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Research and Application of Thermal Power Centralized Control Operation Training System

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Abstract. After investigating the training methods of centralized control operation of many power generation enterprises, it is found that the three contents of on-site equipment, system diagram and procedure are relatively discrete from each other in traditional training, and employees often need to spend a lot of time and energy to initially combine the three contents and understand and learn. Based on WinForm and WeChat mini program platform, the thermal power centralized control operation training system is developed, combining traditional training methods with modern technology. Through software, the actual equipment, system drawings and procedures are combined to provide employees with more intuitive and visual learning methods, so that employees can understand and master knowledge more easily. Improve employee learning efficiency and learning experience.

Keywords. Power generation enterprises; centralized control operation; training system

1. Introduction

Thermal power enterprises are an important part of the energy industry and a crucial guarantee for national energy security. The operation of thermal power enterprises directly affects the stability and development of the national economy. Having a high-quality workforce with excellent job skills is key to the healthy and stable development of thermal power enterprises. Research has found that the training methods for thermal power plant control operations lack liveliness and vividness, significantly impacting the learning efficiency and experience of employees, which is a major pain point in the training of most thermal power enterprise employees today[1]. Furthermore, as thermal power enterprises serve as a critical safeguard for national energy security, they recruit a large number of new employees every year, indicating that the training of thermal power plant control operation staff is a recurring issue. Therefore, making professional training more lively and vivid, enhancing the learning motivation of new employees, and accelerating the pace of mastering the necessary system learning for thermal power units are of significant importance for the healthy and stable development of thermal power enterprises.

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2. System design ideas

The thermal generator set system is mainly composed of three major sections: steam engine, boiler and electric. The number of on-site equipment in the three major sections of the unit is large, the structure is complex, and the on-site equipment layout between the units is different, and the existing system diagram and procedures are relatively discrete teaching materials, and the system diagram is not effectively combined with the actual situation on the site, which slows down the rhythm of system learning and mastering for new employees. To solve this problem, based on the existing system diagram and procedures, this paper collects the information of the three major on-site equipment of steam engine, boiler and electricity of the enterprise thermal generator set, and integrates a number of learning contents such as the learning question bank of the operation duty officer, typical operation ticket, typical accident handling, safety accident bulletin, and practical operation demonstration of the simulation machine into a visual display. The specific system flow is shown in Figure 1.

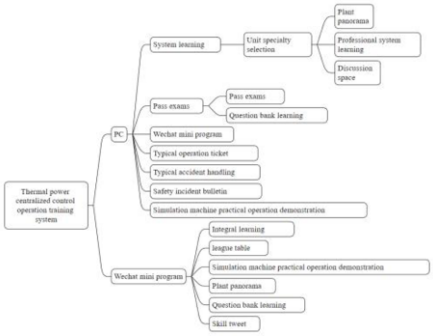

Figure 1. System flow chart

3. PC software design

Training system based on PC. Net Framework development,.NET Framework platform provides Web Control and Winform Control two support Control form application project, the project uses Winform Control to provide the control for PC application development[2-3]. According to the flow chart of the training system, the main functions of the PC-side training system include thermal power unit system learning, passing the exam, typical operation ticket, typical accident handling, safety accident bulletin, simulation machine practical operation demonstration and learning. From the function realization of the whole system, the software structure can be divided into the main form module, the system learning, the main function module, the rest of the sub-function module, the resource base module, etc.

3.1 Main form module

The main form module is the core interface of the training system, the downlink entry and the uplink exit of the system data, and provides the main interface for users to interact with the system. When the user applies the corresponding job number to log in to the training system, the user can access a variety of functional modules on the main

form module, including system learning, passing the exam, typical operation tickets, typical accident handling, security accident bulletin, simulation machine practical operation demonstration, etc., in addition, it also includes menu bar, toolbar, status bar and other elements for navigation and display of the system's functions. Through the main form module, users can conveniently browse and select the required learning content for learning and operation, as shown in Figure 2.

Figure 2. Training system main form

3.2 System Learning Modules

The system learning module is one of the core functions of the training system. The project collects a large amount of on-site equipment information and panoramic picture information, and integrates them to show users in the form of two sub-functional modules of factory panorama and professional system learning, so as to help users fully understand and master the information of steam engine, boiler and electrical three major professional on-site equipment of thermal generator set.

