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Risk-based Test of the Application Effect of RBI Technology in Butanol

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Abstract

In industrial production, safety always comes first. With the continuous development of science and technology, risk-based inspection RBI technology has been widely used in chemical, petroleum, natural gas and other industries. Risk-based inspection (RBI) technology is a method for risk assessment and optimization inspection under the conditions of system safety and economy. As a basic organic chemical raw material, butanol is widely used in medicine, chemical industry, coatings and other fields. In recent years, with the improvement of technology, the domestic production capacity of butanol has gradually become excessive, and the market competition is also very fierce. Although the production process of butanol is not the same in the current factories, in fact, the production of chemical raw materials is accompanied by certain risks, and the hidden safety hazards in the production process cannot be ignored. This paper will combine the development and application of risk-based inspection RBI technology, based on the actual production situation of Lihuayi Refining and Chemical Co., Ltd., analyze the application effect of this technology in butanol and octanol, and provide corresponding theoretical support for industrial production.

Keywords

Risk-based inspection; RBI; Chemical raw materials; Butanol

Safety issues have always been an important issue that cannot be ignored in industrial production. The risks of equipment in the factory will have a great impact on the production process. Risk analysis of equipment, early prediction of possible safety hazards, clear risk levels of equipment, and formulation of inspection plans and plans based on the risk levels of equipment can not only ensure the safety of equipment, but also reduce the corresponding maintenance costs, while ensuring the high efficiency and stability of equipment use. The so-called risk management refers to seeking the minimum risk in the three-dimensional space of social benefits, risks and costs to maximize benefits. The combination of risk management and equipment management needs has emerged in industrial production. In the production process of butyl octanol, equipment safety issues are equally important. In a normally operating factory, usually about one-tenth of the equipment accounts for nearly 90% of the risks. Risk-based inspection RBI technology can help enterprises formulate corresponding inspection and maintenance plans based on the actual safety risk level of the equipment, ensure the long-term efficient operation of the equipment, and escort the actual production [1].

1. The emergence and development of risk-based inspection (RBI) technology

Risk-based inspection technology was first proposed by the American Society of Mechanical Engineers, which first published relevant guidance documents on RBI technology. China began to conduct research in this area in the 1990s.

The first research field was oil and gas, and then gradually developed to petrochemical refineries, chemical plants and other fields. At the same time, domestic universities began to study risk-based inspection RBI technology. Since 2000, Hefei General Machinery Research Institute has cooperated with China Special Equipment Inspection and Research Institute to introduce petrochemical plant system engineering risk analysis technology into RBI research. At the same time, it also combined the national conditions at that time and carried out a series of research on real production conditions. According to the situation at that time, RBI research has made effective progress in improving the failure mechanism database, complex failure mechanism, and dominant failure mode determination under the interaction of multiple failure modes. These breakthroughs have provided an important theoretical and practical basis for the development of risk-based inspection technology [2].

In industrial production, the main reasons for equipment failure are mechanical failure, operational errors, process fluctuations, etc. However, in the actual production process, unknown reasons account for one-fifth of the statistical data, and maintenance and overhaul have an impact on about half of the losses in the statistics. Therefore, it is very necessary to strengthen the research on RBI technology. There are also many equipment and instruments used in the production process of butyl octanol. Traditionally, butanol and octanol are produced by hydroxyl synthesis in the device. Butanol is widely used in plasticizers, dehydrating agents, solvents, etc. Although China's butyl octanol production capacity ranks first in the world, its output cannot keep up with market demand and it will rely heavily on imports. Therefore, the production process of butyl octanol needs to be improved. The production efficiency of the equipment has a very serious impact on production. The application effect of risk-based inspection RBI technology in butyl octanol has a great impact on improving the efficiency of equipment use.

2. Application prospects of RBI technology

Since the 12th Five-Year Plan, China's chemical industry has maintained a high-speed development, and the income and profit scale of the entire chemical industry have also developed rapidly. The quality and efficiency of the chemical industry are accelerating. Overall, the industrial structure has gradually improved and the profitability is also increasing. However, there are still a lot of problems in chemical production, such as non-standard safety control, low professional quality of operators, and untimely equipment maintenance. In recent years, relevant management departments in China have formulated relevant safety management systems and measures for equipment testing in chemical production. However, some companies do not pay attention to safety issues in actual production, there are loopholes at key nodes, and there are also formalities in the inspection process. The production process of butyl octanol needs to pay great attention to equipment safety. If there is a situation of non-standard safety control, there will be major safety hazards. Lihuayi Refining and Chemical Co., Ltd. always puts factory safety first, always pays attention to the production of butyl octanol, and actually applies RBI technology to the management of butyl octanol production equipment. Although risk-based inspection (RBI) technology has only gradually emerged in the past decade or so and is a new technology for equipment risk management, it has a very broad application prospect. Research in the fields of petroleum, natural gas, and chemical industry has gradually matured and has been gradually applied in actual production. The combination of RBI technology and industrial production will improve the safety and reliability of equipment, improve production efficiency, and help enterprises gain greater benefits in market competition [3].

