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YOKOHAMA-JAPAN,AUGUST29-31

EXPERIMENTAL STUDY ON VIBRATION PROPAGATION IN WATER PIPING SYSTEM CONNECTED WITH PUMP

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INTRODUCTION

The structure-borne noise caused by water piping systems connected with pumps influences on the sound environments in rooms of hotels and apartment houses etc. where in silent environment is required. But, the date about the vibration power and the vibration propagation etc. in piping systems are insufficient, and so it is difficult to predict and cntrol of the structure-borne noise quantitatively. It is necessary to make clear the characteristics of vibration in piping systems at first.

In the water piping systems connected with pumps, the pump vibration propagates both through the pipe wall and in the water, and so it is necessary to investigate the propagation about the vibration of pipe wall and sound in water in a piping system connected with a pump were carried out. In this paper these results are described.

MEASUREMENT

The piping system connected with a pump adopted in this investigation is composed as shown in Fig.1. The pump (mother output power:3kw) is able to change the revolution number (water flow speed). Vibration acceleration level (dB re 1E-5m/sec) of pipe wall and sound pressure level (dB re 2E-5N/ m²) in water are measured at each condition of the pump operation as shown in Table 1.

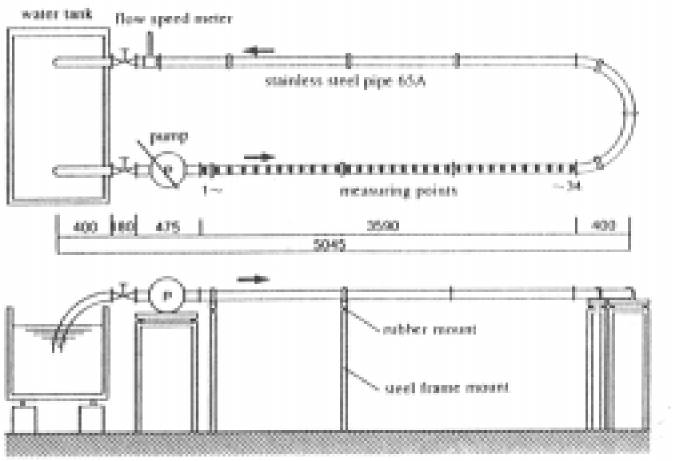

Fig.1 The experimental arrangements for piping system connected with pump.

EXPERIMENTAL RESULTS

[1]Characteristics of pipe wall vibration and sound in water

Power specta of the pipe wall vibration and the sound in water obtained by pump operation and hammer excitation on the pipe wall are shown in Fig.2. From this result, the followings are shown.

a) The vibration and sound are distinguished at the revolution number fn, fn by 6 [number of impeller blades] and these frequencies by 2" [n:ninteger number] .
b) The pipe wall vibration by the pump operation is also distinguished at the frequencies distinguished by hammer excitation. So it is supposed that the pipe wall vibration generated by pump operation is influenced by the natural vibration characteristics of the piping system.
c) On the other hand, it is supposed that the characteristics of the sound in water is decided almost by the characteristics of the pump's own vibration.

Table 1. Measuring condition of the pump

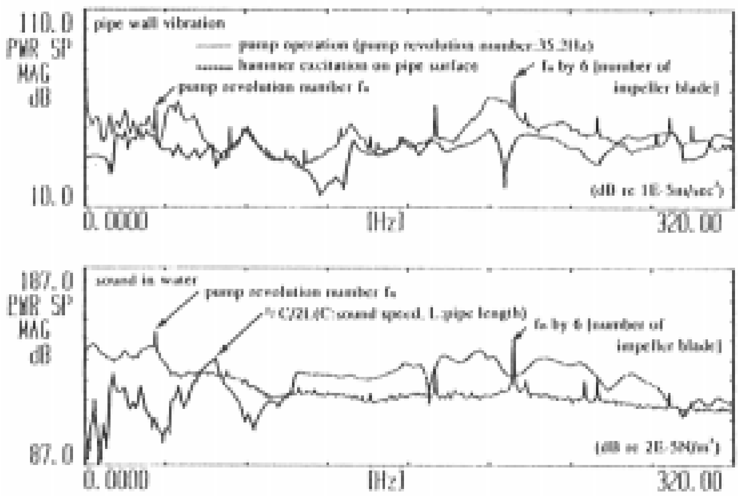

Fig.2 Power spectra of pipe wall vibration and sound in water (measuring point 23)

[2] Characteristics of pipe wall vibration obtained by variation of pump revolution

The pipe wall vibrations obtained by six kinds of pump revolution are shown in Fig.3. The pipe wall vibration is distinguished at same frequencies for each revolution condition as shown at 200Hz. Figure 4 shows the pipe wall vibration normalized by pump revolution number fn. The vibrations at all revolution coditions are not necessarily distinguished at the fn and by 6. So it is supposed that the characteristics of pipe wall vibration are influenced mainly by the natural vibration characteristics of the piping system.

