Case History	Noises Caused by Resonance of Shaft and Gear Mesh Vibrations	Rotating Machinery
Resonance		

Object Machine

Servomotor for machine tool spindle drive

Observed Phenomena

Large noises occurred on the spindle system of a servomotor driven turret processing machine.

Cause Presumed

As shown in Fig.1, the spindle system has a gear box connected to the motor output shaft, and a tool is to be connected to the gear box. By replacing the spindle motor having large noises with a spare motor, the noises were reduced, so that combination of the servomotor and the machine was considered to be the cause. In addition, disassembling the motor having large noises proved the occurrence of a creep phenomenon on the bearing outer ring. Consequently, based on the estimation that the noises were also related to the rotor vibration, investigation was planned to check the noises and vibration as well as natural frequency of each part during operation of the motor.

Analysis and Data Processing

Fig.2 indicates variations in noise spectrum when changing the motor rotational speed, which shows that resonance appeared on NZ = 660 Hz at 1,540 rpm. Thus, in order to identify the resonating position, a hammering test was conducted to determine the natural frequency of the constitutional part. The noise spectrum during hammering of the motor shaft end is shown in Fig.3, which has proved that the shaft natural frequencies lie at 680 Hz and 780 Hz, the former being the 1st order natural frequency of the motor, while the latter representing the shaft end oscillation mode.
Judging from the above, it has become clear that the gear mesh vibration and the natural frequency of the servomotor rotor accidentally coincided to be in a resonance status, causing noises to be generated.

Countermeasures and Results

Possible countermeasures were either to change the gear engagement frequency or to change the shaft natural frequency. This time, the latter method was implemented. The shaft natural frequency varies to a great extent depending on the bearing support stiffness. Therefore, the aluminum flange was changed to a cast iron flange to enhance the fixation of the ball bearing outer rings, and also a pressurized spring was used to increase the bearing support stiffness. As a result, the rotor natural frequency increased and the resonance point within the operation range disappeared, thus solving the noise problem.

Lesson Learned

Resonance may be a problem even for a rotating body having a high natural frequency that requires no consideration for shaft critical speed.

References

Nothing in particular

Keyword

Gear mesh vibration, resonance

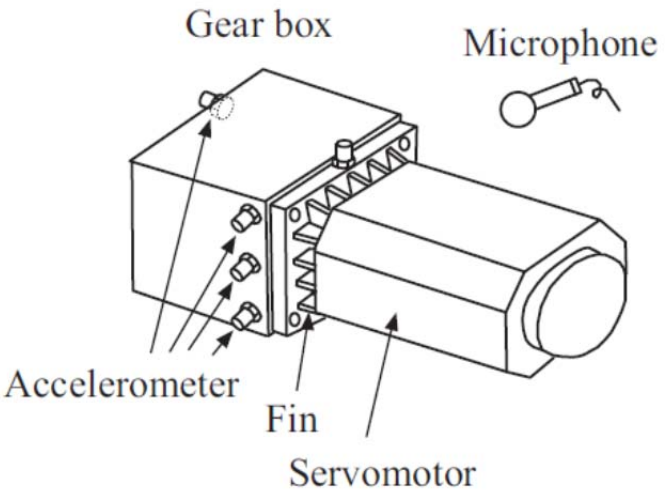
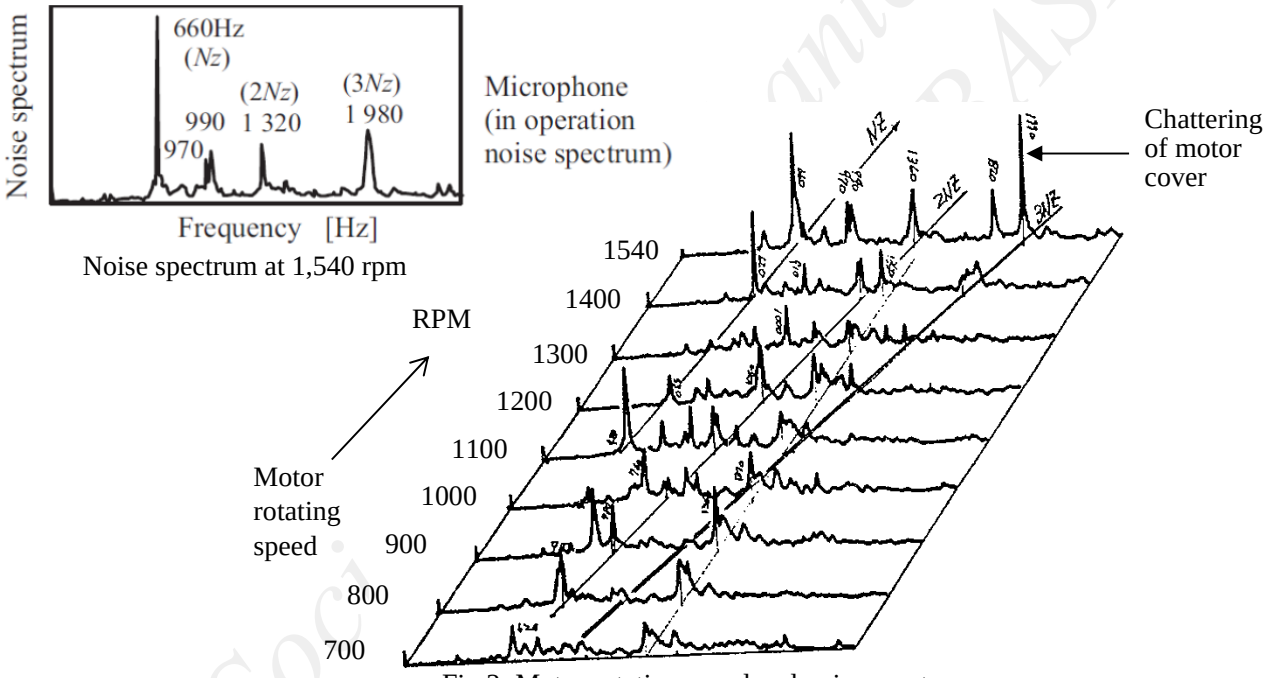


Fig.1: Servomotor and gear box



Noise spectrum at 1,540 rpm

Fig.2: Motor rotating speed and noise spectrum

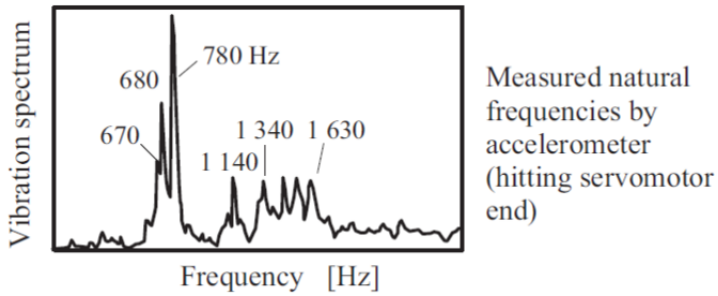


Fig.3: Noise spectrum during hammering of the motor shaft end