Study on a Process Safety Management System

Design of a Chemical Accident Database

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***Abstract*—to fulfil the objective of changing "accident handling, postmortem prevention" to "intrinsic safety, advance prevention" in chemical industry, this paper covers research to develop a process safety management system (PSMS). First of all, the method is proposed based on the survey, which pointed that it is an essential way to take full advantages of accidents information to enhance process safety management. Secondly, the key functions of PSMS are detailed and the needs for accident database are demanded. The defects of chemical database existing were concluded through literature review. Thirdly, the outline design of PSMS chemical accident database is presented. The work can provide some theoretical and practical reference for the study and development of the process safety management system.**

Keywords—process safety management system; chemical accident database; risk factors; safety management plan amendment; decision-making of emergency response plan;

I. INTRODUCTION

To fulfil the process safety management objectives of changing "accident handling, postmortem prevention" to "intrinsic safety, advance prevention" in chemical industry, a wide array of process safety management techniques have been developed [1-8]. Safety performance in the chemical industry has been significantly improved in China over the past ten years[9]. However, similar accidents still occurred in the same plant, even in the same workplace, such as the explosion of an oil pipeline in Dalian in 2010 and in 2011 respectively, and the explosion of an oil pipeline in Qingdao in 2013. This indicates that much more needs to be done to enhance the effectiveness of process safety management in china.

The essence of process safety is to be aware of hazards, to estimate the risks, to reduce risks where possible, to pick up the signals when danger becomes imminent, and to know what to do to neutralize the threat[10]. However, there is many defects in safety management at present. For one thing, although Risk analysis technologies help us recognize hazards and prevent accident, risk factors cannot be definitely decided only by the brainstorming approach. The other side, capability of emergency response teams isn't improved due to the poor experiences. Learning from the experiences of others has long been recognized as a valued and relatively painless process. In the world of process safety, this learning method is an essential tool since industry has neither the time and resources nor the willingness to experience an incident before taking corrective or preventative steps[11] Past accidents can provide us with valuable information about accident precursors, types, causes, consequences ,handling experiences. Availability of these data will help us detect potential risks in workplaces, find the deficiencies of organization performance and practices, extract the lessons to avoid accident recurrence, and mitigate the imminent accident impact on humans and the environment. So it is an essential way to take full advantages of accidents information to enhance process safety management.

An investigation on the management and utilization of the accident information was made in several typical petrochemical plant in china. The result shows that accident data is analyzed and then announced in the whole petrochemical industry. Lessons was obtained. Then the information is stored in the form of electronic document in most of the plant. There is no an unified management platform for sharing the lessons from accident in the whole chemical industry. Therefore, a process safety management system(PSMS) is proposed for this purpose.

The following work of this paper is: firstly, the functions of process safety management system are described and the technical requirements are demanded. Then, an literature review on chemical database in domestic and foreign is provided. Next, to overcome the defects of existing chemical accident database and to meet the requirements of PSMS, an chemical accident database is designed. Finally ,conclusions is drawn.

II. PROCESS SAFETY MANAGEMENT SYSTEM

To improve the effectiveness of process safety management in petrochemical enterprises, a process safety management system is studied. The process safety management system structured in this paper is actually an intelligence information interactive platform for chemical industry peers to solver safety management problems.

Figure 1 describes the main functions of the system. It might include the following :

- ✓ Accident and near misses data collection: the system can timely collect the accident and near-miss accident data in a certain form, which provides important basis for the realization of the other function.
- ✓ Providing references information on hazards the team would not otherwise recognize in Process hazards analysis: this goals can be achieved by exploring the algorithm that can cope with the information collected. Then, users can obtain some advices about risk control and preventive by typing keywords into system. The keywords includes seasons, location, sections, installation or equipment and so on.
- ✓ Safety management improvement : according to accident causation theory, most of the accidents is caused by safety management vulnerabilities. In this paper, the accidents data will be analyzed firstly as figure 2 and figure 5. And then it be stored in databases. By doing so, types of accidents will be associated with all kinds of causes. This will help safety managers find deficiencies of safety management and timely amend it.
- ✓ Fault diagnosis: In the design of the database, accidents precursors is analyzed and stored as figure 4. The data structure make the accidents precursor associated with the type of the accidents. So , Users can apply the platform for fault diagnosis.
- ✓ To assistant decision-making of emergency response plan :data of emergency disposal lessons are organized as figure 6. The system can provide us decision-making for emergency situations according similar condition matching.

The key technologies to achieve above functions are how to build an effective database and how to obtain knowledge required in process safety management from database. In this paper, accident databases of process safety management system are discussed and designed.

