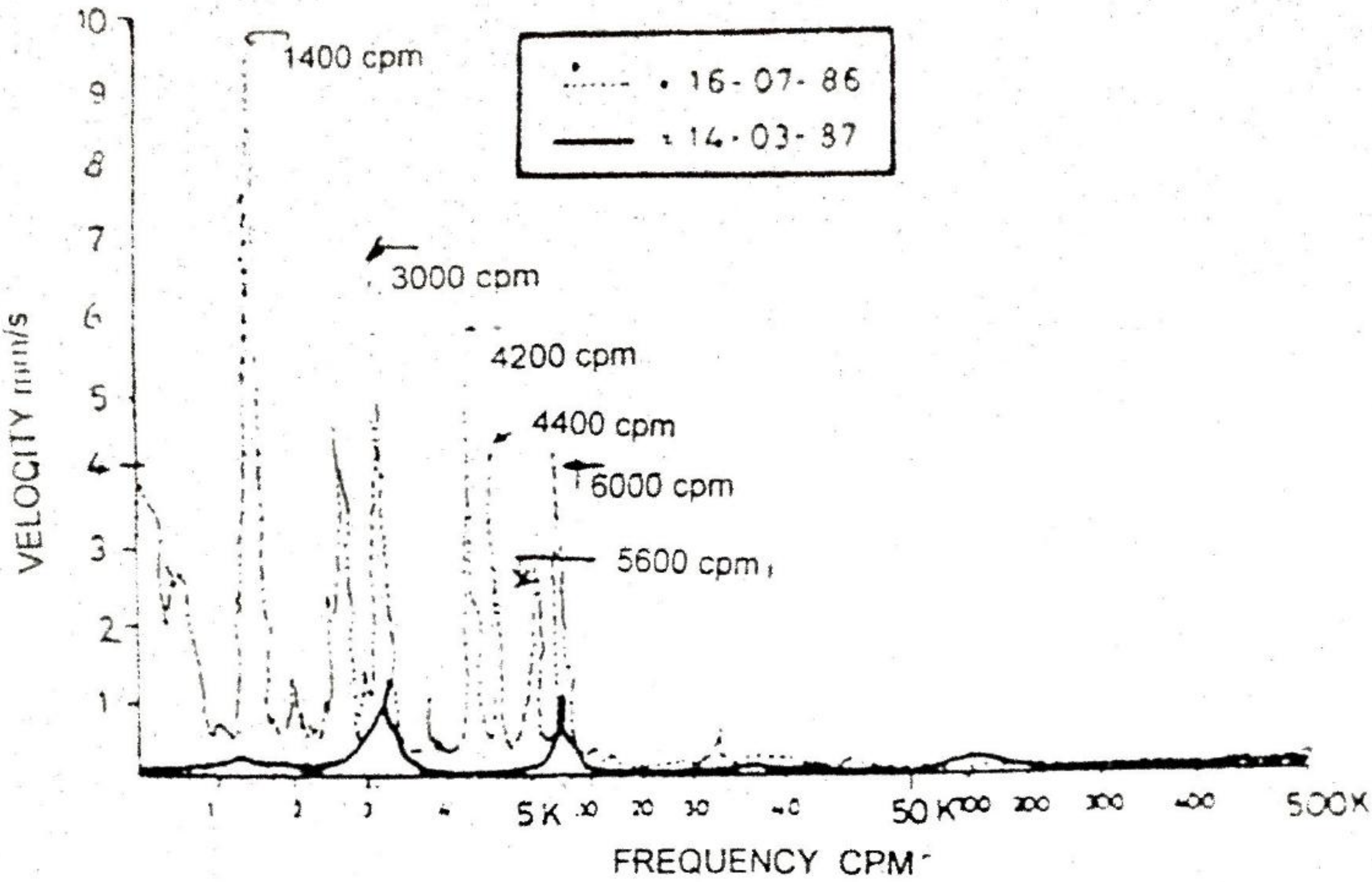

Figure No. 3

8.0 Conclusion

The vibration in bearing No 3 was due to oil whirl which had been eliminated by increasing the uniform loading on the bearing. Generally oil whirl is very common source of the vibration associated with journal bearing and becomes very serious when the amplitude of the vibration on severity of oil whirl is intensive. The approach made in analysis and rectification calls for.

- Correct diagnosis of vibration by clearly understanding the nature and source of vibration
- More emphasis on maintaining the proper loading of the bearings and matching of support pads.

9.0 Acknowledgement

The author wishes to thank SSTPS associated executives for their kind co-operation and help for successful completion of the study and implementation of recommendation. He is also thankful to NTPC management for their valuable suggestion and guidance in preparation and permission to publish this paper in the Conference.

(Published In The 5th "Himer" Symposium)
Hofincons Institute Of Maintenance Engineering & Research
held at Chennai, India. (13th to 15th May'1997)