

GAS PIPELINE LEAKAGE DETECTION METHOD AND APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority of Chinese Patent Application Serial No. 201811325974.1, filed on November 8, 2018 by HEFEI INSTITUTE FOR PUBLIC SAFETY RESEARCH, TSINGHUA UNIVERSITY and HEFEI ZEZHONG CITY INTELLIGENT TECHNOLOGY CO., LTD., and titled with “GAS PIPELINE LEAKAGE DETECTION METHOD AND APPARATUS”.

FIELD

The present disclosure relates to a field of gas pipeline leakage monitoring technologies, and more particularly to a gas pipeline leakage detection method and apparatus.

BACKGROUND

In recent years, with rapid expansion of Chinese urban scale, a scale of an urban gas pipeline network has also grown rapidly. In addition, transportation pipelines of crude oil and refined oil that were originally buried in a suburb become part of the urban now. Most of these pipelines are buried underground, a large amount of flammable gas is directly or indirectly generated if the leakage occurs on them, and the flammable gas diffuses into a surrounding rainwater pipeline network, sewage pipeline network and other municipal inspection wells. Due to the interconnection of the rainwater pipeline network and the sewage pipeline network, the flammable gas can diffuse for several kilometers along the pipelines. When a concentration of the flammable gas reaches an explosion limit, a large-scale serial explosion will occur in the event of the flammable gas meeting an ignition source, thus resulting in destruction of several kilometers of roads and a large number of casualties.

In related technologies, gas leakage exploration means can include monitoring and detecting. The leakage monitoring is mainly to monitor a new process of the pipeline from no leakage to a sudden leakage. While the leakage detecting is to conduct regular detections from the outside or inside of the pipeline, to detect a position where the leakage has occurred, or a weak spot where the leakage may occur on the pipeline. Such as, a touring detection of a gas company belongs to a way of the leakage detecting, and the pipeline leakage is found by regularly detecting the

concentration of the flammable gas surrounding the pipeline. For the pipeline transporting a high-risk medium, the pipeline detection method cannot effectively avoid an occurrence of a series of events after the pipeline leakage, because of a defect in real-time capability.

However, accidents of the gas pipeline leakage are mostly tiny leakages, and gas is compressible. Therefore, many methods, which is based on front-end monitoring of flow or pressure combined with a software model to find the pipeline leakage, do not play a monitoring effect well for the tiny leakage in a medium and low pressure pipeline existing in large numbers in the urban. Table 1 is the statistical classification of the existing pipeline leakage exploration methods. The applicability to the gas pipeline network is comprehensively considered, from feasibility, real-time capability, availability, and other sides of the monitoring technologies. It can be seen that none of the existing monitoring means can directly and effectively solve the problem of real-time detection of urban gas pipeline leakage.

Table 1

Classification of monitoring means		Performance comparison			
		Feasibility	Availability	Real-time capability	Description
Detection method	Gas detection method			×	Cannot continuously monitor, poor real-time capability
	Intelligent ball detection method			×	Cannot continuously monitor, poor real-time capability
	Perceiving optical fiber method	×			Requiring to excavate road surface, very difficult to implement
	Mass balance method		×		Cannot determine a position of a leakage point, cannot monitor the tiny leakage
Monitoring method	Pressure gradient method	×			Not applying to urban gas pipeline network with complex structure, cannot monitor the tiny leakage
	Negative pressure wave	×			only applying to a pipeline transporting liquid
	Pressure point analysis method		×		Cannot monitor the tiny leakage, and also cannot positioning the position of the leakage point

	Artificial neural network method		×		Due to fault modes of the urban pipeline network are more in practice, a final application result is easy to occur an error
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SUMMARY

This application is filed based on the inventor's knowledge and discovery of following questions.

For an explosion accident of the gas leakage, the most ideal treatment means is to select an appropriate exploration method that can monitor the pipeline leakage when the gas has just leaked, to avoid an occurrence of subsequent series of dangerous events. In the case where an existing technology does not detect the pipeline leakage in an early stage of the leakage very well, a method of effectively solving the pipeline leakage is monitoring a location where the flammable gas may gather after the gas pipeline leakage, namely, the underground spaces neighboring or intersecting the gas pipeline. For example, monitoring rainwater and sewage wells, gas valve wells, power wells, and other spaces surrounding the pipeline, the flammable gas leakage is detected, while the explosion accident is avoided to occur in the space having the leakage.

The present disclosure seeks to solve at least one of the problems existing in the related arts to at least some extent.

Accordingly, an objective of the present disclosure is to provide a gas pipeline leakage detection method. The method may implement quick and scientific positioning of the leakage point of the gas pipeline, thereby enabling accurate prediction of the maximum impact range of the flammable gas leakage, facilitating daily safety maintenance of the gas pipeline network and emergency handling of leakage accidents.

