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Research on a New Industrial Intelligent Manufacturing Model for Robot Digital Workshop

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Abstract: Currently, more and more enterprises are introducing robots into factories to achieve large-scale intelligent processing in an automated manner. On this basis, a new industrial intelligent production mode based on robots is proposed. This model has played a significant role in promoting the transformation of industrial production methods. Given its important position in the industry, the article will analyze its operating mechanism in order to provide some reference for the development of Chinese enterprises.

1. Introduction

With the rapid development of technology, enterprises have increasingly high requirements for product quality, and the requirements for product quality are also increasing. The high demand market urgently requires enterprises to enhance their productivity to meet the living needs of the people. Traditional labor-based industrial production is clearly unable to meet this demand. Therefore, more and more enterprises are adopting robots as a substitute for human resources to achieve intelligent digital production. This robot based digital workshop production mode not only has high production efficiency and safety performance, but also avoids the disadvantages of traditional workshop production that is time-consuming and labor-intensive, achieving industrial intelligent manufacturing. In the future, such robot digital workshops will be a major form of industrial intelligent manufacturing mode. Factories actively learn, analyze, and master this new production mode, which will promote the development of the factory itself and improve the automation production level of China's manufacturing industry[1].

2. Connotation of Industrial Intelligent Manufacturing

Industrial intelligent manufacturing is a method of intelligent production led by robots. In the past, the application field of robots in factories was relatively narrow, mainly used for manual work such as painting. But with the further development and maturity of robot manufacturing technology, robots have developed joint recognition systems and visual recognition systems that can perform precise calculations based on actual situations, and their application scope is also becoming increasingly broad. Among them, the digital workshop is the best example. At present, many digital

workshops adopt many intelligent devices and are equipped with many robots to complete daily work. The digital workshop with robots as the main body has greatly improved the production efficiency of enterprises, shortened the production cycle of enterprises, and provided new ideas for the intelligence of enterprises[2].

3. The role of digital workshops

The application of digital workshop technology has brought great benefits to the overall development of the manufacturing industry. According to an overseas research report, its benefits mainly manifest in the following aspects. Firstly, the time required for products to enter the market is greatly reduced; Secondly, reduce the proportion of design changes by 65%; Thirdly, the planned manufacturing process has been reduced by 40%; Fourthly, it reduced production costs by 15%; Fifth, an increase of 30% in production. The digital factory is a complete transformation of traditional factory technology, abandoning outdated design ideas and production methods. Adopting computer-aided design not only ensures the accuracy and reliability of the plan, but also greatly shortens the construction period, reduces costs, and improves the quality of the project. From a time perspective, it can shorten the time required for overall manufacturing and process planning; In terms of quality, the planned quality, efficiency of variant manufacturing, consistency of product data have been improved, and the entire line has been optimized; Save costs, control project changes, and reduce equipment and labor costs[3].

4. The mode of digital workshop manufacturing

Below, we will introduce each part of the robot workshop with a specific case study. This case is an automation project for a large workshop.

4.1. Industrial robot loading and unloading unit

Install two claws on the left and right sides of the robot, one claw for grasping and feeding, and the other claw for cutting. When in use, it can quickly complete the feeding and changing of materials during feeding and unloading. Depending on the manufacturing process, different layout forms can also be used, such as "one to two" layout, "one to three" layout, etc. In addition, it is possible to layout an automated production line consisting of multiple robots simultaneously on multiple machines, corresponding to machine tools such as CNC lathes, punches, and machining centers. The loading and unloading system has greater flexibility and a wider range of applications, and can be used for automatic unloading of various workpieces. Workpieces that can be flexibly used mainly include discs, shafts, and gears. This system can produce in three shifts, and as long as there are enough blanks, it can produce uninterrupted. This method can not only reduce the labor intensity of workers, but also improve productivity[4].

4.2. AGV Logistics System

The AGV transportation system adopts laser guidance and is equipped with anti-collision devices at the front and rear during transportation. Once encountering an impact, it will automatically cut off the power supply and stop moving forward. This system is powered by a stepper motor and can interface with production devices, processes, and robotic arms to achieve direct discharge. Because there are only two cargo spaces, only two items can be loaded at a time, and each cargo space is equipped with a sensor that can detect specific cargo conditions at any time. This system setting can achieve real-time communication between various operational processes,

ensuring timely exchange of information between each other, and also conducive to better completion of docking work[5].

