Case History	Vibration Control of Fan by Stiffening Foundation	Rotating machinery (compressor)
Resonance		

Object Machine

Rotating machinery mounting frame for axial fan (refer to Fig.1)

Observed Phenomena

In the startup process of a rotation testing machine during fan commissioning, rotor vibrations were measured at the bearings. Within the range of the rotational3333 speed up to the rated speed, relatively large vibration peaks due to unbalance vibration appeared (Fig.2).
As this machine is of an under-critical design, there shall be no resonance peaks. The record on the rotor balancing also proves that a very precise balancing was ensured.

Cause Presumed

It is estimated that the rotor system eigenvalue was below the planned value because of weak stiffness of the foundation, as the rotor was placed not on a proper frame, but on a liquid performance test stand. That is, it is well predicted that the stiffness of a temporary stand is weak (Fig.3).

* During operation on a test frame, vibrations often occur due to insufficient stiffness.

Analysis and Data Processing

A hitting test was conducted of the fan casing, so as to determine the natural frequency and mode of the frame.
By dividing into four segments in the axial direction, deflections of the casing and of the concrete frame were checked by means of hitting tests, as a result of which such FFT frequency analysis results and vibration modes as shown in Figs.3 and 4 were obtained.

(1) The results of FFT frequency analysis prove that the eigenvalue of 25.3 Hz component obtained in the hitting test is predominant. The eigenvalue of FFT analysis agrees fairly well with the peak rotational speed of rotor vibrations. The stiffness of the frame decreases as the eigenvalue becomes below the rated speed.
(2) The vibration mode inclines to a greater extent at the floor level and at the concrete foot. The concrete frame and the casing vibrate in a rocking mode rectilinear in the height direction and also proportional to the height.
(3) Thus, it has been determined that the frame foot is weak, while the casing foot is strong.

★ Pay attention to the rotational stiffness of the foot.

Countermeasures and Results

The frame foot was reinforced by concrete.
Although the frame foot had many pipes, reinforcement was made structurally as shown in Fig.5. More specifically, at the foot of the frame, concrete was placed deep and extensively.
Consequently, as shown in Fig.6 "Result of FFT analysis", reinforcement succeeded in raising the eigenvalue up to 40.6 Hz. A rotation test conducted on the reinforced frame provided under-critical vibration response characteristics without peaks up to the rated speed (Fig.7).

Lesson Learned

Shaft vibrations of a rotor system are greatly influenced by the stiffness of concrete base, in addition to insufficient stiffness of the bearing box. It has also become clear that rotors have more resonance than expected.
For rotating machinery using plain bearings, it is necessary to provide the base stiffness much larger than the oil film stiffness.

References

Nothing in particular ★ Typical examples of countermeasures against structural system resonance such as measurement of natural frequencies and check of vibration modes

Keyword

Turbo machine, fan, rotor vibration, foundation, insufficient stiffness, reinforcement by concrete, unbalance resonance

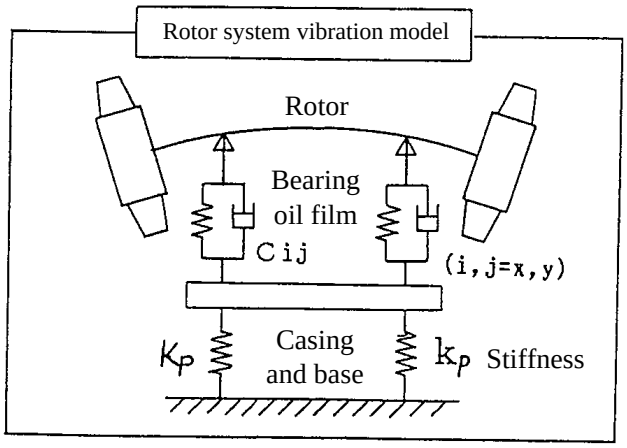


Fig.1: Model of fan and frame

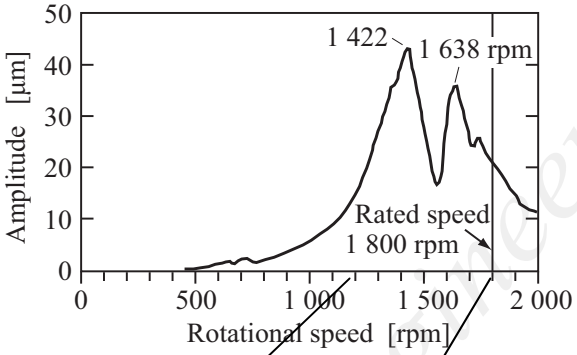
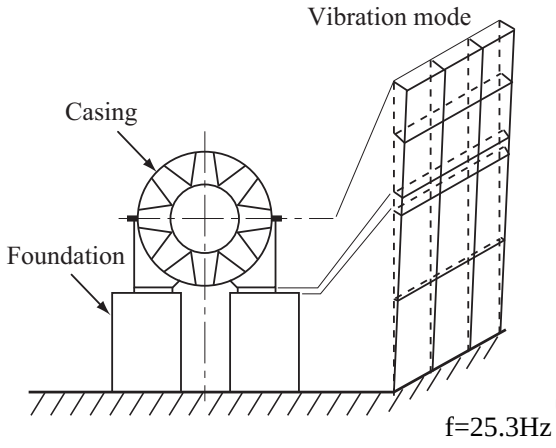


