Design and Development of Welding Data Processing System

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Abstract: Through database technology, welding data management technology and automatic analysis storage technology, a management system for welding process monitoring is designed and developed in C# environment, which realizes the integrated automatic management of real-time analysis, processing, storage and uploading of welding data; at the same time, it can make statistical analysis of historical data and generate reports. In addition, the system also has scalability, which provides technical support for the construction of "intelligent pipeline and smart pipe network" in the future.

1. Introduction
In recent years, the domestic oil and gas pipeline construction quality requirements are higher and higher, the oil and gas control of welding construction process is gradually strengthened, and the concept of "intelligent pipeline, intelligent pipe network" is gradually clarified. At present, the main oil and gas pipelines under construction in China gradually promote the digital construction process management, and increase the application of welding process monitoring technology.

Welding process monitoring refers to the comprehensive monitoring of personnel, machine, material, method and environment in the welding construction process, so as to master the actual situation of welding, facilitate the real-time control of welding process and improve the welding quality. At present, the domestic welding process monitoring mainly includes the unit information, welding parameter information, process information, environmental information and so on.

The unit information mainly includes welding equipment information, welder information, weld joint information, etc. The welding parameter information mainly includes welding current, welding voltage, interlayer temperature, welding speed, wire feeding speed, welding layer information, etc. The process information includes pipe diameter, wall thickness, weld pass number of welding layer, welding parameter range, etc., and the environmental information mainly includes environmental temperature and humidity.

At present, there is no special data processing system for welding process in China. This system uses information processing technology to design and develop a set of management system for welding process monitoring, which provides a solution for current welding process management.
2. Design of the system

2.1. Architecture design
A customized integrated management platform for welding process is built by using high-level computer language (C#) programming. Through the integration of database, socket and HTTP and other computer technologies, a welding data integrated management system with four functional modules including receiving, analyzing, processing and reporting is formed.

2.2. Technical route
The system adopts object-oriented.net programming technology and C# language to develop customized welding data integrated management platform. Data receiving is realized by socket technology, and the requirements of high concurrency and large capacity are realized through program optimization. Data analysis is customized according to actual needs, mainly including the analysis of different message formats, identification of different welding process requirements, classification of different project data. This part of the function is realized by user-defined data structure, reasonable database design and other technologies; data processing includes two functional modules: data storage and distribution. Data storage requires reasonable database structure, convenient data reading and data distribution. It mainly completes the communication and docking with the third-party platform, involving interface definition, transmission form and speed. Data storage mainly depends on database technology, while data distribution is realized by HTTP technology. Data report is the deep processing of collected data, which is mainly for comprehensive welding process evaluation of welded joints. The process is mainly realized by filtering statistics technology of large data.

Through the integration of the above technologies, the system realizes the integration of receiving, analyzing, processing and reporting of welding process data. The logical structure of the technical route is shown in Figure 1.

![Figure 1 logic diagram of system technical route structure](image)

3. Database design
The database data set of welding data processing system is mainly composed of basic data, real-time data and historical data.

The basic data mainly serves the system management process and is the data basis of the system. It is mainly composed of project CDP document, welding procedure specification, equipment reporting information, weld joint coding rules and other regulations and standards.
The real-time data is one of the data subjects of the system, which is generated dynamically in the process of welding construction. It mainly consists of welding seam number, welder information, unit information, welding parameter, abnormal information and so on.

Historical data is another data subject of the system, which is generated after data analysis and processing and kept as final records. The database design structure is shown in Figure 2.

![Database Structure Design](image)

**Figure 2** database structure design

### 4. Function module

According to the actual requirements and data security of welding data management system, the system adopts C/S architecture. The system designs five functional modules, including hierarchical user management, database management and operation, real-time data monitoring, data report generation and
other extended functions. The functional structure of the system is shown in Figure 3, and the functions of each functional module are introduced as follows:

1. Hierarchical user management: users are divided into administrators, owners and ordinary users. System users have the functions of adding users, setting permissions and deleting users.
2. Database management operations: basic data entry, historical data query, data import, export and other functions.
3. Real time data monitoring: select specific equipment or weld joint, display real-time welding parameters, crew information, personnel information and other data, so as to understand the actual welding status on site at the first time.
4. Data report generation: statistical analysis of the overall welding situation according to the weld joint number, make an overall evaluation of the welding process, and provide guidance for the follow-up quality inspection.
5. Other expansion functions: Reserve other information interfaces, such as ambient temperature and humidity, gas flow and field length adjustment, to facilitate the system function improvement.

5. Function realization and application example
The overall structure of welding data management system is C/S structure. The system is designed based on Windows platform and customized by Microsoft. Net programming development technology. It integrates database technology, socket technology and HTTP technology, and develops a set of welding data management system integrating SQL Server database, socket real-time monitoring and HTTP post transmission.

5.1. Data receiving function module
The data receiving function is responsible for receiving the message data uploaded on site. Based on Scoket technology, it has the function of high-capacity, large concurrent real-time online monitoring, and meets the needs of real-time transmission of field data. The specific technical schematic diagram is shown in Figure 4.
The principle of socket communication

Socket is the realization of "open read / write close" mode. The system sets the server as normally open mode, sets fixed IP and port number, opens socket channel through active connection of client, and transmits message data.

5.2. Data analysis function module

The data analysis function is responsible for analyzing and checking the field data message. Based on the customized message protocol, it decomposes and restores the fields with different formats, and automatically calls the process procedures to complete the hierarchical processing of field data and the function of abnormal alarm light to meet the needs of real-time monitoring of field data. The specific technical process is shown in Figure 5.

This part of the function module mainly includes two sub modules: Data layered algorithm and exception alarm processing. Data layering algorithm is a set of multi factor comprehensive algorithm developed for field welding practice. It mainly uses real-time acquisition of current, voltage, angle, time and other parameters to carry out Fourier transform, and determine the specific welding layer information according to the change law in the frequency domain, and encapsulate it into a standard DLL file, which is convenient to call.

The abnormal alarm is mainly based on the comparison between the field welding process specification and the collected data. Through the automatic call of different welding process information, the abnormal alarm information is added, and through the feedback mechanism, the owner, construction, supervision and other units are reminded.
5.3. **Data processing function module**

The data processing function is responsible for storing and uploading the analyzed data. The storage is based on SQL Server database technology, and the redundancy design technology is adopted in the database of this system, which realizes the fast writing and retrieval query of large amount of data, and classifies the real-time data and historical data. The system uses the post transmission technology based on HTTP protocol, for different projects, different nature of data, asynchronous call different post address, complete the data distribution and upload. The technical process is shown in Figure 6.

![Data processing flow](image)

**Figure 6** data processing flow

5.4. **Data report function module**

The main function of data report is to complete the integration and analysis of weld data and make comprehensive evaluation. At present, this part of the content is in the preliminary research stage, and its function is relatively single, but it can meet the current actual needs. In the later stage, more in-depth use will be made for the welding data, and the relationship model between the data and the welding quality will be established to provide technical support for the future welding quality.

6. **Results**

At present, the welding data management system is in the initial research stage in China. During the trial period, the system is constantly adjusted and optimized. In the later stage, in-depth research is needed in terms of data timeliness and data availability, so as to further improve the applicability of the welding data management system, gradually improve the welding process monitoring ability, and provide reliable guarantee for the welding quality.

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