Design and applications of anti-management model in China’s primary refineries

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ABSTRACT
To overcome the weak control of the problem of fragmentation and surface layering on the risk monitoring of the refinery, and to improve the safety management level in the petroleum refining process, The research team decomposes the potential risks of the oil refining system into 5 systems such as ‘personnel, facilities, materials, technology, and environment’ and 106 safety control points, uses semi-quantitative analysis to derive safety evaluation index values, and uses weighted evaluation to derive refining. The overall safety assessment of system risks, and the design of an ‘anti-management’ safety inspection model, focuses on key safety hazards to eliminate hidden accidents. The research model was applied to an oil refinery and two rounds of safety evaluation were carried out. The results were G1 = 84.406, G2 = 91.400, G2> G1, indicating that personnel, machinery and technology have been improved significantly, whereas fuel and environment have been improved slowly, and personnel remained safe. The greatest improvement in quality proves the feasibility of the anti-management risk control model, and its significant issue processing method has a key role. It can provide theoretical models and assistance for the advancement of safety management of petroleum refining and chemical enterprises.

1. Introduction
Oil refineries are highly dangerous as a basic energy industry (Maryam, 2020), and their products are flammable, explosive, toxic, harmful and corrosive, causing frequent accidents in the oil refining industry (Shanjun and Yuanqing, 2020, 2016). Once a production accident occurs in a petroleum refining and chemical enterprise, the damage can range from equipment loss to casualties, and even large-scale environmental pollution (magsahoud ghasemi poor, nastaran mollazadeh, 2019). For example, at around 1:20 pm on March 23rd, 2005, a series of explosions occurred at BP’s Texas refinery, resulting in 15 deaths and 70 injuries, and terrorist attacks were ruled out (Lina & Yong, 2008). At 18:19 on June 2nd, 2011; Chevron’s refinery in Pembroke, England; the 17T302 process storage tank of the amine regeneration unit was ignited due to the accumulation of combustible vapor. An explosion occurred with a shock wave that caused the storage tank to disintegrate. The top of the tank was thrown to a distance of 55 m which nearly hit the fuel pipeline. Eventually, fell on the butane spherical tank. Fortunately, no propane leakage was happened; the accident resulted in 4 deaths; 1 serious injury (Zhenshan & (excerpted translation), 2020). At 1 am on April 26th, 2014, a flash explosion occurred in the oil storage tank area of the Yan’an Refinery of China’s Shaanxi Yanchang Petroleum (Group) Co., Ltd., 3 people were burned and multiple oil storage tanks, plants and equipment in the tank area were damaged Revised formal paper (Anonymous, 2014). On November 22nd, 2016, at the ExxonMobil Baton Rouge refinery in Louisiana, USA, isobutane leaked from the sulfuric acid alkylation unit caught fire which caused serious injuries to 4 workers (Mengrong, 2017). In addition, crude oil collection in refineries are also under high risks. In 2010, BP in the United States had a drilling blowout accident in the Gulf of Mexico, which caused 11 deaths and severe environmental pollution (Jingkai, 2011). In addition to the above-mentioned hazards, the safety impact of the emissions from the refinery on the soil is also worthy of attention, such as Liteboho Ntsohi, Jyabo Usman, Risimati Mavunda & Oscar Kureba(Ntsohi et al., 2021) detected the characteristics of uranium in soil samples from the Serule uranium mine in Botswana, and provided Research data for nuclear radiation safety applications. This shows that a certain amount of toxic emissions is sufficient to cause a certain amount of harm to personnel.

Cases of oil production accidents at home and abroad show that in order comprehensive safety assessments and take targeted management measures for petroleum refining and chemical enterprises is of practical significance to reduce the possibility of accidents and serious economic losses.
2. Literature review

At present, Chinese scholars have researched on the safety management of oil refineries from various levels. Wang Fei (Fei, 2018) used single-factor index and comprehensive index method to gauge the safety evaluation of refinery operations, which has a positive effect. Wang Gaosong (Gaosong, 2020) paid attention to the safety management of the renovation and construction of new projects in the refinery and put forward effective countermeasures. Wei Changhu (Changhu, 2017) put forward useful suggestions for the optimization and control of heating furnaces in oil refineries. Liu Zhongcheng (Zhongcheng, 2016) The continuous expansion of man-made small and medium refineries obsolete equipment and outdated design concepts will lead to explosive accidents in the manufacture process of production equipment. They analyzed the safety problems of the refinery and the countermeasures. Bai Lijing (Lijing, 2016) raised an analysis of the standard operation of the safety facilities of the refinery and designed a reasonable management plan. Zhou Xin et al. (Xin et al., 2020) established the TEA-GHG-OPWM (plant-oriented technical and economic analysis and greenhouse gas emission model) model on the Aspen HYSYSTEM platform and calculated the vacuum residue hydrocracking (VRHCRU) and vacuum residue Oil desulfurization (VRDS-RFCC) two schemes of energy consumption, technical economy and greenhouse gas emissions. Moreover, a new processing method VGOHDT-HTMP-DC (Vacuum Hydrotreating-Hydrogenation and TMP Coupling Process-Delayed Coking) was also developed which had a good impact on technically improving safety management and economic benefits. Bai Haobo et al. (Haobo et al., 2020) proposed a programming model (MINLP, mixed-integer nonlinear programming) for refining and chemical integration projects to achieve the design optimization of multiple interconnected steam power systems, thereby reducing the total annual system Total annualized cost (TAC, total annualized cost) has positive impact on the energy-saving and emission reduction, also sustainable and safe development of the refinery.

