Online corrosion management based on the situation of long-cycle operation of oil refining chemical plants

Chenyang Du, Xiaowei Li*, Chang Liu, Ce Song, Jianyu Lu

China Special Equipment Inspection And Research Institute, Beijing 100029, China

*Correspondence: lixiaowei@csei.org.cn

Abstract. Long-cycle operation of a plant can help enterprises reduce costs and increase efficiency and improve economic benefits, and has now become a goal for enterprises to pursue, but to achieve long-cycle operation of a plant requires the joint efforts of all parties. This paper analyzes the basic conditions needed to achieve long-cycle operation, starting from the development history of the operation cycle of China's oil refining and chemical plants. And focus on the analysis of online corrosion management in the device's long-cycle operation of the important role, and application scenarios. And the current online inspection means for different damage modes are introduced, hope that this paper can make you an in-depth understanding of the common technical means of online corrosion management and its important role in the long-cycle operation of the device.

Keywords: Refinery chemical plants; long-cycle operation; online corrosion management; damage patterns; non-destructive testing technology

1 Introduction

The long-cycle operation of refining and chemical plants is an important embodiment of the technical ability level of enterprises and the comprehensive management ability of enterprises. By ensuring the long-cycle continuous, stable, and efficient operation of oil refining and chemical plants, the production efficiency can be improved, and then the overall production cost can be reduced, thus achieving the purpose of improving the economic benefits of enterprises. The long-cycle operation of oil refining and chemical enterprises in China has also experienced a long development process. Since the 1960s, China's oil refining and chemical industry has just started, and the equipment has been shut down and overhauled following the "one-year overhaul" model. Until the 1990s, with the reform and opening-up, China began to learn and introduce advanced refining technology and management experience from Western developed countries, and gradually developed the operation cycle of refining and chemical plants to a "two-year overhaul". By the beginning of this century, the pursuit of long-cycle operation has become an important operation index of the industry. By the end of the Twelfth Five-Year Plan, the refining units under China Petrochemical Company have achieved "one overhaul every three years". In 2012, the oil refining

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section of China Petrochemical Company began to pilot a "four-year overhaul" in some subordinate petrochemical enterprises. By the end of 2017, ten refinery units of Jinan Refining & Chemical Company, Qingdao Refining & Chemical Company, and Tianjin Petrochemical Company had achieved a "four-year overhaul". Based on the calculation of China Petrochemical's crude oil processing capacity of 270 million tons/year, compared with the "one-year overhaul", the "three-year overhaul" and "four-year overhaul" of oil refining units can avoid the emptying of the processing capacity of 16 million tons/year and 20 million tons/year [1-2] respectively, thus achieving a substantial increase in economic benefits. At present, the oil refining units of Zhenhai Refining and Chemical Company and Daqing Petrochemical Company have achieved "one overhaul every five years". In the future, with the innovation of technology and process, the improvement of inspection and maintenance levels, the improvement of management ability, and the development of online detection means, it is also the general trend for oil refining and chemical plants to develop to a longer operation cycle.

2 The basis for the realization of long-cycle operation of refinery chemical plants

Long-cycle operation of refining and chemical plants is the basis for enterprises to reduce costs and increase efficiency and improve market competitiveness and is also an important guarantee for giving full play to the advantages of refining and chemical integration. Chinese domestic refining and chemical enterprises are now generally facing the pressure of large and aging production units, and at the same time, the crude oil processed tends to be heavy and of poor quality (high sulfur and high chlorine). All these situations have posed higher challenges to the long-cycle operation of refining and chemical enterprises. To help with the long-cycle operation of refinery chemical plants, the following aspects are required:

2.1 Innovative development of technological processes

The technical process mainly refers to the innovation of the technical process of refining and chemical plants, the optimization of process flow [3], the improvement of the operation process, etc., and the operation cycle of the plant is fundamentally extended through technical innovation. Therefore, the innovation and development of technology is an important basis for the long-cycle operation of the device. At the same time, the country's energy conservation and emission reduction, the implementation of the "double carbon" strategy, etc., also put forward higher requirements for the innovation and development of refining and chemical plants.

2.2 Improvement of management level

Management is integrated into the whole process of the long-cycle operation of the plant, which includes equipment management (such as design, selection, installation

management, etc.), personnel management (operators, safety personnel, management personnel, etc.), operation management (process monitoring, personnel inspection, corrosion protection, handling of emergencies, etc.), and integrity management, which is now widely carried out. Through the improvement of the management level, it can help enterprises to improve operational efficiency and reduce unnecessary personnel and cost loss. Therefore, the improvement of the management level is an important guarantee for the long-cycle operation of the plant [4-5].

