Production Scheduling System for Oil and Gas Storage and Transportation Based on GIS and SCADA Technology

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Abstract

During the production and operation of oil and gas storage and transportation, it is necessary to use the detection technology to monitor the parameters about the flow data of related oil and gas storage and transportation, the pipeline parameters, and the operating parameters of the pumping equipment by use of a series of software such as the GIS spatial analysis system, the network system, SCADA software and the system for collecting and analyzing storage and transportation parameters, which can not only realize the automatic operation of oil and gas storage and transportation production but achieve efficient operation by making full use of computer hardware and software systems. This paper studies the GIS system, unifying the parameters of oil and gas storage and transportation pipelines, pipeline locations, pipelines and supporting equipment parameters, spatial information, maintenance records, and detection data, and conducting spatial analysis of the use of storage and transportation pipelines. Based on SCADA software, it detects and controls the production parameters and conditions of the oil and gas storage and transportation system, and gives instructions according to different standards and indicators, which help ensure the orderly operation of oil and gas storage and transportation in all aspects, fully guaranteeing the efficiency, safety and economy of oil and gas storage and transportation production.

Keywords

GIS; SCADA; oil & gas storage and transportation; production; scheduling; system.

1. Analysis of the GIS and SCADA Systems

Spatial location information software involved in this paper generally finds wide applications, which is mainly reflected in the following two aspects: analyzing relevant data parameters on the basis of GIS software, and updating and investing multiple development and research in the software system based on the existing GIS software and finally inventing the integrated software containing spatial location information. At present, GIS has found applications in various fields, including equipment and facilities management, automated graphic production, resource management, large-scale urban development planning, urban population flow management, and oil and gas transportation. In general, however, the functions of the GIS system are mainly: inputting, processing and analyzing relevant data parameters, analyzing spatial position information parameters, searching spatial maintenance information parameters, and outputting and processing related parameters. In contrast, the SCADA system is mainly used for the detection and automated management of real-time data. This technology can be used to collect and organize the data on site and upload it to the central control processing center which can issue commands according to relevant procedures and implement remote control.

2. Analysis of Production Scheduling System Based on GIS and SCADA Technology

There are still some problems in the current oil and gas storage and production scheduling process, which are mainly reflected in the following aspects. First is about whether the resources in the oil and gas storage and transportation scheduling process can be shared, and whether the pipelines and oil tanks involved in the process have the ability to work continuously. Another important issue is the pipeline switching in the process of oil and gas storage and transportation, and the maintenance and repair of damaged pipelines, which invite more constraints on the production scheduling system for oil and gas storage and transportation, making the whole process more complicated. Many scholars have carried out a lot of research on this problem, and have proposed different algorithms to solve the production scheduling problem. However, a single algorithm is far less enough to deal with scheduling problems involved in oil and gas storage and transportation under different situations. Without highly flexible scheduling methods, it is difficult to solve the production scheduling problems of oil and gas storage and transportation through a single mathematical formula or model. Therefore, the author combines the SCADA system and GIS to carry out simulation analysis, forming an oil and gas storage and production scheduling system based on the SCADA system and the GIS technology. The production scheduling system for oil and gas storage and transportation is shown in Figure 1.