[3] Characteristics of sound in water obtained by variation of pump revolution

The sounds in water obtained by six kinds of pump revolution are shown in Fig.5. The sound in water is not distinguished at same frequencies for each revolution condition.

The sounds in water normalized by pump revolution number fn are shown in Fing.6. It is accuracy that the sounds are distinguished at fn by 6 for each pump revolution condition. So the influence of the pump's own vibration characteristics is prominent at sound in water.

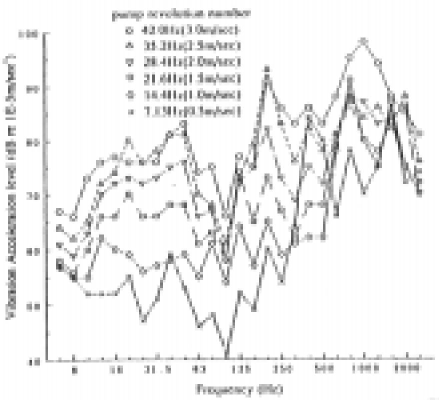

Fig. 3 Pipe wall vibration obtaind by six kinds of pump revolution (measuring point 23)

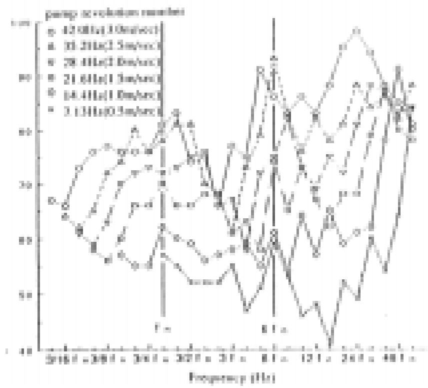

Fig. 4 Pipe wall vibration obtaind by six kinds of pump revolution (normalized by pump revolution number fn, measuring point 23)

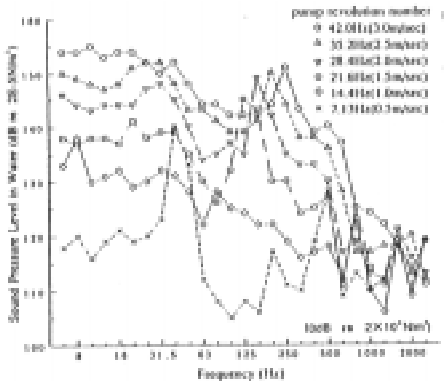

Fig. 5 Sound pressure in water obtaind by six kinds of pump revolution (measuring point 23)

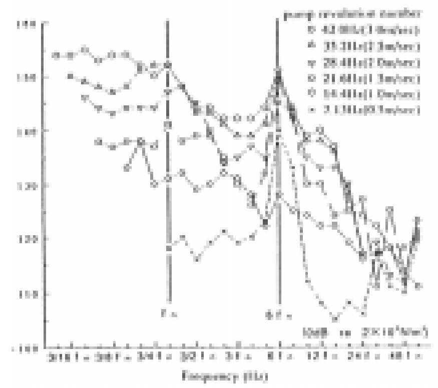

Fig. 6 Sound pressure in water obtaind by six kinds of pump revolution (normalized by pump revolution number fn, measuring point 23)

[4] Dependence of pump revolution at pipe wall vibration and sound in water

The variations of the pipe wall vibration and the sound in water obtained by six kinds of pump revolution are shown in Fig.7. Vibration and sound for pump revolution number fn and fn by 6 are plotted against pump revolution number. It is shown that both the vibration and the sound increase similarly according to the increase of pump revolution number. The general tendencies correspond to the slope of 12dB/twice pump revolution number.

[5] Comparison of pipe wall vibration and sound in water

To investigate the correspondence of the pipe wall vibration and the sound in water, sound pressure level in water is converted into acceleration level. Figure 8 shows the comparison of frequency characteristics. It is shown that the pipe wall level and the water level in water are in agreement at specific frequencies, but in general the latter is larger than the former.