2.3 Improvement of equipment quality

The device is composed of one piece of equipment, and the quality of the equipment directly restricts the long-cycle operation of the device [6], China's long-cycle development of refining and chemical devices since the last century is inseparable from the rapid development of China's manufacturing industry. The ex-factory quality of the equipment is ensured through the improvement of the quality of the supply plates, the improvement of the manufacturing technology and level, the strict control of the ex-factory quality of the equipment, and the increasing improvement of the supervision system. The quality of oil refining and chemical equipment has also directly contributed to the extension of the overall operating cycle of the device.

2.4 Development of online corrosion management and online inspection technology

Online corrosion management refers to the effective management of the overall corrosion cracking of the device without stopping the device. The development of online corrosion management relies on the development of online inspection technology. With the current refinery chemical device for the long-cycle operation of the demand, online corrosion management is more and more widely used, but also greatly promotes the research and development of online corrosion detection technology, the emergence of new detection technology, and greatly enriches the application of online corrosion management scenarios. Online corrosion management plays a very good role in boosting the long-cycle operation of the device. Through online corrosion management, the hidden dangers in the operation of the device can be investigated, reducing the risk of device operation and helping the long-cycle operation of the device.

3 Online corrosion management

Online corrosion management is gradually developed in recent years, based on risk and damage mechanisms, considering site operability, using advanced online detection/monitoring technology, precise corrosion inspection and management implemented during the operation of the device, which can effectively identify equipment hidden dangers and reduce risk levels, thus achieving the dual goals of compliance and safety and guaranteeing the long-cycle safe operation of the device.

3.1 Application Scenarios of Online Corrosion Management

With the demand of enterprises for the long-cycle operation of the device and the rapid development of online inspection means, the application scenario of online corrosion management has become increasingly rich.

(1) to assist enterprises in equipment management: through online corrosion inspection data, to provide data support for the enterprise's equipment corrosion management, to assist enterprises in finding hidden dangers, prevention and control of risks, and to ensure the essential safety of the device;

(2) Coordination of device maintenance cycle: Currently, risk assessment has been written into the regulations [7], because of its targeted, flexible operation, can achieve a balance between economy and safety, so it is widely used in the maintenance of the device, through the combination of risk assessment and online corrosion management to coordinate the maintenance cycle of the device, to solve the device due to various reasons can not stop on schedule, and finally achieve the purpose of legal compliance;

(3) Special inspection: Special inspection mainly refers to the centralized inspection carried out by enterprises for some outstanding problems, such as flanges, small nozzles, pipe supports, heat preservation, etc. Special inspection is problem-oriented and usually carried out during the operation of the device, so it needs to be carried out using online inspection, and special inspection is an important part of online corrosion management;

(4) Over-design life assessment: Over-design life mainly refers to the equipment that has exceeded the design life or been used for more than 20 years, and its failure risk is higher because it has been put into use for a long time. In view of the increasing number of over-design life equipment, the group standard "Guidelines for Evaluation and Inspection of Pressure Vessels with Over-design Life" was issued in 2022[8]. Through the safety assessment and quantitative evaluation of pressure vessels with over-design life, combined with online corrosion management data, it is judged whether they have the conditions for continuous use.

(5) Site unexpected problems: mainly refers to the site due to temporary unexpected circumstances caused by the unplanned stop, due to the urgent situation usually need to use unconventional means to deal with the problem, such as pipe coking to find the coking parts (as shown in Figure 1) and so on. These situations usually require the use of online corrosion detection technology to carry out.

Fig. 1. The detection robot in the pipeline of coking unit finds the coke blocking position

3.2 On-line corrosion management technology based on damage mode

Along with the rapid development of China's petrochemical industry, the current refining and chemical plants present new characteristics. First is the trend of large-scale devices, device scale increases, product output increases, resulting in equipment size increases, parameters increase (high temperature and high pressure), complex structure, accompanied by the deterioration of the medium, making the operation of the device risk also increased exponentially, online corrosion management methods and means also put forward higher requirements; second is the growing trend of aging devices, China's petrochemical industry development Has a history of more than 60 years, most large petrochemical enterprises have been put into use for more than 20 years, these old devices and their related equipment over the design life, no doubt greatly increased the safety risks of enterprises; Finally, the enterprise for the device long-cycle operation of the demand, resulting in a reduction in the number of device stops, the operation of the process of online corrosion management and hidden danger detection needs to increase, these are online corrosion detection These are online corrosion detection technology has put forward more needs and higher requirements.

