Simulation Analysis of the Working Condition of Gas Pipeline Leakage Based on the TGNET

Jieying Luo, Xudi Chen

School of Civil Engineering and Architecture, Southwest Petroleum University, Chengdu 610500, China

Abstract

This paper introduces the background of gas pipeline leakage, and using software TGNET the simulation study on the working condition of gas pipeline leakage, related parameter change rule. Such as a broken pipe leakage of air and gas pressure and flow, leak flow and the change tendency of accumulative flow, provide important basis for the safe operation of gas pipeline.

Keywords

Gas pipe network; Natural gas; TGNET; leak.

1. Introduction

Natural gas as a kind of high quality, efficient and clean energy, to improve the urban energy structure, strengthen environmental protection, reduce air pollution and so on all aspects plays a more and more important role. Natural gas pipeline network scale in towns and cities in our country's rapid development, has become indispensable to urban lifeline, at the same time, the gas pipeline of broken tube leakage accident is increasing, causing casualties and property losses and bring many unstable factors to the society. How to make the broken tube detection system set up reasonable as far as possible, complete equipment for effective, in the event of a pipeline accident can cut production to prevent the worsening in time, ensure safety smooth gas will be must solve the problem for the operation management department. According to the current status and development trend of network, this paper pointed the choice of cases, the case set parameters of leak detection system, using software TGNET for case analysis to simulate the working condition of the pipeline leakage, the parameter change rule, hope that through case analysis of this paper provide a reference for possible problems in practical work.

2. The basic gas state equation

2.1 The ideal gas state equation

Ideal gas state equation: $$\frac{P}{\rho} = RT \quad (1)$$

General gas state equation: $$P = Z\rho RT \quad (2)$$

Van der Waals state equation: $$P = \frac{RT}{V - \mathrm{b}} - \frac{\mathrm{a}}{V^2} \quad (3)$$

Ideal gas does not take into account the size of the real gas molecules and the intermolecular forces, in the shape of van der Waals equation of b is made to the molecular volume correction, a is made to the molecular inter-atomic forces correction.

2.2 The real gas state equation

1). Sarem

Sarem state equation is an old state equation. It solves the general gas equation of state, under the condition of gas transmission pipeline, how to calculate the compressibility. It uses concept of the reduced pressure and reduced temperature (gas pressure, temperature and critical pressure, the ratio of critical temperature), with Legendre polynomial calculate compressibility.

2). RK state equation

$$P = \frac{RT}{V-b} - \frac{a}{T^{0.5}V(V+b)} \tag{4}$$

RK equation is the second parameter equation of state, it is proposed in 1949. A and b are constants in the formula, its numerical calculation methods corresponding to the single-component gas and mix gas respectively have different ways of calculation.

3). SRK state equation

$$P = \frac{RT}{V-b} - \frac{a}{V(V+b)} \tag{5}$$

SRK equation is based on the improved RK state equation, it is put forward in 1972. The formula of the calculation method of a and b correspond to the single-component gas and mix gas also has different algorithms.

4). PR state equation

$$P = \frac{RT}{V-\mathrm{b}} - \frac{\mathrm{a}}{V(V+b)+b(V\text{-}\mathrm{b})} \tag{6}$$

Van der Waals equation in a certain range can already close to a description of the properties of real gas, but it doesn't take into account the influence of temperature and acentric factor, therefore, the applicable scope is limited, PR is after considering the above factors by van der Waals equation derived equation.

5). BWRS state equation

$$P = \rho RT + (B_0RT - A_0 - \frac{C_0}{T^2} + \frac{D_0}{T^3} - \frac{E_0}{T^4}) + (bRT - a - \frac{d}{T})\rho^3 + \alpha(a + \frac{d}{T})\rho^6 + \frac{c\rho^3}{T^2}(1+\gamma\rho^2)\exp(-\gamma\rho^2) \tag{7}$$

Van der Waals equation, SRK equation, and Peng equation is the common problem of molecular inter-atomic forces consider inadequate, leading to inaccurate in medium density is very high. BWRS equation considering the more fixed, and therefore more parameters are introduced. Introduced by the parameter, the more the more consideration, applicable range is wide, the difficulty of solving and solving the greater the amount of calculation.

