Design and Development of Welding Expert System

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Abstract. With the gradual increase of welding laboratory business in recent years and the detection content is gradually widened, the development the informatization of welding related business scheduling, management, as well as experimental data analysis has become a crucial part of the whole welding work. This paper presents a welding expert system, which integrates the functions of experimental data collection, customer entrusting test project recommendation, test data detection, etc., so that users can conveniently and quickly realize customer entrusting information recommendation, welder qualification management and other related work, and test and evaluate the test data rapidly.

1. Introduction

Welding expert system is a computer program system based on welding knowledge, which contains a lot of welding knowledge and can solve practical problems in welding automatically by using professional knowledge. It applies artificial intelligence technology, conducts logical reasoning and decision analysis according to the knowledge provided by welding experts, and simulates the thinking process of welding experts to solve problems requiring welding technology, quality prediction and other aspects.

Welding is an important technology in modern industrial manufacturing and has been a research hotspot in global manufacturing technology. With the development of information technology, the research on welding expert system in developed countries is very extensive. The research on welding expert system began in the mid-1980s. Weld Selector, a welding material selection system jointly developed by the United States Welding Institute and Colorado Mining Institute, is the earliest reported relevant case. After more than 30 years of research, there have been a large number of welding expert systems, whose functions almost cover all aspects of welding [1]. Current welding expert system divided by function content basically has the following kinds:

1) The welding process design system. It can according to user requirements and the characteristics of the welding joint design a reasonable welding process instructions, including material parameters, the welding process parameters, components such as the shape information, and to the existing welding process instructions for storage and effective management [2].

2) Welding process evaluation system. Based on existing welding process standards, the welding process shall be evaluated, including the necessity judgment of welding process evaluation and the design of reasonable verification test, etc.

3) Welder file management and Welder qualification management system. The welder's personal file and certificate will be stored in the database, and the welder's task will be assigned through the call to the database, and the welder's qualification management card will be generated and applied to the actual welding project.
4) **Welding material and equipment management system.** It can manage all the inventory and equipment in the enterprise, realize the regular alarm of equipment maintenance time and the corresponding management of material inventory [3].

Based on the workflow of welding process design in enterprises, this paper represents a welding expert system which integrates the functions of customer entrustment testing project recommendation, welding management, welding result testing, welding process reasoning and so on according to relevant welding standard requirements.

2. Basic Software Function

The three modules are the basic management functions of information, such as the recommendation of testing items entrusted by customers, welding management, and welding result detection

2.1. Recommendation of Testing Items

Some customers are not clear about test items and applicable standards when conducting business delegation [4], and cannot accurately describe their own delegation requirements, the expert system need to relevant information according to the customer as artifact types, the test items, etc. According to reasonable calculation logic, provide users with effective information such as testing content and qualification requirements for recommending the entrusted content, so as to reduce customer questions and improve work efficiency.

The recommendation function mainly relies on the calculation of the edit distance between the information string provided by the customer and the information string in the database to sort the probability of each information match [6]. The result of sorting is the recommended result presented to the customer, and the final test content and eligibility criteria to be confirmed by the user to be finalized.

![Diagram](image_url)

**Figure 1.** The process of recommendation of test items

2.2. **Welding Management**

Welding management is the core module of the welding information management system. This module manages the relevant information in the whole welding process and provides the testing delegation information for the testing module. The function of the welding management system includes the design of the welding process card, the design of the welding products, the function of sending and receiving materials and batch entrusting. The design of welding process card and welding product is mainly aimed at the input and management of welding product information within the department. The management of dispatching and receiving materials of welding management is actually to assign workers for the construction of welding products, which is the preparation before the construction of welding products. The information that needs to be issued includes the information of dispatching supervisor, welder information, equipment information, welding material information, construction site, construction time and other information. Dispatcher supervisor information is
directly selected from the system personnel information, welder information is selected from the system welder information base, equipment information is selected from the system equipment information base, and other information is manually filled in.

Figure 2. The process of welding management

2.3. Function Design of Test Management Module
Examination management is a continuation of the welding management and function extension, the function of examination management is to detect the welding products, through the various testing data to judge whether the welding products. For non-conforming products, send the rework order, and automatically add a record of unqualified product number with a suffix ‘-r’ in the welding product information base.

The test management module includes the following main functions: test process card design, test task assignment, test data recording, test data audit, test report issuance and rework order, etc. The inspection items are divided into 10 inspection items, such as thickness measurement, hardness measurement, ammonia fumigation, eddy current measurement, spectrum measurement, ultrasonic measurement, magnetic powder measurement, ray measurement, permeation and metallography measurement. The design of test process card is mainly aimed at each test item. It is similar to the design of welding process card, and the design idea is similar to the design of welding process card. The current user can check all test process cards in the department, but can only modify or delete the test process card information entered by himself within the scope of authority.

Test data recording is to enter the relevant data obtained from the test of the entrusted welding product into the database, set it as default before the front-end submission without entries, and submit the data recording to the testing supervisor for review. Test data audit is the inspection supervisor’s audit of the accuracy and completeness of the test data entered by the inspection personnel. If the audit passes, the workflow will issue the test report/rework order. If the audit fails, it will go back to the test data record link for modification, and then submit the modification to the inspection supervisor for review.
3. Welding Process Reasoning

3.1. Welding Expert Library
The welding expert database is composed of various welding knowledge points [5]. Through individual constraints of welding conditions, WPS samples are generated under a given decision-making model, and the process is refined according to the results of process evaluation experiment verification and energy consumption cost calculation [7]. The generated results will be returned to the welding knowledge base to form new knowledge. The knowledge of welding includes base material knowledge base, welding material knowledge base, joint form database, groove form database, welding equipment database and other basic databases [8]. By reservation of man-machine interface, input the basic parameters of the pending process, such as plate thickness, material, joint form, optional welding materials and predicted welding method, system dynamic welding procedure Specification (WPS), guide the design of welding procedure specification and welding procedure evaluation.

3.2. Design of Welding Process Reasoning Machine
Forward reasoning is based on deductive reasoning. It is a method of reasoning that deduces a conclusion from known conditions [9]. Forward reasoning rule based reasoning process for a group of first established condition data of dynamic database trigger reasoning machine began to perform reasoning, reasoning machine retrieve dynamic for fact finding to the match in the database, and are looking for matching with the fact that knowledge in the knowledge base, forming a set of knowledge based on input conditions, and from this match as a trigger knowledge reasoning, launched by the conclusions as a new facts in the dynamic database. The reasoning process is repeated until either the solution is successful or the matching knowledge and new facts are no longer available in the dynamic database.

4. Conclusion
As a kind of computer software system, the application of advanced and mainstream software development technology will definitely promote the development of welding expert system. With the continuous improvement of the application level and requirements of the welding expert system, the introduction of mature software development technology and platform will become the trend of the development of the welding expert system. The application of these new technologies, new ideas and new platforms will provide new impetus for the research and development of the welding expert system and other welding engineering application software [10]. Welding process design expert system will remain the focus of welding expert system developers for a long time to exist. According to standard rules and process design engine knowledge and experience, it will be more effective to explore reasonable knowledge representation, construct the knowledge structure of specifications, and find an effective reasoning mechanism to provide convenience for process design [11].

5. References
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