The training system collects 360-degree panoramic picture information of the plant based on the steam engine, boiler and electrical professional plate of each unit[4-10]. Users can visit the on-site equipment of each unit and each specialty through the panoramic module of the training system, understand the layout and connection relationship of the specific professional equipment of the entire thermal power plant, and help users clarify the logical relationship between the equipment. To establish the cognition of the overall structure of thermal power. A large number of text, picture and video labels are added to the key equipment points in the panorama module of the factory site. Users can query and learn the name, model specifications, daily maintenance points, operating procedures, equipment principles and so on by clicking these labels, as shown in Figure 3.

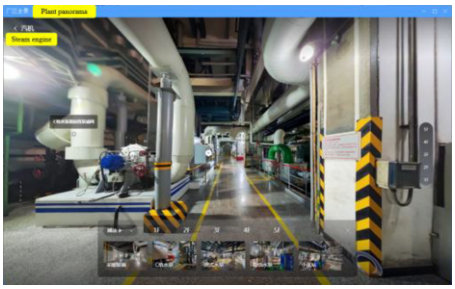

Figure 3. Plant panorama

After the user clicks the system learning module and selects the major of the unit to be learned, the system interface will switch to the system content selection interface as shown in Figure 4. Immediately after selecting the system to be learned, the training system will show the user the knowledge points related to the production operation of the system and relevant equipment points, helping the user to have a deep understanding of the power generation operation. The discussion space also supports users to discuss issues, share learning experiences and so on.

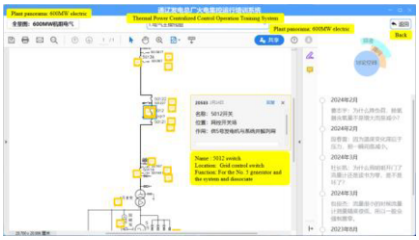

Figure 4. Professional systematic learning

3.3 Pass answering module

Similarly, passing the exam is also one of the core functions of the training system. As shown in Figure 5, according to the operating post system, five checkpoints including single inspector, double inspector, full inspector, secondary watch officer and main watch officer are designed. The system can randomly select a certain number of questions according to the set test requirements and difficulties to form the go-through questions.

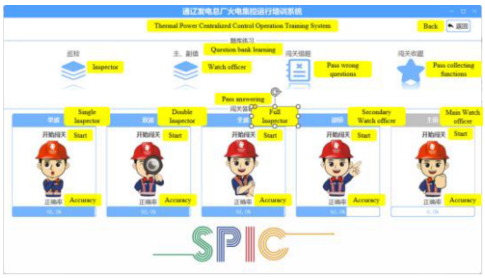

Figure 5. Pass answering checkpoint

After the user learns the relevant professional question bank of the relevant unit, he can play the fun game through the clearance answer module to test and evaluate the self-learning situation, as shown in Figure 6. The pass answering module also provides the pass wrong questions and pass collecting functions, in which users can view and manage the wrong questions and collected questions in the process of pass answering, to help users focus on reviewing and strengthening the grasp of error-prone or important knowledge points.

Figure 6. Pass exams

3.4 Other Sub-function Modules

In the training system, in addition to the main systematic learning and passing questions, a number of auxiliary function modules are also designed as shown in Figure 7, such as typical operation tickets, typical accident handling, safety accident report and simulation machine practical operation demonstration, etc., providing users with rich learning resources to help them master relevant knowledge and skills more comprehensively in the training process, and improve work efficiency and safety awareness. Through the typical operation ticket module, users can learn various operation processes and specifications, improve operation skills and accuracy; The typical accident handling module provides users with actual accident cases and handling methods to help them improve their emergency handling ability and accident prevention awareness. The safety incident report module releases the latest safety incident information in a timely manner, so that users can understand the actual cases and lessons, so as to improve safety awareness and risk prevention ability; The simulator real operation demonstration module provides the simulation operation demonstration when the unit meets the typical accident, so that the user can consolidate the typical accident operation process of the unit and improve the practical operation skills and coping ability.

Figure 7. Sub-function module

3.5 Resources module

The resource library module is used to manage and store various learning resources, including system diagrams, procedures, study question banks, operation tickets, accident handling cases, safety accident reports, etc. The on-site equipment information of each unit is collected and integrated into the software resource library, which realizes the centralized management and convenient call of information. When the user clicks a specific device point in the system diagram learning, the software will invoke

the corresponding on-site information and related knowledge points from the resource library to provide the user with more comprehensive learning support, as shown in Figure 8.

