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Visualization of integrated energy consumption optimization system for all-weather oil pipeline transportation

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Abstract: Due to the depression of oil pipeline transportation in recent years, the low transportation capacity has become a common situation, and the oil transfer pump unit cannot operate under rated conditions and is in a low efficiency area for a long time. In transportation, throttling is often carried out by adjusting the outlet valve, resulting in a large amount of energy loss. Therefore, in order to reduce the energy loss of the whole oil transportation system, including pumps and pipeline outlet valves, and realize energy saving and emission reduction of oil pipeline transportation, a visual all-weather oil pipeline transportation comprehensive energy consumption optimization system is developed, which includes a pipeline transportation experimental platform, a three-dimensional pipeline transportation virtual scene model, an energy consumption optimization mathematical model, a data display and analysis visual model, and can assist managers in formulating energy saving schemes for pipeline transportation operation and also provide virtual practical services for employee training[1].

1. Introduction

1.1. Energy saving is the inevitable choice to balance the development of oil use and ecological environment

Oil pipeline transportation is an important part of China's energy industry, and its energy consumption control is the focus of industrial energy saving. The "Thirteen-Five" comprehensive work plan on energy conservation and emission reduction issued by the State Council emphasizes the promotion of a new generation of information technology in key energy-consuming industries such as petroleum and petrochemical, and the improvement of industrial production efficiency and energy efficiency. The energy saving of oil pipeline transportation system will reduce the cost of oil transportation, and play a positive role in improving global warming and ecological environment, which has research value[2].

1.2. Energy loss in the process of oil pipeline transportation

In the process of oil pipeline transportation, the pipeline is the main energy dissipation part, and the environmental factors affect the friction resistance by affecting the parameters of the conveying medium, while the small growth of friction resistance will produce a large energy loss in the process of oil transmission. Nowadays, the low loss has become the general situation, the oil pump unit in the operation process cannot reach the rated operating conditions and long-term in the low-efficiency zone, generally the throttle outlet valve is used to adjust the throttle, but this method also causes a certain amount of energy loss.

1.3. Optimization of visual comprehensive energy consumption for oil pipeline transportation

In order to reduce the energy loss in the process of oil pipeline transportation, a set of virtual isomorphism visualization model for simulating the actual state of pipeline transportation is established, which can show the operating parameters and energy consumption of the key parts of the oil pipeline conveying system, and introduce the all-weather factors such as temperature into the mathematical model, and through the optimization of the mathematical model, to provide managers with feasible energy-saving solutions to achieve the goal of energy conservation and emission reduction. Through the oil pipeline transmission model virtual practice to provide the operator with visual training services[3].

2. Material and Methods

2.1. Three-dimensional model construction

At this stage, due to the rapid development of computer technology, three-dimensional modeling tool software is also more and more diverse, the common Tinker CAD, 3D Max and so on.

This project mimics a set of simulation laboratories based on oil pipelines. In order to make the system roaming can show good results, establish a high-quality three-dimensional model, and for the future development of a combination of VR system Foundation, in the early collection of a large number of data, measurement size and so on.

2.2. Establishment of three-dimensional roaming in long distance pipeline laboratory

Because the whole oil pipeline simulation laboratory system simulation software is a huge project, the following on the model import, first-person perspective and display interaction to introduce the three-dimensional roaming part of the production.

2.2.1. Import of Unity Engine model

Because of the large number of three-dimensional models of the laboratory simulation system of petroleum pipeline, the experimental console is used as an example to import. First, the experimental console model created with 3d Max is transformed into the FBX format file that corresponds to Unity3d, such as after importing into Unity3d the simulated lab resource file that has been created. Click on the corresponding project in Unity3d to find the model file and material map file that you just imported with the 3d max you used in the project file bar. Then drag it into the lab room that has been built in the scene.

2.2.2. First-person view

First-person perspective refers to the permissions provided to the operator on the PC side to control the free transformation of the angle of view. Help the manipulator to have an immersive feeling, a better understanding of the various parts in the laboratory, to achieve the possibility of experimental operation under the virtual model.

2.2.3. Show Interactions

In terms of display interaction, select two features to introduce, key display interaction and data display interaction.

●Key display interaction

In order to give the operator a true sense of operation, the key changes in the experimental console are associated with the number of open pumps and achieve the same color changes as the actual operation. The method of ray detection is used to mark circular precast bodies belonging to keys, and to monitor the click of left mouse button in real time. Once the left mouse button is pressed, it emits a ray in three-dimensional space to detect collisions with objects such as keystrokes, and if a collision is found, the component information of the object is obtained, and its properties are changed, and the calculation of the algorithm is also initiated.

