

STUDY OF REMOTE HELIUM MASS SPECTROMETER LEAK DETECTION IN ACCELERATOR*

H. Y. He[†], D. H. Zhu, J. M. Liu, Spallation Neutron Source Science Centre, Dongguan, China

Abstract

In order to solve the problem that the vacuum system of the accelerator cannot be close to the operation for a long time, a long-distance helium mass spectrometer leak detection system is explored by studying the structure of the conventional round tube vacuum box of the vacuum system, which integrates the online vacuum leak detection, defect diagnosis and process design, improves the digital operation, realizes the accurate and effective detection of the leak location range and leak rate, and provides the technology for the remote leak detection of the vacuum system support.

Introduction

Vacuum system of the Particle accelerator has shown a close relation with the beam lifetime and stability. If the vacuum system cannot obtain the intended ultimate pressure, one primary reason is the presence of leaks. but the leak hole is usually invisible to the naked eye, we must find out and repair the leak by some methods. Therefore, vacuum leak detection plays an important role in the steady running of the vacuum system.

The method of Helium mass spectrometer leak detection is the most widely used qualitative methods in engineering. Form 1940s, the helium jet method first appeared, then the cover-helium leak detector, accumulated method of sniffer prob or vacuum chamber, and the method of back-pressure emerged one after another. Right now, the helium jet method is most highly applied based on accurately identifying the leaks. Actually, manual identifying the leaks in the underground accelerator tunnel is a hard task when the beam is operating. Meanwhile several workers cooperate simultaneously, which reduce greatly the overall accuracy and efficiency.

The beam channel of accelerator is mainly composed of stainless-steel vacuum box and bellows; The welding seam, removable flange and other process connections are in the environment of high radiation and easy to be damaged for a long time, and there is a very big hidden danger of air leakage. In practical engineering, the static pressure boosting method is mainly used to judge whether there is air leakage in the beam channel, that is, the valve is used to isolate the vacuum box, and after the air extraction reaches a certain pressure, the valve is closed and cut off from the vacuum pump, and the pressure change of the system is measured to determine the approximate area of air leakage. After determining the actual air leakage, the vacuum leak detection method is mainly used at this stage, that is, to explore the leak location and leakage rate through injection method and helium hood method [1].

* Work supported by INSTITUTE OF HIGH ENERGY PHYSICS
[†] hehy@ihep.ac.cn.

Development of Helium Mass Spectrometry Leak Detection

With the rapid development of helium mass spectrometer leak detector, its sensitivity and stability have been improved. The helium leak detection by suction gun method has been used in nuclear power plants, spacecraft, satellites and other practical projects [2]. The principle of suction gun leak detection method is as follows: the helium gas with specified pressure is poured into the object to be tested, and the special suction gun is used to explore outside the object to be tested. If there is a leak in the object to be tested, the helium gas will spill out with the national leak. When the suction gun is facing the leak hole, helium gas is sucked into the leak detector together with the surrounding air, and the output indication is generated, so as to achieve the purpose of leak detection.

The vacuum system of accelerator often contains a lot of equipment with many sealing and welding seams and narrow space, or the radiation effect endangers the personal safety area, so it is very difficult to shut down or close leak detection. As the vacuum pipeline is long, it often takes a lot of time to seal up the leak with vacuum sealing mud until all the leaks are detected one by one. How to take measures to reduce labour intensity and protect personal safety is of great practical value.

The development of computer technology leads the development of measuring instruments to automation and intelligence. In the past 2-3 years, the helium mass spectrometry leak detection technology in China has made a breakthrough, mainly from the traditional industry covering a wider range of industrial sectors, from a single conventional instrument of oil diffusion pump system to the main product of molecular pump [3]. In China, we should absorb foreign advanced technology, accelerate localization, move forward to automation and high level, and launch high sensitivity instruments. For example, the scope of leak rate can be increased, the communication interface can be increased, and the modular design of hardware and software can be realized. For example, zaj2291 instrument of the science and instrument centre of the Chinese Academy of Sciences can switch the measuring range automatically, process the data automatically and connect the printer to realize the one key control of the leak detector to complete the leak detection. However, the development of automatic and intelligent leak detection still has a long way to go.

Exploration of Leakage Detection Data System

Remote control, mobile automatic scanning suction gun in the current application is not much, people use more traditional manual operation means, but the traditional manual operation is to occupy the working space, heavy

workload, low security. In fact, in the actual environment, the automatic scanning suction gun leak detection is affected by the limitations of the environment, such as dust, mobile operating space, complex structure of the tested parts, which makes the detection results not very ideal [4]. It is a challenging task that the suction gun of leak detector can scan the tested components stably and reliably. These problems must be solved in practical design and application.

