Design of an Intelligent Manufacturing Practice Teaching Platform Centered on Innovation Ability

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Abstract. This paper designs and implements a practical teaching platform for relevant majors in the field of intelligent manufacturing, focusing on the cultivation of innovation ability. With MES as the core, six major software and hardware systems were designed, including S7-1500 controller, CNC machining, intelligent warehousing system, auto-detection system, industrial robot, auto guide vehicle (AGV), and au-to-assembly system. Relying on the practice platform, three intelligent manufacturing cases for teaching were designed. Result shows that each case can achieve product manufacturing with a high success rate during the teaching process. This has effectively improved the quality of talent cultivation and achieved the development and utilization of high-quality experimental teaching resources.

Keywords: Innovative ability · intelligent manufacturing · practical teaching · Manufacturing Execution System

1 Introduction

With the rapid development of information technology, represented by big data, the Internet of Things, cloud computing, artificial intelligence, blockchain and other technologies, its integration with industrial technology have promoted the development and transformation of various industries and the continuous emergence of new business types, and made the industry increasingly dependent on high-tech. This has put forward higher requirements for the innovation ability and practical ability of employees, and further put forward requirements for talent training in colleges and universities [1].

Zhang of Nanjing University of Science and Technology has formed an intelligent manufacturing and robot practice innovation training center relying on the integration of the existing resources of the school [2]. Lu of Shandong University built a hardware platform for mechanical and electrical innovation of new engineering courses [3]. In addition, many scholars have designed diverse training modes [4, 5] and virtual simulation training projects [6, 7]. Overall, there are still many practical problems in the practical teaching design of intelligent manufacturing related majors. Due to the high cost of equipment, it is often difficult for existing training platform designs to keep up with

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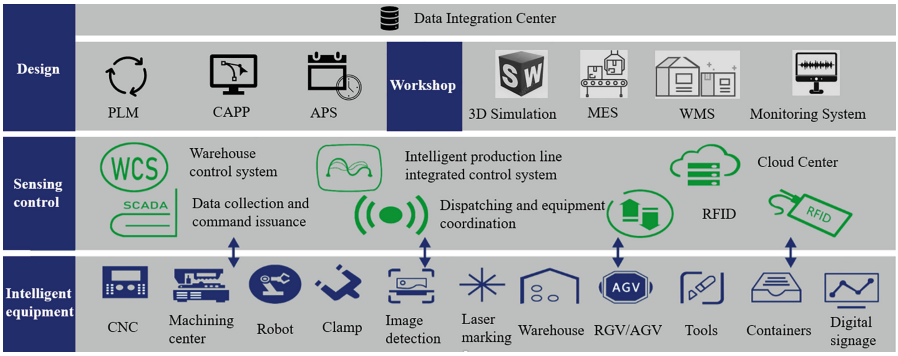

Fig. 1. Diagram of intelligent manufacturing practical teaching platform

the development of the trends. Furthermore, it will lead to severe separation of various parts of the training platform, which cannot form an organic whole of existing equipment and resources. This also cannot guarantee safety and will affect the effectiveness of practical training.

This paper mainly built an intelligent manufacturing innovation hardware platform and practical teaching design ideas are constructed. Finally, the effectiveness of the reform is introduced.

2 Overall Scheme Design of Teaching Platform

The experimental teaching system strives to achieve diversified collaboration, emphasizing the cultivation concept of basic polishing, advanced training, strengthening practice, highlighting innovation, and distinctive features. Aim to cultivate intelligent manufacturing professionals with outstanding innovative spirit and practical abilities. With the industrial level intelligent manufacturing technology as the core, industry equipment was configured. Digital manufacturing platforms were built by DNC (Distributed Numerical Control). ERP (Enterprise Resource Planning), MES (Manufacturing Execution System), CAD (Computer Aided Design) and other information systems were integrated into the platform. Meantime, a traceable product manufacturing process was created by the RFID (Radio Frequency Identification) and global monitoring network. So that all parts of the system can form a complete enterprise level information system, to establish a solid foundation for the implementation of intelligent manufacturing practical teaching design [8, 9]. The architecture diagram is shown in Fig. 1.