●Data display interaction

The data display is for the operator to be able to read the data in the piping system in the first time, and to monitor the running state of the piping system in real time. Using the function of the UI display interface in Unity3d, the energy consumption level of the piping system and the calculated energy saving suggestions are given intuitively.

3. Results

The establishment of the mathematical model determines that the system has the performance of energy saving and emission reduction, based on the actual monitoring data, the mathematical model is established by MATLAB, and the energy consumption effect at this time of the running system is given accurately, and the energy saving suggestion is given according to the result, so as to achieve the role of energy saving and emission reduction.

3.1. Data acquisition and database establishment

PLC Control Data acquisition system is currently widely used in the field of industrial automation control. Compared with other microcomputers, PLC is more suitable for operation in harsh industrial environment, and the data processing capacity is greatly enhanced, programming instructions have modular functions, can solve local programming, monitoring, communication and other issues.

Because MySQL has the characteristics of open source and so on, it is used as a database of this system. The data tables in this database mainly include the number of open pumps oil pump different time periods, the power consumption, pressure and flow rate of each pumping station.

3.2. Server-side development

Server-side development has selected the photon engine as a development tool. Photon server side allows the use of C# programming language for Server logic development, Unity3d is also the use of C# logic development, front and rear end of the same language, the development has a great advantage.

When the client connects to the server, the user sends a request to the server, and the server processes the response to the client, where the processing operation contains an operation on the database. Both the server side and the client need to distinguish between specific request and response types, using different handler functions depending on the type. In order to stabilize the transmission of accurate and complete data, the server uses the TCP/IP protocol to transfer data. Serialize and deserialize the use of XML protocols in data transfer.

4. Discussion

4.1. Future application prospects

The construction of this system can be combined with the actual oil pipeline transportation system, real-time monitoring of operating parameters, when the flow changes, can be pushed to the operator reliable Energy consumption optimization program, auxiliary management personnel to make decisions. During the operation of the system, a large amount of actual pipeline data can be accumulated, according to the relevant temperature, density, flow rate and other parameters of the change, to predict the pipeline transport pump Unit Energy-saving work mode, provided to the management personnel. Managers will feedback the specific situation after the implementation of the program to the system, to help improve the system, to facilitate the self-learning of the system. The more detailed 3d max modeling of some important parts of the pipeline, the training of the system operators in the way of VR, reduce the cost of learning. At the same time, the system and security assessment and other auxiliary systems can be combined to form a set of practical work of a variety of systems combined with a comprehensive optimization system[4].

4.2. Feasibility Analysis

4.2.1. Technical feasibility

Today three dimensional and development engines are diverse and have low learning costs. At the same time, there are many measurable parameters in the oil pipeline system and the precision of the sensor has been greatly improved[5].

4.2.2. Economic benefit Analysis
The system must be for different pump unit system to produce the corresponding virtual model, the main cost comes from artificial cost, low physical cost, suitable for promotion. At the same time, the energy saving benefit brought by the energy consumption optimization of the system has a broad application prospect in China's oil and gas transportation industry.

4.2.3. Market demand feasibility:
China's current 70% of the oil is transported through the pipeline to all parts of the country, its total mileage of oil pipeline has reached 80,000-kilometer, oil transport pipeline has become a relationship between the country's livelihood, the protection of energy supply of the basic facilities, this project will have a large number of markets and good application prospects.

4.2.4. Energy-saving benefit analysis
In practice, this project can be combined with the actual situation to develop sound management measures to avoid the loss caused by oil transmission equipment control problems, and then improve the efficiency of oil transmission pump units, so as to achieve environmental protection and energy saving. The development of this system saves the average unit power consumption 0.11 kw h/t, and implements the environmental protection concept of reducing carbon emissions.

5. Conclusion
In order to reduce the energy loss of the whole oil transmission system, including pump and pipeline outlet valve, and realize the energy saving and emission reduction of oil pipeline transportation, a set of visual and isomorphic integrated energy consumption optimization system of all-weather oil pipelines is developed, which includes pipeline transportation experiment platform, three-dimensional pipeline transmission virtual scene model, energy consumption optimization mathematical model, Data display and analysis visualization model. The system can assist managers to develop pipeline transport operation Energy-saving program, but also for staff training to provide virtual real operation services. The energy-saving benefit brought by the energy consumption optimization of the system has a broad application prospect in China's oil and gas transportation industry, and implements the environmental protection concept of reducing carbon emissions[6].

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