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Research on Safety Management Evaluation of Chemical Enterprises in China

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Abstract: The chemical industry occupies an important position in the national economy, is China's pillar industry and basic industry and has special production characteristics. With the rapid development of science and technology, the workload of the chemical industry, the flow of people and the complexity of the production process is increasing, and the frequency of safety accidents has become higher. Therefore, enterprises pay more and more attention to safety management, and safety evaluation is essential in enterprise safety management. This paper mainly introduces the factors affecting the safety management of Chinese chemical enterprises and the methods and models of safety management evaluation.

Keywords: Chemical industry; Safety management evaluation.

1. Introduction

In recent years, under the influence of social economy and the deepening reform of market economy, the number of chemical enterprises in China is increasing, and the scale of construction is constantly expanding. The safety production of some chemical enterprises has attracted more and more attention from all walks of life, which not only affects the sustainable and stable development of the chemical industry, but also has a negative impact on social economy, ecological environment and people's life and other aspects. In 2021, Inner Mongolia Chemical Co., LTD., a large explosion, resulting in 4 deaths and 3 injuries, the accident is due to the high temperature decomposition explosion when handling materials; In 2022, a major fire accident in Changchun, Jilin Province, killed 17 people and injured three others, due to illegal "gas to oil" transformation of restaurants and dangerous operations during peak hours; In 2022, Sinopec Shanghai Petrochemical Co., LTD. Ethylene glycol plant explosion, resulting in one death, one injury, direct economic loss of 9.71 million yuan, the accident is due to pipe clamp fracture caused by leakage and subsequent explosion; In 2023, a major explosion and fire accident at Liaoning Panjin Haoye Chemical Co., LTD., resulting in 13 deaths and 35 injuries, was caused by an explosion caused by a pipeline leak; In 2023, Shandong Liaocheng Luxi hydrogen Peroxide New Material Technology Co., Ltd. explosion and fire accident, resulting in 10 deaths and 1 injury, caused by hydrogen peroxide device working liquid configuration kettle overpressure explosion; In 2023, Ningxia Ningdong Energy and Chemical Base Changyi Clean Energy Co., Ltd. large deflagration accident caused 4 deaths, direct economic losses of 12.04 million yuan, the cause of the accident is the illegal use of storage tanks, construction units illegal hot fire operation; In 2023, Hebei Tangshan Longquan Chemical Auxiliary Co., Ltd. explosion accident, resulting in 2 deaths and 1 injury, the accident occurred because of production workshop waste water distillation tank; In 2023, Anhui Jinxing Titanium Dioxide Group Co., Ltd. poisoning and asphyxiation accident, resulting in 5 deaths and 1 injury, the accident was caused by workers violating the restricted space operation regulations, inhaling hydrogen sulfide and other toxic gases. All kinds of safety accidents in the chemical industry continue to occur, and the loss is very serious. There is a certain gap between the safety management status of the chemical industry and the high-quality development situation of China's chemical industry. Therefore, in order to effectively prevent the occurrence of safety accidents, it is necessary to fully understand the safety management status quo of the chemical industry, as well as its own industry characteristics. And the safety management work as the primary work of the enterprise work.

2. Research on Safety Management of Chemical Enterprises

China's industrialization process began relatively late compared with foreign countries, and correspondingly, the importance of enterprise safety production was also relatively late, so China's research on safety management evaluation was obviously many years later than foreign countries. However, with the frequent occurrence of various safety accidents, chemical enterprises realized the importance of safety. The state began to pay more and more attention to the safety of chemical enterprises, the relevant laws and regulations, standards and regulations have been promulgated and implemented, all kinds of industrial enterprises and industry management departments also began to attach great importance to safety production. In the past decades, the rapid development of China's chemical industry has brought significant economic benefits, but it is also accompanied by serious safety risks. Many scholars have conducted in-depth research on the issue of safety management in the chemical industry from different angles to improve the safety level of the industry.