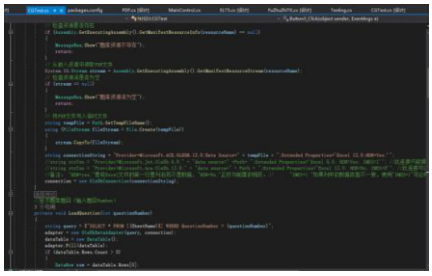

Figure 8. Resources module

4. Mobile terminal software design

In order to improve the practical convenience of the training system users, Tongliao Second FA also independently developed the training system wechat mini program end. Wechat mini program terminal brings together a number of functions, including points answer, score ranking, simulation machine practical operation demonstration, factory panorama, daily technology push and question bank learning.

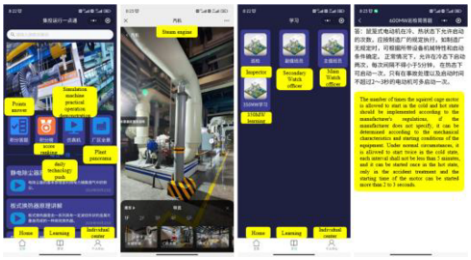

Figure 9. Same function with PC

As shown in Figure 9, functions such as PC simulator practical operation demonstration, factory panorama and question bank learning are also continued in the wechat mini program. Users can visit the factory panorama through the mini program to enhance the intuitiveness and practicality of learning. In addition, you can also study through the question bank, anytime and anywhere to study the question bank, consolidate knowledge, improve learning efficiency. As shown in Figure 10, the integral answer function is a highlight of wechat mini program. The system pushes 10 questions to the user every day, and the user can answer them anytime and anywhere, and it takes a very short time to complete. The system will also record the user's answer points, and rank according to the points, set up reward and punishment rules, encourage users to participate actively, and improve the learning enthusiasm and happiness index of employees. Daily technology push is another feature of wechat mini program, the system pushes a technical knowledge or operation skills every day, to help users continue to learn and improve skills.

Figure 10. Points answer and a daily push

5. Main technological innovations and implementation effects

5.1 Main technological innovations

Thermal power centralized control operation training system breaks the traditional training methods, skillfully integrates modern technology and practical operation, and brings a new learning experience for students. Through the training system, students can intuitively tour the on-site equipment, view system diagrams and procedures, thereby improving learning efficiency and participation. The mobile training system also provides a more convenient and flexible way of learning, and personalized functions such as integral answer and daily push make learning more interesting. Its specific innovation points mainly include the following points:

(1) Improvement of learning efficiency: The centralized control operation training system combines actual equipment, system diagrams and procedures through software to provide students with a more intuitive and visual learning method. Students can directly operate virtual equipment through the system, view system diagrams and procedures, and better understand the working principle and operation process of the equipment;

(2) Diversified learning methods: Through the combination of PC side and wechat mini program side, the training system provides diversified learning methods, including simulation machine practical operation demonstration, factory panorama, question bank learning and other functions, so that users can learn in different ways to increase the interest and practicality of learning;

(3) Personalized learning experience: wechat mini program's points answer, daily technology push and other functions provide users with personalized learning experience, users can learn according to their own time and needs, and through the form of answer points, ranking and other incentives to improve the motivation and effect of learning;

(4) Real-time interaction and feedback: the training system has the functions of pass answering and points answering, which realizes real-time interaction and feedback between users and the system. Users can answer questions at any time, and the system records points and ranks them in real time, providing users with timely learning feedback and increasing the interaction and participation of learning.

(5) Improve user experience and convenience: the wechat mini program of the training system provides users with more convenient and flexible learning methods, and users can learn anytime and anywhere through their mobile phones, regardless of time and place restrictions. At the same time, the diversified functions also enhance the

user's learning experience, enhance the user's recognition of the training system and use desire;

(6) Promote the role transformation of students: The training system can provide a more vivid and vivid learning style, so that students can more easily transform from students to employees. This can facilitate role change and allow students to adapt to the work environment more quickly.

5.2 Implementation effect

After the completion of independent research and development of the training system, the pilot application was carried out for the new employees of the power generation branch of the enterprise. After 4 quarters of pilot application and data feedback, it is found that the effect of the system is remarkable, not only the learning efficiency of employees, learning experience has been improved, but also effectively reduce the cost of new staff training, reduce the equipment loss rate, failure rate, and improve labor productivity.