Another objective of the present disclosure is to provide a gas pipeline leakage detection apparatus.

To achieve the above objectives, embodiments in an aspect of the present disclosure provide a gas pipeline leakage detection method. The method includes: detecting concentration of flammable

gas in a plurality of underground spaces surrounding a gas pipeline; determining whether the concentration of the flammable gas meets a leakage condition; in response to the concentration of the flammable gas meeting the leakage condition, determining that the gas pipeline has a leakage, and acquiring and reporting a current leakage position.

The gas pipeline leakage detection method of embodiments of the present disclosure, determines whether the gas pipeline has the leakage according to the concentration of the flammable gas in the plurality of underground spaces surrounding the gas pipeline, and when there is the leakage, acquires and reports the current leakage position, thus implementing quick and scientific positioning of the leakage point of the gas pipeline, enabling accurate prediction of the maximum impact range of the flammable gas leakage, facilitating daily safety maintenance of the gas pipeline network and emergency handling of leakage accidents.

In addition, the gas pipeline leakage detection method according to the above embodiments of the present disclosure may have the following additional technical features.

Further, in an embodiment of the present disclosure, the method further includes: acquiring a representative value of explosion possibility and explosion damage consequence data of each underground space surrounding the gas pipeline of all underground spaces surrounding the gas pipeline; determining an explosion risk assessment value of each underground space surrounding the gas pipeline, according to the representative value of explosion possibility and the explosion damage consequence data; determining the underground space surrounding the gas pipeline having the explosion risk assessment value greater than a preset value as one of the plurality of underground spaces surrounding the gas pipeline to be monitored.

Further, in an embodiment of the present disclosure, determining whether the concentration of the flammable gas meets the leakage condition, includes: in response to the concentration of the flammable gas in the underground space surrounding the gas pipeline at a current moment and the concentration of the flammable gas in the underground space surrounding the gas pipeline at a previous moment being both greater than or equal to a first preset concentration, and a difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than zero, determining that the leakage of the gas pipeline is a slight leakage; and in response to the concentration of the flammable gas at the current moment being greater than or equal to the first preset concentration, and the difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than or equal to a second preset concentration,

determining that the leakage of the gas pipeline is a serious leakage, in which the second preset concentration is greater than the first preset concentration.

Further, in an embodiment of the present disclosure, the method further includes: identifying a current dangerous area, according to the current leakage position and the concentration of the flammable gas; controlling a preset alarm device to alarm, according to the current dangerous area and a preset alarming mechanism.

Further, in an embodiment of the present disclosure, the method further includes: controlling an opening degree of a corresponding gas pipeline valve, according to the leakage position.

To achieve the above objectives, embodiments in another aspect of the present disclosure provide a gas pipeline leakage detection apparatus. The apparatus includes: a detecting module, configured to, detect concentration of flammable gas in a plurality of underground spaces surrounding a gas pipeline; a determining module, configured to, determine whether the concentration of the flammable gas meets a leakage condition; a processing module, configured to, in response to the concentration of the flammable gas meeting the leakage condition, determine that the gas pipeline has a leakage, and acquire and report a current leakage position.

The gas pipeline leakage detection apparatus of embodiments of the present disclosure, determines whether the gas pipeline has the leakage according to the concentration of the flammable gas in the plurality of underground spaces surrounding the gas pipeline, and when there is the leakage, acquires and reports the current leakage position, thus implementing quick and scientific positioning of the leakage point of the gas pipeline, enabling accurate prediction of the maximum impact range of the flammable gas leakage, facilitating daily safety maintenance of the gas pipeline network and emergency handling of leakage accidents.

In addition, the gas pipeline leakage detection apparatus according to the above embodiments of the present disclosure may have the following additional technical features.

Further, in an embodiment of the present disclosure, the apparatus further includes: an acquiring module, configured to, acquire a representative value of explosion possibility and explosion damage consequence data of each underground space surrounding the gas pipeline of all underground spaces surrounding the gas pipeline; an assessment module, configured to, determine an explosion risk assessment value of each underground space surrounding the gas pipeline, according to the representative value of explosion possibility and the explosion damage consequence data; a setting module, configured to, determine the underground space surrounding

the gas pipeline having the explosion risk assessment value greater than a preset value as one of the plurality of underground spaces surrounding the gas pipeline to be monitored.

Further, in an embodiment of the present disclosure, the determining module is further configured to, in response to the concentration of the flammable gas in the underground space surrounding the gas pipeline at a current moment and the concentration of the flammable gas in the underground space surrounding the gas pipeline at a previous moment being both greater than or equal to a first preset concentration, and a difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than zero, determine that the leakage of the gas pipeline is a slight leakage; in response to the concentration of the flammable gas at the current moment being greater than or equal to the first preset concentration, and the difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than or equal to a second preset concentration, determine that the leakage of the gas pipeline is a serious leakage, in which the second preset concentration is greater than the first preset concentration.

