

ABSTRACT
ISROMAC-9

Analytical and Experimental Investigations on Misaligned Rotors

J. S. Rao
and
R. Sreenivas

QuEST India Private Ltd.,
No. 30, 7th Cross
A. Dasarahalli
Magadi Main Road
Bangalore 560079

Jsrao@quest-india.com

A. Chawla
Indian Institute of Technology
New Delhi 110016

This paper is concerned with theoretical and experimental investigations carried out on misaligned rotor systems.

A 3D finite element of a coupled Jeffcott rotor system is modeled using hexahedral elements. The two Jeffcott rotors are coupled by means of an automeshed coupling. Two power transmitting pins are connected across the coupling halves. Misalignment is introduced to the driven shaft and the misalignment forces induced in the coupling pins are analyzed.

The model is rotated statically and misaligned forces are obtained at equiangular locations. It is found that the forces vary at the frequency of the shaft speed and the harmonic analysis of the force variation indicates that the system is excited by odd harmonics from 1x to 7x in case of parallel misalignment. The axial force variation is also obtained and the corresponding harmonic analysis is also performed. The amplitudes of these forces are found to be in good agreement with the derivation of Gibbons (1976).

An Orbital analysis of the misaligned rotor system is performed. Multilobed orbits, see Bloch and Geitner (1984), are obtained and presented.

A test rig consisting of two coupled Jeffcott rotors is designed and fabricated. Parallel misalignment of 0.5mm is introduced to the driven shaft and the dynamic response of the system was analyzed for the harmonic components present in it in the direction of misalignment. The orbits are found to be multilobed around the one-third critical speed region. At around the half critical speed region, *Limacon* (see Lee, 1993) shaped orbits are observed. For a more severe value of misalignment (1mm), “8” shaped orbits are observed around the half-critical speed region. The harmonic components in the direction of misalignment for the two values of parallel misalignment of the experimental rotor, the axial vibration of the disc are also reported in the paper.

The predominant radial characteristic of parallel misalignment and the predominant axial characteristic of angular misalignment are clearly identified, see Cempel and Haddad (1991). The fact that misalignment orbits are directional in nature, see Bloch and Geitner (1984) are identified and investigated. Multilobed orbits which indicate severe misalignment are obtained for severe values of misalignment around the critical speed region, see Bloch and Geitner (1984). Backward whirl was observed between the two critical speeds, see Rao (1994). The fact that minor values of misalignment give rise largely to once per revolution component of vibration (see Ehrich (1991), is also investigated and presented in the paper.

Key References

1. Bloch, H.P., and Geitner, F.K., *Practical Machinery Management for Process Plants. Volume 2, Machinery failure Analysis and Troubleshooting*, Gulf Publishing Company, 1983.
2. Cempel, C. and Haddad, S.D., *Vibroacoustic Condition Monitoring*, 1992, Ellis Horwood, England.
3. Ehrich, F.F., *Handbook of Rotor Dynamics*, McGraw-Hill, 1992.
4. Gibbons, C. B., "Coupling Misalignment Forces", *Proceedings of the Fifth Turbo-machinery Symposium*, Gas Turbine Laboratories, Texas A&M University, 1976, pp.111-116.
5. Goodwin, M.J., *Dynamics of Rotor-Bearing Systems*, Unwin Hyman Ltd, London, 1989.
6. Lee, C.W., *Vibration Analysis of Rotors*, Kluwer Academic Publications, USA, 1993.
7. Lee, Y.S., *Modelling and Vibration Analysis of Misaligned Rotor-Ball Bearing Systems*, Ph.D Thesis, KAIST, Korea, 1998.
8. Piotrowski, J., *Shaft Alignment Hand-book*, Marcel Dekker Inc, 1995.
9. Rao, J.S., *Rotor Dynamics*, John Wiley & Sons, New York, 1994.
10. Rao, J.S., *Vibratory Condition Monitoring of Machines*, CRC, Boca Raton, 2000.
11. Rao, J. S. and Sreenivas, R., Dynamic Analysis of Misaligned Rotors, Paper CP048, *VETOMAC-I*, Bangalore, 25-27 October 2000
12. Sekhar, A.S., and Prabhu, B.S., "Effect of Coupling Misalignment on Vibrations of Rotating Machinery, " *Journal of Sound and Vibration*, Vol. 185(4), 1995, pp.655-671.
13. Subbiah, R., Bhat, R.B., Sankar, T.S., and Rao, J.S., "Backward Whirl in a Simple Rotor Supported on Hydrodynamic Bearings", *Instability in Rotating Machinery, NASA Conf. Publication*, 2409, 1985, p.145.