Case History / Self-excited Vibration	Hysteresis Whip in Gas Turbine Connected with Gear Coupling	Rotating machinery (turbine & generator)

Object Machine

Gas turbine

Observed Phenomena

Self-excited vibration

Cause Presumed

As shown in Fig.1, the gas turbine rotor is supported by rolling bearings, and is connected through intermediate shaft with gear couplings to a pinion shaft supported by journal bearings. At this shaft system, a self-excited vibration occurred as indicated in Fig.2. Immediately after passing the critical speed of the shaft system, this vibration developed. And after reaching the rated speed, the frequency was increased as the load increased.

Since this shaft system has no element as a cause of self-excited vibration other than hysteresis of the gear couplings, it seemed that the cause was hysteresis whip due to internal damping of the rotor. The phenomenon of the increase in frequency in accordance with the load is considered to have developed by the enhanced stiffness of ball bearings caused by increased thrust load applied on the gas turbine, thus resulting in increasing the natural frequency.

Analysis and data processing

Shaft vibrations were measured at the gear coupling sleeves (Point 2 in Fig.1), whose frequency and amplitude are illustrated in a Campbell diagram (Fig.2).
From this diagram, the generation process of forced vibration and self-excited vibration is readily understood.

Countermeasures and Results

As a result of replacing the gear coupling at Point 1 in Fig.1 with a diaphragm spring type coupling, the self-excited vibration completely disappeared. The gear coupling at Point 4, on the other hand, remains as it is, because the journal bearing side has an adequate damping effect.

Lesson Learned

The largest element for internal damping of the rotor is hysteresis of gear couplings. Use of a gear coupling for a damping-free shaft system requires attention to be paid.

References

Yamauchi, S. and Someya, T.: *Self-Excited Vibration of Gas-Turbine Rotor with Gear Coupling*. CIMAC, Helsinki, 1981

★ For machines operated in excess of critical speeds, the use of couplings having looseness such as gear couplings should be avoided.

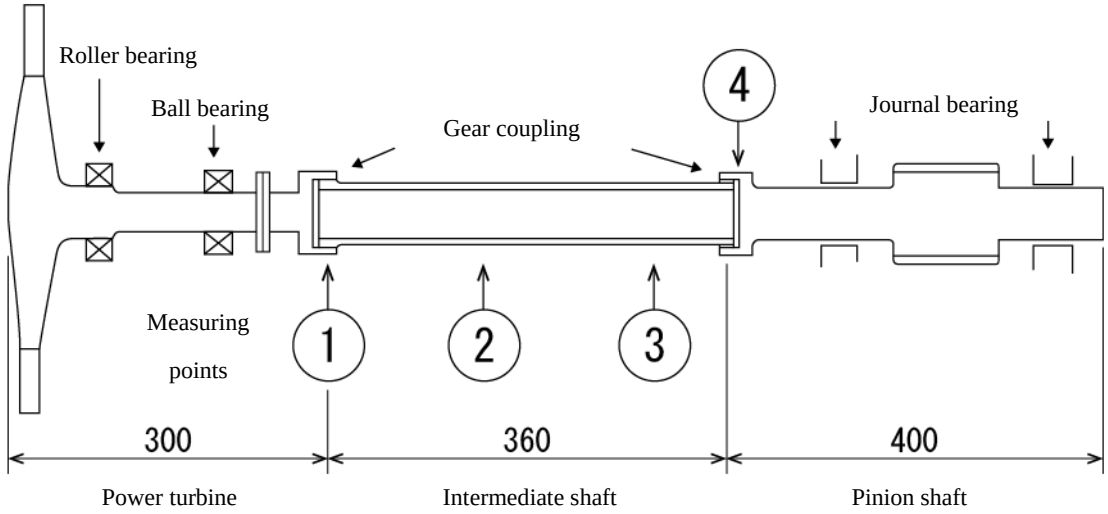

Fig.1 Gas turbine shaft system

★ It seemed that the increased natural frequency coincided with the frequency of rated rotation speed, becoming the critical speed.

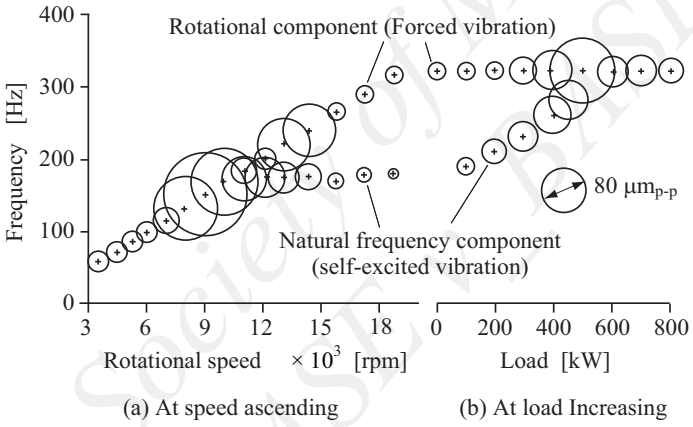

Fig.2 Campbell diagram of vibration measurements