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Research on Smart gas safety supervision system based on IOT technology

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Abstract. Gas management units have a large number of gates to be supervised. This paper introduces an intelligent gas well management system. By installing all kinds of intelligent sensing terminals in the gas well, it can monitor the massive gas well in real time, and form the gas well internet of things with the help of NB-IOT technology, and gather the data to the data analysis cloud platform. Finally, the perception data is processed and analyzed in the data analysis cloud platform, so as to conduct safety supervision and accuracy of the massive gas wells. At the same time, it uses the historical monitoring big data collected by the system for a long time to build the risk prediction model of the gas well, and carries out the safety risk level assessment and fault prediction and early warning for the key gas well, so as to comprehensively realize the intelligent management of the gas well.

Keywords: Narrow band Internet of things (NB-IOT), Gas Well, Intelligent Management, Risk prediction of gas well.

1. Introduction

Gas pipeline is an important city's infrastructure, and it is also an important basis for the normal operation and service of natural gas supply services. In recent years, the number of accidents in underground gas pipeline is increasing. How to strengthen the safety management of underground gas pipeline and improve the work efficiency of early warning and post disposal is the most important things of the gas management department. Therefore, how to correctly deal with the relationship between safety and production; how to perform the monitoring function of gas pipeline accurately, real-time and quickly, and carry out the gas network information effectively, so as to ensure the safe and efficient operation of gas pipeline network is particularly important and urgent.

Gas ownership units have a large number of gas wells that need supervise every day, and it has the characteristics of many kinds and wide distribution. The traditional supervision means are not only unable to prevent in place all the time, but also have low efficiency and high cost. Moreover, it is easy to receive fault information for too long or difficult to locate the fault gas well timely and accurately.

Through the construction of smart gas safety supervision system based on Internet of things technology, the electronic identifier and various intelligent sensing terminals are installed in the gas wells of the gas ownership department. Real time monitoring and intelligent sensing of gas well cover opening, noise, liquid level, pressure, temperature and other parameters. With the help of narrow band



Internet of things technology to form gate well Internet of things, the front-end sensing data is sent back to the data analysis cloud platform in real time.

The intelligent analysis and processing of sensing data on the cloud platform can realize the fine management and real-time monitoring of the gate well safety, so that the management unit has the comprehensive management and control ability of the gate well with all-round and multi-means, and can provide strong support for emergency disposal.

2. Technical solutions

Smart gas safety supervision system based on Internet of things technology includes intelligent perception layer, data transmission layer and data analysis cloud platform. The intelligent sensing layer is used to collect all kinds of state data of sluice shaft in real time; In the data transmission layer, NB-IOT (Narrow Band Internet of Things) technology is used to realize the real-time transmission of massive gas well sensing data; Data analysis cloud platform is used to receive, store and process the front end sensing data in real time, and warning, predicting, early warning of gas well fault.

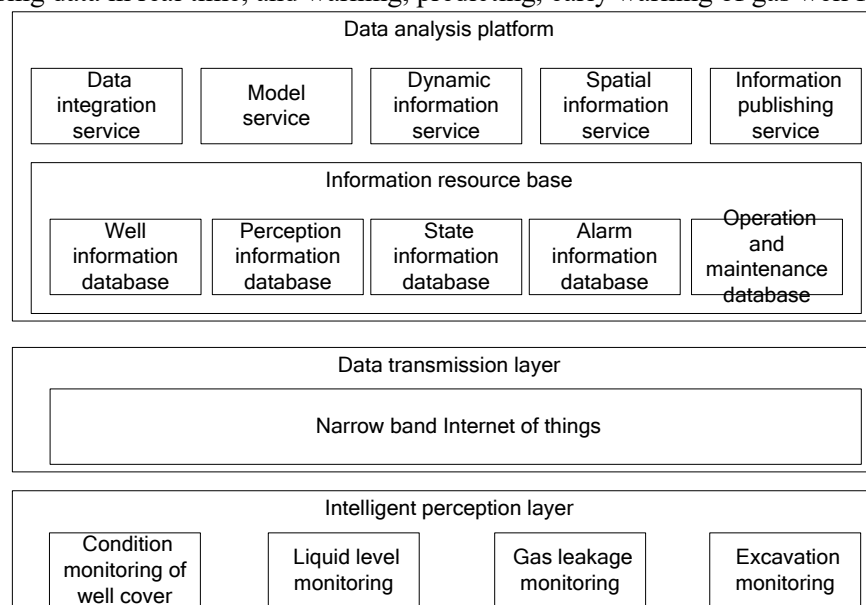


Figure 1. Smart gas safety supervision system based on Internet of things technology

2.1. Front end intelligent sensing

The intelligent sensing terminal installed in the massive gas well not only collects the parameters of various gas well covers, noise, liquid level, pressure, temperature and other parameters through a variety of sensors, but also conducts preliminary analysis, filtering and conversion of the original sampling data of the sensor, so as to complete the local storage of the data.

At present, the gas ownership department has the most urgent demand for the daily monitoring of well cover, liquid level, gas leakage and third party construction damage.