Further, in an embodiment of the present disclosure, the apparatus further includes: an identifying module, configured to, identify a current dangerous area, according to the current leakage position and the concentration of the flammable gas; an alarming module, configured to, control a preset alarm device to alarm, according to the current dangerous area and a preset alarming mechanism.

Further, in an embodiment of the present disclosure, the apparatus further includes: a controlling module, configured to, control an opening degree of a corresponding gas pipeline valve, according to the leakage position.

Additional aspects and advantages of embodiments of the present disclosure will be given in part in the following descriptions, become apparent in part from the following descriptions, or be learned from the practice of the embodiments of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of embodiments of the present disclosure will become apparent and more readily appreciated from the following descriptions made with reference to the drawings, in which:

Fig. 1 is a flow chart illustrating a gas pipeline leakage detection method according to an embodiment of the present disclosure.

Fig. 2 is a flow chart illustrating a leakage determining according to an embodiment of the present disclosure.

Fig. 3 is a schematic diagram illustrating to a typical flammable gas leakage monitoring curve according to an embodiment of the present disclosure.

Fig. 4 is a schematic diagram illustrating pressure curves of a beginning port and an ending port of a pipeline in one week according to an embodiment of the present disclosure.

Fig. 5 is a schematic diagram illustrating a fitting curve of concentration changes in one day according to an embodiment of the present disclosure.

Fig. 6 is a schematic diagram illustrating a gas consumption curve of a user and a peak regulation curve in one day according to an embodiment of the present disclosure.

Fig. 7 is a schematic diagram illustrating a typical biogas monitoring curve according to an embodiment of the present disclosure.

Fig. 8 is a schematic diagram illustrating a flammable gas diffusion area (no connected well within a maximum diffusion range) according to an embodiment of the present disclosure.

Fig. 9 is a schematic diagram illustrating a flammable gas diffusion area (a connected well existed within a maximum diffusion range) according to an embodiment of the present disclosure.

Fig. 10 is a schematic diagram illustrating a gas pipeline having a possibility to occur a leakage according to an embodiment of the present disclosure.

Fig. 11 is a schematic diagram illustrating no connected well in a possible diffusion area according to an embodiment of the present disclosure.

Fig. 12 is a schematic diagram illustrating a connected well existing in a possible diffusion area according to an embodiment of the present disclosure.

Fig. 13 is a block diagram illustrating a gas pipeline leakage detection apparatus according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

Reference will be made in detail to embodiments of the present disclosure. Examples of the embodiments of the present disclosure will be shown in drawings, in which the same or similar elements and the elements having same or similar functions are denoted by like reference numerals

throughout the descriptions. The embodiments described herein according to drawings are illustrative, used to explain the present disclosure, not construed to limit the present disclosure.

Description will be made in detail below to a gas pipeline leakage detection method and apparatus provided according to embodiments of the present disclosure with reference to the drawings. Firstly, the gas pipeline leakage detection method provided according to embodiments of the present disclosure is described with reference to the drawings.

Fig. 1 is a flow chart illustrating a gas pipeline leakage detection method according to an embodiment of the present disclosure.

As illustrated in FIG. 1, the gas pipeline leakage detection method includes acts in the following blocks.

At block S101, concentration of flammable gas in a plurality of underground spaces surrounding a gas pipeline is detected.

It can be understood that, in the embodiments of the present disclosure, the concentration of the flammable gas in the underground spaces may be sensed in real-time, by arranging flammable gas intelligent monitoring sensors in the underground spaces neighboring the gas pipeline, thereby effectively predicting and warning of the explosion accidents in the underground spaces, and eliminating a dangerous source in bud.

Further, in an embodiment of the present disclosure, the method of the embodiment of the present disclosure further includes: a representative value of explosion possibility and explosion damage consequence data of each underground space surrounding the gas pipeline of all underground spaces surrounding the gas pipeline are acquired; an explosion risk assessment value of each underground space surrounding the gas pipeline is determined, according to the representative value of explosion possibility and the explosion damage consequence data; the underground space surrounding the gas pipeline having the explosion risk assessment value greater than a preset value is determined as one of the plurality of underground spaces surrounding the gas pipeline to be monitored.

