A Study of Active Control Method of Pipeline System

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Abstract: In this paper, the active control of the vibration of the pipeline was investigated using the test method. And an active control system with certain control algorithm is designed based on the Piezoelectric Effect of Piezoelectric. A closed-loop control has been made at the energy concentration mode of this liquid infusion pipeline, which has two fixed ends. The results show that the active control system has a good reduction effect on the vibration of the pipeline.

Key-Words: *Active control, Piezoelectric ceramics, Vibration, Pipeline*

1. Introduction

As we all known, liquid-filled pipeline systems exist in many fields, such as marine engineering, biological engineering, electrical industry, petroleum energy industry, nuclear industry, warships, aircraft device and daily life [1]. However, because of the effects of multi-physics, multi-scale and fluid-structure interaction (FSI), the vibration characteristics of the pipeline system is not only complex, but also harmful [2]. More seriously, with the pressure of pipeline system increases, high-pressure pipeline will have severe hydraulic shock. The resulting vibration can cause pipeline damage, fracture or even other more serious consequences. Therefore, it is necessary for us to analyze and study the vibration control method of pipeline system.

2. The principle of active control

The active control means adding some actuators in the controlled object system and adjust the output of the actuator by the control algorithm, so that the output of the actuator and the vibration of the controlled device are offset, so as to achieve the purpose of reducing vibration [3]. Active vibration control system mainly consists of sensors, controllers and actuators. And it has the advantage of active adaptability and rapid response, and the process of controlling is more direct and effective.

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The principle of active control test is shown in Figure 1. Two groups of piezoelectric ceramics are pasted in the middle of the tube. A group of piezoelectric ceramics is used as a piezoelectric sensor, and the other group is used as a piezoelectric ceramic actuator. Using the electromagnetic vibration table for pipeline vibration, the vibration frequency will be measured by piezoelectric ceramic sensor. Amplitude and phase information will be collected and sent to the piezoelectric ceramic controller (PCC). The PCC will outputs the inversion control signal of the same frequency with the vibration signal of the pipeline .So that the piezoelectric ceramic actuator can produce power acting on the pipeline. Thus the active control of the pipeline system can be achieved.

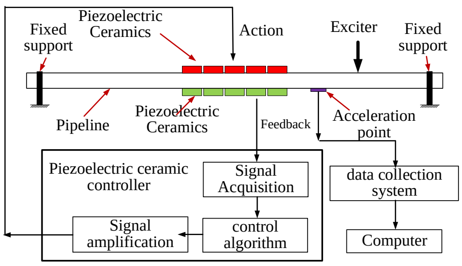


Figure 1 The principle diagram of the test

3. Result and analysis

The test system consists of pipeline system, electro-magnetic shaker, acceleration sensor, piezoelectric ceramic controller, NI acquisition box, signal acquisition software and other components. The test system is shown in Figure 2.

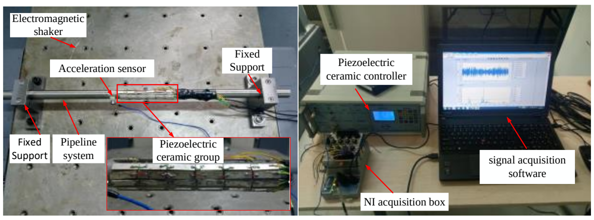
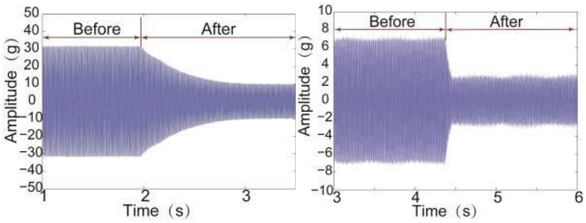


Figure 2 The diagram of test system

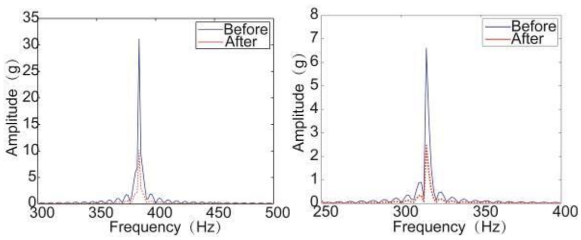
At first, we can use the finite element analysis software to calculate the modes of the fixed support pipeline at both ends. According to the analysis, the first mode bending frequency of the pipeline is 386Hz with the energy concentrated. Similarly, under the cantilever condition bending frequency is 316Hz with energy concentrated in the second order.

And then, a constant frequency excitation of 386Hz was performed using an electromagnetic shaker at an energy of 0.2 g, and then, the acceleration sensors are used to acquire and compare the vibration acceleration values before and after the control. The time domain diagram of acceleration signal of controlling process is shown in Figure 3. The frequency domain diagram of controlling before and after is shown in Figure 4.



a .Fixed at both ends condition b. cantilever condition

Figure 3 The time domain diagram of acceleration signal



a .Fixed at both ends condition b. cantilever condition

Figure 4 The frequency domain diagram of acceleration signal

Extract its vibration amplitude, we obtain the amplitude comparison before and after control shown in Table 1

Table 1. Amplitude Comparison of Controlling

Boundary conditions	time	Amplitude (g)	degree of declining
Fixed at both ends	Before control	31.14	67.5%
	After control	10.12	
Cantilever condition	Before control	6.588	62.5%
	After control	2.468	

From the table, we can see that under the condition of both ends fixed, the value of amplitude decreases from 31.14g to 10.12g with a decreasing range of 67.5%. the value of amplitude decreases from 31.14g to 10.12g with a decreasing range of 67.5% under cantilever condition.

4. Conclusion

In this experiment, a set of active control system was established with the piezoelectric effect of piezoelectric ceramics. Through the test and analysis, we can draw some conclusions following:

(1) Under the condition of pipeline fixed at both end or cantilever, the active control system of the pipeline have both good damping effects.

(2) It is feasible to use the piezoelectric ceramics for active control. The vibration reduction effect is remarkable. This will provide a new method for the future active control of pipeline.

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