Non-Destructive Evaluation of Water Flow Conditions in Deteriorated Pipeline using Acoustic Emission Method

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Abstract

For the effective evaluation of hydraulic conditions of pipeline system, it is necessary to evaluate not only steady flow parameters but also unsteady flow conditions. In this study, quantitative evaluation of water flow performance is going to be performed, applying acoustic emission (AE) and image analysis in pipeline. The AE generation behavior is correlated with water head loss in flow conditions. Using AE parameter analysis, a relationship different water head loss conditions and flow characteristics is correlated. By monitoring AE waves based on these results, the improved water flow condition is successfully evaluated by AE.

Keywords: Pipeline, Water Flow, Non-destructive inspection, Acoustic emission

1. Introduction

In service pipeline systems, non-destructive monitoring of flow conditions in pipeline system is the most important maintenance for optimum management [1-2]. Deterioration of pipeline systems often results in overt-through degradation of water-tightness or water leak phenomena caused by reduction of water flow performance [3-5]. For effective maintenance and management, non-destructive testing method need to be developed, because pipeline system is installed underground and the damage cannot be checked visually in service. In recent researches, it was reported that elastic wave method (e.g. acoustic emission, ultrasonic) is effective for evaluation of water-flow conditions in pipeline system [6-10]. The acoustic emission method is passive technique for detection of elastic wave from civil structures [11]. In this study, AE method is applied to be detecting a flow conditions in inner improved pipeline. This paper reports quantitative method for evaluation of flow conditions in pipeline system using AE parameter analysis.
2. Non-destructive identification of flow characteristics in pipeline system

2.1 AE Monitoring Procedure

AE monitoring was applied to be detecting a flow conditions in two type experiments which were composed inner improved pipeline (Case 1) and normal pipeline (Case 2). The laboratory model test was conducted to model pipeline system (L=15m, Photos 1 to 3) which was made by acrylic pipe of 100mm diameter. A velocity of water flow was 0.0 to 2.5m/s. The water flow signals were detected by AE. AE events generated under water flow in model pipeline were counted up to end of flowing process by AE processor (SAMOS; PAC). AE sensor of 150 kHz resonance was attached at surface of the model pipeline. AE monitoring conducted with 6-channel system was employed (Ch1-Ch6). For event counting, the threshold level was set to 40dB, and total amplification was 60dB. In Ch.1, AE monitoring was conducted with image analysis. The flow form in pipeline was inspected with image analysis by high speed camera.

Photo 1. Test set up for AE and image analysis in model pipeline system
Photo 2. Outflow section in model pipeline system (triangular weir)

Photo 3. Overview of model pipeline system
3. Results and discussion

3.1 Detected AE waves

The simulated flow conditions are composed 2 types (Case1 improved flow condition, Case 2 non-improved flow condition). The AE monitoring was applied to pipeline system, continuous type AE waves were detected when improved flow conditions in pipeline system which was monitored low amplification in Case 1. On the other hand, Case 2 was detected high amplitude AE which was caused by high energy loss in inner pipeline.

3.2 Quantitative evaluation of flow conditions by AE parameter analysis

The improved flow conditions in each monitoring site are evaluated by AE parameters. A typical relation between AE parameter and water velocity is shown in Figures 1 and 2. The cumulative AE hits are low at a low velocity conditions in Case 1. On the other hand in Case 2, high AE hit rate were detected same flow conditions in Case 1. This phenomenon is affected by water head loss in inner flow conditions. Figure 3 shows characteristics of water flow conditions. A relationship between AE parameters and water velocity in Case 1 is similar to that of water flow parameter C. These results are suggested that the AE generation behavior may be a key factor for the energy loss of water flow conditions in pipeline, while the cumulative AE hits is really sensitive to it. This is because detected AE waves are affected by existing water flow form (Figure 4), which is reflected inner roughness of pipe material.
Figure 2. Relation between water velocity and cumulative RMS

Figure 3. Characteristics of water flow parameter
Figure 4. Detected water flow images
4. Conclusion

In this study, the acoustic emission (AE) method was applied to evaluation of flow conditions in inner improved pipeline. The analytical results show that improved flow conditions in pipeline system could be quantitatively evaluated by AE parameters. As for the relationship AE hit rate, RMS and hydraulic conditions are evaluated. To conclude, evaluation of improved flow could be quantitatively evaluated through NDT monitoring using acoustic emission method.

References