3. TGNET profile and the pipeline leak transient operating mode simulation analysis

3.1 TGNET profile

Software TGNET is scientific American companies offering gas gathering pipe network transient simulation software, can on the computer for large complex gas gathering pipe network for steady state and transient simulation, can analyze the normal condition and accident conditions of gas transmission pipeline, testing and evaluation of gas pipeline design or operating parameter Settings, ultimately to optimize system performance. Use of this software can also provide real-time simulation software configuration modeling data.

3.2 working condition of pipeline leakage simulation case analysis

Because of long distance pipeline broken tube leakage is a kind of extreme conditions, occurrence frequency is very low, less leakage condition of actual data from the field and leak high randomness, it is difficult as the foundation data to research on the regularity analysis, at the same time, At the same time, due to the cost of long distance pipeline leakage condition almost not feasible experiment research, numerical simulation and its high accuracy, low cost, high adjustable features are widely used in pipeline operation condition of the study, So in order to find the pressure flow and tube stock change rule of long distance pipeline leakage, it is necessary to carry out the pipeline simulation analysis.

Build pipelines and setting various parameters (figure 1),there are one supply, one delivery , four section of the pipeline, two cut-off valve and a leak leak. Basic parameters of the pipes in the following figure:

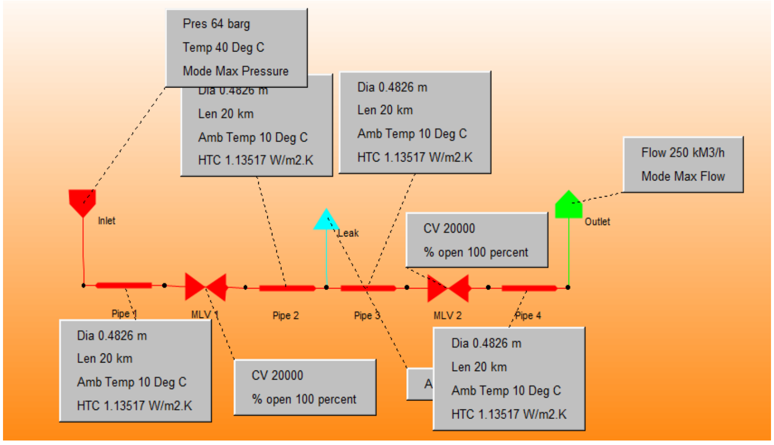

Figure 1. The basic situation of pipe

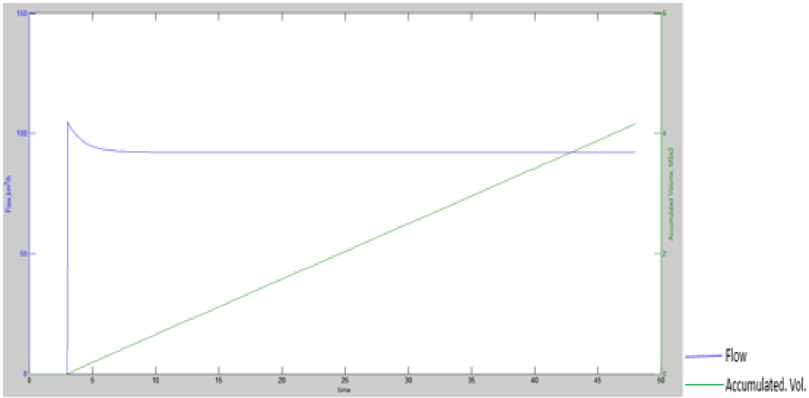

Figure 2. The flow rate and the cumulative flow rate of the leakage point change with time when the leakage aperture is 5cm.

The gas relative density is 0.6 and calorific value is 37 MJ/M3, This instance selection SAREM state equation. SAREM equations have many advantages:

High precision within the scope of Most of the normal running pressure of gas.

Describe the parameters of the gas less, only relative density, calorific value and the content of our fleet (it can be obtained by gas components).

