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Study on Computer Aided Failure Analysis System of Chemical Equipment

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Objective: To study the failure analysis system by means of chemical equipment computer. Methods: To test and detect the failure of parts of chemical equipment, then determine the form of failure, find out the main cause of failure, and study the related improvement and preventive measures. Results: The cause and mode of failure are found out timely and accurately. Conclusion: The application of chemical assembly computer in the study of failure analysis system has obvious effect and it is beneficial to improve the accuracy of research results, so it has higher application value.

1. Introduction

As the development scale of the chemical industry continuously expands, the requirement for the reliability of chemical equipment is increasing. At the same time, the failure of chemical equipment parts is becoming more and more prominent, which exerts a great influence on the safety and stability of the whole system, and also brings a disadvantage to the development of chemical industry. There are many causes for the failure, so it is very necessary to analyze the causes of the failure, but the actual analysis will refer to the information and knowledge of maintenance, materials, manufacture, installation, use, process design and other aspects. The failure analysis can only be carried out with the help of the typical cases accumulated in the past experience, so as to summarize the conclusions close to the actual situation. Most of the staff responsible for failure analysis have rich practical experience and very thorough analyses on various typical cases. The work experience and professional level of these staff are the important guarantee to ensure the validity of the failure analysis data of chemical equipment. However, from a realistic point of view, the practical experience and most of accumulated typical cases of failure analysis staff are kept in different regions or departments, and it is very difficult to query or borrow for reading the typical cases of failure analysis across regions and departments. In addition, the failure of chemical equipment is a very complex process, and in the process of failure, it is difficult to master the change law of its environmental conditions. The application of the traditional failure analysis and evaluation method not only takes a lot of time, but also cannot meet the requirements for the rapid development of the society and the production of the chemical industry.

2. Literature review

With the rapid development of the chemical industry, the demand for the reliability of equipment is becoming higher and higher. At the same time, the failure of the components of chemical equipment is often affected by many factors. The analysis of the causes of its failure involves many aspects of knowledge and information such as material, process design, manufacturing, distribution, installation, use and maintenance. It is a comprehensive and practical application technology. It usually needs to rely on a great number of typical cases accumulated in the past from practical experience to analyse and summarize the conclusion that is reasonable in accordance with the reality. These rich failure analysis cases, which have been accumulated in the long-term production practice, are valuable knowledge wealth for the analysis of the failure of petrochemical equipment, but much of knowledge wealth is scattered in different regions, departments or personnel of different units, cross regional and interdepartmental inspection. It is very difficult for people to learn from these typical cases. At the same time, the failure of petrochemical equipment is a complicated

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process, and the failure environment is often changed. It is time-consuming and time-consuming to use the traditional failure analysis to meet the needs of modern rapid production. With the application and development of computer related technology, such as database technology, artificial intelligence technology and network programming technology, Gao and others provide technical support for information and intelligent process of chemical equipment failure analysis (Gao et al., 2015). The computer aided failure analysis system of chemical equipment is a system that uses computer related technology to send and design. It realizes the different users in different regions using different Internet tools (such as smart phone, tablet computer, notebook, desktop computer, machine and so on) to visit and use for the safety of petrochemical equipment. Reliable operations are provided for service and technical support.

In the early days, the failure analysis in our country only provided some advice for the production problems and did not receive enough attention and no unified organizational form. With the development of globalization, intelligence, service and high technology in China's petrochemical equipment, the form and content of the early failure analysis work and the methods used have become more and more unable to meet the needs of objective production. This state is until the beginning of the 1980s China Mechanical Engineering Society. The Institute first convened the first National Conference on mechanical equipment failure analysis until it was changed.