(1) Condition monitoring of well cover

The gas well cover plays an important role in protecting the internal facilities and external pedestrians of the gas well. The loss of the gas well cover caused by the missing of the well cover, the malicious removal of the well cover, or the negligence of the inspectors, will bring great security risks. A well cover condition monitor is installed on the well cover to actively sense and real-time monitor the opening and closing state of the gas well cover. In case of abnormal conditions such as illegal opening and displacement of the well cover, the alarm information can be sent to data analysis cloud platform immediately.

One or more of magnetic sensor, photosensitive sensor and ultrasonic sensor can be used in data acquisition module of the gas well cover condition monitor.

(2) Liquid level monitoring

Because of the design, construction or the sealing of the gas well cover, water seepage in the gas well will cause different degrees of damage to the internal facilities of the gas well. The liquid level monitor is installed in the gas well to monitor the liquid level in the gas well in real time. Once the safety threshold is exceeded, the alarm information can be sent to data analysis cloud platform immediately.

In order to accurately collect liquid level information, the data acquisition module of liquid level monitor usually adopts the dual sensor scheme, which uses ultrasonic liquid level sensor and immersion liquid level sensor to measure the current liquid level height. The immersion liquid level sensor probe is installed below the blind area of the ultrasonic liquid level sensor probe. After the device is turned on, first turns on the immersion level sensor for liquid level measurement. If all contacts of the immersion sensor are not immersed in water, the measurement data of the immersion sensor is invalid, and the ultrasonic sensor is opened for liquid level measurement; otherwise, the measurement data of the immersion sensor is valid, and there is no need to turn on the ultrasonic sensor.

(3) Gas leakage monitoring

The medium in the gas pipeline is gas, which is flammable and explosive. Once the leakage occurs, the risk is very high, so it needs to be monitored. The gas leakage monitoring equipment can monitor the running state of the pipeline in the gas well by collecting the gas concentration information in the gas well in real time, and master the gas leakage situation in the gas well in real time. When the gas leakage concentration reaches the flammable and explosive or the set threshold value, the alarm information can be sent to data analysis cloud platform immediately.

The gas intelligent monitoring terminal can adopt laser type principle detector, and the detector adopts explosion-proof structure design, which can be used in harsh underground environment.

(4) Excavation monitoring

With the increasing speed and scale of urban construction, the damage accidents caused by the third party construction on urban gas pipeline network are also increasing. Once the urban gas pipeline is damaged by the third party construction, especially the high-pressure gas pipeline and the important medium pressure main pipeline, it will not only affect the normal gas consumption of gas users near the accident area, but also cause gas explosion accidents or other secondary disasters. The excavation monitor is installed on the wall below the gas well for vibration monitoring, so as to monitor the third party damage of gas pipeline network and prevent the occurrence of false excavation

2.2. Real time data return

The sensing data processed by the intelligent sensing terminal is uploaded to the database of the gas well intelligent management system through the NB-IOT to realize the network coverage of the Internet of things.

As a technology applied to low-speed services, NB-IOT has significant advantages of large connection, wide coverage and low power consumption. In the case of the same base station, NB-IOT can provide 50-100 times more access than the existing wireless technology, which can easily meet the needs of massive monitoring equipments networking; NB-IOT has strong indoor coverage ability, which can increase 20dB transmission gain compared with LTE, equivalent to 100 times of coverage area capacity. It is very suitable for the application of gate shaft, which requires deep coverage. In addition, the power consumption of NB-IOT equipment is very small. The normal communication and standby current are mA and UA levels. The standby time of the module can be as long as 10 years, which can greatly simplify the later maintenance of the gas well monitoring.

2.3. Data analysis on the cloud platform

The front-end sensing data is transmitted to the data analysis cloud platform through NB-IOT. The platform stores these data in the information resource library to realize the centralized management and sharing of information, and uses various services to conduct intelligent analysis and processing of gas pipeline status information. Once the illegal opening of the well cover, the well liquid level exceeds the warning threshold, the gas leakage concentration reaches the warning threshold, and the third party's

illegal excavation behavior which is uploaded to the data analysis cloud platform of the gas well intelligent management system, the platform can timely display the reported alarm and the position of the opened well cover according to the well cover equipment number and map position, and timely inform the management department to carry out operation and maintenance and solve the fault. At the same time, the data analysis cloud platform can timely inform the relevant management departments to take measures to reduce the occurrence of the gas well accidents after making high-risk prediction and early warning for key points.

The platform integrates front-end perception data through information resource databases such as gas well information database, perception terminal information database, gas well status information database, alarm information database, prediction and early warning information database, operation and maintenance database, and provides data integration services, model services, dynamic information services, spatial information services, information publishing services.

(1) Information database

After integrating the front-end sensing data, the platform classifies and stores the front-end perception data in the gas well information database, perception terminal information database, gas well status information database, alarm information database, prediction and early warning information database, operation and maintenance database and other information resource databases.