It is understandable that due to there are a large amount of underground spaces surrounding the gas pipeline, when carrying out an arrangement of such sensors, it must be selected typical spaces for monitoring from the large amount of underground spaces, according to a certain criteria, thus ensuring the feasibility and sufficiency of monitoring. The risk assessment may generally be performed on the underground spaces neighboring the gas pipeline, and optimization of points arrangement is carried out, according to explosion risk values of the underground spaces. The

explosion risk assessment of the neighboring underground space mainly considers two parts: the first one is the representative value of explosion possibility; the second one is the explosion damage consequence. In brief, it is to select these underground spaces with higher risk point to carry out the arrangement of the sensors, and an optimization idea of the arrangement is mainly based on self-risk control for the inspection well where the sensor is arranged.

At block S102, it is determined whether the concentration of the flammable gas meets a leakage condition.

In an embodiment of the present disclosure, determining whether the concentration of the flammable gas meets the leakage condition, includes: in response to the concentration of the flammable gas in the underground space surrounding the gas pipeline at a current moment and the concentration of the flammable gas in the underground space surrounding the gas pipeline at a previous moment being both greater than or equal to a first preset concentration, and a difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than zero, determining that the leakage of the gas pipeline is a slight leakage; in response to the concentration of the flammable gas at the current moment being greater than or equal to the first preset concentration, and the difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than or equal to a second preset concentration, determining that the leakage of the gas pipeline is a serious leakage, in which the second preset concentration is greater than the first preset concentration.

It is understandable that, the first preset concentration may be 0.5% VOL, and the second preset concentration may be 1% VOL, otherwise these can be set according to an actual situation, by those skilled in the art, and these are used here as examples, but not made specific limits.

For example, as illustrated in Fig. 2, a monitoring point A of the inspection well arranged with a device monitors the concentrations C_1 and C_2 at two adjacent sampling moments t_1 and t_2 . In a case of the concentration C_2 at the sampling moment t_2 greater than or equal to 0.5% VOL, if the concentrations C_1 and C_2 are both greater than 0.5% VOL, and $C_2 - C_1 > 0$, it is determined that there is a slow leakage in the gas pipeline near the well; if $2C_2 - C_1 \geq 1\%$ VOL, it is determined that there is a rapid leakage in the gas pipeline near the well.

At block S103, in response to the concentration of the flammable gas meeting the leakage condition, it is determined that the gas pipeline has a leakage, and a current leakage position is acquired and reported.

It is understandable that if the concentration of the flammable gas meets the leakage condition, that is, it is determined to be the slight leakage or the serious leakage, the current leakage position should be reported. How to determine the source of the leakage will be explained in detail as follows.

There are two sources of gas for a methane concentration warning in the inspection well. One is biogas produced by microbial anaerobic fermentation of organic matter in the well, and the other is the flammable gas leakage from the adjacent gas pipeline. The above two may be distinguished from changes of the methane concentration over time. For the flammable gas leakage, the change of concentration has a greater relationship with pressure of the pipeline. That is to say, during the period when gas consumption of the user is larger, the flammable gas leakage will become smaller. Otherwise, during the period when the gas consumption of the user is smaller, the flammable gas leakage will become larger, such as, the concentration in the well at resident non-meal time is higher than the concentration in the well at meal time. For the biogas, it is produced by anaerobic fermentation. The anaerobic fermentation is a complex microbiological process. Research indicates that temperature affects growth rate of methanogens and metabolic rate of methanogens against the matrix, by affecting activity of certain enzymes in cells of the methanogens. Under an usual circumstance, if the temperature is 35 °C, the activity of the methanogens in the pipeline reaches the highest, and production of the methane is also the largest accordingly, i.e., there is a correlation between an approximate curve of changes of biogas concentration and the temperatures. Further analysis that the well will alarm while the concentration of the biogas exceeds a standard, it presents a trend that the concentration of the methane in the well is higher at night than at day.

The methane gas monitored in the underground spaces neighboring the gas pipeline network, on the one hand, may come from the leakage diffusion of the natural gas pipeline, and on the other hand, may also come from the biogas formed by the microorganisms in a dark and humid environment of the underground space. There is a larger difference between the natural gas and the biogas in composition, because the fermentation does not produce ethane, and the natural gas currently used domestically contains 1 ~ 2% VOL of the ethane, so that a current common method of an enterprise is to determine whether the gas is natural gas or biogas, by using a portable ethane analyzer to analyze whether there is the ethane in the gas. A technology used to ethane monitoring in the inspection well is not yet mature currently, price of the sensor is expensive, and monitoring the concentration of the ethane has not been considered in a system. Under this context, if accuracy of alarm needs to be improved, sources of the methane may be distinguished by a change

rule of the monitored concentration of the methane. Through an analysis of a large number of monitoring data, it is found that the concentration of the methane monitored in the flammable gas leakage shows a periodic change, and the concentration of the methane monitored in the biogas is related to the change of the temperature. The typical curve law analysis is as follows.