Figure 11. Pilot application effect data

As shown in Figure 11, since the pilot application of the training system for 4 quarters, the average score of the employees in the quarterly examination has not decreased but increased under the premise that the training courses have been reduced from 4 courses per month in the previous 4 quarters to 1 course per month. The alarm times of centralized control operation parameters such as main steam, reheat steam temperature, mill outlet temperature, main steam pressure, desulfurization and denitrification, and water level of each vessel decreased by 24.01% compared with the previous four quarters. The average score of employees in the quarterly examination has been improved, and the effective reduction of the number of unit operation parameter alarms means that the enterprise training cost and equipment maintenance cost have been improved, and the specific enterprise benefits brought by the training system are as follows:

(1) Saving the cost of training courses: the training courses have been reduced from 4 courses per month in the last 4 quarters to 1 course per month, and the examination scores of employees have increased instead of decreasing, effectively reducing the cost input of staff training courses;

(2) Reduce the attritional rate: The development and application of the training system enables employees to be familiar with the operation and troubleshooting process of the equipment in the virtual environment, which reduces the misoperation and improper maintenance of the actual equipment, reduces the attritional rate of the equipment, extends the service life of the equipment, and thus reduces the cost of maintenance and replacement of the equipment;

(3) Improve labor productivity: Traditional training methods take a longer time to understand and master the relationship between actual equipment, system diagrams and procedures. By combining these contents with each other, the training system provides a more intuitive and image learning way, making it easier for employees to understand and master knowledge, so as to improve the efficiency and productivity of training, apply the knowledge more skillfully in the work, and improve labor productivity.

6. Conclusion

This paper deeply studied the pain points of production line, grasped the pain points of traditional thermal power centralized control operation training mode under the condition of zero capital investment, innovatively applied modern technology, and independently developed the training system on PC and mobile. The multi-end training system provides a variety of learning methods and personalized learning experience, including factory panorama, pass answer, daily push and other personalized functions, to provide users with a rich, convenient and personalized learning experience, so as to promote the learning enthusiasm and happiness of employees. In addition, after the pilot application and feedback collection of the training system, it is found that the effect of the system is significant, not only the learning efficiency of employees, learning experience has been improved, but also effectively reduce the cost of new staff training, reduce the equipment loss rate, failure rate, and improve labor productivity. The success of the pilot application has also promoted the promotion of the training system to other professional sectors such as maintenance, safety and environmental protection and related departments to meet a wider range of training needs.

References

[1] Zhu He, Fan Jiudong, Wang Jie. Consideration on the importance and effective measures of safety production management in thermal power plants [J]. Engineering Technology and Management, 2024, 8 (6):

[2] Li Shuolin. General Teaching System Based on WinForm [D]. Huazhong University of Science and Technology,2020.

[3] Wei Liming, Ji Shubin, Sun Jialong. Design and implementation of Equipment Management System based on WinForm [J]. China New Technology New Product,2020(03):11-12.

[4] Olga V,Vladimir Z,Ivan M , et al. Automated training system with advanced knowledge control[J]. Procedia Computer Science,2022,213.

[5] Wang Yuwen, Nie Yuqiang. Construction of Thermal Power Unit Simulation Training System [J]. Journal of Anhui Electrical Engineering Vocational and Technical College,2016,21(03):122-125.

[6] Kwak Hyun-min, To Chi-man. Design of training system based on Virtual Reality technology [J]. Information Recording Materials,2022,23(12):104-107.

[7] Ning M. Research on the Framework of the Software Development Security Testing System Based on the Attack Mode[J]. BASIC & CLINICAL PHARMACOLOGY & TOXICOLOGY,2020,126.

[8] Jiahui D ,Daoyi L ,Kadir O , et al. Development of CryoVR, a virtual reality training system for hands‐on cryoEM operations [J]. Acta Crystallographica Section D, 2022, 78 (7): 903-910.

[9] Li X ,Xianqi L ,Junwei Z , et al. Simulation of Switching Operation Based on Virtual Reality Method [J]. Journal of Physics: Conference Series, 2020, 1650 (3): 032121-.

[10] Hakim L D ,Abdullah G A ,Mulyadi Y , et al. The Development of Dispatcher Training Simulator in a Thermal Energy Generation System [J]. IOP Conference Series: Materials Science and Engineering, 2018, 288 (1):.