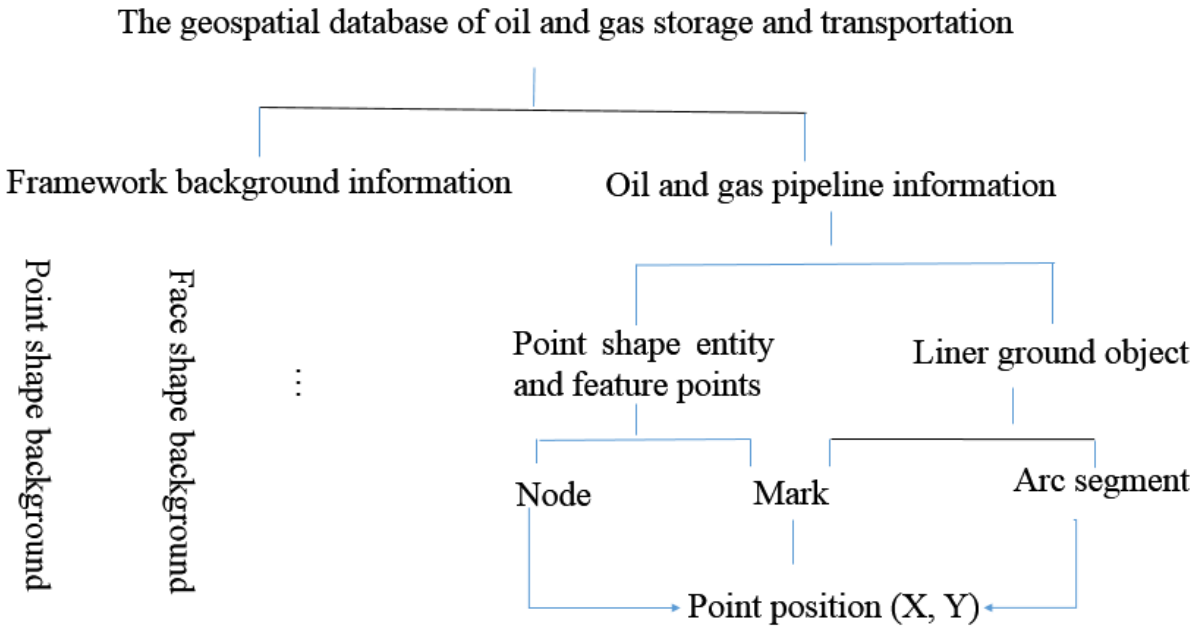

Figure 1 The concept map of the production scheduling system for oil and gas storage and transportation

2.1 Production Scheduling Simulation System for Oil & Gas Storage and Transportation

In the stimulation study of the production scheduling system for oil and gas storage and transportation, the most important part lies in the physical, geometric and mathematical calculation models of oil and gas storage and transportation production process under various conditions. Besides, methods for accurate analysis of physical and mathematical models are essential. Based on the energy conservation equation, the momentum conservation equation and the material balance equation of various fluid flows, the author studies and conducts numerical simulation calculation on the flow classification of oil and gas storage and transportation. Calculating with the above equations, the author can truly stimulate various laws and the distribution of various physical parameters involved in the process of fluid flow. The specific simulation flow chart is shown in Figure 2.

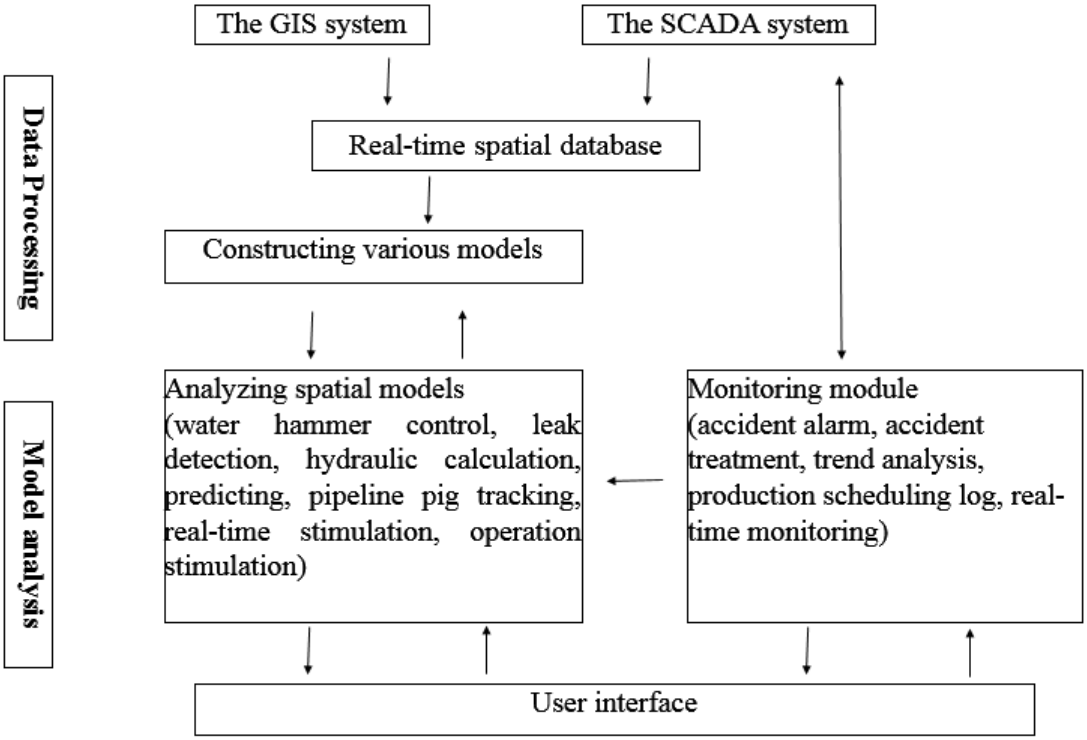

Figure 2 Simulation flow chart

2.1.1 Division of the Production System for Oil & Gas Storage and Transportation

The division of the system for oil and gas storage and transportation is mainly carried out from the following aspects: the first station of oil and gas storage and transportation, the intermediate station of oil and gas storage and transportation, the pipelines of oil and gas storage and transportation, the terminal station of oil and gas storage and transportation and so on. During the process of numerical simulation, it is necessary to establish geometric and physical models for the system mentioned above and set relevant boundary conditions.