(1) Typical flammable gas leakage monitoring curve

As illustrated in Fig. 3, it illustrates a flammable gas leakage curve monitored from June 22 to July 3, 2016. It can be found that there is no intuitive rule between the change in concentration and temperature, but there is a certain regularity in time. The overall curve shows a periodical change with one day as a period, the concentration reaching a peak around 4 a.m., while being lower in daytime, especially reaching the lowest point at nightfall period. Fig. 4 is a schematic diagram illustrating pressure curves of a beginning port and an ending port of the pipeline in one week of a civil gas pipeline in an urban. From this figure, it can be seen that the pressure of the beginning port of the pipeline has always maintained to be relatively stable, the pressure of the ending port of the pipeline has presented to be obviously periodical change over the change of the gas consumption, and the period is about 24 hours. In this figure, a time corresponding to the highest pressure point a is 28 o'clock, which is around 4 a.m. on Tuesday; the lowest pressure point is at 115 o'clock, which is around 7 p.m. on Friday. This periodic rule and changing trend are basically consistent with the change of the concentration of the flammable gas leakage.

Data of the monitoring point at a day is taken for a single-period analysis. The data is monitored in real-time and uploaded every 30 minutes, and forty-eight sets of data is uploaded totally. The data is plotted as a scatter diagram and performed with fitting regression. The fitting curve is a sine curve with a similarity of 0.99585. The concentration in the well begins to rise from 0 o'clock to reach the highest around 5 a.m., then keeps dropping during the daytime, and reaches the lowest at nightfall, later begins to rise again.

Fig. 5 is a schematic diagram illustrating the gas consumption curve of the ending port of the pipeline in one day. From 0 o'clock to 6 a.m., average gas consumption is lower than average gas supply, the peak regulation curve rises till to the maximum value, and the pressure of the system rises. And after that until about 8 p.m., the average gas consumption is higher than the average gas supply, the peak regulation curve drops till to the minimum value, the pressure of the system drops, and the pressure of the ending port of the pipeline drops to the lowest value. After 9 o'clock, the pressure enters a rising stage again. Fig. 5 and Fig. 6 each illustrates during one day the curve of the concentration change in the well when the flammable gas is leakage, and the curves of change

of residential gas consumption and the peak regulation, and the changing trends shown in the two figures are basically the same, with a fairly high degree of coincidence.

According to the above analysis, the change rule of the flammable gas concentration monitored when the flammable gas leakage occurs is related to the pressure of the gas pipeline. The greater the pressure, the larger the leakage, and the higher the monitored concentration. In fact, the pressure monitoring device or flow monitoring device of the ending port of the gas pipeline is very limited, so the pressure curve or flow curve at the monitoring point cannot be fully obtained. But for the ending port of the gas pipeline, the corresponding rule of the residential gas consumption is relatively stable. For example, at meal time of a residential area, the gas consumption is large, the pressure in the pipeline is low, and the leakage will decrease, while at the early morning the gas consumption is small, the pressure in the pipeline is high, and the leakage will increase accordingly. The rule of the residential gas consumption presents the periodical change with time, and a period is usually one day, so the curve of the concentration change presents the periodical change rule.

(2) Typical biogas leakage monitoring curve

Several typical scenes with high biogas, is selected. As illustrated in Fig. 7, it is not difficult to see from the curves that the concentration change does not present obvious regularity in time, while the concentration curve and the temperature curve have shown a strong regularity: the temperature increases, the concentration increases, and the temperature decreases, the concentration also decreases, and the temperature remains stable, the concentration also remains unchanged. The rule of the concentration changing in the well with the temperature is related to the activity of the microorganisms. The microorganisms produced the methane in the underground space are mainly methanogens. Most methanogens belong to medium temperature type, and can maintain activity between 10°C and 65 °C under an anaerobic environment, and the most appropriate temperature is between 20°C and 45 °C. In this interval, the higher the temperature, the stronger the fermentation effect, the higher the monitored concentration.

Further, in an embodiment of the present disclosure, the method of the embodiment of the present disclosure further includes: a current dangerous area is identified, according to the current leakage position and the concentration of the flammable gas; a preset alarm device is controlled to alarm, according to the current dangerous area and a preset alarming mechanism.

It can be understood that, in embodiments of the present disclosure, after determining the leakage source, the dangerous area is further identified, according to the location of the leakage

source and the current concentration of the flammable gas, and an early warning is sent out in time, thereby, effectively improving reliability of the detection, avoiding potential danger by the timely early warning. How to identify the dangerous area will be further explained as follows.

In embodiments of the present disclosure, a leakage diffusion model is first determined, and then the dangerous area is identified, according to the leakage diffusion model. Details include the following.