(1) Research on safety management

Markway pointed out that special processes, equipment and the high frequency of hazardous substances in the chemical industry increase the risk of accidents. Therefore, it is necessary to strengthen the risk assessment and control measures in the production process. [1] Geng Yunlei studied the regulatory role of the government in safety management, stressed the importance of laws, regulations and policy systems, and proposed that stricter regulations are needed to guide enterprises to improve their consciousness of safety management. [2] Xu Feiyan pointed out the characteristics of

safety culture in the chemical industry and expounded the important role of safety culture construction in enhancing employees' safety awareness and reducing safety accidents. Through case analysis, the successful experience and advanced practices are summarized, which provides a reference for other chemical enterprises, aiming at promoting chemical enterprises to establish a popular safety culture and provide a solid guarantee for safe production. [3] Xiao Ping et al. studied the importance of safety education and training in enterprises, emphasizing that regular training and drills should be used to enhance employees' emergency response ability. [4] In addition, Zhang Zhiyuan analyzed the application of human factor engineering in chemical safety, and believed that the occurrence of human error can be effectively reduced by optimizing the working environment of operators and improving the design of man-machine interface. [5] Jin Zhi believes that the chlor-alkali chemical industry is an important part of China's industry, and doing a good job in the chlor-alkali chemical industry is conducive to the good development of metallurgical industry and light industry. In view of the existing safety problems in the development process of chlor-alkali chemical industry, the standard measures of equipment safety management should be strengthened. [6] In order to improve the level of safety management in the petrochemical industry, Li Tong believes that the promotion and application of information technology will develop into an important trend, and considers a series of challenges caused by the application of information technology, and believes that the organic combination of information means and safety management should be strengthened to achieve high-quality development of the petrochemical industry. [7] Qi Nan investigated the current situation of emergency management in Chinese chemical enterprises. Through professional research and investigation, he accurately found out the effective measures of internal accident emergency management in enterprises, such as setting emergency work content, introducing new technologies, enhancing safety management awareness, reducing accident safety risks and building emergency prevention systems, to improve the handling level of enterprise safety accidents. [8] In addition, Cheng Yawei studied the application of artificial intelligence data platform in safety evaluation. Artificial intelligence can make the production process more simple, make the production control more closely, and provide scientific basis for the development of safety strategies for chemical enterprises. [9] In order to promote the overall improvement of chemical safety management, scholars have gradually realized the necessity of systematic thinking. Wang Lei proposed that from the perspective of system engineering, various safety management modules should be integrated to form a more efficient safety management system, to promote the safe, coordinated and sustainable development of mining work. [10] Wang Dengxue suggested adopting total quality management in chemical safety management, and taking safety index as one of the core performance assessment elements of enterprises, which can effectively promote enterprises to continuously optimize the safety management mode in production activities and ensure the long-term safe operation of chemical production. [11] With the deepening of the concept of green chemical industry and clean production, the application of green chemical technology in safety management has gradually become a hot spot. In order to promote the long-term healthy development of the industry and contribute to the sustainable development of the environment. [12] In addition, Zhao Feng put forward the concept of "integrated management of safety and environmental protection". Based on the perspective of risk prevention and control, he analyzed the shortcomings of safety and environmental protection management in China's chemical parks and the integrated management strategies of safety and environmental protection, hoping to gradually improve the safety and environmental management mechanism of China's green chemical parks and ensure the effectiveness of safety and environmental management in green chemical parks [13].

