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System dynamics analysis for petrochemical enterprise fire safety system

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Abstract

To study the changes of fire safety system in oil tank storage area. This paper analyzes the influencing factors of fire safety in oil tank storage area from the aspects of personnel consciousness, fire control facilities, fire control management and technology and establishes the causal relationship analysis. On this basis, the flow pattern model and variables are determined, and the simulation model of fire safety system in oil tank storage area is constructed. Finally, the applicability of the model is verified by the case of Nanjing Liahe chemical industrial park. Research results revealed the complex causality both among fire safety factors and between factors and the system safety level, and could dynamically predict the development trend of system security level in a certain period of time, which can provide theoretical basis for making countermeasures of strengthening the fire safety of enterprises in the chemical park and guiding the enterprise fire safety management.

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Keywords: Chemical park; petrochemical enterprise; fire safety; system dynamics; sensitivity; simulation model

1. Introduction

Because of its own characteristics, petrochemical enterprises have a great danger of fire safety, and fire safety accidents often cause great harm. Therefore, the fire safety of petrochemical enterprises not only involves a complex task at all levels of the society, but also a systematic engineering of scientific, technical and professional integration. On March 27, 2012, a fire broke out in the plant of special amine in the chemical plant of Nanjing Liahe district, Nanjing, Jiangsu province. At 6:07 on April 21, 2015, an explosion occurred in the petrochemical company of Yangzi petrochemical co., Ltd. of Nanjing chemical industrial park. A worker died in a fire at Nanjing Jinling chemical factory in Nanjing, Jiangsu province, at around 11:20 PM on March 13, 2017. In view of the severe situation of fire safety in Nanjing chemical industry park, this paper selects chemical enterprises in Nanjing Liuhe chemical industry to carry out research on fire safety system.

Fire safety and economic and social development are closely related. The change trend of the number of fatal accidents has a greater correlation with the GDP, the tertiary industry growth rate and the proportion of the secondary industry [1]. L Tang on the current fire hazards exist in the careful analysis of the problem, put forward a new strategic path to better strengthen the practical application of fire work[2]. Fire risk characteristics, fire safety protection, emergency rescue and planning security of the park are divided into four primary evaluation indexes. The first level index is divided into 24 secondary evaluation indexes, and finally constructed the tree - shaped fine chemical zone fire safety evaluation index system [3].

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From the existing literature, it is mainly from qualitative analysis to discuss the fire safety of chemical enterprises. In this paper, we use the theory of system dynamics to discuss the related problems of fire safety in chemical enterprises by combining qualitative and quantitative methods. Based on the characteristics of chemical enterprises and the theory of integrated application system dynamics. This paper establishes a model based on the analysis of personnel training, fire control facilities, fire control management and technical level on the impact of fire safety level. According to the simulation results, the corresponding management countermeasures and suggestions are put forward, which is of great significance to realize the effective prevention and control of chemical enterprise fire and protect people’s life and property.

This paper mainly studies the level of fire safety based on personnel consciousness, equipment and facilities, fire safety management and technical level as the main factors, and establishes the following diagram.

![Fire safety level of petrochemical enterprise](image)

The second chapter introduces the basic theory (system dynamics and fire safety theory) used in this paper. The third chapter introduces the analysis and construction of the influencing factors of fire safety in petrochemical enterprises. The fourth chapter introduces the construction of fire safety simulation model of petrochemical enterprises. The fifth chapter takes the Nanjing Luhe Chemical Industry Park as an example to simulate the system dynamics.

2. Basic theory

2.1. System dynamics theory

System dynamics is a cross-disciplinary new discipline that recognizes and resolves system problems and is a subject of analytical information feedback systems. It is a branch of management disciplines and mathematical systems, but also a horizontal discipline used to communicate in the fields of nature and social sciences.

System Dynamics (SD), appeared in 1956, is the founder of the United States Massachusetts Institute of Technology Jay. W. Forreste Professor, in 1958 he analyzed the production management and inventory management and other enterprise problems when the system simulation Method, which was originally called industrial dynamics.

Vensim simulation software is a visual model tool, the user can define the dynamic system, and its file to save, but also can define the model, the system simulation, simulation analysis and optimization of the system [4].

Using SD to analyze all kinds of complex problems, the following four steps must be followed:

1. Identify the final results and causes
2. Model simplification
3. Model test
4. Model optimization

Petrochemical enterprise fire safety system is a large number of factors, large scale, complex internal structure of the system, but also a multi-input, multi-output, multi-interference, multi-time-varying dynamic system. Fire safety system is an organic whole of personnel training, fire control facilities, fire control management and technical level. At the same time, fire safety system can be regarded as a subsystem of disaster forming subsystem and disaster management subsystem. Among them, the two systems and subsystems between the various factors of mutual influence, interrelated, the existence of multiple internal feedback structure, is a continuous production and development process. It is generally believed that the basic structural unit of the system is a feedback loop, that is, the state of the coupling system, the rate (or decision) and the information of a loop.

2.2. Fire safety theory

The fire stems from the loss of control in time and space. The process involves four components, such as matter, momentum, energy and chemistry. From the point of scientific research object, the fire process essence refers to the three-
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