1. Leakage diffusion model

There are two cases of the diffusion of the flammable gas. On the one hand, the flammable gas can diffuse through soil to the neighboring underground space or surface of ground. On the other hand the flammable gas can diffuse into adjacent municipal pipelines (such as sewage pipelines, cable trenches), and diffuse along the pipeline. A diffusion radius of the flammable gas is affected by several factors, such as covering medium, diffusion time, leakage volume, leakage pressure and other factors. The covering medium of the pipeline is related to the maximum range of the flammable gas leakage diffusion, and may be divided into two cases to discuss whether the connected well exists in the leakage range.

(1) No connected well within the maximum diffusion range

If there is no connected well within the maximum diffusion range, the flammable gas diffusion area has a great relationship with a material quality of a road surface, and the leakage diffusion area is illustrated in Fig. 8.

(2) The connected well existed within a range of 12.5 m

There exists a connected well within the maximum range of the leakage point. Due to the interconnection of the rainwater pipeline and the sewage pipeline, the flammable gas may diffuse into the surrounding rainwater pipeline network, sewage pipeline network and other municipal inspection wells, and the flammable gas can diffuse a long distance along the pipelines. When the concentration of the flammable gas reaches an explosion limit, a large-scale serial explosion will occur in the event of the flammable gas meeting an ignition source, resulting in destruction of several kilometers of roads and a large number of casualties. As illustrated in Fig. 9, for example, 2# is the sewage well. If the sewage well 2# is a measuring point, measured data shall prevail; if the sewage well 2# does not have the measuring point, and the sewage well 3# has measured the methane, then the sewage wells 2# and 3# are both areas where explosion may occur; if the sewage well 3# dose not measure the methane, then the sewage well 2# is the explosion point, but the sewage well 3# is not; if the sewage well 2# and 3# are both not the measuring points, then the

sewage well 2# is the explosion point, but the sewage well 3# is not.

2. Dangerous area identification

Considering that most gas pipelines are actually buried under urban roads, the diffusion range of the flammable gas is also affected by a limit of cement road surface or asphalt road surface. Draw a circle with a flammable gas leakage well as a center and R_3 as a radius, and look for all the gas pipelines L_i in this area, $i = 1, 2, 3 \dots n_1$, n_1 is a positive integer. A union set of the all gas pipelines is the gas pipelines that may leak, and then by a relevant department monitoring on-site, the specific location of the pipeline leakage is determined.

Draw a circle with one endpoint of L_i as the center and the maximum diffusion range R_3 of the flammable gas as the radius, take the zone where the circle swept by moving along L_i as S_i , the swept zone is a possible diffusion area. All inspection wells in this area are the dangerous areas. If there is the connected well in the dangerous area, one well upstream and one well downstream from the connected well are also classified as the wells that may explode.

Further, in an embodiment of the present disclosure, the method of the embodiment of the present disclosure further includes: an opening degree of a corresponding gas pipeline valve is controlled, according to the leakage position.

It can be understood that, in embodiments of the present disclosure, after identifying the dangerous area and sending out the early warning, the corresponding gas pipeline valve is controlled, according to the determined leakage position. For example, when the serious leakage is determined, the valve on the leaked pipeline should be closed in time, to prevent the flammable gas from continuing to leak and avoid the harm caused by the continuous leakage. For another example, if the leakage is relatively slight, the opening degree of valve may be reduced according to an actual situation. Therefore, on the one hand, it may ensure a user to use the flammable gas normally, on the other hand, under the premise of ensuring safety, it may reduce the flammable gas leakage to the uttermost, and prevent to bring security risk.

By a way of specific embodiments, the leakage detection method of the gas pipeline will be further explained as following.

As illustrated in Fig. 10, there is the gas pipeline nearby the inspection well A, objectively having a condition for occurring the flammable gas leakage. The concentration curve changes drastically, and the peak value mostly appears in the early morning, then the flammable gas leakage is determined.

Draw a circle with A as the center and R_3 as the radius, and look for all the gas pipelines L_i in

this area, these pipelines are the gas pipelines that may leak.

Draw a circle with one endpoint of L_i as the center and the maximum diffusion range R_3 of the flammable gas as the radius, take the zone where the circle swept by moving along L_i as S_i , the swept zone is a possible diffusion area. All inspection wells in this area are the dangerous areas. In addition, the area where the flammable gas may be diffused has two cases. As illustrated in Fig. 11, there is no connected well within the possible diffusion area. As illustrated in Fig. 12, there exists the connected well within the possible diffusion area. If there is the connected well in the dangerous area, one well upstream and one well downstream from the connected well are also classified as the wells that may explode, for example, 2# is the sewage well. If the sewage well 2# is the measuring point, the measured data shall prevail; if the sewage well 2# does not have the measuring point, and the sewage well 3# has measured the methane, then the sewage well 2# and 3# are both areas where explosion may occur; if the sewage well 3# dose not measure the methane, then the sewage well 2# is the explosion point, but the sewage well 3# is not; if the sewage well 2# and 3# are both not the measuring points, then the sewage well 2# is the explosion point, but the sewage well 3# is not.