Allow users to customize gas properties.

Heat capacity at constant pressure and specific heat at constant volume from assuming an ideal gas.

Open the temperature tracking, in OPTION/LEAK of SIMULATION dialogue frame chooses IMPLICIT algorithm. Implicit mode (implicit) can be used in the steady state and transient calculation. If the final steady state solution depends on the initial distribution of the flow field, or the Inlet boundary state of each phase is not very clear, should choose the transient calculation of the implicit model. If the final steady state solution does not depend on the initial distribution of the flow field, and r the Inlet boundary state of each phase is very clear, you can use the steady state calculation of the implicit model. Choose IMPLICIT algorithm in order to obtain high accuracy. A dynamic script is established, assuming that the leakage occurs at 4th hours, and the leak site forms a circular hole which is equivalent to 5cm (10cm) in 0.1 hours, and simulating the change of working conditions within 48 hours.

When the leakage diameter is 5cm, the software can simulate the pipe network dynamically, and the flow rate of the leakage point can be obtained. In 0-4 hours (figure 2), the leak point is no gas flow out of the pipeline because of no leakage of the pipe, In 4-4.1 hours, leak in the pipeline within 0.1 hours, so the leakage flow increased dramatically, At 4.1 hours the amount of leakage reached a peak of 104.665, with the leakage of natural gas, the pressure of the pipeline gradually decreased, and finally tends to be stable, so after 10 hours, the flow trend curve gradually tends to be stable. From the figure can be seen from the beginning of the leak when the cumulative flow rate increases in a linear way.

When the leakage diameter is 10cm, the TGNET is used to simulate the pipe network.

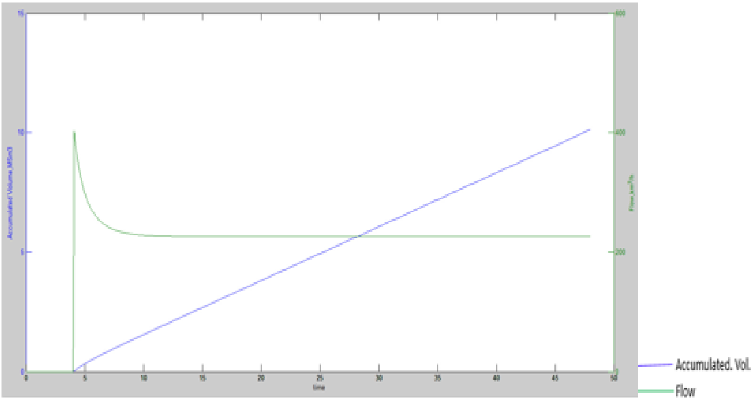

Figure 3. The flow rate and the cumulative flow rate of the leakage point change with time when the leakage aperture is 5cm.

Comparing figure 2 and figure 3, therefore, in the case of other conditions unchanged, increase the diameter of the leak, the leak flow also increases, the corresponding cumulative flow will also increase, but the overall trend within 48 h did not change.

If the aperture leakage has been maintained at 5cm, the pipe stock inventory change trend chart as shown in Figure 4, in the figure the curves of blue, purple, green and red represent pipe storage trends curves of pipe1, pipe2, pipe3 and pipe4. It can be seen that after fourth hours the stock of the leak began to decrease sharply, and then tend to be stable.

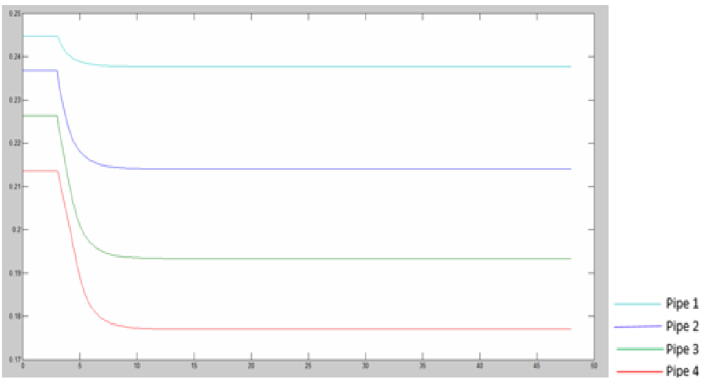

Figure 4. The curves of different section tube stock over time

Figure 5 is the trend of supply flow and pressure curve, it can be seen that gas supply point of gas supply as a result of the leak leakage in the first four small sharply reduced constantly, then leveled off. The constraint condition of max pressure of supply is 64, and max pressure is set to mode. so the pressure trend diagram of the gas source point has been stable in the 64BARG no change.