3. Advantages of RBI technology

RBI technology determines equipment risk through quantitative risk assessment and calculates the average probability of failure. Equipment risk is expressed in the form of precise data, which is clearer and more explicit [4]. Many companies do not pay too much attention to equipment risk during the production process and are not clear about the possible parts of equipment failure, which can easily lead to blind inspection or invalid inspection. In the production of butyl octanol, risk-based inspection can grasp the overall risk status of each device, and can also compare the risk levels of each device, unit, and section. It can identify the areas with higher risk coefficients in the equipment, conduct reasonable analysis, and formulate corresponding risk reduction measures. At the same time, it can also extend the inspection cycle of the equipment and increase the service life of the equipment [5].

4. Production and processing of butyl octanol

In 1944, the Ruhr Company in Germany had already established the world's first high-pressure hydroxyl synthesis equipment. At that time, the high-pressure hydroxyl synthesis method was one of the main production processes of

butyl octanol. Although the high-pressure cobalt method was very mature at that time, it had the disadvantages of high reaction pressure, serious equipment corrosion, and long maintenance costs and maintenance cycles during the production process. In the subsequent development, the equipment and production process were continuously improved and perfected. In the 1970s, the low-pressure synthesis method was more competitive in the market than the high-pressure hydroxyl synthesis method, and gradually replaced the high-pressure hydroxyl synthesis method, and its share in the production of butyl octanol increased. However, the high-pressure hydroxyl synthesis method was retained in the production of high-carbon alcohols and played an important role in the hydroxyl alcohol preparation reaction.

Medium-pressure cobalt transformation technology was invented by Shell in the 1960s. This was the first time that medium-pressure hydroxyl synthesis technology appeared. In the following two decades, many companies also invented new medium-pressure methods and continuously improved them. Based on the rhodium method, a more stable hydroxyl synthesis method was developed. However, this method did not obtain technical approval and was widely used at the time. The medium-pressure hydroxyl synthesis technology has many advantages, such as high boiling point of the product, rhodium is more soluble in water, by-products are not easy to accumulate in the reaction, etc., and the catalytic reaction has high selectivity, which can realize the recovery of metal rhodium in the catalyst. The low-pressure carbonyl synthesis method is divided into Rep technology, Mitsubishi Chemical technology, BASF technology, Eastman technology, UCC/Daw/Johnson Mattey technology. Rep technology can only be used in the production of butanol. In actual applications, the production capacity of the catalyst is low and the unit consumption is high, so it has not been widely promoted and applied. The catalyst used in Mitsubishi Gosei Technology is a rhodium complex. The process has lower reaction pressure and temperature, and the product obtained from the reaction also has a higher positive isomerism. The catalyst can also maintain high activity, with less rhodium loss. The catalyst can be recovered after production, and the deactivated catalyst can be regenerated inside the device. Although this process has many production advantages, the production process is longer, more equipment is used, and it is necessary to ensure that the equipment uses high-quality stainless steel. The overall cost is high, and the required equipment investment is also greater.

BASF low-pressure carbonyl synthesis process BASF low-pressure carbonyl synthesis technology is the same as Mitsubishi Chemical's low-pressure carbonyl synthesis technology. The catalyst used is a rhodium phosphine complex. The catalyst is prepared with alcohols and can be directly transported to the reaction machine after preparation. A major feature of this process is the low remote consumption of raw materials and public works, which is also a significant advantage of this process. It also has a high positive isomerization ratio and high selectivity flexibility. In actual production, a bubble tower reactor and liquid phase hydrogenation process can be used to simplify the operation process. The carbonyl synthesis process of Eastman Company in the United States has been transformed many times, and the process conditions have been continuously optimized in application. It has achieved good results in production. The outstanding feature of this technology is that the product plan is flexible and has low loss, which can well meet market demand. UCC/Daw/Johnson Mattey low-pressure carbonyl synthesis process rhodium catalyst low-pressure carbonyl synthesis technology is developed by three companies. At present, about 60% of the world's butanol production uses this technology. The process is divided into liquid phase circulation process and gas phase circulation process, which enables the reactor to obtain a higher volume utilization rate and maintain a faster reaction speed, which can greatly improve the reactor capacity [6].

5. Necessity of applying RBI technology in butanol

The production process of butyl octanol involves the use of a variety of instruments and equipment. Dangerous situations exist in the industrial production process. Through risk-based inspection technology, we can reasonably analyze the risk status of equipment use, timely plan production plans, reasonably arrange the use time of equipment, and reduce production losses caused by equipment. In production, once a problem occurs in the equipment, repair will affect the production progress. The safety hazards caused by equipment problems cannot be ignored. The implementation of the RBI project actually comprehensively organizes and summarizes the information of factory equipment to form an information database, which is very helpful for the equipment management department. At the same time, in the process of implementing RBI management, a cross-departmental knowledge core group integrating process, equipment, corrosion, safety, etc. was generated, which changed the previous situation of non-circulation of knowledge between departments [7].