According to the gas pipeline leakage detection method provided in embodiments of the present disclosure, it is determined whether the gas pipeline has the leakage according to the concentration of the flammable gas in the plurality of underground spaces surrounding the gas pipeline, and when there is the leakage, the current leakage position is acquired and reported, thus implementing quick and scientific positioning of the leakage point of the gas pipeline, enabling accurate prediction of the maximum impact range of the flammable gas leakage, facilitating daily safety maintenance of the gas pipeline network and emergency handling of leakage accidents.

Secondly, a gas pipeline leakage detection apparatus provided according to embodiments of the present disclosure is described with reference to the drawings.

Fig. 13 is a block diagram illustrating a gas pipeline leakage detection apparatus according to an embodiment of the present disclosure.

As illustrated in Fig. 13, the gas pipeline leakage detection apparatus 10 includes a detecting module 100, a determining module 200, and a processing module 300.

The detecting module 100 is configured to detect concentration of flammable gas in a plurality of underground spaces surrounding a gas pipeline; the determining module 200 is configured to determine whether the concentration of the flammable gas meets a leakage condition; the processing module 300 is configured to, in response to the concentration of the flammable gas

meeting the leakage condition, determine that the gas pipeline has a leakage, and acquire and report a current leakage position.

The apparatus 10 of embodiments of the present disclosure may implement quick and scientific positioning of the leakage point of the gas pipeline, thereby may enabling accurate prediction of the maximum impact range of the flammable gas leakage, facilitating daily safety maintenance of the gas pipeline network and emergency handling of leakage accidents.

Further, in an embodiment of the present disclosure, the apparatus 10 further includes: an acquiring module, an assessment module, and a setting module.

The acquiring module is configured to acquire a representative value of explosion possibility and explosion damage consequence data of each underground space surrounding the gas pipeline of all underground spaces surrounding the gas pipeline; the assessment module is configured to determine an explosion risk assessment value of each underground space surrounding the gas pipeline, according to the representative value of explosion possibility and the explosion damage consequence data; the setting module is configured to determine the underground space surrounding the gas pipeline having the explosion risk assessment value greater than a preset value as one of the plurality of underground spaces surrounding the gas pipeline to be monitored.

Further, in an embodiment of the present disclosure, the determining module 200 is further configured to, in response to the concentration of the flammable gas in the underground space surrounding the gas pipeline at a current moment and the concentration of the flammable gas in the underground space surrounding the gas pipeline at a previous moment being both greater than or equal to a first preset concentration, and a difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than zero, determine that the leakage of the gas pipeline is a slight leakage; in response to the concentration of the flammable gas at the current moment being greater than or equal to the first preset concentration, and the difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than or equal to a second preset concentration, determine that the leakage of the gas pipeline is a serious leakage, in which the second preset concentration is greater than the first preset concentration.

Further, in an embodiment of the present disclosure, the apparatus 10 further includes an identifying module, and an alarming module. The identifying module is configured to identify a current dangerous area, according to the current leakage position and the concentration of the

flammable gas; the alarming module is configured to control a preset alarm device to alarm, according to the current dangerous area and a preset alarming mechanism.

Further, in an embodiment of the present disclosure, the apparatus 10 further includes a controlling module. The controlling module is configured to control an opening degree of a corresponding gas pipeline valve, according to the leakage position.

It should be noted that the above explanation and description of the embodiments of the gas pipeline leakage detection method also applies to the embodiments of the gas pipeline leakage detection apparatus, which is not to be repeated here.

According to the gas pipeline leakage detection apparatus provided in embodiments of the present disclosure, it is determined whether the gas pipeline has the leakage according to the concentration of the flammable gas in the plurality of underground spaces surrounding the gas pipeline, and when there is the leakage, the current leakage position is acquired and reported, thus implementing quick and scientific positioning of the leakage point of the gas pipeline, enabling accurate prediction of the maximum impact range of the flammable gas leakage, facilitating daily safety maintenance of the gas pipeline network and emergency handling of leakage accidents.

In addition, terms such as “first” and “second” are used herein for purposes of description and are not intended to indicate or imply relative importance or significance or to imply the number of indicated technical features. Thus, the feature defined with “first” and “second” may comprise one or more of this feature. In the description of the present invention, “a plurality of” means two or more than two, unless specified otherwise.