In addition to China, many scholars have proposed their opinions on the safety management of oil refineries. Alam Md Zahangir et al. (Zahangir et al., 2021) believe that there are four major threats to any refinery: electrical, mechanical, civil and chemical problems. The biggest one is combustion and the entire system is difficult to manage. The research team used a multi-stage early warning system to prevent oil refinery fires. Risk research and assessment to reduce the occurrence of fires. Dinarijana AAB et al. (AAB et al., 2021) conducted a risk assessment on the process of product handling and chemical processes in the refinery from the perspective of social risk assessment of terminals and refining units to understand the risk level and propose mitigation measures when the risk is irresistible. Ancione Giuseppa et al. (Giuseppa et al., 2020) believed that the emission of volatile organic compounds caused by the loading and transportation of hydrocarbons in the refinery constitutes a risk to human health and develops a comprehensive health risk assessment method for the products of the refinery, which can be used as a reference for practical applications. Carvalho Flavia Cortines et al. (Cortines et al., 2020) analyzed the factors causative to the cardiovascular risk of refinery workers from the perspective of the health of refinery workers. Similarly, American scholars Williams, Shan et al. (Williams et al., 2020) are studying the oil refinery in Texas. After the plant, it is believed that the incidences of some cancers (bladder cancer, breast cancer, colon cancer, lung cancer, lymphoma and prostate cancer) are closely related to the distance from the refinery. People living in the range of 0–10 miles are more distant than those living in the range of 0–10 miles. People 21–30 miles from the refinery are more likely to be diagnosed with related diseases. Therefore, refineries should also pay attention to the radiation safety management of toxic substances in the refinery. Ayşu Zekişoğlu & Şule Parlar(Zekişoğlu & Parlar, 2021) analyzed the safety of ionizing radiation from the perspective of employee health. After all, the health of employees is closely related to the work itself. Radiation can also have pathogenic effects on human internal organs. For example, Eon-Seok Lee, Won-Tae Kim, Ga-Young Park, Manwoo Lee & Tae Gen Son(Lee et al., 2021) measure the radiation of mice, which is safe for the human liver to be affected by radiation. The scope was researched. Therefore, it is also necessary for the refinery to do comprehensive safety protection. These studies not only provide a good reference for the safety management of the refinery itself, but also have scientific significance for the occupational health, labor protection and residential location of the refinery workers.

To sum up, many oil refinery safety management work is to analyze the safety management infrastructure, design concepts and personnel factors from different perspectives. On the one hand, it deeply digs into a certain category of problems, and on the other hand, it analyzes the overall safety. There is a lack of control or superficial control, and there is still a lack of in-depth exploration and quantitative analysis of the systemic safety management of petroleum refining and chemical enterprises. In order to overcome the weakening of the risk monitoring of the refinery caused by the fragmentation and formalization of the problem, the research team decomposed the potential risks of the refinery into five systems of ‘personnel, facilities, materials, technology and environment,’ and used the ‘anti-management’ safety inspection model to the system which is further decomposed into 106
indicators for judgment and analysis. The weighted evaluation method is used to derive the overall safety evaluation of the refining system risk, hoping to provide a theoretical model and evaluation method for the safety management of petroleum refining and chemical enterprises.

3. Refinery danger analysis and anti-management model

3.1. Discover the root cause of danger

According to the statistics of accidents in the world’s petroleum refining and chemical enterprises, the main dangers of oil refineries come from fire, explosion, poisoning, electric shock and falling from high altitude (Anonymous. Explosions, 2019; DuBose, 2019). From the perspective of enterprise safety science and management, no matter what kind of accidents are inseparable from the five systems of ‘personnel, machine, material, process and environment.’ If these five systems operate in harmony then accidents will be reduced and can be avoided, otherwise potential accidents would occur. For example, Tang Bin and He Chen (Bin & Chen, 2015) combined the analysis of the US Chemical Safety and Hazard Investigation Commission on the fire and explosion accidents caused by the material leakage of the Giant refinery in the United States, and profoundly analyzed the causes of the explosion accidents from the aspects of pipeline opening, energy isolation, and locking and tagging. The operator found the cause of the accident that the alkylate recirculation pump could not be turned to report for repair when the alkylate recirculation pump was switched. On the second day, the maintenance team leader assigned mechanical engineers and mechanics to repair. The goal was a 1/4-turn stopcock. The mechanic mistakenly thought that the cutoff channel was actually the valve open. As a result, the alkylate gasoline suddenly leaked during the operation with a pressure of 1.03 Pa and a temperature of 176°C, and the entire refinery was roaring and messy. CSB analyzed the reasons and believes that although the lock-out and tag-out isolation have been in place, they just cover up the core problem, and secondly, the valve design and operation experience has a huge deviation. Therefore, the pressure relief is not completed, the energy is not isolated, and it is always in danger.

The above cases show that the carelessness and experience of the personnel have led to failure to follow the operating procedures completely, resulting in tremendous damage to the machinery, materials and the environment. Going deeper into the reasons, I found that the personnel’s safety awareness was weak, the professional skills were lacking, the safety management was not persistently grasped, and they were in danger without knowing it. Although the process is in the mainstream state of technology, when safety management requires complete coordination of several indicators, any error will interfere with the whole. The working methods of the other systems are similar, so we must start from the above five major systems, dig deep into the root causes of the accident, and find a fundamental way to solve the problem and avoid the accident.

