Case History	Blade Passing Vibration in Horizontal Pump	Rotating machinery (pump & water turbine)
Resonance		

Object Machine

Large capacity boiler feed pump (11,000 kW) for thermal power station (Fig.1); double volute type 5-blade impeller

Observed Phenomena

During variable speed operation, the bearing box had a large vibration in a high frequency region.
The major component of the vibration was (rotational speed) × (number of blades) (Fig2, Fig.5).

Cause Presumed

Among a large number of similar pumps in actual operation, this one is the only large unit. Thus, examination was made of the conditions where excitation force of the impeller has a significant effect.

(1) Resonance of higher order of the shaft system
(2) Resonance of bearing box
(3) Excessive excitation force or excitation efficiency

Analysis and Data Processing

Investigation was made of resonance points and others through a vibration tracking analysis. As a result of shaft system vibration analysis, it was estimated that the vibration was related to a higher order vibration mode of the shaft system (Fig.3).
Based on an assumption that the mounting angle is different because this machine has a double key impeller, difference in the response in case of various combinations was examined (Table 1, Fig.4).

Countermeasures and Results

According to Table 1 and Fig.4, the impeller mounting angle was changed, which succeeded in reducing the vibration to 1/3 or less as shown in Fig.5 and Fig.6, without introducing any countermeasures for the pump.

Lesson Learned

It has been demonstrated that, as in the case of normal unbalance, modal balancing is also effective for liquid excitation force. However, precise calculation of a higher order vibration mode is not an easy task.

References

Kanki, H.; and Kawakami, T. “Reduction of Pump Vibration Applying Modal Balancing of Hydraulic Excitation”. *Proceedings of the 3rd International Conference on Rotordynamics.* IFToMM, LYON. 1990.

Keyword

Pump hydraulic force, balancing

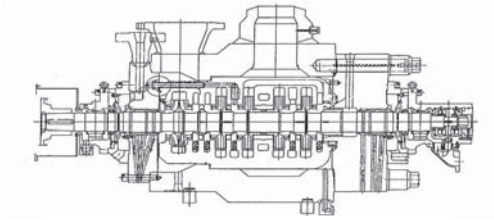


Fig.1: Tested Boiler Feed Pump

Table 1: Impeller vane angle and phase angle of exciting force

Case No.	1st	2nd	3rd	5th	4th
1	0 (0)	28.8 (144)	39.6 (198)	3.6 (18)	43.2 (216)
2	0 (0)	28.8 (144)	39.6 (198)	3.6 (18)	7.2 (36)
3	0 (0)	28.8 (144)	39.6 (198)	39.6 (198)	43.2 (216)
4	0 (0)	28.8 (144)	39.6 (198)	39.6 (198)	7.2 (36)
5	0 (0)	28.8 (144)	3.6 (18)	3.6 (18)	43.2 (216)
6	0 (0)	28.8 (144)	3.6 (18)	3.6 (18)	7.2 (36)
7	0 (0)	28.8 (144)	3.6 (18)	39.6 (198)	43.2 (216)
8	0 (0)	28.8 (144)	3.6 (18)	39.6 (198)	7.2 (36)
9	0 (0)	64.8 (324)	39.6 (198)	3.6 (18)	43.2 (216)
10	0 (0)	64.8 (324)	39.6 (198)	3.6 (18)	7.2 (36)
11	0 (0)	64.8 (324)	39.6 (198)	39.6 (198)	43.2 (216)
12	0 (0)	64.8 (324)	39.6 (198)	39.6 (198)	7.2 (36)
13	0 (0)	64.8 (324)	3.6 (18)	3.6 (18)	43.2 (216)
14	0 (0)	64.8 (324)	3.6 (18)	3.6 (18)	7.2 (36)
15	0 (0)	64.8 (324)	3.6 (18)	39.6 (198)	43.2 (216)
16	0 (0)	64.8 (324)	3.6 (18)	39.6 (198)	7.2 (36)