Fig 1 The main functions of process safety management system

III. LITERATURE REVIEW ON DOMESTIC AND FOREIGN CHEMICAL ACCIDENT DATABASE

The increased awareness and impetus to prevent and control major accidents involving chemicals has resulted in greater transparency and an increase in available information on chemical accidents, especially in developed countries[12]. PUPAD (Pondicherry University Process-industry Accident Database)[13] was developed to assist past accident analysis. The Major Accident Reporting System (MARS) of Major Accidents Hazard Bureau (MAHB) of the European Union is used by both European Union (EU) and Organization for Economic Co-operation and Development (OECD) member countries. The US Accident Reporting Information System (IRIS) was developed by the National Response Center (NRC) under the United States Coast Guard. The Relational Information System for Chemical Accidents Database (RISCAD) is developed by Japan. There are three different chemical safety-related databases in china: the Accident Inquiry System (AIS) of State Administration of Work Safety (SAWS), the Chemical Accident Cases (CAC) of the China Chemical Safety Association (CCSA) affiliated to SAWS, and the Daily Accidents Information (DAI) of the National Registration Center for Chemicals (NRCC) affiliated to SAWS. These three databases are publicly and freely accessible via online inquiry systems. However, databases vary in terms of objectives, coverage, and structure according different function for systems. Analyzing and comparing the databases of chemical accidents in the world and in China leads to the following conclusions[12]:

- ◆ None of these databases covers all the information necessary for accident analysis.
- ◆ The current databases do not function well as information and data analysis platform regarding all aspects of chemical accidents
- ◆ Especially information on responsible organizations, causal factors, consequences, actions taken/emergency responses, and effectiveness of follow-up actions on the accidents is often absent or incomplete.
- ◆ It is impossible to compare or combine data from these databases systematically, due to the differences in organization of the databases.
- ◆ Evaluation on each accident does not exist at all, leaving no base to judge the accuracy of the data and the effectiveness and effects of the actions taken.

Therefore, in the next section a chemical accident databases is designed to meet the needs of process safety management system.

IV. DESIGN OF DATABASE FOR PROCESS SAFETY MANAGEMENT SYSTEM

To meet the actual needs of process safety management system and overcome the shortcomings of accident database described above, the conceptual data models is constructed by analyzing a large number of accident cases from different petrochemical plants from 2006-2013. The general entity-relationship (E-R) of PSMS is shown in figure 1. The entities of accident cases include accident precursors, basic information, all kinds of causes and lessons/experiences of emergency response. The rational organization of these data help users obtain references information on risk factors, safety

management weaknesses, the dynamic evolution of accident scenarios and decision-making for emergency response.

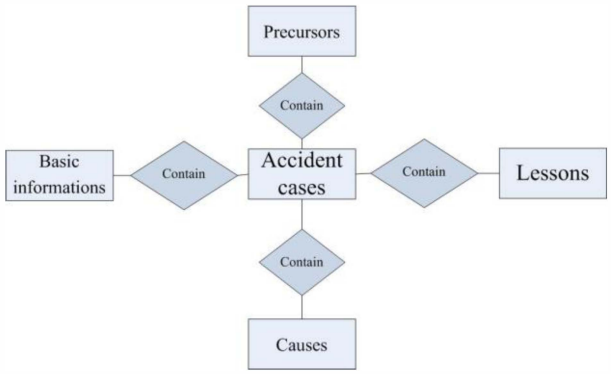

Fig 2 The general entity-relationship of PSMS

To detail the attributes of accidents case, a branch of E-R of PSMS is described in figure 2 to figure 6 respectively. And then, the logical data models is formed. It contains 12 basic tables and 9 case tables. Basic tables is designed for maintenance and case tables for storage of accident cases.

Basic tables:

Table 1 basic information of the case: (serial number, case, precursors, level, related plants, related workplace, related section, related installations, equipment, harmful substances, site ,date, losses, season, general description)

Table 2 type of accident: (type ID, type)

Table 3 level of accident: (level ID, level)

Table 4 plant: (plant ID, plant, local, related products)

Table 5 workplaces: (workplaces ID , workplaces，plant)

Table 6 sections: (sections ID, section，workplaces)

Table 7 installation:(installation ID, installation，section)

Table8 equipment: (equipment ID, equipment，installation)

Table9 harmful substances: (substances ID, substances，equipment, properties)

Table10 accident precursors :(precursors ID, precursors，case, descriptions, pictures,)

Table 11 accident causes: (causes ID, immediate causes, indirect causes, root causes，case)

Table 12 lessons: (lessons ID, advisable lessons, inadvisable lessons，case，effect of disposal)

Case tables:

Table 1 case: (serial number, case, precursors, type, level, losses , seasons, site, causes, lessons ,plant, workplace, section, installation, equipment, substances, general description)

Table 2 case precursors : (precursors ID, precursors, case)

Table 3 case types : (type ID, type, case)