3.2. Anti-management model design

(1) Working principle. Based on a large number of studies on accidents in petroleum refining and chemical enterprises, the research team found that anti-management is a relatively basic concept of ‘positive management.’ Daily management belongs to a type of positive management, called management work, which varies with the scope of work. However, increase in work intensity, increase in personnel, and simple positive management can neither cover everything nor solve all problems. In this context, it is necessary to narrow the scope of work, concentrate superior resources, solve a small problem or eliminate a certain hidden danger. In terms of specific operations, starting from the results and phenomena of the problem, first clarify a focal problem, equip a corresponding team. Secondly, use divergent thinking to find out the cause of the problem, propose effective methods and measures, and finally focus on implementation to eliminate all hidden dangers that may cause accidents (see Figure 1).

(2) Build a model. According to the fishbone diagram, PDCA and safety inspection and analysis principles, on the basis of constantly looking for the cause, feedback is continuously carried out, and then the problem is solved. 3.1 The case shows that although the failure has been discovered and measures have been taken, the focus of the alkylate recirculation pump and the 1/4-turn plug valve has not been fixed, which has buried hidden dangers, causing casualties and huge losses. Therefore, based on the above ideas, an anti-management model (Figure 2) was established to conduct a comprehensive and focused inspection of the focal issues.

(3) Model analysis. The anti-management model is divided into three parts: A, B and C. Part A is mainly for the basic work of petroleum refining and chemical enterprises. Part B is predominantly aimed to discover the problems, phenomena and results of the refinery in the integrated process of refining and chemical. Also development of a focused problem and finally collecting and
intervening in management without going into any doubt or realizing any doubts with explanations and. Part C is the summary, sublimation and application of basic work and anti-management work which reflects the effectiveness of anti-management. The three parts of ABC form a self-contained system, constitute an anti-management model, and intervene in the risk control factors of the refinery.

To sum up the above content, the anti-management security management model is divided into A, B and C three modules. These three modules are interrelated and hence influence each other. They also have strong support for the whole model. This is the basic research idea of the whole thesis.

4. Research design

4.1. Method

According to the production and operation characteristics of petroleum refining and chemical enterprises, use safety management and system safety analysis to interpret the safety management system of the refinery into five evaluation systems. These five systems include personnel, machinery, materials, technology, and environment. The accident statistics analysis method is then used to determine the weight of the variables of each system then use the item detection method in the anti-management model to establish the safety evaluation level of each index.
Subsequently, use the weighted average method to determine the overall data and safety level of the refinery safety management system. Lastly, invoke the anti-management work method to give feedback and verify the effect of the second safety level upgrade.

After determining the research steps, we must focus on the exact application of the anti-management model. The anti-management model is based on the standards and norms related to the refinery’s production and operation system. It discriminates and checks the known hazard categories, design defects in the engineering and the system, the potential hazards and harmfulness related to general process equipment, operations and management, and methods and patterns. This study established the model based on mining the potential risks of the refinery and its use for the safety management evaluation of the refinery of a petrochemical company in a province. Hence, it has proved that the model can improve the safety management level of the petroleum refining system.

4.2. Classification of refinery safety levels

Divide and determine the safety level of the refinery’s production system and indicators. The first is to determine the safety grade classification standard of the refinery safety management system and indicators. The classification standard is shown in Table 1. Secondly, the expert scoring method is used to conduct safety inspections on the various indicators of the safety management of the refinery, and the corresponding safety evaluation standards are obtained according to the results of the checklist and then the safety level of the index is determined according to the safety level classification standards.

According to the above indicators, the weight coefficient and semi-quantitative safety checklist of the safety management index of the refinery are obtained. The safety evaluation score of each index is also achieved and the weighted average method is used to obtain the overall safety evaluation score of the refinery. Assuming that the overall safety score of the safety management system of a petrochemical company’s refinery is M, then

\[
M = \sum_{i=0}^{n} R_i M_i
\]

In formula (1), n is the number of safety management indicators for the refinery; \( R_i \) represents the weight coefficient of the safety management indicators and \( R(\text{Ratio}) \) satisfies the conditions:

\[
\sum_{i=0}^{n} R_i = 1
\]

Then according to Table 1, the overall safety level of the marine safety management system is M. If the security level is different then the strength, time, and quantity of the security management measures taken should correspondingly be different. If the safety level of the safety management system of the refinery obtained through the safety management evaluation procedure of this model is less than 60 points, which is at a level I. It means that the safety management of the refinery is weak and the probability of accidents is high. Therefore, it should be shut down for inspection immediately. Only through rectification and effective measures can we continue to operate. Therefore, if an oil refinery is at a level I, it must quickly attract high attention, shut down immediately for investigation, apply anti-management models to focus on difficult points or hidden accidents, and take decisive measures to correct them in a very short time.

4.3. Determination of weight coefficient

At present, there are many weight calculation methods for multiple system factors, mainly including the analytic hierarchy process, fuzzy mathematics method, 1–9 scale calculation method, etc. Different industries should choose appropriate weight determination methods. For the safety management of petroleum refining and chemical enterprises, the weight coefficients of each risk system can be analyzed rendering to the statistical results of accidents. According to Swiss Re’s analysis and statistics of 102 accident cases in the petroleum industry (Wen, 2002), the determination of the weight coefficients of the five major systems of the refinery can also be calculated accordingly.