( ) Phase angle

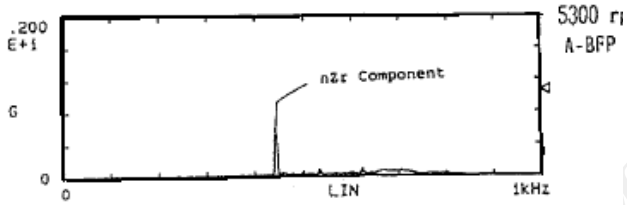
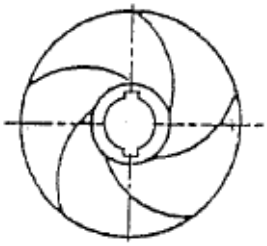


Fig.2: Typical example of vibration spectrum measured on the boiler feed pump bearing



double key

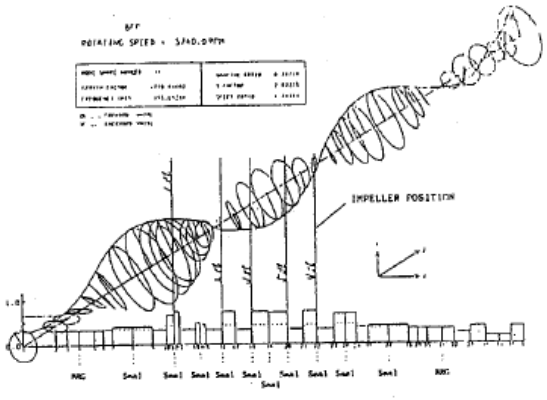


Fig.3: Typical mode shape for multistage centrifugal pump

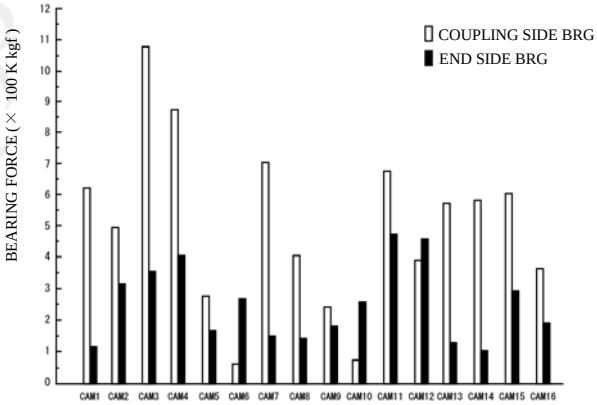
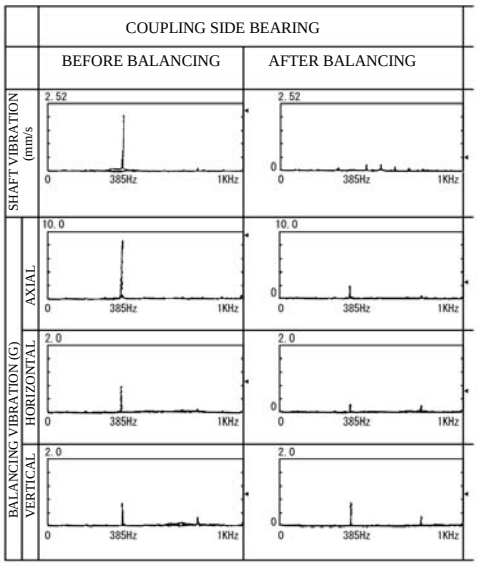


Fig.4: Calculated response on 5,740rpm for 16 cases



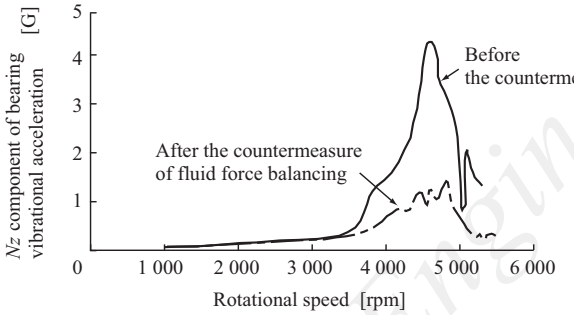


Fig.5: Measure vibration response