The gas well information database stores the gas well basic information such as well number, type and location; the perception terminal information database stores the basic information of perception terminal such as the number, type and installation position of the perception terminal; the gas well status information database stores the corresponding perception data of the gate well; the alarm information database stores the gas well, sensing terminal and alarm information; the prediction and early warning information database stores the risk level and fault prediction and warning information after the safety risk assessment of the key gas well by model service; the operation and maintenance database stores the information related to the repair and replacement of the gas well and the perception terminal after the system issues the early warning.

(2) Platform support services

The platform provides business support for users through data integration services, model services, dynamic information services, spatial information services, information publishing services and other services.

The data integration service can receive, store and preprocess the gas well status and alarm information sent by the perception terminal in real time; the model service generates the risk prediction model of the gas well, and evaluates the risk level of the key gas well, so as to realize the gas well fault prediction and early warning; the dynamic information service can dynamically update the status and alarm information of the gas well and the fault prediction and early warning information in real time. The spatial information service can display the distribution, status and alarm information of the gas well on the map; the information release service can actively release the gas well status and warning information, fault prediction and early warning information to the client. These services can not only realize the centralized monitoring and management of the gas well status, but also provide data support for timely operation and maintenance service.

The operation and maintenance management module provides flexible organization and user management functions, establishes an organization unified with the actual business, and flexibly organizes users by establishing groups, which is convenient for system managers to manage and authorize users. By adding functions such as resource management and role management, the flexibility of authority allocation is realized to meet a variety of business needs; According to the log management function, it can realize the full record of user operation and system operation status, and provide log query, statistics and abnormal alarm functions. The system manager can analyze and deal with the abnormal information by functions. The platform monitoring function can help the operation and maintenance person to get the statistics of the system online access users, server visits and service access response, and master the system details of operation.

(3) Risk prediction model of gas well

The risk prediction model of gas well needs to quantify the possibility and consequence severity of the accident, calculate and evaluate the risk level, and give the risk prediction in advance. Considering the complexity of city gas well and accident causes, the semi quantitative method based on fuzzy mathematics theory can be used. It is very effective to recognize the fuzziness of failure factors and their relationship and give full play to the advantages of fuzzy mathematics which is suitable for nonlinear system or inaccurate or even difficult to establish mathematical model of the system. Firstly, the risk factors of gas well are analyzed to determine the main factors affecting the safety of gas well, and the mathematical model of comprehensive evaluation index system of safety management is established. Secondly, combined with China's gas design standard, the comprehensive evaluation index is quantified, and the weight of each index in the safety management system of gas well is determined by AHP. Finally the risk prediction model of gas well is generated.

At the same time, during the operation of the intelligent gas well management system, the basic data and status data collected by the system continue to increase and be preserved for a long time, which will form the big data for the construction, operation and maintenance and management of the gas well, which can provide accurate, scientific and efficient basic data for the future construction and management of gas wells. Therefore, on the basis of semi quantitative method based on fuzzy mathematics theory, combined with machine learning method, the advantages of big data and theoretical experience can be combined to optimize and adjust the important parameters in the risk prediction model of gas well, so as to continuously improve the accuracy of the model. The basic steps are as follows: firstly, the risk factors of gas well are analyzed to determine the main factors affecting the safety of gas well, and the mathematical model of comprehensive evaluation index system of safety management is established. Secondly, combined with China's gas design standards, the main influencing factors are determined, the comprehensive evaluation index is quantified and AHP is applied to determine the weight of each index in the safety management system of sluice shaft. Finally, taking the index as the initial weight, based on the historical monitoring data of gas well, the machine learning method is used to optimize and adjust the initial weight, and the risk prediction model of gas well is trained.

Whether the semi quantitative method based on fuzzy mathematics theory or the gas well risk prediction model combined with machine learning method, the effect of risk prediction in the initial stage of application may be biased and not ideal. However, with the continuous enrichment and accumulation of basic data of gas well, it will become increasingly accurate and play a more and more significant role in the prediction and early warning of gate shaft safety accidents.

3. Conclusion

With the rapid development of the gas industry, gas operation safety problems have gradually become prominent, especially the gas well safety accidents occur frequently. Due to the flammable and explosive characteristics of gas, once a safety accident occurs, it often has a large impact and serious consequences.

Based on the current gas management unit's most urgent needs for gas well monitoring, such as well cover, liquid level, gas leakage and third-party excavation, the intelligent management system can realize real-time monitoring and intelligent perception of massive sluices by installing intelligent sensing terminals such as well cover monitor, liquid level monitor, gas leakage monitor and excavation monitor, and with the help of NB-IOT technology The technology forms the gas well internet of things, efficiently gathers the front-end sensing data to the data analysis cloud platform, carries out unified processing and analysis of the sensing data on the data analysis cloud platform, carries out scientific and effective safety supervision on the massive gas well, accurately locates the gas well alarm, timely carries out the operation and maintenance, and effectively predicts and warns the key gas well in advance, which greatly realizes the intelligent management of the gas well. It is of great significance to provide support for emergency disposal of gas pipeline well and to prevent gas well accident.

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