As a highly active ‘personnel’ system, its significance affects the other four aspects. Its safety control indicators include the degree of awareness of the dangers of production objects, accounting for 20.2%; weak safety awareness, and lack of skills lead to errors. It accounts
for 17.2%; the weakening of emergency and prevention capabilities leads to danger, accounting for 8%; the above data can be combined to determine that the personnel weight accounts for 45.4% (Anonymous. Explosions, 2019). By analogy, the weight coefficients can be obtained as (0.454, 0.341, 0.044, 0.106, 0.055), and this coefficient ratio is also in line with the view of the American safety management scientist Heinrich (Ge & Guo, 2016; Jinchangwan, 2020), who believes that the cause of the accident is 88% It is the human factor and 10% is the material factor. With the development of enterprises, safety culture has also become one of the influencing factors (Atsuo, 2021; Wenqing et al., 2020; Zhijun, 2020). This article predominantly uses anti-management models to improve the safety level of refineries based on previous studies, so the impact of safety culture is not considered for the time being.

5. Empirical analysis

5.1. Determine the research object

After conducting an in-depth survey of 20 petroleum refining and chemical companies in six provinces and one city in East China. The sampling principles for obtaining relevant targets are as follows: first, the production scale is medium to high-end and the general enterprise has more than 500~2,000 labors. The second is the rich series of petroleum products, including most petroleum products. The third is that the refinery has excellent production machinery and the production process is relatively complex, consequently, there is room for improvement. Fourth, the logistics distribution system is complete, the process is scientific, and the delivery system and the procurement system can be organically combined. The H Refinery is representative of many subjects in terms of personnel, scale, output value, and degree of mechanization. Based on comprehensive expert opinions, the research team selected H Refinery as the research object.

5.2. The anti-management model interferes with the safety of the refinery

Apply the anti-management model to the safety management evaluation of the H refinery. The steps are as follows: First, the refinery production system is divided into five major safety systems and indicators, which are included in the weight coefficient (see 4.3). The second is to obtain the result score of the safety checklist of each index through the anti-management model and obtain the safety evaluation score of each index, and determine the safety level of the index according to the safety management system and the safety level classification table of the index. The third is to obtain the overall safety level of the engine room through the weighted average method according to the safety evaluation scores of the subsystem indicators and the corresponding weight coefficients. The fourth is to use the interval tracking method to carry out the second anti-management model intervention behavior, then compare and analyze the effectiveness of the model and the possibility of promotion.

In the initial work of the five subsystems, the researchers paid attention to collecting comprehensive management information, combined with literature and actual accident case summary for the safety inspection.

5.2.1. Personnel risk inspection

Personnel is the most important factor in the labor force, and the work quality of production personnel is directly related to the normal operation of refinery production. According to analysis, more than 50% of oil refining safety accidents are caused by improper operation by staff (Gui et al., 2020). Therefore, the safety management inspection of personnel is the top priority, as shown in Table 2.

It can be seen from Table 2 that the personnel’s index safety evaluation score is 76.44. According to Table 1, the safety level of people is III, which belongs to the critical safety level. According to the requirements of the anti-management model, it can be seen from Table 2 that the main problems with human safety indicators are: the general manager and safety management personnel have insufficient drills on the emergency response plan for accidents; the employees have insufficient awareness of the dangers of the workplace; Insufficient awareness of safety attitudes toward potential safety hazards and operational hazards; insufficient handling and response capabilities of team leaders to work abnormalities; insufficient knowledge and skills of employees in an emergency evacuation, self-rescue and rescue, etc. Research by Rowa Aljondi(Aljondi et al., 2021) et al. has shown that an individual has the necessary safety management knowledge to help control the damage caused by the outside world. Therefore, safety management measures must be taken from the above specific aspects to improve the safety level of human indicators. In addition, each shortcoming must be thoroughly explored and resolved according to the principle of anti-management.

5.2.2. Risk control of production machinery

Oil refining equipment is a kind of mechanical equipment that cracks raw materials. It is mainly composed of reactors, buffer tanks, cooling systems, oil and gas separators, oil-water separators, dust removal devices, odor removal devices, and negative pressure devices (safety devices). The research team and experts believe that the most important machines in petroleum refining are distillation towers and coking furnaces. The distillation towers are mainly used to distill crude oil
Table 2 Personnel safety index inspection.

| NO. | Security control point                                | inspection criteria | Scoring |
|-----|--------------------------------------------------------|---------------------|---------|
| 1   | Refinery safety system                                 | 0-1-5-7-9           | 9       |
| 2   | Refinery management activities                         | 0-1-5-7-9           | 7       |
| 3   | Overall awareness of management safety management      | 0-1-5-7-9           | 7       |
| 4   | Operator's proficiency in this process                 | 0-1-5-7-9           | 9       |
| 5   | Record sheet of daily overhaul at the basic level of the refinery | 0-1-5-7-9 | 7       |
| 6   | Skills training for special operations in refineries   | 0-1-5-7-9           | 7       |
| 7   | Establish and strengthen the safety management awareness of all employees | 0-1-5-7-9 | 7       |
| 8   | How well the responsible person has established a safety management system | 0-1-5-7-9 | 7       |
| 9   | Responsible person's investment in safety management funds | 0-1-5-7-9 | 7       |
| 10  | Responsible person's safety management organization and staffing situation | 0-1-5-7-9 | 7       |
| 11  | Safety inspection and spot check of safety management technicians | 0-1-5-7-9 | 7       |
| 12  | Personnel allocation for special inspection of employees' safety appearance | 0-1-5-7-9 | 0       |
| 13  | Three-level safety education for refinery employees     | 0-1-5-7-9           | 9       |
| 14  | Facility operators' awareness of the dangers of workplaces and positions | 0-1-5-7-9 | 7       |
| 15  | The actual situation of refinery operators complying with operating procedures | 0-1-5-7-9 | 7       |
| 16  | The operator's actual knowledge of potential safety hazards and operational hazards | 0-1-5-7-9 | 7       |
| 17  | Refinery operator training and induction                | 0-1-5-7-9           | 9       |
| 18  | The rationality, operability and adaptability of the emergency plan | 0-1-5-7-9 | 9       |
| 19  | Rehearsal of the emergency response plan by the management personnel of the refinery | 0-1-5-7-9 | 7       |
| 20  | Refinery employees' emergency response capabilities for emergencies | 0-1-5-7-9 | 5       |
| 21  | Refinery emergency rescue organization and personnel response capabilities | 0-1-5-7-9 | 5       |
| 22  | Emergency rescue personnel's operating skills for accident handling equipment | 0-1-5-7-9 | 5       |
| 23  | Accident emergency rescue knowledge of refinery managers | 0-1-5-7-9 | 7       |
| 24  | Refinery staff's ability to operate protective equipment | 0-1-5-7-9 | 7       |
| 25  | Knowledge of emergency evacuation, self-rescue and first aid for employees of the refinery | 0-1-5-7-9 | 7       |

