Case History	Thermally Induced Bending Vibration of Gas Compressor	Rotating machinery (compressor)
Forced Vibration		

Object Machine

A gas compressor (140 kW, 4,500 m^3/h, rated rotating speed of 11,400 rpm) for unloading vaporized gas of LNG

Observed Phenomena

The compressor suddenly made an emergency stop during operation around the rated shaft speed due to the pressure drop of sealant gas N_2 in the seal. When the gas pressure returned to normal 10 minutes later and the compressor restarted, both suction and discharge piping were found to vibrate with increasing amplitude at shaft speeds above 5,000 rpm, limiting operation at shaft speed under 5,000 rpm. When the compressor was overhauled, the rotor was found to have bent plastically, as shown in Fig.1, resulting in contact with the casing surface.

Cause Presumed

The temperature of vaporized gas of LNG is normally around -100°C. Assuming that the ambient air of about 30°C entered the seal due to pressure drop of N_2, the rotor surface in the seal could have been partially exposed to the temperature difference of 130°C instantly, which may have caused thermal bending of the rotor.

Analysis and Data Processing

(1) An analysis of the original rotor vibration characteristic resulted in no significant problems.
(2) When part of the room-temperature rotor was exposed to liquid nitrogen deliberately, measured bending of the rotor was found to be sufficient enough to account for the phenomenon observed.

Countermeasures and Results

The sequence of emergency stop procedure was modified in order to prevent the ambient air from entering the seal even when the pressure of N_2 seal gas drops. No such phenomenon has recurred since then.

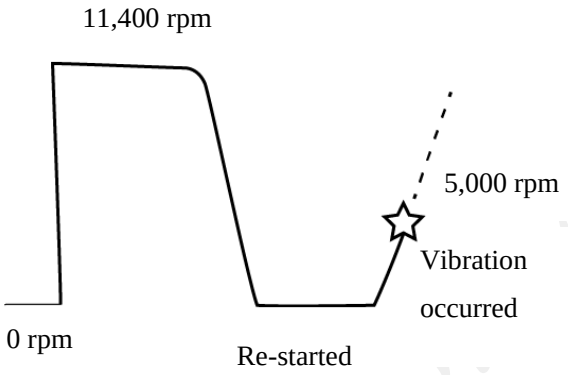
Lesson Learned

Hot rotor kept at standstill is well known to often bend thermally. Furthermore, it need be noticed that thermally induced bending may take place when a cold rotor is exposed partially to the hot ambient air.

Keyword

Forced vibration, thermally induced bending, gas compressor

★ If the thermal bending does not exceed the elasticity limit, the bending will disappear eventually. But if a large temperature difference occurs very rapidly, plastic deformation will take place. In such case, the bending will remain as a permanent deflection eventually.



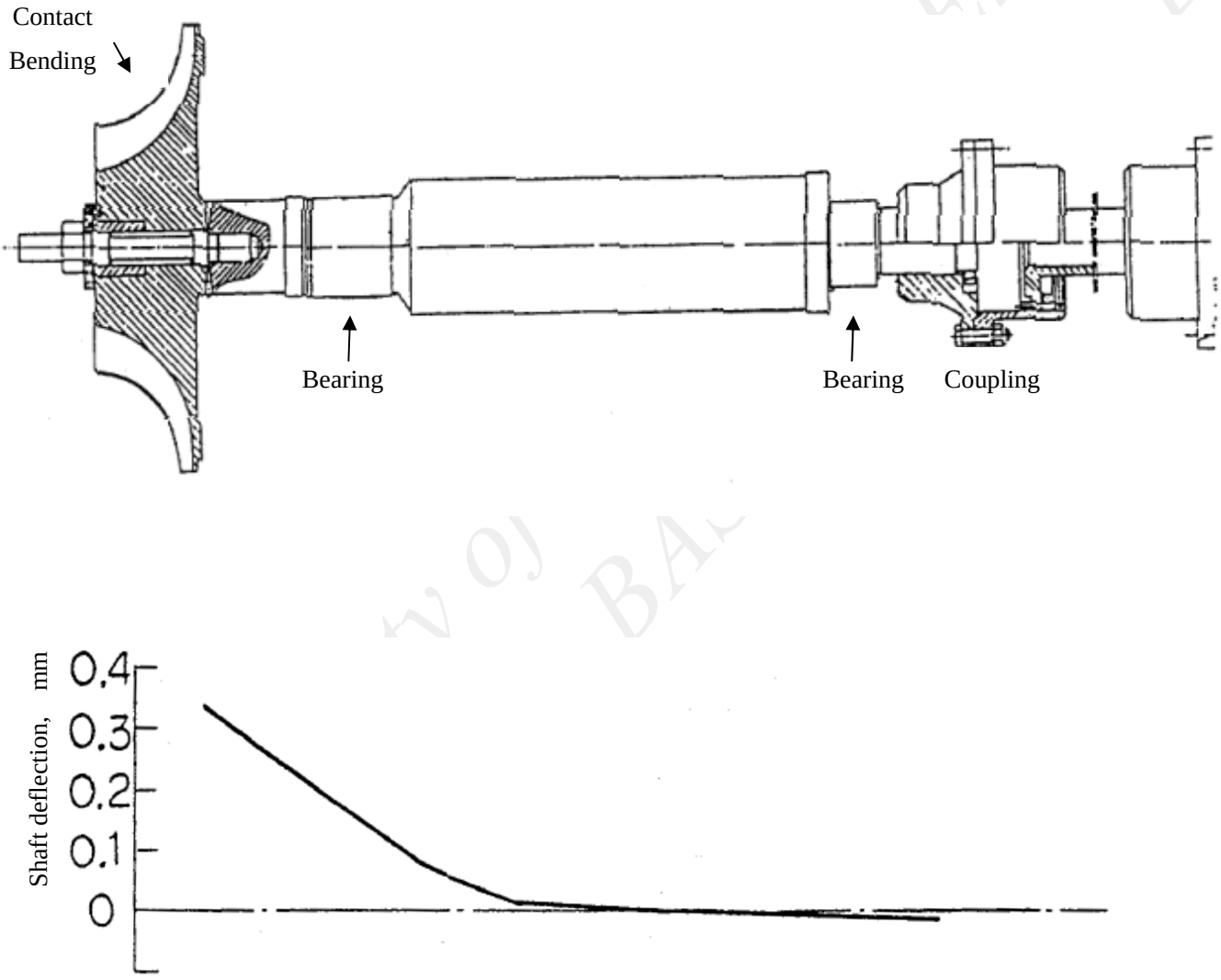


Fig.1: Measured plastic bent of gas compressor shaft