High radiation area can be used for remote automatic seal detection, which is suitable for practical projects such as nuclear power station and spacecraft, and has high application value. It can improve the automation level for equipment detection and improve the operation efficiency and safety of personnel. If the nozzle can increase the camera and other equipment, it can provide necessary image information for other remote operation, and then fully grasp the movement process of the equipment, and improve the accuracy and efficiency of remote operation.

The remote positive pressure suction gun leak detection method is used in the environment of high radiation, dust pollution and complex structure of the tested components. Its technical indicators not only complete the leak detection, but also involve the remote controlling movement and so on. Therefore, remote positive pressure suction gun leak detection is composed of terminal leak detector and automatic mobile suction gun. Through the pre-setting of the detection position and the remote control of the suction gun by the mechanical arm, it can reach the surface of the detection part and complete the exploration from far to near and from bottom to top. This method is suitable for the situation where the working environment is bad and the risk is high, and the leakage location and leakage rate need to be judged.

The problems in practical engineering are explored and studied. The remote helium injection method and positive pressure suction gun leak detection equipment are prepared. A database system integrating remote vacuum leak detection device, conventional vacuum sample leak detection database system platform, vacuum leak detection process design system platform and leakage detection information management platform is designed, as it is shown in Fig. 1.

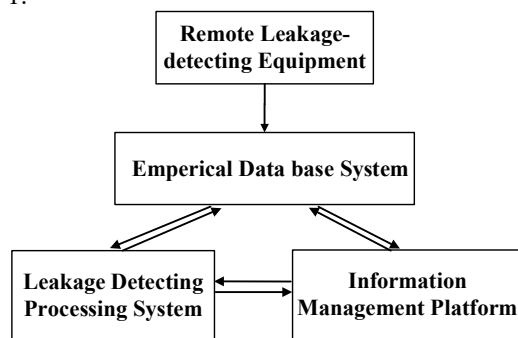


Figure 1: Sketch of leakage detecting database system.

The remote vacuum leak detector can realize the remote operation of the leak detector, the control of helium by the switch of the spray gun, the automatic alignment of the

possible leak of the tested device, the spraying of helium by the spray gun, and the online display of the corresponding leak position and leak rate data of the spray gun of the leak detector [5].

The data platform is used to store and manage the leak detection data, including the basic data of the specimen, the leak detection experimental data and the mature leak rate judgment diagnosis case data.

The process design is based on the test data of the remote leak detection device to realize the automatic design and printing of the leak detection process of the conventional vacuum box weld and the connecting seam by helium injection method.

Based on the leak detection database platform and process design system platform, the leak detection information management platform realizes the online management and control of the leak detection process.

Research and design the adaptive spray path of helium for conventional pipeline vacuum box [6], as shown in Fig. 2. The universality and systematization need funds to conduct in-depth research, establish mature leak defect judgment and solutions, improve the automation level of helium injection leak detection technology, realize remote leak detection diagnosis and data sharing, reduce labour intensity, and ensure personal safety.

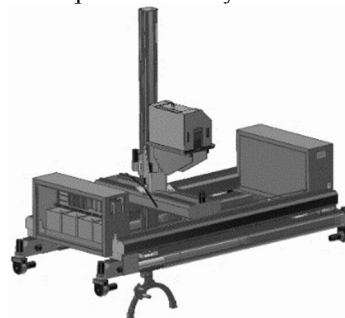


Figure 2: Design of remote leakage detector.

REFERENCES

- [1] S. U. Lin, "Application of smart ball leakage detection technology in long distance pipeline", *Pipeline Technique and Equipment*, vol. 1, pp. 30-31, 2017.
- [2] Q. L. Wang and R. Jian, "Design and development of welding database and expert system for aviation", *Electric Welding Machine*, vol. 9, pp. 16-20, 2018.
- [3] W. F. Liu, "Design of remote monitor system for CSRE cluster-jet target", *Nuclear Electronics & Detection Technology*, vol. 6, pp. 1171-1172, 2008.
- [4] Y. C. Li, "Design of leakage-detecting system at blast-furnace pipe", *Automation & Instrumentation*, vol. 11, pp. 169-170, 2014.
- [5] S. S. Peláez *et al.*, "Comparing Physical Container Closure Integrity Test Methods and Artificial Leak Methodologies", *PDA Journal of Pharmaceutical Science and Technology*, vol. 73, no. 3, pp. 220-234, 2019.
doi:10.5731/pdajpst.2018.009332
- [6] H. Y. He *et al.*, "Design of Remote Helium Mass-Spectrometer Leak-Detector", *Chinese Journal of Vacuum Science and Technology*, vol. 40, no. 2, pp. 128-131, 2020.