Vibration Resonance	Vibration of Belt-driven Roots Blower	Rotating Machinery

Object Machine

Roots blower driven by four V belts (three lobes, refer to Fig.1), 45kW, rotational speed a little less than 30Hz

Observed Phenomena

From the roots blower bearing mechanical seal, oil leakage occurred (1cc/hr, standard: 4cc/day or less). Examinations revealed that the blower main body had large vibrations, and that increasing vibrations caused the amount of leakage oil to be remarkable. Vibration measurement indicated that the major frequency was 33.8Hz, with a half amplitude of 50μm0-P, which reached twice the permissible value specified by the blower manufacturer (Fig.2).

Cause Estimation

Vibration frequencies varied according to the rotational speed. Since self-aligning type roller bearing are used, the vibration frequencies that occurred on the roller bearings was checked, but there was no agreement. The major component of vibrations corresponded to the frequency originating from the pulley belt.

Analysis and Data Processing

As the resolution of data frequency was rough, the exact rotational speed of the blower N was predicted from 12th higher harmonic of the rotational speed in Table 1. Assuming that N = 356.3/12 = 29.69Hz, diameter of the blower side pulley d = 220mm (value on the drawing), rotational speed of the motor N_m = 25Hz, the diameter of the motor side pulley D was assumed to be 261.3mm. Center distance between the large and small pulleys W = 840mm, thus the total length of belt $L \approx 2W + \pi d/2 + \pi D/2$ = 2,436mm. The belt rotating frequency f is obtained by pulley circumferential length (πd)/belt length (L) × rotational speed (N). This frequency is also called a belt joint (discontinuity of stiffness) passing frequency. As the harmonics of this frequency normally appears, a frequency to occur by the blet is given by Equation (1). The fundamental frequency (n = 1) in this case was 8.42Hz.

$$f = n\frac{\pi d}{L}N \qquad (n = 1, 2, 3, 4\cdots) \qquad (1)$$

Although joints in the four belt-construction could not be visually observed at all, reviewing the frequency analysis (Table 1) from the above viewpoint proved that higher harmonic components of the joint passage frequencies (belt frequencies) were remarkable, while the remaining were integer-multiple of the rotational speed of the blower.
Hammering in the vertical direction of the common base for blower installation resulted in a strong response of a 37Hz natural frequency on the anti-drive side base, which is close to the major component of vibrations of 33.8Hz (4th of belt frequency).

Countermeasures and Results

Blower installation bolts are overhung and fixed on the flange portion (horizontal plate) of the channel (refer to Fig.3a). With an intention of increasing the stiffness (stiffening) of the common base, temporary ribs were inserted between the top and the bottom flanges, and moreover, the gap beneath the base channel was filled with mortar (Fig.3b). Consequently, the natural frequency was raised to 55.2Hz, and the half amplitude of vibrations was 10μm0-P (mainly 16.9Hz component). After confirming that the installation of ribs posed no problem, the ribs were welded as a countermeasure. As for the oil leakage from the mechanical seal, the amount of oil leakage of 0cc for nine days was confirmed, thus this problem was also settled.

Lesson

Belt-driven machines always involve vibrations of a belt rotation frequency, to which attention shall be paid.

References

Nothing in particular.

Keywords

V belt, pulley, channel, common base, rib stiffening, belt rotation frequency

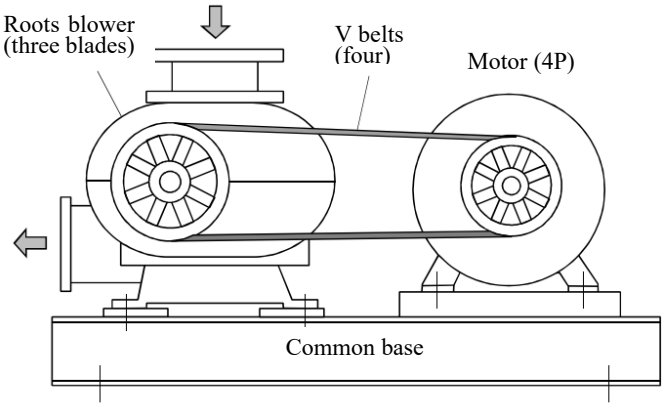


Fig.1 Belt-driven roots blower

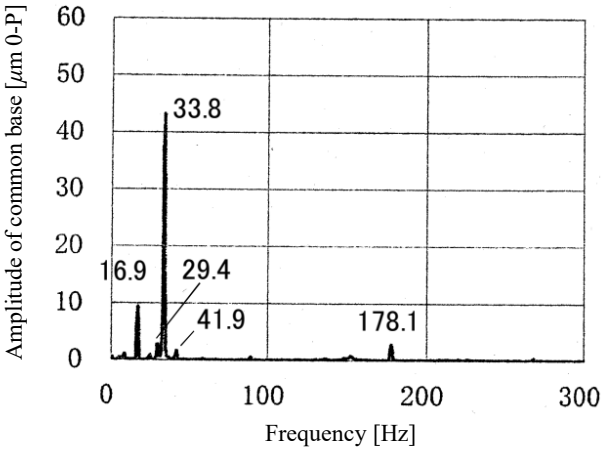
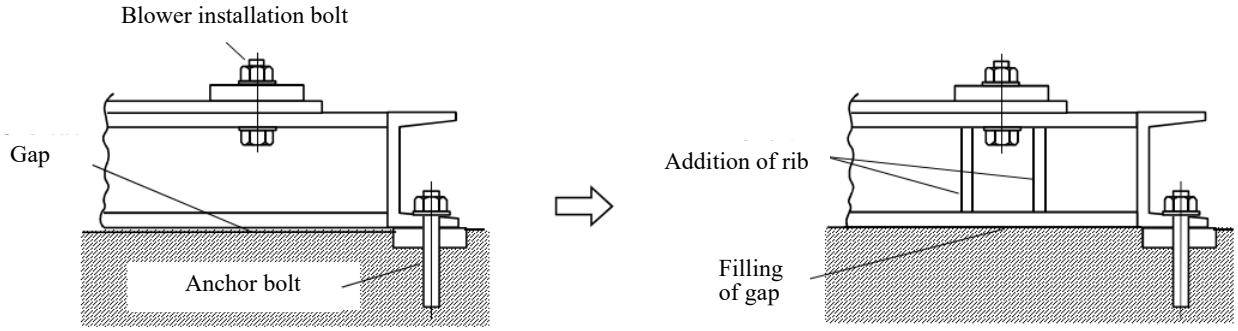


Fig.2 Vibration of common base

	Measured frequency [Hz]	Amplitude [μm 0-P]	Phenomenon
1	33.8	43.3	4 times the belt frequency
2	16.9	9.5	2 times the belt frequency
3	178.1	2.9	6 times the rotational speed
4	29.4	2.8	rotational speed
5	41.9	1.7	5 times the belt frequency
6	8.4	1.2	fundamental belt frequency
7	25.0	0.9	3 times the belt frequency
8	356.3	0.9	12 times the rotational speed
9	152.5	0.8	18 times the belt frequency
10	89.4	0.6	3 times the rotational speed

Table 1 Measured frequencies and their phenomena



(a) Before taking countermeasures

(b) After taking countermeasures

Fig.3 Stiffening of common base (additional ribs on the blower installation position + filling of gap under channel)