Table 4 case causes: (serial number, case, immediate cause, indirect cause, root cause)

Table 5 case lessons : (serial number, case, advisable lessons, inadvisable lessons)

Table 6 recommendation for risk prevention: (recommendation ID, risk factors, case)

Table 7 association list : (association ID, precursors, case)

Table 8 Causal correlation : (correlation ID, root causes, case)

Table 9 lessons: (keyword ID, lessons, case)

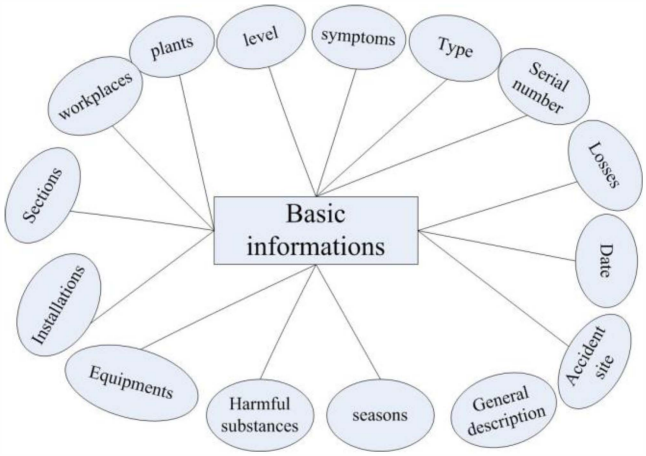

Fig 3 A branch of E-R of PSMS: basic information

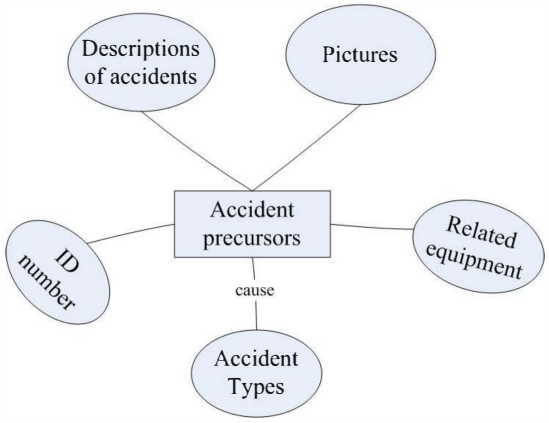

Fig 4 A branch of E-R of PSMS: precursors

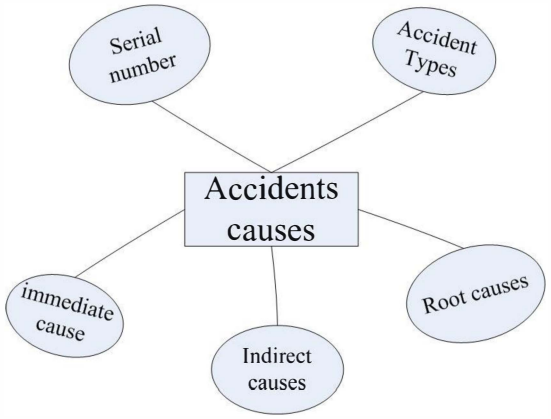

Fig 5 A branch of E-R of PSMS: causes

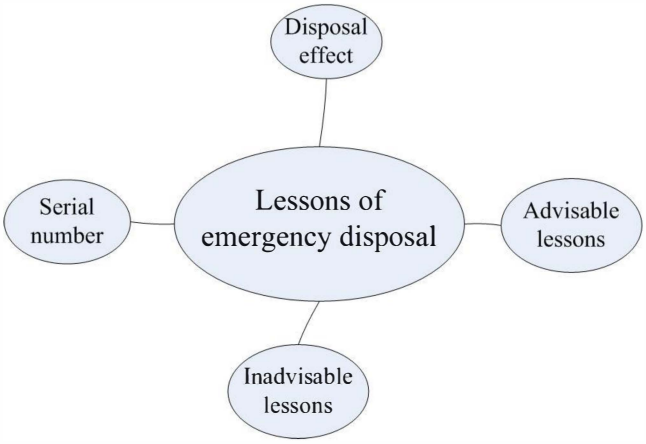

Fig 6 A branch of E-R of PSMS: lessons

V. CONCLUSION

According to the survey, a process safety management system is proposed in this paper. The system will provide an intelligence information interactive platform for peers from chemical industry in risk prevention, safety management plan amendment, fault diagnosis and decision-making of emergency response plan. The key technologies of it are the design of chemical accident database and acquisition of knowledge. Literature review on domestic and foreign chemical accident database is made and shortcoming is concluded. The conceptual data models are constructed based on an analysis of a large number of accident cases. And then, the logical data models are formed. The work can provide some theoretical and practical reference for the study and development of the process safety management system.

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