Vibration Self-Excitation	Vibration due to Cavitation of Mixed Flow Pump	Rotating Machinery

Object Machine

Vertical mixed flow pump, 370min^{-1} – 6.5m^{3}/sec – 15.9m (Fig.1)

Observed Phenomena

During a large flowrate operation of a pump in the factory test, excessive vibrations (12-14mm/s-rms) in the vertical direction (shaft axial direction) and peculiar noises like a train sound were generated, but partial to rated flowrate operations experienced no problem.

Cause Estimation

- Peculiar noises called a train sound like "choo-choo" were identified.
- In the large flowrate area, excessive vibrations in the shaft axial direction with a frequency of 15 to 20Hz (non-synchronous with rotation) occurred, while this frequency varied depending on the flowrate.
- In the frequency area of this vibration, there is no natural frequency of the structural system (verified by means of FEM and impact test).

Thus, the above is assumed to be unstable vibrations due to cavitation of the pump suction portion.

Analysis and Data Processing

Fig.2 shows the frequency distribution of vibrations in the shaft axial direction of the bearing housing, where occurrence of excessive vibrations of about 17Hz was observed in the large flow area (122% Q_{opt}). Judging from the fact that the suction level was considerably lowered or the shape of the flow passage was narrowed, and the peculiar noises (with a frequency nearly equal to that of the bearing vibrations), it was thought that unstable vibrations occurred due to cavitation caused by inadequate $NPSH_a$ (Net Positive Suction Head available). Changing the flowrate caused the dominant frequency of vibrations in the axial direction changing as indicated in Fig.3, which is characteristic of unstable vibrations due to cavitation when the cavitation number changes. In this case, vibrations suddenly increased at a frequency of about 17Hz. In this connection, it is considered that resonance occurred with the natural frequency of a liquid column of the tube in the factory layout (and also in a locked-in condition).

Countermeasures and Results

[Countermeasures] The shape of a suction pump bellmouth was modified (to obtain a moderate and smooth aperture).

[Results] Area of occurrence of excessive vibrations was shifted to the large flowrate area, thus no problem at all in the operation area. Shaft-directional vibrations of the bearing housing after taking countermeasures are given in Fig.4, which clearly indicates a sharp decrease in vibrations.

Lesson

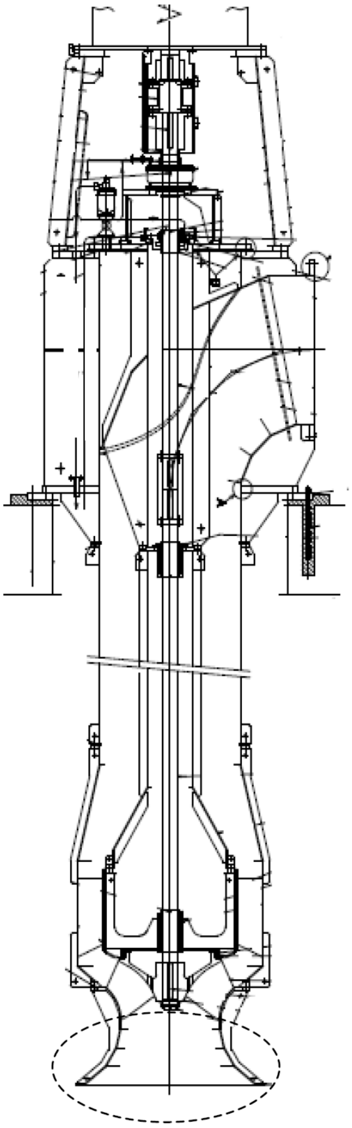
- Prior examination is essential because an unstable phenomenon of fluid involves a very high energy and dangerous
- In this case, before conducting an analysis of measurement data, the cause was nearly determined by means of observation of the phenomenon (mainly noises) at site and hearing in the field, thus effective countermeasures were established (as a matter of fact, data analysis was conducted as a proof). Complicated problems may be solved much quickly by observing the phenomena at site, rather than just looking at data.