The Beijing University of Chemical Technology designed and developed a pure Chinese metal corrosion database based on the operating system, using relational databases and language programming, including the corrosion data of different kinds of different materials in different concentrations and temperatures of different kinds of candle media. Li and Wen can add, delete, modify, print data on the database. And more than 10 query functions are developed (Li and Wen, 2014). The equipment anticorrosion system of large petrochemical enterprises was studied by the Qilu Petrochemical Industries Co equipment office by Zhang and others, and the relational database structure and language programming were used to design the network version of the petrochemical enterprise equipment anticorrosion information management system (Zhang et al., 2016). The system adopts the structure. In the client system, the menu system and the production flow chart are used to query the two interfaces. The user can operate the image on the graphical interface. It is very convenient for the user to locate and use. Cao Hui and others of the College of materials of Beihang University have studied and developed a network-based case library of the failure of pressure pipe container, which uses a relational database to store the case data of various pressure pipe containers and programming it with computer language. A great number of cases of pressure pipe container failure are collected and arranged in the case base, and the cases are displayed in the form of illustrations and letters, and the cases can be inquired in different ways. Tian Wende, a chemical engineering college of Qingdao University of Science & Technology, studied the failure analysis system of petrochemical equipment based on risk detection. The system was based on the most popular standards at that time. The original standard is optimized in the aspects of database structure, data filtering, computer management and human-computer interface interaction. The frequency of each factor can be calculated according to the plant equipment management data, thus providing a reference for improving the safety and reliability of petrochemical production. Hu Yingming of Jiangxi University of Science and Technology has studied the failure analysis of engine valve wear and the construction of the knowledge base of expert system. The system uses the latest popular "rule frame" method of generalized fault tree representation to express the knowledge in the knowledge base of the expert system and puts forward the related structure and maintenance work of the knowledge base. On this basis, the database is built as a database platform. But the knowledge in the knowledge base is mainly from professional books, and the knowledge is not broad enough.

In recent years, many foreign experts and scholars have done a lot of similar attempts. For example, Spinner and other expert systems are used to determine failure modes in steam pipes and petrochemical industries of power plants respectively (Spinner et al., 2015); Hou describes a program based on image processing technology and pattern recognition technology to distinguish different kinds of fracture surface topography (Hou, 2015). It has been reported that the mechanical punched card failure analysis data have been used in the technical centre of the West Germany (Djeddi et al., 2015). The holes in the edge of the card represent some of the design, material, process and fracture characteristics of the failure events. Using these holes can easily retrieve the failure analysis events with certain attributes. The centre of the card is the description of the event. The number of cards accumulated by the centre was already above Zhang (Gupta and Mishra, 2016). To overcome the low efficiency of mechanical punch card retrieval, a computer aided failure analysis system is also proposed. It can be seen from abroad that some attempts have been made in some aspects of computer aided failure analysis in foreign countries (Al-Shanini et al., 2014).

To sum up, with the development of the chemical equipment manufacturing industry towards globalization, intelligence, network and service, the demand for the reliability of petrochemical equipment is becoming more and more high. In this paper, the computer aided failure analysis system of petrochemical equipment based on Internet is designed and developed by using network programming technology, database technology and artificial intelligence technology. It realizes the access and use of different users with different Internet tools and provides failure analysis techniques and technical support for the safe and reliable operation of petrochemical equipment.

3. Research Methods

Based on the neural network model, this study determines the failure mode and causes by combining with the failure analysis technology. Based on case reasoning process, which includes representation, retrieval, correction, verification, application, learning and storage, the method mainly simulates that a person retrieves solutions to previous related cases in the brain when encountering a problem, combines these solutions with a new thinking mode to solve the problem, and enters the successful cases in the database for future reference; when these solutions cannot solve the problem, usually the weak method will be used to solve. BP neural network has a lot of neurons (nodes) connected with each other into a non-linear network structure system, which is also a simulation of human thinking mode to solve new problems by combining with the past cases, and information transmission methods include forward propagation and backward propagation. The ordering of the case types and the data representing the classification of the case types are detailed in Table 1. For example, in the data sheet, the item number of Category I equipment type is 65, the item number of Category II chemical equipment is 67, and the item number of Category III piping is 71, thus indicating the type path as 65|67|71. The ordering refers to the order under the upper category.

Table 1: Case type table

The field names	The data type	Field size	Fields that	example
ALLXJ-d	Automatic numbering	4	Case type number	The pipe
ALLX_name	The text	30	Case type name	71
ALLX-opid	digital	30	Top case type number	Equipment type
ALLXjopname	digital	4	Top-level case type name	65
ALLX_secid	digital	430	Class ii case type number.	67
ALLX_secname	digital	30	Class 2 case type name.	Chemical uipment
ALLX_path	digital	30	Case type classification	6567171
ALLXJ3X	digital	4	Case type ordering	3