2.1.2 Analysis of Supporting Simulation Mathematical Model

When establishing the mathematical model for the basic equipment, we need to transform the geometry of the internal space and the geometric models of the flows of the equipment so as to form mathematical models of the equipment under different initial conditions, pump operating conditions and boundary conditions. The field application process usually includes various processes such as operation, start, and stop of the pump set.

Establishing the mathematical model for leak detection is crucial, mainly because the loss of fluid in the production process of oil and gas storage and transportation is unavoidable. Therefore, it is necessary to establish a mathematical model of fluid flow loss and position detection, a software-based model which is identified with the actual pipelines in terms of size, shape and the operating parameters. By use of such a mathematical model, precise monitoring can be realized on the velocity, temperature, flow rate, leak point and other parameters of the fluid in the pipelines. Meanwhile, we can also predict possible leakage by stimulating the flow state of the fluid in the pipelines with the help of software. Based on these operations, it is then possible to make comparison between the actual operation parameters of oil and gas storage and transportation and those stimulated on computers and conduct an analysis of leakage situations in the whole process.

The establishment of the mathematical model under boundary conditions is mainly about optimizing the target value of the mathematical formula. By constraining the geometric and physical boundary conditions of the fluid space, the numerical simulation analysis of the oil and gas flow model of the whole pipeline can be realized. At the same time, it is necessary to analyze and study the possible

water hammer effect model so as to minimize its impact on the curved parts of the pipelines during oil and gas storage and transportation.

2.1.3 Design of Simulation Software

The design of oil and gas storage and transportation simulation software is mainly composed of the following parts: the basic parameter system of oil and gas storage and transportation pipelines, the first station system of oil and gas storage and transportation, the intermediate station system of oil and gas storage and transportation, the terminal station system of oil and gas storage and transportation, and the internal computing system of the pipeline, the parameter system of fluid information in pipelines, the loss detection system for oil and gas storage and transportation, and the water hammer system for oil and gas storage and transportation. Among them, the internal computing system of the pipeline is more important because it mainly displays the fluid flow interface through the computer terminal. Besides, this system can not only visually demonstrate the change rule of fluid flow during the oil and gas storage and transportation process, but predict abnormal situations, enabling the monitors to find an abnormality at the first time. Other systems correspond to different technological flows during operation. Besides being able to manage the oil and gas storage and transportation system remotely, computer controllers can also provide more accurate and reasonable equipment operating parameters through simulation software.

2.2 Simulation of Production Scheduling of Oil & Gas Storage and Transportation Based on SCADA and GIS Technology

In general, the data of the production of oil and gas storage and transportation recorded by the SCADA system is dynamic. The system analyzes the detected information during the operation and feeds it back into the judgment module of the system which determines whether to interrupt production according to the pre-designed instructions of the computer. However, the SCADA system generally records and analyzes the parameters involved in the process of oil and gas storage and transportation and cannot predict the future state of oil and gas storage and transportation, which means that computer intelligent decision-making and judgment needs to be improved. Besides, the number of RTU system modules it contains is limited, so the SCADA system can only record parameters of the oil and gas storage and transportation production for some specific locations. Although the SCADA system can perform detailed analysis and control of the operation parameters of the system for oil and gas storage and transportation, it fails to display the various positions of the production state in the oil and gas storage and transportation pipelines. In contrast, the GIS technology can be used to precisely control and detect the position information of the oil and gas storage and transportation system; but it does not possess the function of analyzing and managing the operation data. If the SCADA system can be combined with the GIS technology, the functions of the two can be better realized, thus making a great difference to the production scheduling system for oil and gas storage and transportation.

2.2.1 Technological process of Production Scheduling Stimulation

Through the above analysis and research, it can be known that the GIS system has no advantages in managing the production data of oil and gas storage and transportation. However, this system can accurately locate the spatial position in the production process of oil and gas storage and transportation. By contrast, although the SCADA system can manage the production data of oil and gas storage and transportation accurately and efficiently, it cannot locate spatial positions. In order to enable the GIS system and the SCADA system to play a role in the production scheduling system of oil and gas storage and transportation, it is necessary to develop a new program to interface with the systems mentioned above, and re-develop the system, thus fully guaranteeing the production scheduling of oil and gas storage and transportation.