Take the calculated index value as 76.44

Table 3. Equipment risk safety checklist.

| NO. | Security control point                                    | inspection criteria | Scoring |
|-----|----------------------------------------------------------|---------------------|---------|
| 1   | Compressor unit (including refrigerator) inspection      | 0-1-5-7-9           | 9       |
| 2   | Inspection of steam turbine units (including smoke turbines and expanders) | 0-1-5-7-9 | 9       |
| 3   | Pump equipment inspection                                | 0-1-5-7-9           | 9       |
| 4   | Fan detection                                            | 0-1-5-7-9           | 7       |
| 5   | Detection and elimination of reducer                    | 0-1-5-7-9           | 7       |
| 6   | Conveying machinery inspection                          | 0-1-5-7-9           | 7       |
| 7   | Dry filter machinery inspection                          | 0-1-5-7-9           | 7       |
| 8   | Sewage treatment machinery inspection                    | 0-1-5-7-9           | 7       |
| 9   | Finished product forming packaging machinery inspection  | 0-1-5-7-9           | 7       |
| 10  | Working status inspection of pneumatic, electro-hydraulic transmission structure | 0-1-5-7-9 | 9       |
| 11  | Stirrer detection                                        | 0-1-5-7-9           | 7       |
| 12  | Detection of soot blower                                | 0-1-5-7-9           | 7       |
| 13  | Detection of the flue baffle                            | 0-1-5-7-9           | 7       |
| 14  | Crane tube inspection                                   | 0-1-5-7-9           | 9       |
| 15  | Coking device, hydraulic decoking lifting device detection | 0-1-5-7-9 | 9       |
| 16  | Equipment antifreeze and anti-condensation detection    | 0-1-5-7-9           | 7       |
| 17  | Equipment safety shield and filter inspection            | 0-1-5-7-9           | 7       |
| 18  | Stability inspection of ladders, platforms, and railings | 0-1-5-7-9           | 9       |
| 19  | Heat exchanger leakage elimination (DN<1 M, PN<6.4MPa)  | 0-1-5-7-9           | 9       |
| 20  | Storage tank container cleaning and replacement          | 0-1-5-7-9           | 9       |
| 21  | Reactor, furnace equipment, pipeline inspection          | 0-1-5-7-9           | 9       |
| 22  | Power transformer testing                               | 0-1-5-7-9           | 7       |
| 23  | High-voltage electrical equipment testing                | 0-1-5-7-9           | 9       |
| 24  | High and low voltage power distribution device detection | 0-1-5-7-9           | 9       |
| 25  | DC power supply device detection                        | 0-1-5-7-9           | 9       |
| 26  | Cable lines, lighting devices                           | 0-1-5-7-9           | 7       |
| 27  | Lightning protection device (lightning rod, etc.) detection | 0-1-5-7-9 | 9       |

Take the calculated index value as 89.3

to produce gasoline, kerosene, heavy oil and residual oil. The coking furnace mainly catalyzes the decomposition of heavy oil into light oil crude oil. In petroleum processing, coking is the abbreviation of residual oil coking, which refers to heavy oil (such as heavy oil, vacuum residue, cracked residue and even asphalt, etc.). The process of deep cracking and condensation reaction at a high temperature of about 500°C is to produce gas, gasoline, diesel, wax oil and petroleum coke.

After crude oil enters the refinery, it will go through different operating procedures according to different processing requirements. Crude oil distillation is divided into several different boiling point ranges (i.e. fractions) called one-time processing. One-time processing includes atmospheric distillation or atmospheric and vacuum distillation; The reprocessing of the fractions obtained from the primary processing into commercial oil is called secondary processing. The secondary processing includes catalysis, hydrocracking, delayed coking, catalytic reforming, hydrocarbylation, hydrofinishing, etc. The commercial oil is obtained from the secondary processing. The process of basic organic chemical raw materials is called tertiary processing. The tertiary processing includes the cracking process to produce chemical raw materials such as ethylene and aromatics. According to the anti-management model, the important components and system facilities of the distillation tower and coking furnace are tested, as shown in Table 3.