The development of online corrosion detection technology is mainly based on the actual operation of the equipment in the process of damage mode. At present, the refinery chemical equipment operation of the main loss mode by the following four: corrosion thinning, surface cracking, buried defects, and material deterioration. The following is a brief introduction to the four damage modes of online corrosion detection technology.

3.2.1 Corrosion thinning.

Corrosion is one of the main problems of the current refinery chemical equipment failure, for the corrosion of the online detection technology means is also very rich, common are as follows:

(1) electromagnetic ultrasound detection: electromagnetic ultrasound principle is the high-frequency coil with high-frequency excitation current will form an induced eddy current on the surface of the test piece, the induced eddy current in the role of the applied magnetic field will be subject to the action of the Lorentz force to produce electromagnetic ultrasound. Because there is no ordinary thickness gauge piezoelectric wafer Curie temperature limit, its measurement temperature range can reach 500 ℃, with high measurement accuracy, small error (± 0.01mm), no grinding, and other advantages, is widely used in the field of online thickness measurement;

(2) MsS long-distance guided wave detection: MsS technology is based on the magnetostrictive effect of ferromagnetic materials and its inverse effect as a detection technology, suitable for long-distance buried pipelines, overhead pipelines, large diameter pipelines online corrosion detection (temperature range -20 ~ 200 ℃, each detection range of 30 ~ 50 meters), can quickly detect large areas of corrosion suspicious parts;

(3) Pulsed eddy current detection: Pulsed eddy current detection is a newly developed electromagnetic detection technology. Compared with traditional eddy current detection technology, the excitation source of pulsed eddy current detection signal is a

rectangular square wave with a certain duty cycle, and its principle can approximate the corresponding process after DC voltage or current is turned off. The corrosion detection of the base metal can be carried out without stopping and removing the coating on the surface of the workpiece. The lift-off between the probe and the component is large, and no coupling agent is needed, so it can be used for wall thickness corrosion detection under complex working conditions such as high temperature and underground. The highest detectable temperature can reach 600℃;

(4) Infrared thermal imaging detection: infrared thermal imaging technology as an emerging and efficient non-destructive testing means is widely used in online inspection and monitoring [9], which has the advantages of large detection area, fast detection, non-contact, high sensitivity, intuitive and accurate defect information. Mainly applied to insulation damage detection, usually, insulation damage parts of the insulation layer under the corrosion situation is high, so it can be indirectly found through infrared thermography detection under the insulation layer corrosion situation. Infrared thermal imaging detection of insulation damage is shown in Figure 2.

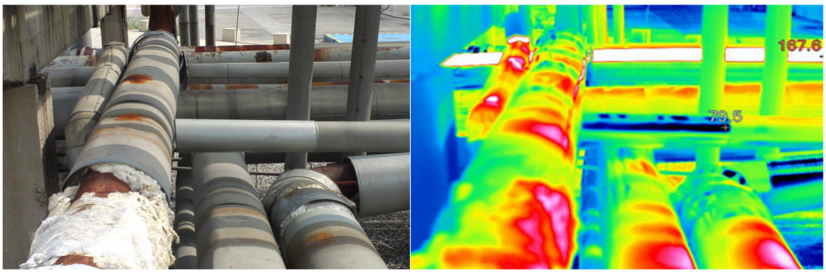


Fig. 2. Infrared thermal imaging insulation layer detection

3.2.2 Surface cracking

In the refinery chemical plant, in addition to corrosion thinning, surface cracking damage mode is the most common, the following several online detection means are currently used more:

(1) AC electromagnetic field detection (ACFM): Alternating current field measurement-ACFM is a new electromagnetic nondestructive testing technology developed based on Alternating current potential drop-ACPD, which can quickly detect surface defects and near-surface defects of all ferromagnetic materials and non-ferromagnetic conductive materials. The principle is that the excitation coil induces a uniform alternating current in the workpiece, and the induced current disturbs the position of defects such as cracks and corrosion, thus distorting the space magnetic field. The defect detection and evaluation can be realized by detecting the distorted magnetic field. This method does not need to polish the detected part and coupling, and the highest detection temperature can reach 350℃.