6. Suggestions for the subsequent development of RBI technology

There is a bright future in using risk-based inspection technology for risk assessment and control in industrial production. my country's research and application of RBI technology is in its infancy, and more in-depth research is needed to obtain greater benefits. my country should keep pace with the world's advanced technology, while constantly developing and innovating. It should also strengthen the standardization, research and application of RBI technology. In response to the problems that may arise in actual production, this article puts forward corresponding suggestions from the following points.

6.1 Strengthen the development of evaluation software with independent intellectual property rights

At present, more and more companies in China's butyl octanol industry have begun to use RBI technology to conduct risk assessment and formulate inspection plans. However, the evaluation software used is almost all from foreign countries. Although foreign technology in this area is relatively advanced and complete, it is still not in line with China's national conditions in some aspects. For example, the software is all localized in Chinese, not easy to operate, and the price is high. At the same time, it is also not conducive to the development of China's RBI technology. Therefore, we must strengthen the development of evaluation software with independent intellectual property rights and realize the nationalization of technology as soon as possible.

6.2 Establish a comprehensive information database

RBI is a long-term and repetitive work that needs to be constantly updated and improved in practice. A large amount of information data support is an important guarantee for its good application. The results obtained after each device evaluation are an important source of data in the library, including information on damage mechanism, failure mode, consequence analysis, etc. On the one hand, China is still in the early stage of using RBI technology, the inspection projects carried out are not popular, the number of devices evaluated is also limited, and a set of complete information databases of its own has not yet been established. This is one of the main gaps with foreign countries; on the other hand, the development of today's RBI technology is still only maintained in the production and operation activities of high-risk industries such as petrochemicals and nuclear industries that may explode, leak, and pollute, but some special equipment with high-risk characteristics, such as large amusement facilities, passenger ropeways, construction machinery, etc., are not included in the scope of application. Therefore, information data in these fields is generally missing, which to a certain extent limits the development and promotion of RBI technology. Therefore, it is necessary not only to establish a complete information database applicable to the domestic petrochemical industry, but also to expand the source of information to other high-risk industries.

6.3 Cultivate practitioners with professional knowledge

RBI technology is an advanced tool for testing equipment risks. However, tools need people to operate and use them. In the long-term use process, in addition to the gradual improvement of objective conditions, people's subjective initiative has also had a profound impact on the development of this technology. Therefore, it is necessary to strengthen the training of talents in this area, form a good management mechanism, and build a professional team that masters risk analysis and evaluation, inspection plan formulation and risk reduction and control, to meet the urgent needs of related industries in China.

7. Conclusion

The professional definition of RBI is the process of implementing risk assessment and risk management for equipment. In this process, the focus is on the risk of medium leakage in pressure equipment caused by material degradation and failure and the implementation of risk control through detection. The main purpose of implementing RBI technology in industrial production is to rationally allocate maintenance and inspection resources, reduce maintenance and overhaul costs as a whole, reduce cost expenditures, make equipment more stable and safer, and ensure that enterprises gain higher market competitiveness during the production and processing process. The application of risk-based inspection RBI technology in butyl octanol is a demand for enterprise development. RBI technology is an advanced risk engineering concept, which is very useful for dealing with the relationship between safety and economy, and can effectively improve the competitiveness of enterprises. It is also a need for enterprise management. A

systematic and complete management system is indispensable in enterprise development. Good risk monitoring can also ensure the timely formulation of risk response plans to reduce unnecessary losses. RBI technology is a demand for equipment management.

References

[1] Song Xiaomiao. Application of risk-based inspection technology in atmospheric and vacuum devices[J]. Information Recording Materials, 2018, 19(11): 200-203.

[2] Wang Yu. Research on the application of risk-based inspection technology for safety valves in oil refining[J]. Petrochemical Technology, 2017, 24(4): 179-182.

[3] Huang Tao. Application of risk-based inspection technology in special equipment inspection[J]. Journal of Baotou Vocational and Technical College, 2020, 21(4): 14-16.

[4] Li Hechen, Cheng Liang, Qu Zhi. Brief analysis on the application of RBI technology in petrochemical plants[J]. Chemical Industry Management, 2020(15):88-89.

[5] Li Wei, Meng Zhongying, Liu Liliang, et al. Application of RBI technology in online inspection of industrial pipelines[J]. Chemical Machinery, 2019, 46(5): 595-598.

[6] Wang Pengfei, Jiang Lingyun, Li Chen, et al. Preparation of catalyst for butanol synthesis and industrial side-line research[J]. Inorganic Salt Industry, 2021, 53(5): 105-110.

[7] Xu Wenli, Wang Liang, Wang Meng. Development of production technology of 1,2- butanol [J]. Digital User, 2017, 23(44): 241.