Figure 6 is the trend of delivery flow and pressure curve, The pressure of the gas point after the leak leakage decreased after achieve stability. The constraint condition of max flow of delivery is 250, and max flow is set to mode. So the flow of gas point no change has been steady in 250.

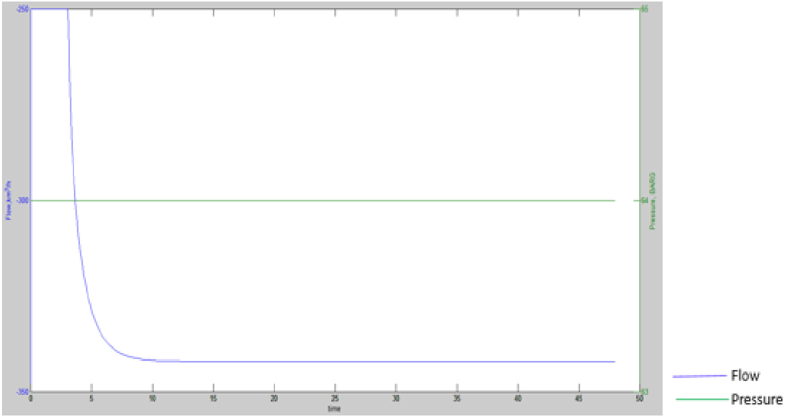

Figure 5. The curve of pressure and flow rate of supply over time

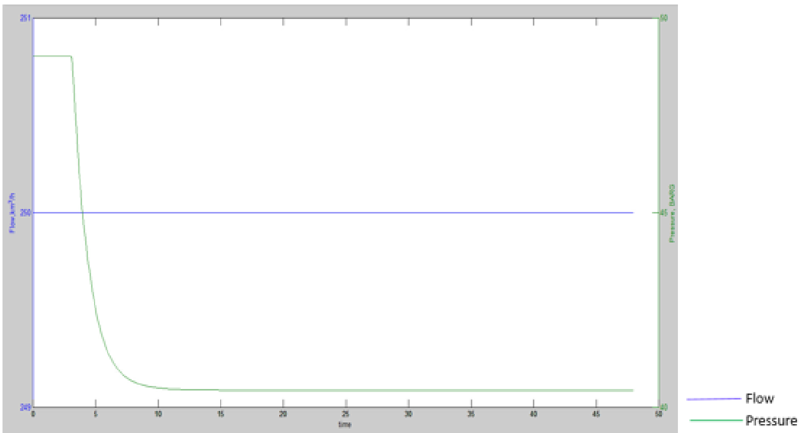

Figure 6. The curve of pressure and flow rate of delivery over time

It is assumed that the leak was discovered in sixth hours, and the shut-off valve at both ends of the leak pipe section was closed. Meanwhile, the gas source and the user were shut down. The dynamic script was modified to the following table:

Table 1. 6 hours after the modification of the dynamic script

	Device Type	Name	Setpoint	Units	Initial	4	4.1	5.99	6	48
1	Block Valve	MLV 2	% open	percent	100			100	0	0
2	Block Valve	MLV 1	% open	percent	100			100	0	0
3	Supply	Inlet	Pressure Maximum	barg	64			64	0	0
4	Delivery	Outlet	Flow Maximum	kM3/h	250			250	0	0
5	Leak Delivery	Leak	Diameter	m	0	0	0.05			0.05

Using TGNET to do dynamic simulation, get the flow trend curve at the leak point， Figure 7. At the same time, discharge peak flows of the leak did not change, because of the closure of the leakage pipe at both ends of the shut-off valve, and turn off the gas source and the user, so in the sixth hour began flow curve was beginning to change. At this time the cumulative flow curves by the original linear straight line change curve, and finally tends to be stable.