Fig.2: Journal vibration (before taking countermeasures)



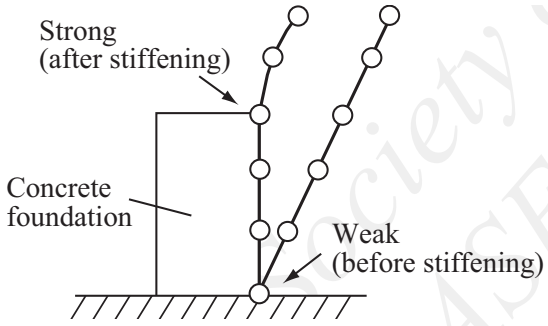


Fig.3: Fan frame and vibration model

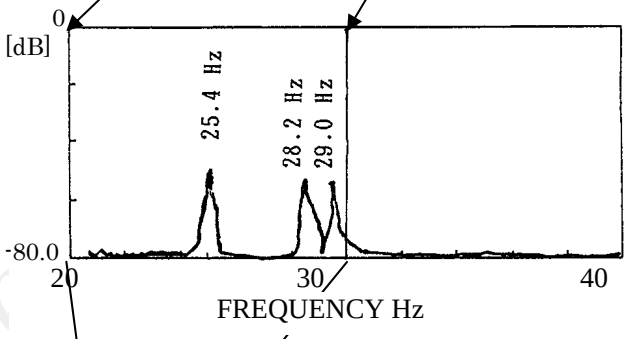


Fig.4: Result of FFT analysis

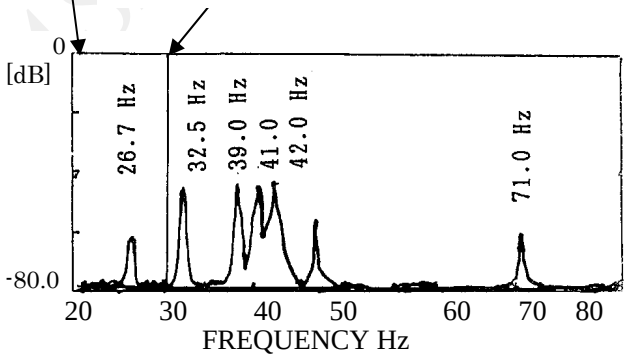
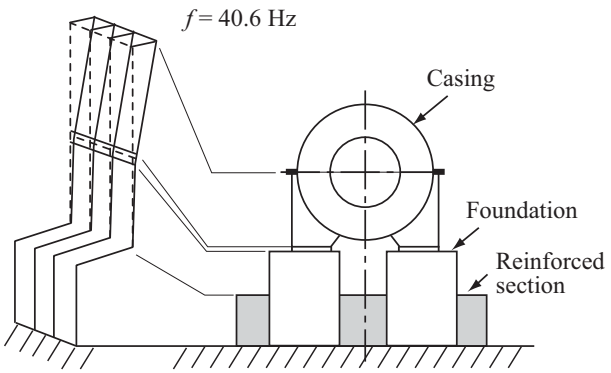


Fig.6: Result of FFT analysis

Vibration mode



f=40.6Hz

Fig.5: Reinforcement of concrete frame and vibration mode

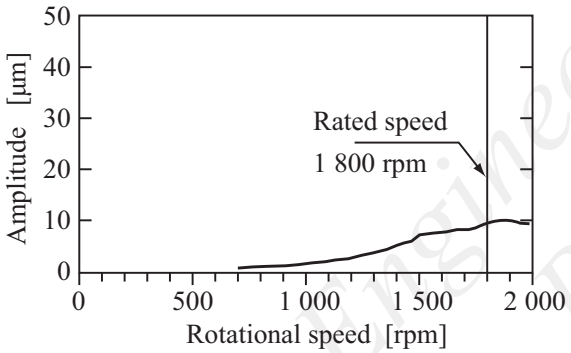


Fig.7: Journal vibration (after taking countermeasures)