A Study on the Vibration Characteristics of Piping through Vibration Test for Small-bore Pipes

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1. Introduction

Piping system plays a very important role in the power plant sector as well as in nuclear power. The piping systems take part in transporting the fluid to various components inside the power plant, and if it breaks down, it will create crucial influences in terms of operability. Piping system is to be heavily influenced by the surrounding environment due to their closest accessibility to plant components and facilities. Partially, it is very vulnerable to the vibrations generated by the movements of the components and the fluids. Such vibrations come up to be one of the critical threats to the integrity of the piping. [1~3] When it comes to the welded pipes, especially, micro-cracking due to fatigue can occur, along with high risks to grow into the scale undermining the integrity of the piping. The incidents of rupturing of small-bore piping welds have been being reported more often than not. In the case of offshore nuclear plants, most of the fatigue failures used to be reported as the ruptures on the welds of the small-bore pipes owing to high cycle vibration fatigue. [4~5]

As such, the pipe welding itself has very contradictory relations when to say in terms of its economy and safety, specifically speaking, highly cost saving at the price of the safety. Irrespective of the controversies, it has been put to use even for safety-grade piping due to its high conveniences. However, the studies have been done in the focus on the ruptures due to poor welding, incomplete penetration, etc. in most cases, while those for fatigue failure due to vibration fall still far short.

In this study, the test specimens of various pipe types have been fabricated so as to carry out the resonance frequency vibration tests, whose test results were quantitatively evaluated. In a way to check out the variations of resonant frequencies, the vibration characteristics of pipes depending on the deficiencies have been analyzed. In the future, such vibration characteristics of pipes are going to be utilized for the development of vibration monitoring system.

2. Vibration Test

2.1. Vibration specimen

In order to analyze the vibration characteristics of pipes, the specimens were prepared according to the shape of the pipe. As a startup of the test, firstly, cracks were machined on the flat test specimens to observe what influences to be inflicted on the resonant frequencies in the event of the occurrence of cracking. The cracks were made to have a constant size and resonant frequency has been checked up one by one. For the secondary test specimen, two flat plates were butt welded. And the defect was machined uniformly in the horizontal direction on the welded part. The third test specimen was welded to the extent of 180°~ 315° in order to identify the extreme influence of weld defects in the actual pipe. The fourth test specimen was welded according to the shape of the pipe. The shape was Cantilever type and Complex type, respectively, and defects were machined in the welds after welding.

Table 1 Butt welding specimen specification

No.	Weight(g)	Defective shape
1	371	Depth(mm) _0.35, 0.7, 1.0, 1.4
2	495	Depth(mm) _0.35, 0.7, 1.2, 1.5, 2.0
3	724~728	Degree _180˚, 225˚, 270˚, 315˚
4	1,065 ~ 2,108	Shape _Cantilever, Complex

2.2. Vibration testing devices

The test devices put to use in this paper are configured as shown in Fig. 1. They comprise a shaker device, a non-contact speed sensor, a contactable acceleration sensor, and a signal analyzer. Non-contact speed sensor can be used in remote and special environments, and contactable acceleration sensor is intended to add up reliability to the data by measuring the vibration of the actual test specimen. The vibration signal analyzer can convert the analog signal coming from the test specimen into digital signal through FFT conversion, and confirm the amplitude with respect to the frequency.

2.3. Test method

The vibration test was carried out with reference to the standard of KS C 0240, and the resonance frequency range before and after cracking was confirmed and recorded in the evaluation paper.

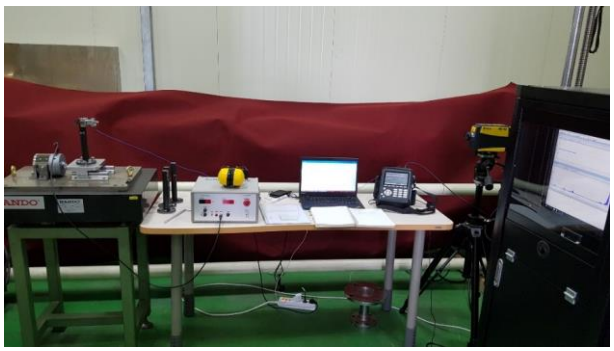

Fig. 1 Picture of Vibration test equipment

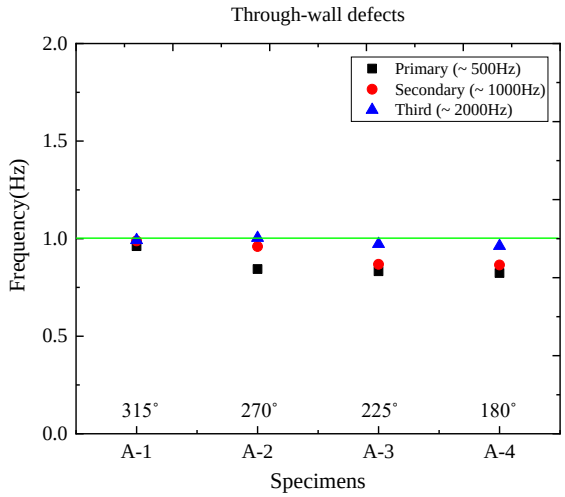

Fig. 2 vibration test result (through-wall defects)

Four kinds of defective specimens were fixed to shaker at constant force. Then, a sine wave test was carried out. The frequency used ranged 100 ~ 2,000 Hz, and the frequency was input with regular intervals, making use of the equipment controller. The variations of resonance frequencies were recorded by each specimen and the frequencies and range band were quantitatively sorted out.

3. Conclusions

In order to analyze the vibration characteristics of pipes, vibration tests were carried out using the flat type test specimen of the basic test specimen, and the actual pipe test specimen taking into consideration the actual pipe shape. From the test results, the following conclusions were drawn.

1) If a defect exists, the influences at resonance frequency were shown, which came to be significantly different depending on the depth and size.

2) If the direction of the defect is the same as that of vibration, it influences more greatly.

3) If the size of the defect progressed over 40% of the thickness of the test specimen, a new resonance frequency range below the average took place.

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