Table 3 shows that the safety value of the machine is 89.3. According to Table 1, the safety level of the machine is IV, which belongs to the general safety level. According to the requirements of the anti-management model, it can be seen from Table 3 that 12 indicators are lower than 9 points, out of which 1 item is 5 points, so it should be monitored as a focal issue. Analyzing the reasons, the sewage treatment workers went home due to illness and the work was
not completely handed over, which resulted in the missing checklist, but the sewage treatment plant was in normal operation.

5.2.3. Oil risk control
The transportation and storage of crude oil are full of risks, and semi-finished and refined oil must be managed carefully. The safety of the process operation of the oil tank farm plays an important role in the production of oil refining enterprises. It is responsible for the receiving, storage, shipping, and metering tasks of crude oil, component oil, and refined oil in the refinery. Each oil tank farm is closely connected with refining production from the crude oil tank farm that provides raw materials for specific production devices to the middle Product oil tank farm, product oil tank farm and oil storage tank farm etc. The tank farm is the source and end of production in the refinery. The safe operation of the oil tank farm process will directly affect the stability of the production process and the overall throughput. The oil tank farm is very important to the refining production. Therefore, strengthening the safety responsibility management of the process operation safety of the oil tank farm in the refinery is an important factor in reducing process safety and losses. The main tests are shown in Table 4.

Table 4 shows that the risk index value of oil is 92.59. According to Table 1, the safety level of oil is the highest level. According to the requirements of the anti-management model, it can be seen from the Table 4 that there are 4 indicators which are worthy of attention. To be included in the scope of the focus problem, the staff need to find out the cause and take safety measures to prevent accidents.

### Table 4: Oil risk safety checklist.

| NO. | Security control point                              | inspection criteria | Scoring |
|-----|-----------------------------------------------------|---------------------|---------|
| 1   | Crude oil transportation and storage route inspection | 0-1-5-7-9           | 9       |
| 2   | Airtightness inspection of rectifier system          | 0-1-5-7-9           | 7       |
| 3   | Temperature control and detection of medium conveyed by a hot oil pump | 0-1-5-7-9           | 7       |
| 4   | Detection of Corrosion and Thinning of Outlet Pipeline of Decompression Tower Pump | 0-1-5-7-9           | 9       |
| 5   | Install a quick shut-off valve for the pipeline from the bottom of the tower to the high-temperature pump | 0-1-5-7-9           | 7       |
| 6   | Whether the desalination safety valve is sealed and discharged | 0-1-5-7-9           | 9       |
| 7   | Replacement of shielded magnetic pump for centrifugal pump containing H2S medium | 0-1-5-7-9           | 9       |
| 8   | Oil tank aging and accessories detection            | 0-1-5-7-9           | 9       |
| 9   | Whether the oil tank breathing valve is condensed   | 0-1-5-7-9           | 9       |
| 10  | Whether the flame arrester is blocked               | 0-1-5-7-9           | 7       |
| 11  | Fire embankment inspection                          | 0-1-5-7-9           | 9       |
| 12  | Static electricity and lightning detection          | 0-1-5-7-9           | 9       |

Take the calculated index value as 92.59

5.2.4. Technical risk control
Process technology is an important technical guarantee for the development of new products and the upgradation of old products. The development of new products and the renewal of old products are generally not only changes in appearance, but also improvements and enhancements in product performance, function, and structure. The innovation and stability of process technology is the guarantee of production and operation. The system detection is shown in Table 5.

It can be seen from Table 5 that the technical index safety evaluation score is 96.29. According to Table 1, the technical safety level is 6, which is the highest safety level. According to the requirements of the anti-management model, any hidden production hazard cannot be ignored. The system has 9 indicators or lower than 9, so it must be included in the focus of the processing range.

5.2.5. Environmental risk control
Environmental factors have a relatively large impact on production safety. H.A.P. Smit & J. Bezuidenhout (Smit & Bezuidenhout, 2021) studied and pointed out the influence of climate and weather on radon exposure mitigation in two cities. For refineries, the environment also includes many factors. The quality of production environment factors not only affects the improvement of enterprise production efficiency, but also have a direct relationship with the physical and mental health of production operators. The environmental management of the refinery primarily has the following indicators, as shown in Table 6.

It can be seen from Table 6 that the environmental index safety evaluation score is 90.48. According to Table 1, the safety level of people is 6, which is the highest safety level. According to the requirements of the anti-management model, it can be seen from Table 2 that there are potential safety hazards in the six indicators and each shortcoming must be thoroughly explored to make up for it.

5.3. Overall safety value and secondary intervention results
Comprehensive Table 2 to Table 6, the safety evaluation score of the safety management system of H refinery can be obtained by the safety evaluation score of each index and its weight. According to the algorithms in (1) and (2), the safety evaluation score of the enterprise safety management system is:

\[
G_1 = 76.44 \times 0.454 + 89.30 \times 0.341 + 92.59 \times 0.044 + 96.29 \times 0.106 + 90.48 \times 0.055 = 84.406
\]

(3)

According to the anti-management model, researchers should first grasp the appearance characteristics of
Table 5. Technical process risk safety checklist.

