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Leak detection, experimental and theoretical comparison of characteristics of transient flow in polyethylene pipelines

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ABSTRACT: Polyethylene pipes are widely used in pressurized water systems. In the design and interpretation of the ram-trapped signal for diagnostic purposes, viscoelastic behavior of polyethylene tubes should be taken into account. The aim of this study is to detect leakage, and experimental and theoretical comparison of pressure wave velocity and over pressure of transient flow in polyethylene pipes with different Reynolds number. To achieve the objectives of this paper, a physical model was developed in laboratory of the Faculty of Water Sciences Engineering of Shahid Chamran University of Ahwaz and developed two different models of control and a leakage system was and were conducted a number of water-hammer tests. The leakage accuracy in this model increased with increase of Reynolds number. The highest and the lowest percent of the relative error for computational and experimental leakage were estimated 48.8% and 2.02% through a leak hole of 5 mm for experiments with Reynolds numbers of 1283 and 12974, respectively. Also, this inaccurate study shows the relationship between the theory of compressive velocity and overpressure in the polyethylene transfer pipes, so that the compressive velocity obtained from theoretical relationships is less than its actual value, as well as the relative error of the overpressure in leakage experiments Increasing the Reynolds number increases between the amount of the laboratory and the theory.

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1-Introduction

Water is one of the natural resources that is not possible without that life. Water losses in distribution and transmission systems are one of the main problems not only in developing countries but also globally[1] Which occurs due to various reasons such as burnout, corrosion of pipes, interruptions, occurrence of the ram shock phenomenon, drifts, landings, etc., which is called non-accounted water (UFW) [2]. In some cases, leakage can be accompanied by the outflow of heavy water, resulting in damage to ground-based and underground facilities, including roads, buildings, vehicles and other infrastructures; therefore, the determination And leakage control is one of the most important and complex issues in the engineering of water supply systems. Different definitions of leakage are given, most commonly known as the amount of water released from uncontrolled elements [3]. Covas et al. (2004 and 2005) showed that mechanical behavior and viscoelasticity of polyethylene pipes cause a significant decrease in the fluctuations of the transient flow pressure and increase the scattering of compressive waves[4-5].Huang et al. (2015), in order to determine the location of leakage in the pipelines and the elastic water supply network, experiments on the water supply network were carried out in three different scenarios, in each scenario, the leakage location and extent was different [6]. The purpose of this study was to investigate and compare the experimental and theoretical compressive wave velocity and transient flow overload in polyethylene transfer pipes in different Reynolds to detect and locate leakage in polyethylene transfer pipelines.

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2-Methodology

To achieve the objectives of this paper, a laboratory model was constructed at the Hydraulic Lab of the Faculty of Science and Water Engineering of Shahid Chamran University of Ahwaz. This model is made up of a 45-meter-wide water-pressure headed reservoir, disconnected and plug-in pipe and polyethylene tube with specification, external diameter 63 mm, length 158 m, wall thickness of 6.5 mm, Young's modulus 1.43 Giga-Pascal and Poisson 0.46 ratio was made. Experiments were conducted at different rates to create different Reynolds in the system. To create a flowmeter, a disconnect and disconnect valve with a closing capability of 0.2 seconds was installed linearly at the end of the pipe.

Also, to measure the discharge of the ultrasonic discharge, a data logger was used to record the data related to the pressure close to the valve. Disconnecting and connecting the flow during the creation of the flowmeter. To mitigate the noise the data extracted by the data logger filtered them using the MATLAB program and then analyzed. The experiments carried out in this study were conducted as control tests and experiments with 5, 6, and 7 mm leakage diameters in 5 different Reynolds (Re) and a leakage distance of 117.4 m from the reservoir, which is the data of the control experiments in Table 1.

Table 1. Calibration in Different Flows

Test name	Q (Lit/s)	(H_0) tank's head (m)	Re
1	0.05	45	1261
2	0.25	45	6306
3	0.5	45	12613
4	0.75	45	18919
5	1	45	25225

3-Results and Discussion

The five and one Reynolds have the highest and lowest overpressure, respectively, and in all Reynolds, the test has a higher overpressure than leakage experiments. This overload is due to the fact that the flow rate of the outlet from the pipe when the flow is transient to The reason for the valve closure is zero and due to the decrease in the flow rate, the drop in pressure decreases and the pressure increases along the tube, and when the overpressure of the ram moves through the duct and reaches the leak point, some pressure is due to leakage With a larger discharge (according to the aperture relationship), it is removed from the steady state, and the ejection It does not create excess pressure, the larger the size of the leak, the less pressure buildup.