(2) Research on safety management evaluation methods and models

In addition, many studies focus on the construction of safety assessment models to improve the accuracy of risk assessment. Deng Qing pointed out that in the actual production process, enterprises should choose the appropriate evaluation method according to their own production situation, adopt one evaluation method as the main and multiple evaluation methods to determine the qualitative and quantitative analysis of safety hazards, and should formulate targeted safety preventive measures to ensure the smooth and orderly [14] production. According to the characteristics of the coal chemical industry with high flammable and explosive risk, Sun Chao studied the risks existing in the coal chemical industry from the aspects of safety management and inherent danger. On the one hand, the analytic hierarchy process was adopted to quantify the management of the enterprise itself; on the other hand, the inherent risk evaluation method was used to evaluate and grade the inherent risk, so as to classify the whole enterprise into coal chemical enterprises The safety development of the company provides reference suggestions [15]. Luo Huifeng proposed a chemical risk assessment model based on fuzzy comprehensive evaluation method, which summarized several risk factors such as personnel, equipment, environment and management. The model showed good adaptability in the face of complex chemical processes, and provided support [16] for optimizing safety management. In order to solve the uncertainty of risk assessment process, Wang Lunyan proposed a comprehensive evaluation model of safety risk of shield tunnel construction based on entropy weight - set pair analysis - cloud model. The final evaluation result was obtained by comparing the risk factors with the preliminary judgment results, and its effectiveness [17] was verified by a project case. Peifei applied the "4M" theory to analyze the factors affecting the safety management of power supply enterprises from the four aspects of personnel, equipment, environment and management, built its evaluation index system, used the analytic hierarchy process and fuzzy comprehensive analysis, and finally concluded that enterprises should pay attention to strengthening supervision and staff skill training [18]. Su Xiaoya proposed a risk assessment method based on the normal cloud model, which selects evaluation indicators based on intrinsic security, uses the forward cloud generator to mitigate the risk matrix threshold, and optimizes the evaluation results through the reverse cloud generator, so as to obtain the cloud feature number and generate the corresponding two-dimensional cloud map. By comparing the actual cloud image with the standard cloud image, the risk level of each evaluation index is determined, which provides a new risk assessment tool [19] for the safety management of LNG chemical plants. In addition, Long Yanjiang believes

that it is necessary to strengthen the safety protection awareness of internal employees, identify the influencing factors of project safety management performance and their interactions, and build a safety management performance analysis model from the overall perspective of the project based on system dynamics to evaluate the cultivation of the comprehensive impact of the safety management behaviors of all participants in the construction project on the project safety management performance. Thus, the possibility [20] of danger can be reduced. Wang Ce proposed a safety management evaluation system of chemical enterprises based on fuzzy analytic Hierarchy Process (FAHP). The accuracy and objectivity [21] of the evaluation were effectively improved by grading through a hierarchical index system. Zhang Fanghua adopted the fuzzy comprehensive evaluation method to evaluate the risk of chemical enterprises, and got a reasonable evaluation result, which provided a scientific basis [22] for the risk prevention of chemical industry. Zhang Hong studied the risk assessment method based on Bayesian network, and pointed out that the method can effectively assess the risk of complex petrochemical system, and is suitable for promotion and application [23] in high-risk industries. Liang Yang proposed a data-driven safety evaluation model based on big data analysis technology. The structure safety evaluation method based on data analysis can judge the structure safety level in the absence of certain types of data, which further improves the accuracy and timeliness [24] of judgment. In addition, Cheng Yawei studied the application of artificial intelligence data platform in safety evaluation. Artificial intelligence can make the production process more simple, make the production control more closely, and provide scientific basis [25] for chemical enterprises to formulate safety strategies. Chen Qide pointed out that the international advanced management system PSM will play a good evaluation effect in the chemical industry, and the chemical industry needs to establish a safety management system [26] with PSM as the core. Li Xiangqian put forward that the implementation of process safety management (PSM) is inevitable, compared with the elements of OSHA in the United States, compared with HSE management, safety production standardization elements, and proved the effectiveness [27] of the implementation of process safety management through case studies. Chen Qian established the safety evaluation system of LNG receiving station, established the safety warning level, and obtained a scientific weight calculation method and an improved safety evaluation model after revising the extension theory with the combination weighting method. Finally, he verified the safety evaluation model with a case, and concluded that the safety evaluation model has certain reference value and can make timely early [28] warning for the safe operation of LNG receiving station. He Baolin established the safety rating system for drilling and workover operations, combined the expert consultation method with the analytic hierarchy method, used the fuzzy comprehensive evaluation method to determine the membership matrix of each index, and then multiplied the membership matrix with the weight ratio to calculate the result and determine its safety level. The results show that the safety rating system of drilling workover operation is reasonable, the membership matrix and weight ratio matrix are accurate and reliable, and the system safety evaluation is scientific and reasonable [29]. Liu Jikun used the order relation analysis (G1) method to determine the subjective weight of each evaluation index, the CRITIC method to determine the objective weight, and combined with the cloud model theory to establish a fire risk evaluation model of lithium-ion battery energy storage power station. Taking an energy storage power station as an example to carry out the fire risk grade evaluation, the results show that the comprehensive cloud characteristic value of the fire risk of the energy storage power station is (71.3104, 1.2142, 0.2568), the fire risk grade is in "medium risk", and there are serious problems in the operating environment and fire protection design and other aspects and need to be improved. This paper provides a reference [30] for fire prevention and risk control of lithium-ion battery energy storage power station. Liu Lu constructed two evaluation models of BP and LMBP neural network from four aspects of human behavior, state of things, management and environment respectively, obtained the safety production situation of enterprises, and put forward corresponding improvement measures [31]. In order to ensure the safe operation of submarine crude oil pipelines, Zhang Ying proposed the analysis method of submarine crude oil pipeline leakage risk based on DEMATEL and logic tree. This method can identify the complex influence relationship among the risk factors of subsea crude oil pipeline leakage, determine the weak link of pipeline leakage emergency treatment and take compensation measures, which can provide methodological support [32] for the analysis and control of subsea crude oil pipeline leakage risk. Yu Bo effectively integrated the subjective weight of analytic hierarchy process and the objective weight of entropy weight method, and used the combined weighted matter-element extension model to evaluate the fire in a coal mine. The model was compared with the traditional evaluation methods, and it was concluded that the model was not only accurate in the evaluation results, but also could reflect the deviation degree within the evaluation grade, effectively improving the accuracy [33] of the evaluation results. Lei Zhen combined the improved AHP with DEMATEL. By combining the two, the comprehensive weight is obtained, which not only considers the role of each index on the upper index in the safety evaluation index system, but also considers the influence degree between the two indexes, avoids the limitation of a single expert opinion, and the weight obtained is more reliable and deterministic, effectively improving the objectivity and science [34] of weight seeking.