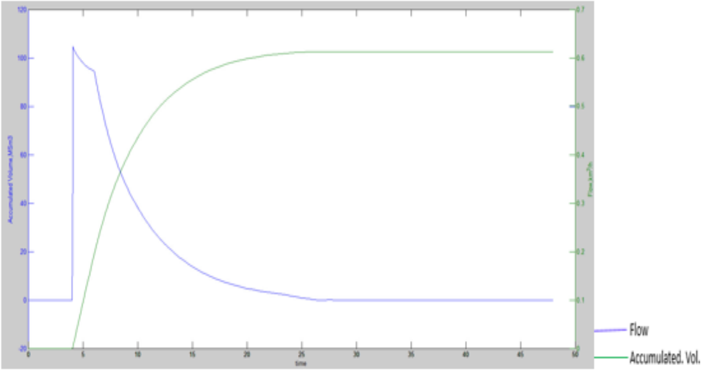

Figure 7. The curve of pressure and flow rate of delivery over time after take measures

At this time, the 4 pipe section of the pipe stock change trend curve as figure 8, in the figure the curves of blue, purple, green and red represent pipe storage trends curves of pipe1, pipe2, pipe3 and pipe4. Although the close of the leakage pipe at both ends of the shut-off valve, but the leak is still continuing in the leakage point, so tube stock of pipe2 and pipe3 drastically reduced, finally remained at a very low level after six hours. However, because pipe1 and pipe4 closed the supply and delivery as well as the shut-off valve in sixth hours, so the pipe tube has no change after sixth hours.

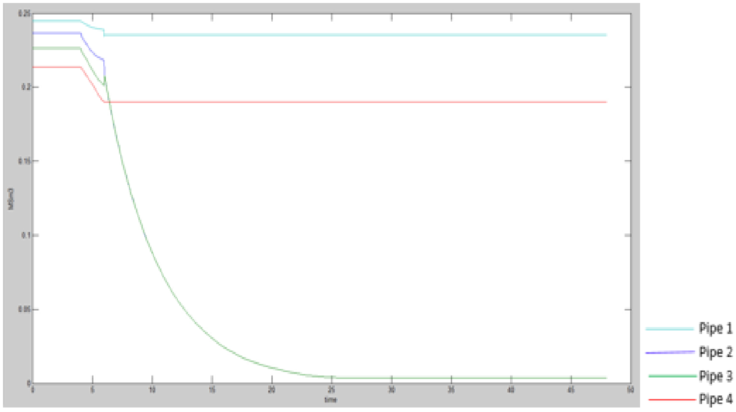

Figure 8. The curves of different section tube stock over time after take measures

4. Conclusion

Analyzing the results and graphics, We can drew the following conclusion:

(1). In the case of the same other conditions, the greater the diameter of the leak, the more the flow of leakage, the cumulative flow is also more.

(2). Because of the supply and delivery set constraint conditions max pressure and max flow, At the same time, the constraint conditions are set to mode. so the flow trend of the supply is not changed with the time.

(3). After the pipeline leakage, the stock of the pipe is reduced sharply in a short time, and then tends to be stable.

(4). After the leak was discovered and taken, the leakage flow rate of the leakage point decreased at six hours, and finally tended to be stable.

(5). After the leak was discovered and taken to take measures, the leak is still continuing in the leak point, so the pipe stock of the pipe between the cut off the valve have a sharp reduction after in the six hours, and finally maintained at a very low level. the pipe of in front and back of shut-off valve because of the supply, delivery and shut-off valve closed after sixth hours. So the tube stock no change after 6 hours.

Urban gas pipeline network is an important part of urban infrastructure. The safe operation of gas pipeline network concerns the people's life , property security, social stability. To ensure safe operation are the need for the development of urban construction in the new era and the current needs of urban safety management. Gas leakage is inevitable, so the management department should strengthen the basic management, improve the technical level, to further explore new methods of the gas pipe network leakage accident prevention and control.

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