3-1- To obtain the leakage gap from the end of the tube and compare it with the laboratory value:

The transient current signal in the case of a leakage tube exhibits a unique effect that does not exist in a healthy tube, and this effect is related to the input of the signal in the leakage station at the measuring station. Also, transient flow signals in the leakage system will be deprecated sooner. In Figure 1, having the start time of leakage, we can obtain the leakage distance from the pressure measurement location (in this study, the back of the cutoff and flow coupling) using the t = 2L / a relationship. Where t is the time of the sweep of the wave to the point of the leakage effect, L is the leakage distance and a compressive wave velocity. The maximum and minimum percent of the relative error is related to the 5 mm leak diameter, which is respectively a slow flow (Reynolds 1283) with a relative error of 48.8% and Reynolds 12974 with a relative error of 2.02%.

According to Figure 2, with the increase of the Reynolds number in the different leakage diameters, the relative error of the calculated leakage calculation is reduced, with a low percentage of relative error in Reynolds and a relative error percentage in the Reynolds, as well as by increasing the Reynolds number, the relative error in diameter Different leaks converge.

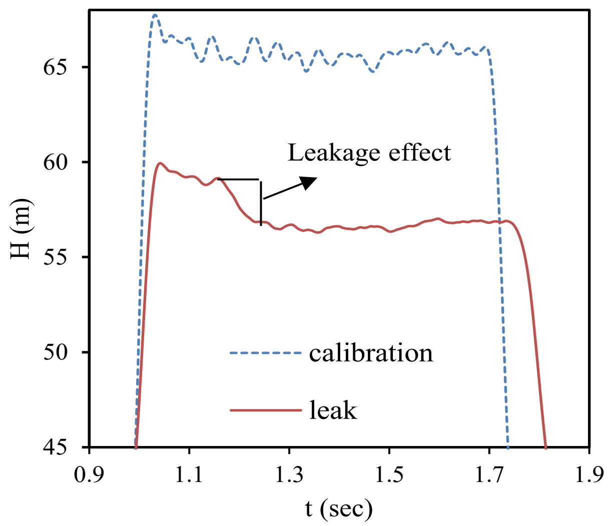

Figure 1. Comparison of Transient Flow Signal Signals in a Healthy Pipeline with Viscoelastic Tubing Leakage

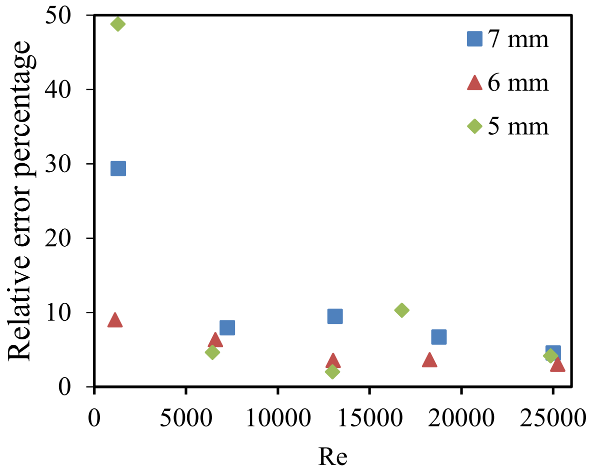

Figure 2. The relative error of computational and laboratory leakage distances in different Reynolds at three leaks of 5, 6 and 7 mm

3-2- Laboratory Pulse Comparison with Its Theoretical Quantity

There is a difference between theoretical and laboratory overload pressure, which is lower in the control tests than in the presence of leakage experiments. In leakage experiments, with increasing Reynolds number, the relative error of this parameter increases between the amount of the laboratory and the theory. This indicates that the relationship between the over pressure theory and the viscoelastic tube has a low accuracy, and in the presence of leakage in the model, this fact is more apparent.

3-3- Percentage loss of excess pressure in the transmission system in the presence of leakage and control:

Percent loss of excess pressure is:

$$\text{Percent loss} = ((\Delta H_t - \Delta H_l) / \Delta H_t) \times 100 \qquad (1)$$

Where ΔHt is the amount of excess pressure in the control test and ΔHl is the amount of excess pressure in the leak test. According to Figure 3, with increasing Reynolds number, the loss of overpressure model increases in the presence of leakage compared to the non-leakage model. The percentage of loss of overpressure in the 7 mm leakage with the highest Reynolds increases and the 5 mm leakage has the lowest rate of variation, which indicates that increasing the leakage diameter increases the percentage of loss of excess pressure. A remarkable point in this diagram is that in the Reynolds, a difference in the percentage of loss of excess pressure between the leaks is high, but with a Reynolds increase, this difference is reduced, so that in the Reynolds, the difference is five. This indicates that with increasing Reynolds number, the percentage of loss of excess pressure is dependent on the leakage diameter.

4-Conclusions

As the leak diameter increases, a lower pressure is observed in the compressive wave crust. Also, by increasing the Reynolds number, the increase in excess pressure and the relative error of the leakage site in the different leakage diameters decreases. This study showed that the compressive velocity is less than the actual value obtained from experiments. There is a difference between theoretical and laboratory overload pressure. This difference is less in the control tests than in the presence of leakage experiments. By increasing the Reynolds number, the loss of overpressure is almost independent of the leakage rate, so that the loss of overpressure in each of the three diameters is approximately equal.

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