JOURNAL BEARING VIBRATION

This section deals with plain bearings in high-speed rotating plant such as turbines and rotary compressors. It does not apply to reciprocating engines. The bearings of rotating plant include both journal and thrust bearings. In practice, only the journal bearings play a significant part in rotor vibration, and the journal bearings alone are discussed here.

Rotor vibration phenomena are complicated; the rotor, bearings and bearing supports are involved. The journal bearing oil film increases the flexibility of the system and introduces damping; but occasionally the film excites vibration, or fails to restrain unstable vibration excited elsewhere.

The most important types of vibration in which the bearings play a significant part are set out in Table 1. the conditions of occurrence and remedies suggested by experience are stated briefly. The out-of-balance vibrations which head the list are frequently experienced; the other types, which are of unstable character, are encountered less frequently. when instability is experienced, the simple remedy of changing the running condition should first be tried; Table 3 gives some suggested changes additional to the oil supply variation of Table 1. If changing the running condition is ineffective, a change in build must be tried, as indicated in Table 1.

Some bearing designs which have been found beneficial in resisting vibration are shown in Figs 1, 2 and 3. Another design sometimes found sericeable is the tilting-pad journal bearings; this has been used more in American than in British practice.

The primary precautions against vibration is good design. Table 2 sets out important design features. First-class workmanship in manufacture and erection is imperative for good running.

Operating conditions have great influence on bearing vibration. Table 3 gives information on this, with suggestions for improvement when vibration is associated with the operating condition. Attention must be paid to the vibration instruments which are provided on modern turbine installations.

Observations of vibration trouble, and of remedies found in service, should be reported to the manufacturer of the plant.

TABLE 1 TYPES OF BEARING VIBRATION				
SOURCE OF VIBRATION	**CHARACTER AND FREQUENCY RELATIVE TO SHAFT SPEED x**	**CONDITIONS OF OCCURRENCE**	**SUGGESTED REMEDY**	**REMARKS**
Out of balance (permanent)	Steady, x	Rotor out of balance or journals misaligned (with 3 or more bearings)	Re balance and check journal alignment	Some vibration usually present
Out of balance (thermal wander)	Varying amplitude, x	Thermal distortion of rotor	Improve starting and operating techniques	Mainly on rotors with high temperature inlet
Bearing (light load instability)	Irregular, less than x	Light bearing load e.g. turbine at 50 rev/s with bearing loading less than 0.4 MN/m^2 (60 lbf/in^2)	a) Vary oil supply condition b) Stabilised bearing (Fig 2)	Mainly on small turbines
Bearing (half speed whirl)	Whirl at or close to x/2	Within narrow speed range close to twice critical speed	Change critical speed of rotor	
Bearing (low frequency whirl)	Whirl at lowest critical speed, below x/2	Over wide speed range	a) Vary oil supply conditions b) Elliptical bearing (Fig 1), or three-land bearing (Fig 3)	Greatest risk when critical speed is below 0.4 x
Steam force	Whirl at lowest critical speed, below 0.65 x	Instability above certain load on turbine	a) Vary oil supply condition b) Elliptical bearing (Fig 1), or three-land bearing (Fig 3)	Mainly on HP turbine of set of high rating
Synchronous whirl	Very slow build-up of amplitude, x	May occur during starting or on change of load condition	a) Vary oil supply condition b) Shorten bearing, or (if elliptical) increase vertical clearance	Intermittent on certain sets. Sometimes mistaken for thermal wander

TABLE 2 DESIGN FEATURES AFFECTING BEARING VIBRATION	
DESIGN FEATURE	**REQUIREMENTS**
Critical speeds	No critical speed near normal running speed. No critical speed close to half running speed. Lowest critical speed above 40% of running speed when possible
Bearing design	Adopt special bearing design, as listed in Table 1, where there is risk of any type of unstable vibration. Use same bearing design at both ends of each rotor
Maintenance of bearing alignment	Design plant to ensure little or no distortion of stationary parts, either thermally or under load, which may change bearing alignment

TABLE 3 OPERATING CONDITIONS AFFECTING BEARING VIBRATION		
CONDITION	**OBSERVED VIBRATION**	**MEANS OF IMPROVEMENT**
Starting	Responds to speed or temperature change	a) Follow instructions provided b) Pass rapidly through critical speed ranges; elsewhere change running conditions slowly and steadily
Loading	Responds to load change	a) Follow instructions provided b) Change conditions slowly except in emergency
Journal bearing alignment	Responds to change	a) Examine operating conditions affecting alignment. Reduce variation if possible b) In overhaul, reset alignment allowing for variation in service
Oil supply to bearings	Responds to change in condition	a) Follow instructions provided b) Try changes in pressure and temperature of oil supply. Watch oil outlet temperature and bearing temperature

Further reading

Smith, D M Journal Bearings in Turbomachinery (Chapman & Hall, 1969)