Reference throughout this specification to “an embodiment,” “some embodiments,” “one embodiment,” “another example,” “an example,” “a specific example,” or “some examples,” means that a particular feature, structure, material, or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the present disclosure. Thus, the appearances of the phrases such as “in some embodiments,” “in one embodiment,” “in an embodiment,” “in another example,” “in an example,” “in a specific example,” or “in some examples,” in various places throughout this specification are not necessarily referring to the same embodiment or example of the present disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments or examples.

Although explanatory embodiments have been shown and described, it would be appreciated

by those skilled in the art that the above embodiments cannot be construed to limit the present disclosure, and changes, alternatives, and modifications can be made in the embodiments without departing from spirit, principles and scope of the present disclosure.

What is claimed is:

1. A gas pipeline leakage detection method, comprising:
 - detecting concentration of flammable gas in a plurality of underground spaces surrounding a gas pipeline;
 - determining whether the concentration of the flammable gas meets a leakage condition;
 - in response to the concentration of the flammable gas meeting the leakage condition, determining that the gas pipeline has a leakage, and acquiring and reporting a current leakage position.
2. The method of claim 1, further comprising:
 - acquiring a representative value of explosion possibility and explosion damage consequence data of each underground space surrounding the gas pipeline of all underground spaces surrounding the gas pipeline;
 - determining an explosion risk assessment value of each underground space surrounding the gas pipeline, according to the representative value of explosion possibility and the explosion damage consequence data;
 - determining the underground space surrounding the gas pipeline having the explosion risk assessment value greater than a preset value as one of the plurality of underground spaces surrounding the gas pipeline to be monitored.
3. The method of claim 1, wherein, determining whether the concentration of the flammable gas meets the leakage condition, comprises:
 - in response to the concentration of the flammable gas in the underground space surrounding the gas pipeline at a current moment and the concentration of the flammable gas in the underground space surrounding the gas pipeline at a previous moment being both greater than or equal to a first preset concentration, and a difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than zero, determining that the leakage of the gas pipeline is a slight leakage;
 - in response to the concentration of the flammable gas at the current moment being greater than or equal to the first preset concentration, and the difference between the concentration of the

flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than or equal to a second preset concentration, determining that the leakage of the gas pipeline is a serious leakage, wherein the second preset concentration is greater than the first preset concentration.

4. The method of claim 1, further comprising:

identifying a current dangerous area according to the current leakage position and the concentration of the flammable gas;

controlling a preset alarm device to alarm, according to the current dangerous area and a preset alarming mechanism.

5. The method of any of claims 1 to 4, further comprising:

controlling an opening degree of a corresponding gas pipeline valve according to the leakage position.

6. A gas pipeline leakage detection apparatus, comprising:

a detecting module, configured to detect concentration of flammable gas in a plurality of underground spaces surrounding a gas pipeline;

a determining module, configured to determine whether the concentration of the flammable gas meets a leakage condition;

a processing module, configured to, in response to the concentration of the flammable gas meeting the leakage condition, determine that the gas pipeline has a leakage, and acquire and report a current leakage position.

7. The apparatus of claim 6, further comprising:

an acquiring module, configured to acquire a representative value of explosion possibility and explosion damage consequence data of each underground space surrounding the gas pipeline of all underground spaces surrounding the gas pipeline;

an assessment module, configured to determine an explosion risk assessment value of each underground space surrounding the gas pipeline, according to the representative value of explosion possibility and the explosion damage consequence data;

a setting module, configured to determine the underground space surrounding the gas pipeline having the explosion risk assessment value greater than a preset value as one of the plurality of underground spaces surrounding the gas pipeline to be monitored.

8. The apparatus of claim 6, wherein, the determining module is further configured to,
in response to the concentration of the flammable gas in the underground space surrounding the gas pipeline at a current moment and the concentration of the flammable gas in the underground space surrounding the gas pipeline at a previous moment being both greater than or equal to a first preset concentration, and a difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than zero, determine that the leakage of the gas pipeline is a slight leakage;

in response to the concentration of the flammable gas at the current moment being greater than or equal to the first preset concentration, and the difference between the concentration of the flammable gas at the current moment and the concentration of the flammable gas at the previous moment being greater than or equal to a second preset concentration, determine that the leakage of the gas pipeline is a serious leakage, wherein the second preset concentration is greater than the first preset concentration.

9. The apparatus of claim 6, further comprising:
an identifying module, configured to identify a current dangerous area, according to the current leakage position and the concentration of the flammable gas;
an alarming module, configured to control a preset alarm device to alarm, according to the current dangerous area and a preset alarming mechanism.

10. The apparatus of any of claims 6 to 9, further comprising:
a controlling module, configured to, control an opening degree of a corresponding gas pipeline valve, according to the leakage position.