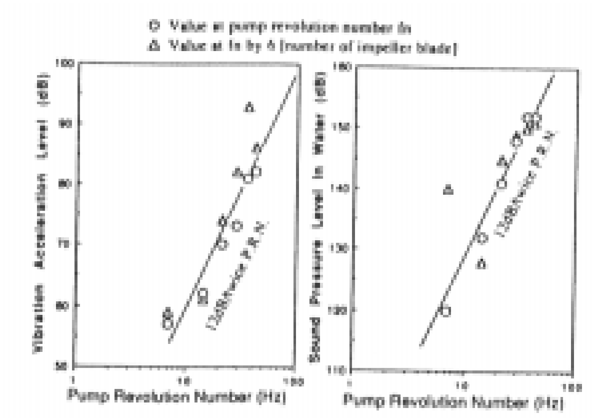

Fig. 7 Dependence of pump revolution at pipe wall vibration and sound in water.

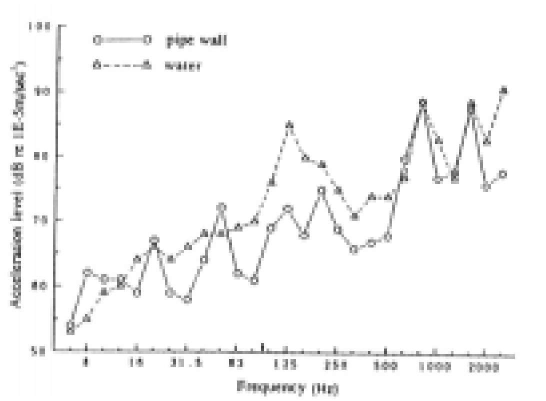

Fig. 8 Comparison of pipe wall vibration and sound in water (average value of total measuring points, pump revolution number 21.6Hz)

Figure 9 shows the comparison of distribution of the pipe wall vibration and the sound in water in axial direction at the distinguished frequencies. From this result the followings are shown.

a) The pipe wall vibrations distribute irregularly at each frequency. It is supposed that these distributions are caused by the natural vibration modes of piping system.

b) The values of sound in water is almost constant at each position at the lower range than the frequency (=125Hz) at which the wave length is equal to the pipe length. At the higher frequency range the values distribute irregularly. The distribution profiles are different from the pipe wall's one.

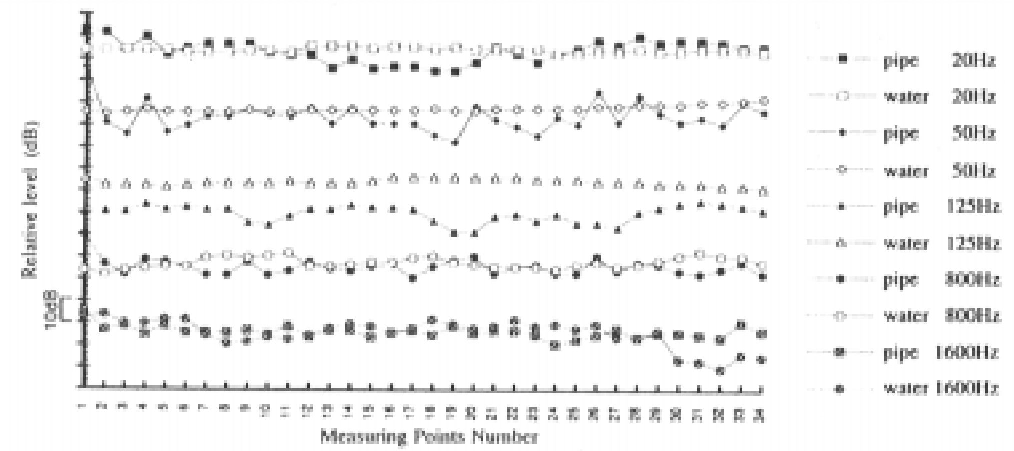

Fig. 9 Comparison of distribution of pipe wall vibration and sound in water in axial direction (pump revolution number 21.6Hz)

CONCLUSIONS

From our investigations the followings are concluded.

1) The characteristics of the pipe wall vibration generated by the pump are influenced mainly by the natural vibration characteristics of the piping system.

2) The characteristics of the sound in water generated by the pump are influenced mainly by the characteristics of pump's own vibration.

3) Both characteristics are not so much influenced mutually.

REFFERENCES

[1] E.J.Richards, National Physical Laboratory Symposium 1961, No.12, Paper B-3(1963)