Case History	Torsional Vibration of Diesel Engine Generator System	Transportation machinery
Forced Vibration		

Object Machine	Diesel engine generator system (Fig.1) 1,000 kW, 720 rpm

Observed Phenomena

This system was installed as an emergency power source for a plant. After installed, this system was operated 5 to 6 times a month as a power source to construct the plant itself. Seven months later, a large vibration and noise suddenly occurred, and the system would not operate any more. When overhauled and inspected, the generator rotor was found fractured. The fracture surface showed the shell patterns typical of fatigue failure.

Cause Presumed

The dominant frequency of time-varying torque of the engine increases with increasing shaft speed and also the cylinder number due to fluctuating gas pressure in each cylinder, while the engine shaft system has its own natural frequency of torsional vibration. On the other hand, when starting up the engine system, the dominant frequency of the exciting torque normally passes the natural frequency of the torsional shaft vibration before the rated speed is reached. Consequently, torsional resonance of shaft takes place each time start up. The fracture is presumed to have occurred due to excessive amplitudes of torsional shaft vibration repeated at the resonance point larger than estimated at design stage.

Analysis and Data Processing

Figure 2 shows the variation of shaft torque with time, measured by means of FM telemeter system when starting up another system identical to the fractured one. The maximum torque amplitude reads five times that of the rated torque at the resonance frequency of 61 Hz and at the shaft speed of 600 rpm. Figure 3 shows the calculated results of the first and the second natural frequencies and corresponding vibration modes. Consequently, the torsional resonance takes place when the 6 *n* frequency (*n*: rotational frequency) of the excitation torque agrees with the first natural frequency of the torsional vibration.
Figure 4 shows the calculated variation of torque while increasing shaft speed passes the resonance point. Both of the amplitude and configuration of the envelope waveform in Fig.4 are fairly in good agreement with the measurements in Fig.3.

Countermeasures and Results

Figure 5 shows the sectional view of a silicon oil torsional damper attached to the shaft end of the diesel engine. The optimal viscosity of the oil was selected based on the simulation of damper performance. Figure 6 shows the simulation result of the varying torque with the damper being installed, resulting in the reduction of the torque at the resonance by 45%.
No similar problems have recurred during the eight years since the damper was installed.

Lesson Learned

Diesel engine generator systems are progressively so designed as to increase power output, operate at higher speed and attain further downsizing, resulting in smaller shaft diameter and higher excitation torque. Consequently, conventional design method cannot serve the purpose, while the simulation technologies described are useful to obtain more reliable design solutions.

References

Sasaki, et al. 1981. *Vibration Design Guideline for Vessels*: Nippon Kaiji Kyokai (October 15, 1981)

Keyword

Diesel engine, torsional vibration, generator, torsional damper, simulation

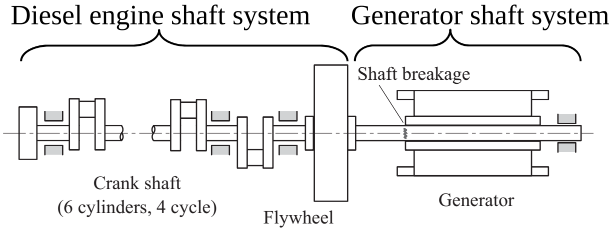

Fig.1: Diesel engine generator system

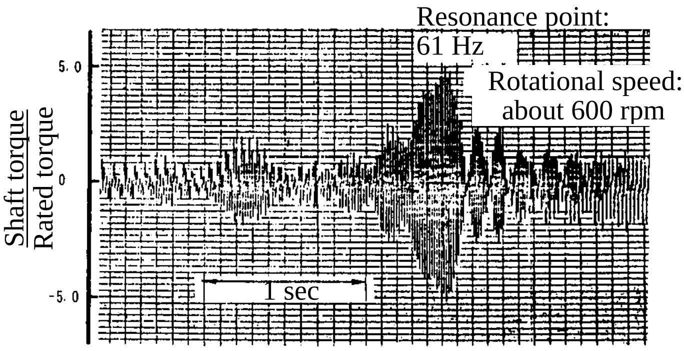

Fig.2: Result of shaft torque measurement during startup

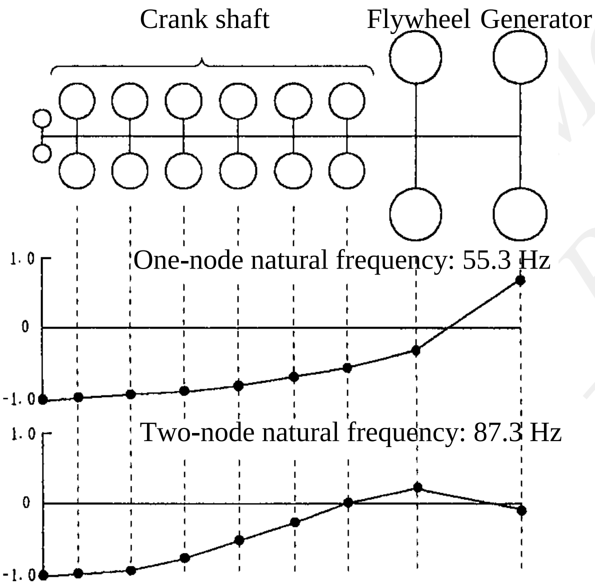

Fig.3: Torsional natural frequency and vibration mode (calculated value)

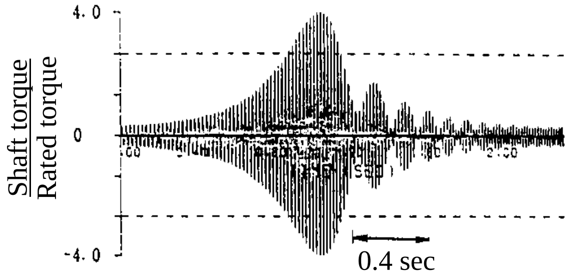

Fig.4: Result of simulation when passing the resonance point

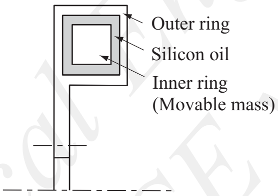

Fig.5: Construction of silicone damper

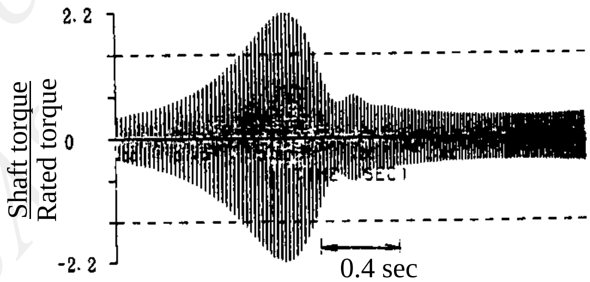

Fig.6: Result of simulation when mounting a silicone damper