Noise / Resonance	Abnormal Dominant Noise Occurred from Surface Washer of Filter Basin	Plant

Object Machine

Surface washer (piping: diameter 1 or 2 inches, length about 2m, 4 nozzles with φ6 and 7 holes)

Observed Phenomena

A filter basin of the water purification plant has a construction with the cross-section view as shown in Fig.1. The surface washer periodically cleans the surface of a sand layer located on the uppermost part of the filter layers, that is, water jet flow is blown out of the nozzles to the surface of the sand layer under water, so as to remove clogging of the sand layer. When washing, abnormal noise with the spectrum as shown in Fig.2 occurred. The noise level in the air about 1.5m above the water surface was about 85dB(A). As shown in Fig.3, each branch pipe has four nozzles in per one tube and several dozens of these branch pipes are installed, so that there are several hundreds of nozzles in one basin. One time surface washing finishes in several minutes, but the purification plant consists of a large number of such basins, so that very harsh noises occur from any of these basins, day and night.

Cause Estimation

Pulsations of nozzle jet flows resonates with bending vibrations of the branch pipes or with liquid columns in the branch pipes.

Analysis and Data Processing

After measurement in field as shown in Fig.3, it was proven that radiation noises were caused by underwater sounds in the basins from the spectrum of a hydrophone noise shown in Fig.4. A spectrum obtained from the vibration acceleration sensors mounted at the end of branch pipes was similar to that of the underwater sounds, and also confirmation was made from the phase relationships among several sensors that there was no resonance with bending vibrations of branch pipes. It was thus assumed that liquid column resonance happened in the branch pipes. Acoustic mode analysis conducted for branch pipes using the general-purpose acoustic analysis software (SYSNOISE) proved the existence of the 1.5 and 3 resonance mode waves in the branch pipes around 1,400Hz and 2,900Hz (refer to Fig.5). On the other hand, detailed measurements were conducted to examine the mechanism of abnormal noise generation by installing one actual branch pipe in a testing water tank. These measurements revealed that, as shown in Fig.6, the frequency of vortex rings emitted from the nozzle hole as a sound source is proportional to the discharge speed for the same nozzle diameter, and that St falls in the range of 0.40 to 0.59 and 0.78 to 1.02, respectively. It was also verified that the above depends to a great extent on the liquid column resonance of the piping system. Pressure variations due to discharge of vortex from the nozzles are amplified by resonance, resulting in the radiation of dominant noises.

Countermeasures and Results

Since a big modification of piping dimensions is impracticable, countermeasures against abnormal noise was considered mainly sound sources. Nozzles as a sound source is a precise casting, having seven holes in total on the bottom (one) and the sides (six). These holes of the current nozzles have a tapered shape on both the outer and inner sides. As a result of test using several kinds of prototype nozzles, nozzles having tapered holes only on the inner side have been adopted, as they are effective in restricting the emission of vortex rings. Fig.7 shows the cross-section view of the currently used nozzle and the improved one, while on Fig.8, noise spectrum is given that was obtained during washing after installing the improved nozzles on actual filter basins.

Lesson

Even a vortex flow coming from a small hole may produce abnormal noises if resonance occurs when they are installed in a large number. Adequate modification of resonance conditions of a fluid piping system by controlling part of flow may be effective in avoiding the occurrence of such noises.

References

Maruta et al., Proceedings of the Japan Society of Mechanical Engineers, No.920-60, pp51-54; Minorikawa et al., Ebara Engineering Review, No.177, pp.9-15

Keywords

Fluid self-excited sound, liquid column resonance, dominant sound, noise, orifice sound, water purification plant, surface washer, jet flow, low Reynolds number, emission of vortex rings, acoustic field analysis