References

Nothing in particular

Keywords

Pump, cavitation



Modification of suction flow passage for improvement

Fig.1 Vertical pump

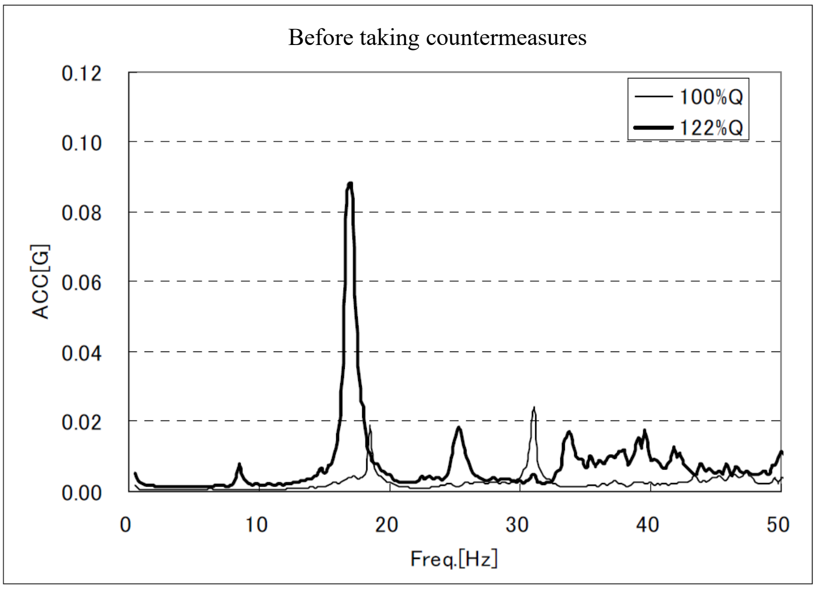


Fig.2 Vibration in the vertical direction of top bearing before taking countermeasures

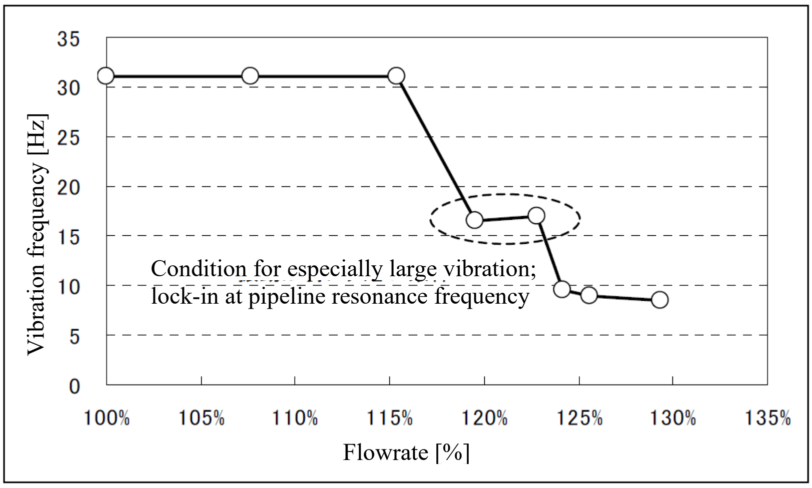


Fig.3 Relationship between dominant frequency of shaft vibration and flowrate

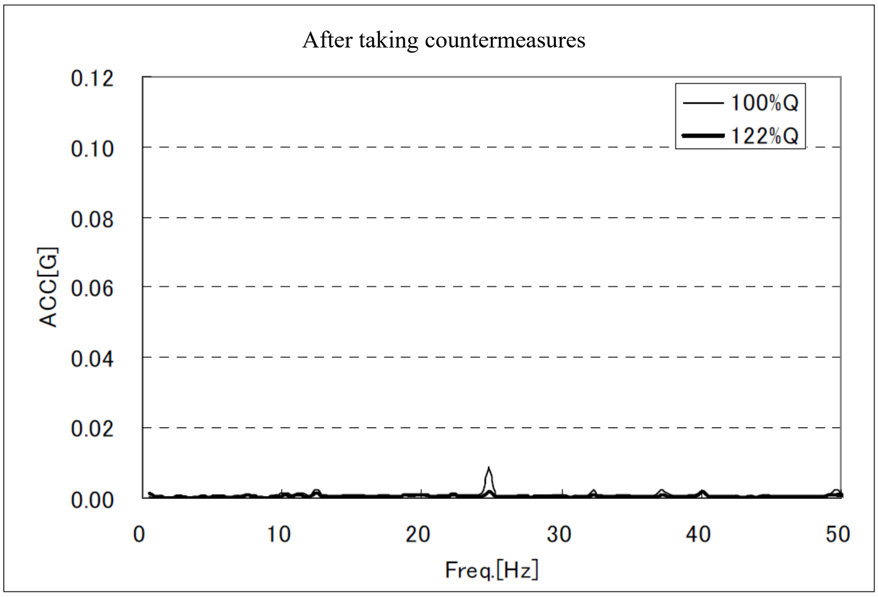


Fig.4 Vibration in the vertical direction of top bearing after taking countermeasures