| NO. | Security control point                                                                 | Inspection criteria | Scoring |
|-----|----------------------------------------------------------------------------------------|---------------------|---------|
| 1   | Master the safety control level of crude oil pumped to the heat exchanger               | 0-1-5-7-9           | 9       |
| 2   | After the heat exchange temperature reaches 80°C-120°C, add water                       | 0-1-5-7-9           | 7       |
| 3   | Know that the amount of demulsifier is 10~30                                           | 0-1-5-7-9           | 7       |
| 4   | Control the temperature of the desalination degree of crude oil at 105~140°C           | 0-1-5-7-9           | 9       |
| 5   | Master and control the working pressure 0.8~2MPa                                        | 0-1-5-7-9           | 7       |
| 6   | Master the amount of water injection 5%~7%                                             | 0-1-5-7-9           | 9       |
| 7   | Master the actual strong electric field gradient is 500 ~ 100 V/cm                      | 0-1-5-7-9           | 9       |
| 8   | Grasp the weak electric field gradient is 150 ~ 300 V/cm                               | 0-1-5-7-9           | 9       |
| 9   | Know that the desalination rate of the primary desalination tank is between 90% and 95%| 0-1-5-7-9           | 9       |
| 10  | Mastering the secondary water injection is to increase the water volume of crude oil and increase the dipole coalescence of water droplets. | 0-1-5-7-9           | 7       |
| 11  | Know that the salt content of the crude oil after desalinated water is less than 3 mg/L, and the water content is less than 0.2% | 0-1-5-7-9           | 9       |
| 12  | Know that the deacidification temperature is 110 ~ 130°C to remove naphthenic acid in crude oil | 0-1-5-7-9           | 9       |
| 13  | Master the heat exchange of crude oil after pretreatment to 230 ~ 240°C                 | 0-1-5-7-9           | 9       |
| 14  | Know that non-condensable gas accounts for 0.15% ~ 0.4% of crude oil weight            | 0-1-5-7-9           | 9       |
| 15  | Know that the oil at the bottom of the primary fractionation tower is pumped to the heat exchanger and heated to above 280°C | 0-1-5-7-9           | 9       |
| 16  | Knowing that the constant pressure furnace is heated to 360 ~ 370°C into the atmospheric tower | 0-1-5-7-9           | 9       |
| 17  | Knowing that the heavy oil is pumped out and sent to the vacuum furnace, heated to 380 ~ 400°C into the vacuum distillation tower | 0-1-5-7-9           | 9       |
| 18  | Knowing that after condensing and cooling, use 2 ~ 3 stage steam evaporator to extract non-condensable gas | 0-1-5-7-9           | 9       |
| 19  | Master to maintain the remaining pressure at the top of the tower 0.027 ~ 0.1MPa        | 0-1-5-7-9           | 9       |
| 20  | When mastering the production of aviation kerosene, the highest heating temperature of crude oil is 360 ~ 365°C | 0-1-5-7-9           | 9       |
| 21  | Master the bottom temperature of the initial distillation tower, atmospheric tower and vacuum tower of the crude oil distillation unit is generally 5 ~ 10°C lower than the temperature of the evaporation section | 0-1-5-7-9           | 9       |
| 22  | When using steam stripping, the bottom temperature of the stripping tower is about 8~10°C lower than the sideline temperature | 0-1-5-7-9           | 9       |
| 23  | Generally, 0.5% to 0.6% of the activator is added, and the extraction rate will increase by 2% to 17%. | 0-1-5-7-9           | 7       |
| 24  | Master the use of various forms of expansion tube and ash removal technology              | 0-1-5-7-9           | 7       |
| 25  | Know the wide application of ceramic fiber insulation materials, which can reduce heat loss | 0-1-5-7-9           | 9       |
| 26  | Know to strengthen the heat recovery of flue gas, reduce the heat loss of exhaust flue gas, develop and apply various forms of air preheaters | 0-1-5-7-9           | 7       |
| 27  | Master the configuration of the waste heat boiler; use effective monitoring instruments and computer control management. | 0-1-5-7-9           | 7       |
| 28  | The operator is proficient in the main operating conditions of delayed coking: the outlet temperature of the heating furnace is 495 ~ 505°C, the pressure of the coke tower is 0.18 ~ 0.28MPa (gauge pressure), and the temperature at the bottom of the fractionation tower is not more than 400°C. | 0-1-5-7-9           | 7       |

Take the calculated index value as 96.29

Errors, find out the causes of accidents, and especially define the potential hidden dangers clearly. Secondly, we should pay attention to find the focus of the accident. For example, the focus of the first subsystem is personnel. Finally, we should put forward specific solutions to the focus problems and give play to the effect in the actual safety management to get equation (4). This is the basic principle of equation (4).

After the overall inspection of 5 major systems and 106 indicators, several focal issues were identified and the internal reasons were discovered to the greatest extent, which was fed back to the H refinery. After 6 months of full mobilization and rectification, the following results were obtained after reevaluation:

\[
G_2 = 89.78 \times 0.454 + 91.37 \times 0.341 + 93.68 \times 0.044 \\
+ 97.21 \times 0.106 + 91.93 \times 0.055 \\
= 91.400
\]

Combining (3) and (4), we get Figure 3. It can be seen directly from Table 4 that the improvement range of each related system is far from the overall safety value.