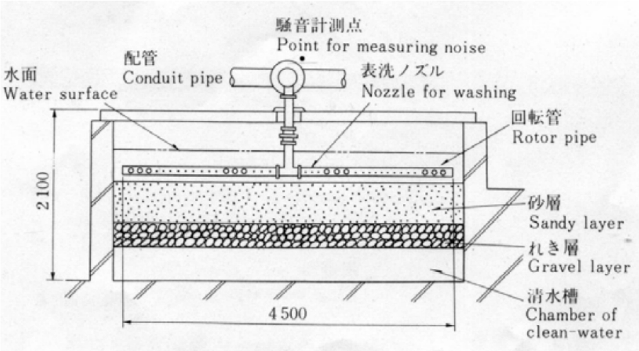

Fig.1 General arrangement of the filter basin for the water purification plant

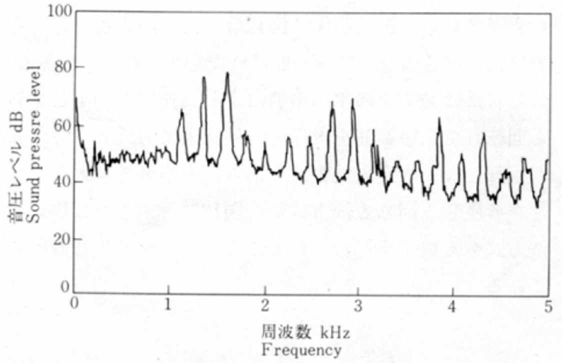

Fig.2 Spectrum of radiation sound during surface washing

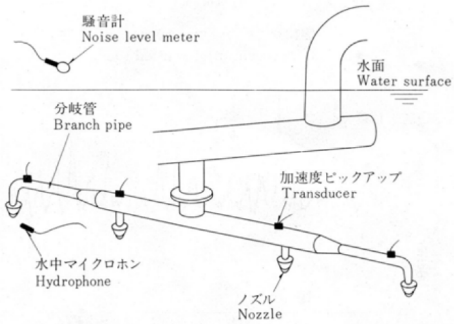

Fig.3 Overview of measurement of abnormal noise from surface washer nozzle

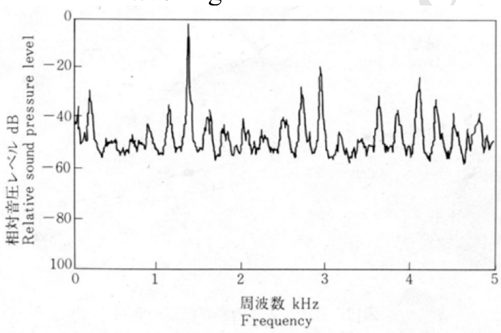

Fig.4 Noise spectrum of hydrophone

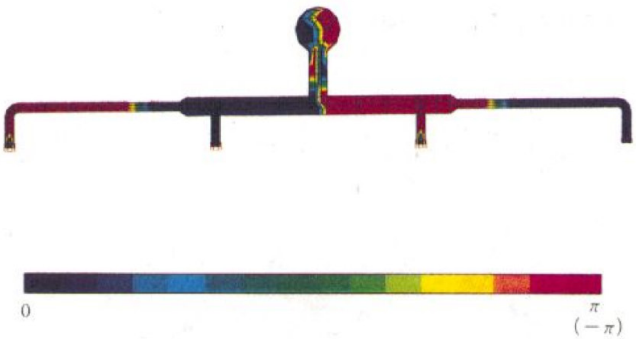

Fig.5 Acoustic mode inside a branch pipe near 1,400Hz (sound pressure and phase distribution)

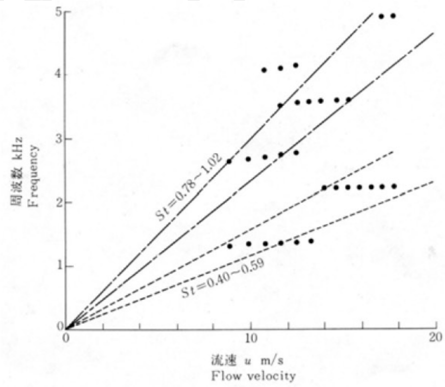

Fig.6 Relationship between noise emission speed and dominant frequency

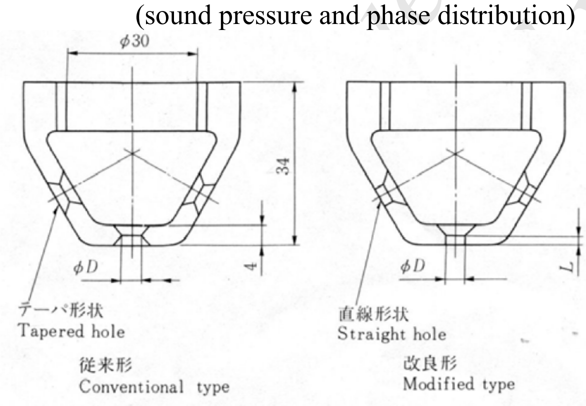

Fig.7 Cross-section shape of surface washer nozzle

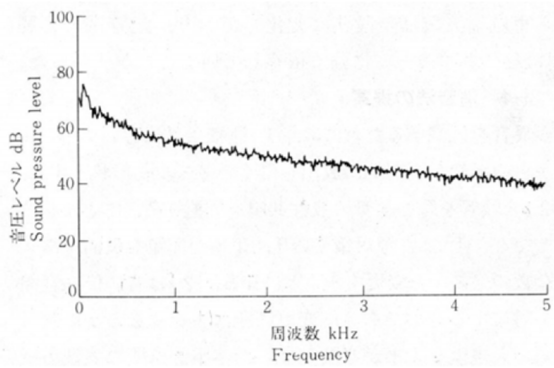

Fig.8 Spectrum of radiation sound after taking abnormal noise measures