3. Summary

Safety management has been developing for a long time in China, and relevant research results are abundant. China pays more attention to the systematization of safety management. Many research literatures have analyzed the dangerous and harmful factors affecting safety management, and these factors are usually classified and identified from the perspective of personnel, equipment, environment, management and materials based on the "5M1E" theory. In addition, China's research also pays special attention to the improvement and optimization of system design and emergency management, and brings these factors into the scope of safety management. As an important branch in the field of safety management research, China's research on safety management evaluation has also formed a relatively standardized and perfect research paradigm. The core content of safety management evaluation lies in the construction of relevant evaluation index system and the selection of evaluation methods. Chinese scholars comprehensively apply existing evaluation methods. From the initial quantitative

evaluation to the current combination of qualitative and quantitative evaluation, a relatively rich research method innovation results have been formed.

4. Research Trend and Development of Safety Management Evaluation

At present, some regulations of safety management evaluation of China's chemical enterprises are not clear and perfect, and the second is that the research methods are not intelligent enough, so the future policies and regulations of China's chemical industry will be more stringent, and the evaluation system will be more standardized; Intelligent equipment and information technology will be integrated and developed, and the application in safety evaluation will be significantly enhanced; Self-developed safety assessment methods will gradually replace the models introduced earlier, and an evaluation system in line with China's national conditions will be formed. The number and professional level of safety assessment agencies will increase significantly. To sum up, in the future, safety management evaluation research of China's chemical enterprises will be more legalized, intelligent and standardized, and pay more attention to the integration of production, university and research and green transformation.

5. Conclusion

The trend of mass data in power system provides a basis for load characteristic analysis and prediction model establishment, but the classical load forecasting method can not afford such a huge time and computing resource consumption. The problem of over fitting in large sample set will affect the prediction accuracy. In this paper, a power load forecasting model is built by using the BP neural network model, making full use of the powerful data processing function of Clementine and preventing the over fitting function. The experimental results show that the BP neural network model has good predictability and robustness, and has a certain practical application value.

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