8 - 13 The Application of Virtual Simulation and Commissioning Technology in Accelerator Control System

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The development of digital twin technology has brought new opportunities and challenges to the design and development of accelerator control systems. The CiADS plant is complicated, and the control system structure and interlock logic are complex[1]. In order to break away from the dependence of traditional control system design on physical equipment, extend the life cycle of accelerator control system design, and improve system reliability and safety, the CiADS control team attempted to apply virtual simulation and commissioning technology to digitize the accelerator control system and conduct virtual design, development, and commissioning the simulation system[2]. The virtual simulation commissioning system for accelerator control system is shown in Fig. 1.

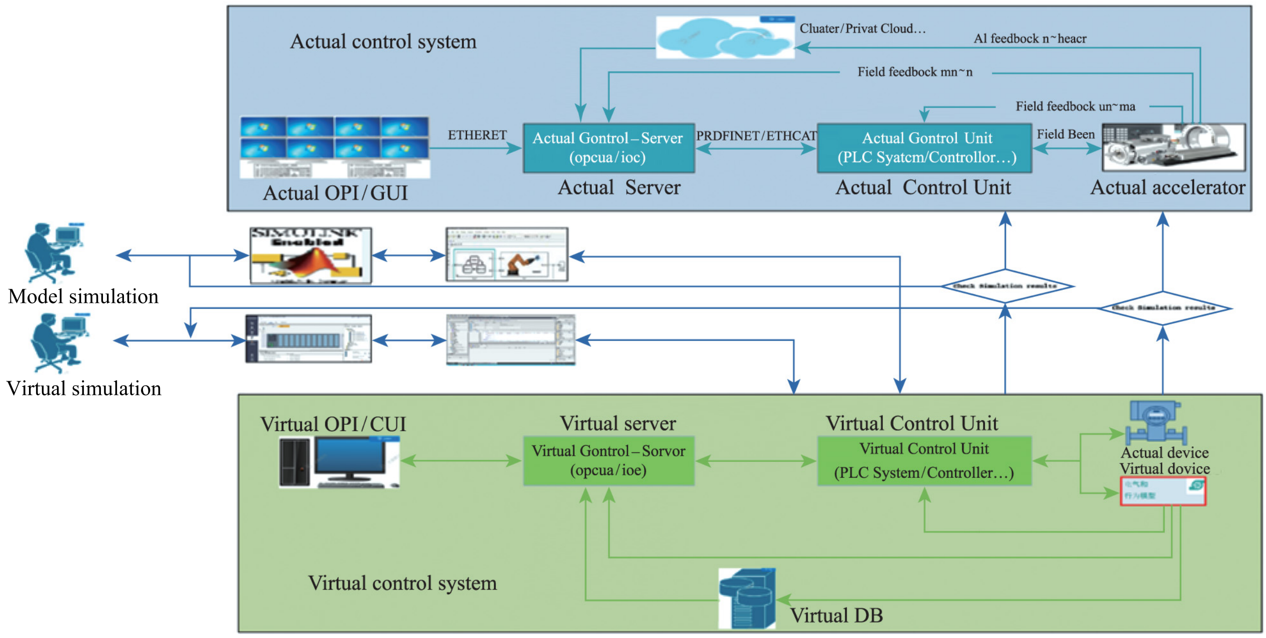

Fig. 1 (color online) Virtual simulation commissioning system for accelerator control system.

The accelerator virtual simulation and commissioning system achieves virtual simulation of the OPI, IOC server, controller, controlled device, and control network through simulation servers, minimal hardware systems, network devices, and simulation software. The configuration, composition, control program, and parameter settings of the entire simulation system are completely consistent with the actual control system. Based on simulation platform, design and development personnel can realize system design and development, as well as online functional testing, logic rehearsal, and system commissioning. After repeating regression testing and verification, the entire control system can be deployed on real physical equipment on-site by design personnel through manual copying or remote deployment.