(2) large lifting away from the array eddy current detection: array eddy current is a new eddy current detection technology that emerged in the last decade, it will be a multiple eddy current detection coil according to the geometry of the inspected workpiece to special design, packaging, and then through rapid electronic control and pro-

cessing to achieve rapid and effective detection of materials and parts. For carbon steel welded joints, the surface cracking of the butt weld can be detected without grinding, and the detection process does not produce electric sparks, which can greatly reduce the safety risks of online inspection. At present, the large lifting off array eddy current detection is mainly used in natural gas field stations and another high-risk inconvenient grinding pipeline;

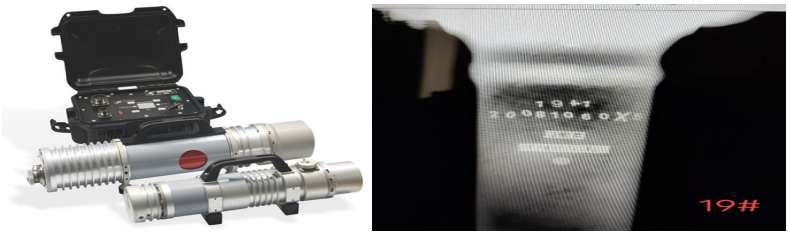
(3) Acoustic emission detection: The principle is that long-cycle service equipment whose structure is subjected to external or internal forces that produce plastic deformation or cracking releases strain energy in the form of elastic waves. The use of acoustic emission sensors to sense the signal released during crack expansion, to obtain the characteristic parameters of the acoustic emission source inside the structure, can achieve the detection and location of structural crack activity defects. Online acoustic emission detection is often used for online leak monitoring [10] and active crack defect monitoring;

(4) Eddy current detection of balanced field: Using the principle of electromagnetic induction, the alternating magnetic field around the coil induces current (this current is called eddy current) on the metal surface when the coil is excited by a sine wave current and approaches the metal surface. It is mainly used for surface crack detection of equipment. The detection method has the advantages of no need for polishing, high detection speed, and the highest detectable temperature can reach 300°C.

3.2.3 Buried defect.

Buried defects are usually produced in the manufacturing process, but less in the use process. Therefore, there are few online detection methods for buried defects, and the following are widely used at present:

(1) Digital radiography (DR): The biggest difference between digital radiography (DR) and ordinary radiography (RT) is that the detector replaces the film, completes the detection and conversion of the signal, and displays the digital information directly on the computer, without the need to go through the darkroom processing and other links. The quality of digital radiographic images and the information they contain far exceed that of ordinary film imaging. It can detect defects such as unfused, porous, and cracked welds, determine the size and location of the defect plane projection, and the defect detection rate is higher than that of ordinary radiographic inspection. The site protection distance is also greatly reduced, making it easier to implement and protect personnel on site. Digital ray equipment and imaging as shown in Figure 3.



(a) Digital ray detection equipment (b) Digital radiography picture

Fig. 3. Digital ray detection equipment and imaging picture

(2) Phased array detection: Phased array detection technology is an ultrasonic non-destructive testing technology developed in recent ten years, and its basic concept comes from phased array radar technology. The principle is that by controlling the phase of each array element of the ultrasonic transducer, a flexible and controllable composite beam can be obtained, and dynamic focusing and imaging detection can be carried out, which can improve the detection sensitivity, resolution, and signal-to-noise ratio.

3.2.4 Material deterioration.

At present, the on-line high-temperature detection method for material deterioration mainly focuses on the detection direction of creep deformation caused by high temperature, and the high-temperature detection method for tissue transformation caused by high temperature has not been effectively applied at present. Common creep deformation detection methods are as follows:

(1) 3D laser deformation scanning: aiming at the local deformation problem of equipment in high-temperature creep, the 3D model of the measured object is quickly reconstructed by using the principle of laser ranging, and the deformation and deflection of the component are measured, and calculated through 3D coordinates, to realize the visual detection of deformation;

(2) Fiber creep detection: Strain and temperature can be directly measured by using fiber grating sensor [11-12], and other parameters related to strain and temperature can be indirectly measured. By collecting speckle images before and after structural deformation and making correlation analysis, the displacement, local strain, and average strain of the structure are obtained, and the creep damage of equipment is predicted.

4 Concluding remarks

The long-cycle operation of oil refining and chemical plants has become a consensus. In addition to technological innovation, management improvement, and quality improvement, online corrosion management has become an important support to ensure the long-cycle operation of the plant. With the rapid development of online inspection technology and a large number of applications in the online operation of the device, it is believed that the future is very likely to replace parking inspection and testing, thus helping enterprises to achieve the true sense of the continuous operation of the device.

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