5.4. Data analysis

It can be seen from Figure 3 that under the guidance of the anti-management model, the background and cause of the focus problem were found to the maximum, and measures were taken. The safety score of the refinery personnel increased most significant from 34.7 to 40.65, indicating the training of personnel. Constant attention to safety management is conducive to improve the safety of refineries. The improvement of machinery and technology is followed. The improvement of machinery from 30.45 to 31.16, with a range of 0.71 shows that the mechanical performance is relatively stable and the technology is relatively mature. There is still room for improvement in the control of technology and machinery by managers and operators. The increase in oil and environmental safety values reached 0.05 and 0.08. Although the increase was not significant from the perspective of the anti-management implementation process, but managers and front-line operators attribute great importance to oil safety. The basic product of the refinery is oil, which is the foundation of the establishment. While the environment is basically in a stable state, we can only tap the potential from within and continue to carry out
Table 6. Index safety check of the external environment.

| NO. | Security control point | Inspection criteria | Scoring |
|-----|------------------------|---------------------|---------|
| 1   | Natural disasters such as mudslides outside the refinery | 0-1-5-7-9           | 9       |
| 2   | Dangerous degree of weather and rainfall on the day of refinery production | 0-1-5-7-9           | 9       |
| 3   | Significant hazards in the surrounding environment outside the refinery | 0-1-5-7-9           | 9       |
| 4   | The safe distance between the production site of the refinery and the surrounding enterprises with major sources of danger | 0-1-5-7-9           | 7       |
| 5   | Interference distance between surrounding residential areas and refinery | 0-1-5-7-9           | 7       |
| 6   | The rationality of the distance between the external rescue team and the refinery | 0-1-5-7-9           | 7       |
| 7   | The reasonable feasibility of the internal layout structure of the refinery production site | 0-1-5-7-9           | 9       |
| 8   | Reasonable feasibility of safety planning and design of oil refinery production base | 0-1-5-7-9           | 9       |
| 9   | The rationality of the fire-fighting facilities configuration in the production site of the oil refinery | 0-1-5-7-9           | 9       |
| 10  | Are safety warning signs set up in important parts of the refinery production site? | 0-1-5-7-9           | 7       |
| 11  | The rationality of the fire-fighting passage design in the production site of the refinery | 0-1-5-7-9           | 9       |
| 12  | The obstructed degree of fire-fighting passages in the production site of the oil refinery | 0-1-5-7-9           | 9       |
| 13  | Reliability of transportation tools in refineries | 0-1-5-7-9           | 7       |
| 14  | The catalytic cracking slurry pump is located in the open part of the fractionation tower | 0-1-5-7-9           | 7       |

Take the calculated index value as 90.48

SS management to ensure the smoothness and clean-up of the internal environment.

According to the principle of anti-management, the researchers found that the five major system risk problems were collected as (18, 12, 4, 9, 6). For the sake of intuition, assuming there are several risk control points, further research found that these factors are like people. A specific factor is closely related. Therefore, for the refinery, improving the quality of personnel is the biggest focus, as shown in Figure 4. The research team found that whether refinery managers can find the focus factors that are closely related to the five subsystems is the focus of improving the level of safety management.

6. Discussion

(1) The perfect combination of experience and rules. In the refinery production process, belts are constantly worn, oil pipelines often expand and contract with heat, and oil products are not the same. The machine system is always in different working conditions. Therefore, operators must always pay attention to changes in working conditions. Make judgments and decisions based on experience. When safety hazards arise, first follow the refining operation method to gradually check and then make a comprehensive judgment based on your own experience. Any attempt to find the focal problem and seek the cause by relying

Figure 3. Comparison chart. NOTE: 1:staff 2:machine 3:oil 4:technology 5:setting 6: gross value

Figure 4. Focus problem picture.
solely on experience and rules is somewhat one-sided and may cause heavy casualties.

(2) Combination of management and methods. Fragmentation and superficiality of refinery management work are the Achilles heel of the smooth progress of the refining process. Positive management is traditional management, active management, and overall management, while anti-management focuses on the summary of problems, the concentration of difficulties and the accumulation of difficulties. Finally, the focus of system problems is formed and the reasons are found from many aspects, subsequently take measures. Also, pay attention to the appropriateness of the method.

(3) Points to note when operating the anti-management model. The ultimate measure of anti-management is to solve the focal problem. The measures here must not only solve the problems that have already occurred but also have a certain preventive nature so that similar mistakes will not be made again. The principle of anti-management actions are as follows: first, the scope is small, so it is easy to concentrate resources to discover hidden dangers. Secondly, enlargement, to find out the crux of the problem and lastly, measures must be appropriate and not overcorrect.

(4) A perfect combination of safety awareness and technology. In the dangerous field, the existence of safety awareness must run through the entire work process. When the duty manager requires personnel to report to work, each person needs to write a safety language, which can be an idiom, a sentence, or a straightforward expression. In short, a safety statement is the earliest liability every day. In addition, the daily work process and safety precautions as well as today’s production tasks take 10 minutes to browse and think, and the duty manager answers questions at any time. The main points of technology are especially emphasized by technical personnel so that the content of the safety pre-class meeting is substantial and practical.

(5) Expand the scope of safety management target objects. It is necessary to find the cause of the accident from the actual situation, and to find a solution is also the key point, but there are still hidden dangers in doing these tasks. For example, strengthening human training can overcome corresponding shortcomings and reduce the possibility of danger. However, the training of employees is only one aspect. It is more necessary to find recruiters with strong safety awareness and deep safety culture from the source. Therefore, in the safety management of oil refineries, attention should be paid to expanding the relevant research objects, and as far as possible, all factors related to safety management should be included in the scope of sight and supervision. Regarding the technical problems that arise in the production process, a dedicated work team is organized to tackle technical problems, thereby eliminating potential safety hazards. Through the above technical management methods, the safety management level of the refinery can be effectively pushed to a new level.

7. Conclusion

(1) The anti-management model acts on the refinery, and the result is significant and feasible.

(2) Personnel is the most active factor in productive labor, and exerting influence is the most significant factor for improvement. People are the focus of safety factors in refineries.

(3) There is still room for improvement in mechanical systems and technical systems.

(4) Oil system and environmental system need continuous improvement.

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