4. Research Results and Discussion

4.1 Common failure mode of chemical equipment

According to the macroscopic characteristics of failure of components and parts of chemical equipment, the failure can be divided into three types: fracture failure, surface damage and other failure. In the failure mode of chemical equipment, fracture failure is the most important and dangerous failure mode. It accounts for a large proportion of the entire failure of chemical equipment, is often a sudden failure and catastrophic failure, and usually results in heavy losses of property and human casualties. Fatigue fracture, and stress corrosion and oxygen embrittlement caused by environmental media are the three main forms of fracture failure of chemical equipment. Surface damage refers to the surface damage and defects that may occur during the production and fabrication of chemical equipment, and some substances that affect the surface, such as oxide layer, rust spot, grinding burr, glow arc mark, glow spatter, agent, and glow defect, most of which are potentially harmful to the oxidation protective film. The surface damage modes of chemical equipment are mainly wear failure and corrosion failure. Among other failure modes, deformation failure is the most common. Deformation failure refers to that the components and parts cannot continue to bear the load of the original design and carry out the expected function or hinder the normal work of other parts due to deformation. It is often divided into elastic deformation failure and plastic deformation failure. Other failure modes mainly include deformation failure, which is one of the common failure modes of chemical equipment. Parts of chemical equipment cannot continue to bear the original design of the load and perform its intended functions or prevent normal work of other parts because of deformation, said that the part suffers from deformation failure.

3.1.2 Material type of chemical equipment

There are two kinds of materials for chemical equipment: nonmetal and metal. In this study, metal materials are mainly involved. By summarizing a large number of failure cases of chemical equipment, this study concludes that the common materials of chemical equipment include carbon steel, cast iron, alloy steel and stainless steel, among which, carbon steel can be divided into medium, low and high-carbon steel; cast iron can be divided into common cast iron such as gray cast iron, malleable cast iron, and nodular cast iron, and various iron with special performance such as erosion-resistant, heat-resistant, and wear-resistant cast iron; alloy steel can be divided into chromium alloy steel, manganese alloy steel, and iron alloy steel according to the type of alloy elements. Stainless steel can be divided into austenite, duplex, ferritic and martensitic.

4.2 Design of subsystem database of case base

3.2.1 Basic contents of the database

This study summarizes a large number of typical case of failure analysis of chemical equipment and concludes that the basic contents of the subsystem database of case base include source, release time, author information, abstract, reference, failure time, equipment type, equipment model, manufacturer, production time, failure location, the failure mode judged preliminarily, the failure cause predicted preliminarily, use time, service life, size and shape of the failure component, material/material type, and service environment (temperature, pressure, medium, etc.) of the failure component, test item, test piece preparation, instrument model, instrument name, test standard, test analysis technology, test result, failure form, main cause, secondary cause, preventive measures, improvement measures, etc.

3.2.2 Structure design of data table

Because the subsystem of case base not only provides the case reference for the users, but also is the main source of the failure analysis and evaluation of cases of subsystem. Therefore, according to the basic contents contained in the database of subsystem of case base, the database of subsystem of case base is designed with tables on Case Type, Basic Information of Cases, Case Summary, Original Information of Cases, Test Information of Cases, Conclusions and Suggestions of Cases, and Full-Text Information of Cases. See Tables 2-1 to 2-7 for the structure of each data table. This study takes a typical case of chemical equipment, that’s, Failure Analysis on Cracking of High Pressure Steam Pipe Head [26], as an example to illustrate the specific meaning of each parameter in the data sheet. The Case Type should be designed with the case name, the number of the case at Level I, II and III, the ordering of the case type, and the data representing the classification of the case type.

Table 2: Case Type

The field names	The data type	Field size	Fields	Example
ALL-d	Automatic numbering	4	The case number	High pressure steam pipe
AL_name	The text	30	Name of the case	71
ALLX-id	digital	4	Case type number	84
GY-id	The text	4	Case source information number.	98
ALLZL_-id	digital	4	Case detection information number.	98
ALJC_-id	The text	4	Case conclusions and recommendation Numbers	98
ALJL_-id	The text	30	Case sorting	3
ALQW-id	digital	4	Case number	98