3 Design and Implementation of Teaching Platform

3.1 Design of Hardware System

The foundation of constructing teaching platform is the hardware design of masters and slaves. With MES as the core, Profinet and Profibus were used for the communication of masters and slaves [10]. The design of hardware system mainly includes S7-1500 controller, CNC machining, intelligent warehousing system, auto-detection system, industrial robot, auto guide vehicle (AGV), and auto-assembly system. The main function of

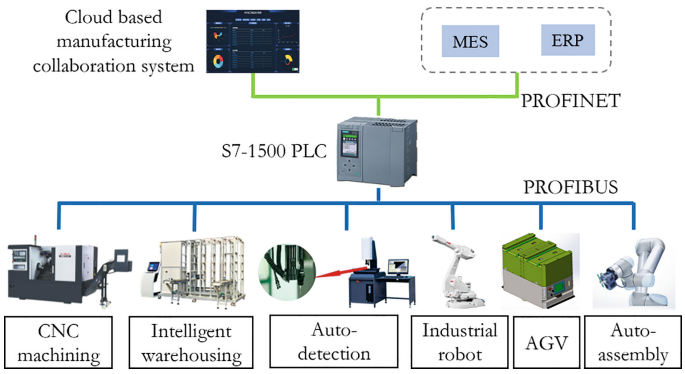

Fig. 2. The connection of PLC controller and other devices

S7-1500 controller system is receive commands from cloud-based manufacturing collaboration system, communicate with slaves, and collect data from slaves. The network cables were used to connect the PLC and other devices, as the Fig. 2 shown.

The CNC machining system is mainly responsible for the processing of raw materials. The intelligent warehousing system is mainly responsible for the management of materials and products, mainly composed of an IoT sensing system and a robotic arm with a PLC1200 controller as the core. The auto-detection system is mainly responsible for testing the qualification rate of products. Industrial robot is mainly responsible for handling products and materials. AGV is mainly responsible for the autonomous transportation of materials at various workstations. The auto-assembly system mainly uses two UR5 collaborative robots to complete the interactive assembly of products.

3.2 Design of Software

Each device has an IP address and relies on vertical information flow and horizontal end-to-end network. With the network, multiple intelligent manufacturing cases were designed based on hardware equipment. After receiving instructions from the cloud based intelligent manufacturing system, the S7-1500 PLC controller will first communicate with the intelligent warehousing system based on the type of task, so that the robotic arm can retrieve the corresponding materials. Then, under the communication of the network, the AGV will transport the materials to the corresponding processing center according to the requirements. After processing completed, the product will be transported by AGV to the laser marking system for digital management. Next, a three-coordinate measuring instrument is used to test the qualification rate of the processing situation, to select qualified products for the next step of product assembly. After the assembly is completed, they can be transported to the intelligent warehousing system by AGV for storage. The software process case is shown in Fig. 3.

4 System Verification

To verify the reliability, stability, and effectiveness of the teaching platform. This paper designed three teaching cases to complete multiple tests of the platform, and the intelligent manufacturing practice teaching platform is shown in Fig. 4. The basic functional testing, performance testing, stability testing, and detection testing of the platform were completed in the actual class process. The testing results are shown in Table 1.

The main reasons for failure are twofold: insufficient machining accuracy leading to failed detection or assembly process failure. The experimental data also indicates that the more complex the processed product, the higher the failure rate of the teaching

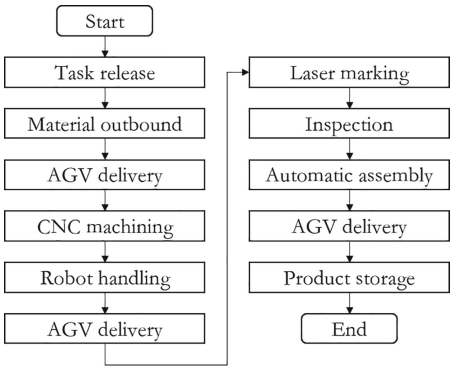

Fig. 3. System Integration Diagram

Fig. 4. Intelligent manufacturing practice teaching platform

Table 1. Intelligent manufacturing practice teaching platform

Test cases	Number of tests	Number of passes	Successful rate
Little gyroscope	200	197	98.5%
Big gyroscope	200	187	93.5%
Pen container	200	199	99.5%

platform. Therefore, emphasis should be placed on improving the accuracy of assembly in the future work.

5 Conclusions

An intelligent manufacturing practice teaching platform centered on innovation ability based on MES has been designed using S7-1500 controller and many other industrial equipment. And multiple intelligent manufacturing cases were designed based on hardware equipment for teaching. However, it also requires stable and reliable assembly method, and the accuracy of the detection system is also limited, which needs to be continuously improved and optimized in future research.

The intelligent manufacturing practical teaching platform centered on innovation ability conforms to the trend of educational informatization, fully utilizes modern information technology, closely combines the forefront of industry and the latest achievements. With the cultivation of students' innovative practical ability as the core, relying on high-level experimental teaching and management teams, and using in class experiments and extracurricular innovation competition activities as carriers, the platform innovates teaching models, a continuous and progressive experimental teaching system was conducted, that conforms to the characteristics of the discipline and the laws of student growth education, as well as a new experimental teaching model that combines online and offline, in class and extracurricular activities, and virtual and real activities. This has effectively improved the quality of talent cultivation and achieved the development and utilization of high-quality experimental teaching resources.

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