The production platform of oil and gas storage and transportation is established based on the GIS system and the SCADA system; and the two systems carry out statistical analysis of production parameters on the platform. In addition to reading the spatial position information, this platform can

also manage the production data. With this platform system, users can access both spatial and production data at the same time, and issue instructions for the next step according to the content accessed.

The data analysis process is mainly to complete the data sharing between the GIS system and the SCADA system. In this process, external data is obtained from the interface, and the acquired data should be tested and analyzed to ensure accurate and efficient information reading. After the data read enters the data analysis process system, it is converted into a system-specific format. Finally, the process unifies the data of the oil and gas transmission and forms a database.

The model analysis process mainly analyzes and researches the feedback data of users, and performs matching selection for the applicable model. After the matching model is selected, relevant parameter information is extracted from the database for analysis, from which the analysis results and feasibility suggestions obtained are then fed back to the users.

2.2.2 Analysis of Production Scheduling Stimulation Model

The mathematical models involved in the simulation model analysis of the production scheduling system for oil and gas storage and transportation are mainly the mass conservation equation, the momentum conservation method, and the energy conservation equation of fluid flow. The simulation data of the above equations are all derived from the platform. Meanwhile, the current simulation software possesses a coupling function, so data parameters of different modules can be shared.

The water hammer simulation model needs to analyze the data in the platform before operation, mainly including the flow rate, temperature, pressure, fluid velocity, fluid density, pipeline temperature and other production and spatial position parameters of oil and gas storage and transportation production. At the same time, the water hammer simulation model designs protective measures for the water hammer part based on the results obtained from the software simulation. Common water hammer simulation software should possess the functions of providing pre-water hammer protection, recoding all water hammer accidents, conducting effect analysis and offering countermeasure support.

The real-time simulation model can simulate the operating state of the fluid in the pipeline and obtain dynamic information data of the fluid. The model can feed the obtained information parameters back to the users in the form of dynamic images or animations, and provide them with parameters of flow rate, temperature, pressure and flow velocity at various positions in the pipeline during the production process of oil and gas storage and transportation.

The system optimization model exists in the steady state operation mode and the dynamic operation mode during the platform operation. The staff generally input relevant data collected in a period of time into the platform for processing, and operate relevant parameters through the model so as to obtain the optimal operation plan and issue timely instructions for the production scheduling.

The pipeline leakage model monitors the temperature, pressure and fluid velocity in the pipeline by setting the sensing device. If the above parameters are abnormal, the real-time monitoring data will be fed back to the central control system for the detection and analysis of the leak point. Meanwhile, the analytical results will be fed back to the field staff who then check and locate the leak point based on the feedback information.

3. Conclusion and Suggestion

Based on the GIS and SCADA systems, this paper establishes an integrated platform for the production process of oil and gas storage and transportation which can guide the production scheduling of oil and gas storage and transportation. Studies and stimulation of parameters with such an integrated platform can offer reliable technological support for ensuring the safety and efficiency of oil and gas storage and transportation, thus possessing profound significance.

References

[1]. Wang Daqing & Liang Ping. Fuzzy Logic Interference Method for the Accident Risk Probability Matrix of the Oil-gas Storage Installations [J]. Journal of Safety and Environment, 2017, 17 (01): 16-20.

[2]. Zheng Yunping, Zhou Yanshu & Wang Yuchun. Application and Outlook for Comprehensive Evaluation Index Weight in Oil & Gas Storage and Transportation Engineering [J]. Oil & Gas Storage and Transportation, 2014, 33 (09): 928-932.

[3]. Li Yanfang. Analysis of Safety Management of Oil and Gas Storage and Transportation from the Perspective of Environmental Protection and Energy Conservation [J]. Oil-Gasfield Surface Engineering, 2014, 33 (10): 7-8.

[4]. Liang Fachun, Zhang Shuwen & Cao Xuewen. Construction and Practice of National Experimental Teaching Demonstration Center of Oil & Gas Storage and Transportation [J]. Experimental Technology and Management, 2014, 31 (07): 115-117+148.

[5]. Jin Junqing & Zheng Yunping. Application of FLUENT Software in Oil and Gas Storage and Transportation Engineering Design [J]. Natural Gas and Oil, 2013, 31 (02): 27-30+39+5.

[6]. Li Hanyong, Chen Jiaqing, Dai Jingjun, Gao Jie & Lei Junyong. Reform of the Experimental Teaching System for Oil and Gas Storage and Transportation Engineering [J]. Research and Exploration in Laboratory, 2013, 32 (03): 179-183.

[7]. Yao Wei. The Current Situation and Development of Standardization in Oil & Gas Storage and Transportation Industry in China [J]. Oil & Gas Storage and Transportation, 2012, 31 (06): 416-421+488.