Table 3: Basic Information of Cases

The field names	The data type	Field size	Fields that	example
GY_id	Automatic numbering	4	Case summary number	High pressure steam pipe
AL_id	digital	4	The case number	98
GY__come	The text	50	Source of case	The pressure vessel
GY_time	Time/date	8	Issuing annual	2013
GY_zzn	The text	50	Author's name	Meng qingwu, wang qiao li.
GY_zza	The text	50	The author unit	Northeast petroleum university
GY_zzt	The text	6	The author zip code	163318
GY_zy	note	1000	Case Chinese abstract	To find out the high temperature steam pipe seal.
GY_gic	The text	50	Case key	Head; Cracking; Steam pipe
GY_ztflh	The text	50	Middle chart classification number	TH49; TQ055.8; 03
GY_bsm	The text	4	Document identification code	B
GY_wzbh	The text	50	Article number	1001-4837 (2013) 11-0
GY_doi	The text	50	doi	10. 3969/j. issn. 10

Table 2 shows the basic information of cases and is mainly used for saving case name, case type, case summary, original data and detection information of cases, conclusions and suggestions of cases, and full-text information of cases.

The Test Information of Cases mainly includes test items, test piece preparation, instrument model, instrument name, test standard, test result and other information. Since a case includes a plurality of test items, there are also a lot of information such as corresponding test piece preparation requirements, instrument model names, and test standards and results. Table 3 only lists the situation for a case where there is only one test item. When there are multiple test items, the contents of data form will dynamically add the contents according to the actual situation.
To facilitate full-text reference by the users, all information of the case is stored in the Full-text Information of Cases, see Table 5. The Conclusions and Suggestions of Cases stores the final analysis conclusions of the cases and the corresponding improvement measures. In general, a case has multiple conclusions and corresponding suggestions, and the database will dynamically add the conclusions according to the actual situation, as shown in Table 6.

Table 4: Test Information of Cases

The field names	The data type	Field size	Fields that	Example
ALJC—id	Automatic numbering	4	Test item name 1.	98
ALJC_nainel	The text	30	Case detection information number	Macro check
ALJC_sjzbl	The text	100	Test item name 1 corresponding to the sample preparation	There is no
ALJC_sbxhl	The text	50	Test item name 1 corresponding device model	There is no
ALJC_sbmcl	The text	30	Test item name 1 corresponding device name	There is no
ALJC_bzl	The text	50	Test item name 1 corresponding detection standard	There is no
ALJCJgl	note	500	Test item name 1 corresponding test result.	Head - side wall outside.

Table 5: Full-Text Information of Cases

The field names	The data type	Field size	Fields that	example
ALQW-id	Automatic numbering	4	Case number	98
ALQWjitle	note	1000	Full story	In petrochemical and power plants and other enterprises.

Table 6: Conclusions and Suggestions of Cases

The field names	The data type	Field size	Fields that	example
ALJL-id	Automatic numbering	4	Case conclusion and suggestion number	98
ALJL-JI1	The text	100	Conclusion the case1	The failure mode is thermal fatigue.
ALJ-LJ12	The text	100	Conclusion the case2	The main reason is long-term rainfall.
ALJL-J13	The text	100	Conclusion the case3	The organization of forging process.
ALJ-LJyl	The text	100	Conclusion the case1	For high pressure steam pipeline protection.
ALJLJy	The text	100	Conclusion the case2	Attention and strict control of high pressure.
ALJLJy3	The text	100	Conclusion the case3	Improved high pressure sealing head processing system.

5. Conclusions

After a series of theoretical studies, the following conclusions are obtained: (1) The in-depth and systematic study of a large number of typical case of chemical equipment find that the the subsystem database of failure analysis case data can be divided into three categories: form, material and equipment type, which can be incorporated into the database of the subsystem of failure analysis case data to provide the relevant reference for the failure analysis. (2) According to the basic contents and types of the subsystem of failure case data, this study designs the Case Type, Basic Information of Cases, Case Summary, Test Information of Cases, Conclusions and Suggestions of Cases, and Full-Text Information of Cases and completed the planning of the overall structure of the subsystem of case data. It also adopts advanced technical means to design and develop the subsystem of failure analysis case data. (3) Based on subsystem of the failure analysis and evaluation of chemical equipment of neural network model, this study establishes the basic contents of the subsystem database, provides important reference basis for designing the overall structure and data table of the subsystem, and designs and develops each module of the subsystem on the basis of computer technology, to ensure the effectiveness of computer aided failure analysis studies.

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