Compared with the traditional design and development process, the system design and development based on the virtual simulation and commissioning platform can advance the accelerator control system design, development, and commissioning time by 1∼2 years, while extending the design and development cycle by 1∼2 years. The number of regression tests is increased, and software quality is improved. Ultimately, the workload on-site is only simple deployment and , saving labor, time, and capital costs.

Currently, the CiADS control team is experimenting with new technologies and methods to establish data connections and communications between the accelerator control system simulation, electrical system simulation, and mechanical system simulation, in order to achieve the ultimate goal of the CiADS digital twin system.

References

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8 - 14 Experimental Research of Extremely High Spatial-resolution Cascaded High Energy Electron Radiography at HERPL

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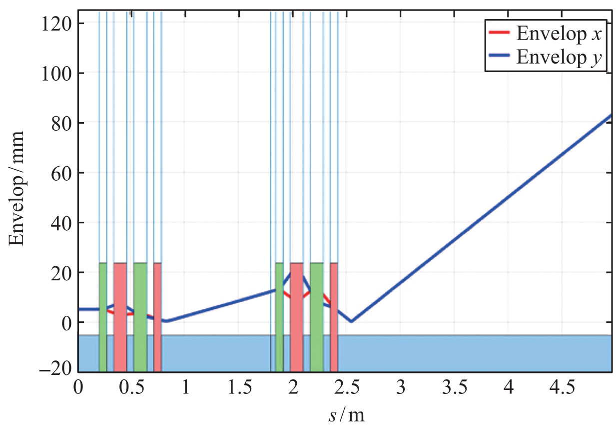
To study the structure and characteristics of nuclear materials, many diagnostic tools has been proposedt. With the main features of the strong penetrating power, high space-time resolution, and large area density diagnostic range High Energy Electron Radiography (HEER) has been proposed as a new diagnostic technology for nuclear materials. Therefore, High Energy Electron Radiography experimental platform(HERPL) dedicated to HEER experiment research had been established. A common electromagnetic lenses composed point to point imaging beamline with a magnification of 10.18 has been designed and built, and the imaging spatial resolution of 0.8 μm was obtained that demonstrates the imaging capability of HEER for material imaging diagnosis. In this paper, the HEER experiment with a cascaded quadrupole based imaging system has been proposed and designed to further improve the spatial resolution of image and expand its scope of application. The microcracks inside the nuclear material can be diagnosed with improved the imaging spatial resolution, and the dynamic imaging study of the formation process of the internal pores of the nuclear material can be carried out with combining the ultra-high temporal resolution of HEER.

According to the principle of HEER, the imaging resolution will be improved as the magnification increases. Therefore, an cascade imaging lens with a magnification of 16.6 was designed to improve the imaging spatial resolution. Figure 1 shows the electron trajectories in the cascade HEER imaging lens system.



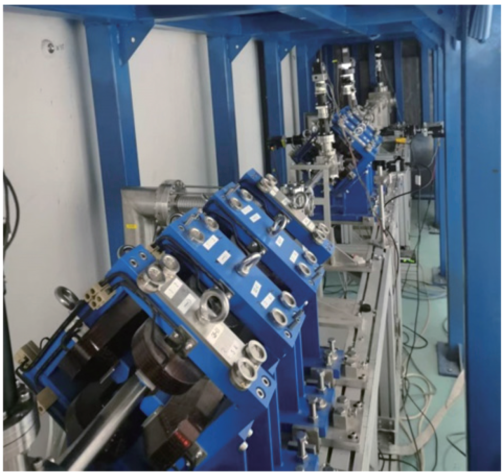


Fig. 1 (color online) HEER cascade imaging lens layout and electron trajectories.

The relevant simulations of the cascade imaging experiment have been completed. A standard 100 mesh molybdenum TEM grid with a hole width of 200 μm, a bar width of 50 μm and the thickness of 25 μm was used in the experiment, and the experimental results with a spatial resolution of 0.6 μm was obtained in the experiments. Figure 2 shows the HEER experimental result of the TEM grid.