4.3. Stereoscopic Warehouse

General angle steel is the main component of a three-dimensional warehouse. In each warehouse, there is a positioning device and a sensor, which can ensure the position of the pallets is more accurate, and the sensor can detect any vacancies in the warehouse in a timely manner. The main functions of a position are twofold. Firstly, it can be used to store parts related to motors, as well as certain process and semi process materials; Secondly, it is possible to accurately record the material situation of each warehouse, making it easy to check at any time when needed in the future. In a fully automated three-dimensional warehouse, automated handling of goods is achieved with a stacker crane as the center. Its components mainly include horizontal walking, lifting mechanism, cargo platform, and electrical control system. The stacker crane works on the ground track and can reach a straight line, with high positioning accuracy. This is mainly due to the use of servo motors for driving in all axial directions[6].

4.4. Information System

In the entire digital workshop, the main equipment includes a digital design analysis system, information management and analysis system, information security protection system, and the overall control unit of the system.

4.4.1. General control unit of the system

On this basis, a data collection method based on data collection and data collection is proposed. At the same time, the system also has many advantages and functions, such as monitoring the working status of equipment, calculating the production quantity of products, and conducting remote monitoring and operation. In the upper and lower material systems of three-dimensional warehouses and industrial robots, touch screen control systems are installed, and communication can be carried out between each control system to real-time grasp the working conditions of each component. When a certain device malfunctions, its control panel will prompt the fault in the form of an alarm, so that the operator can detect the fault in the first time. At the same time, because communication between various operating platforms is possible, they will also reflect the problem in some way. When they discover a problem, they will first analyze the problem, and then after solving the problem, cancel the alarm to restore it to normal. It should be pointed out that each operating platform can control corresponding devices, but for devices on other platforms, they can only be monitored and cannot be controlled. The control system is jointly executed by multiple users, but each user's permissions are different, and it also automatically records each user's operations, such as login time, operation information, and so on. Only the main control unit can effectively monitor and manage the entire line[7].

4.4.2. Subsystem of digital design

The subsystem of digital design mainly involves designing parts such as rotors, motor stators, and gears, and communicating in real-time with DNC and machine tool CNC systems to complete the entire machining process of the parts. On this basis, various components were processed and assembled.

4.4.3. System for Information Analysis and Management

The information analysis and management system has relatively simple functions, and its main task is to collect, analyze, and statistically analyze information.

4.4.4. System for safety protection

This security protection system consists of three main components. The first step is the security measures for the door lock, which means that there must be a dedicated door lock in order to enter the access control system for maintenance and repair. When the key is removed, it will automatically come off the line and be protected by multi-level series connection. However, it can also be set with a safety grating throughout the line to separate the movement range of the robotic arm from manual loading and unloading, in order to improve safety. The second aspect is the robot's own protection, aimed at preventing collisions between robots. This system allows the robotic arm to automatically check its position and reset it to zero after machining a part. The third module is a button that can be used for emergency shutdown, which can effectively control errors that occur on the machine tool in a short period of time[8].

5. New mode of industrial intelligent manufacturing in robot digital workshop

Exploring the new mode of industrial intelligent manufacturing in robotic digital workshops requires a detailed analysis and understanding of the operational process of this type of digital workshop.

5.1. Production Line

In the factory of digital robots, a feeding and unloading system is installed on the assembly line, and each machine is equipped with handles for feeding and unloading. According to the "one to two" and "one to three" modes, automatic feeding and unloading are carried out, combining multiple assembly lines to form a complete assembly line.

5.2. Material transportation

The AGV material system is an important system for docking robots with equipment such as assembly lines and machine tools. The AGV logistics system is a logistics transportation system guided by lasers and driven by stepper motors. In addition, a sensor is installed at each position to determine whether the goods at each position have been transported during material transportation. In addition, to prevent collisions, each transportation equipment is equipped with anti-collision protection devices. The so-called anti-collision device is actually a type of "brake" that can forcibly stop goods in the event of an accident.

5.3. Warehouse Management

In the robot digital workshop, each three-dimensional warehouse is equipped with positioning equipment and sensor equipment. By using a positioning device, precise placement of items has been achieved; With the assistance of sensors, the robot can accurately determine whether the warehouse location is unmanned. Under digital control, some semi-finished products, blanks, etc. can be stored in corresponding locations in the warehouse. When the robot is installed, the basic information of the products and blanks can also be recorded simultaneously for management personnel to transport. In addition, palletizing equipment is also an important link in warehouse

management. In terms of warehouse management, the stacker crane can provide both linear guidance and axial drive. The robot can achieve precise positioning along the straight path set by the stacker crane.

5.4. Workshop Control

In the digital production process, overall control of the production process is very important. The robot digital workshop has established an overall control system, and only under the action of this control system can various information in the workshop be shared and effectively interacted. This system not only controls the entire workshop, but also monitors and transmits information to various processes. For example, in warehouse management, the control system can assist robots in communicating through touch screens and assembly lines; Different permissions can be set for different users. In addition, the control system can also pop up a prompt message when a unit in the robot digital workshop encounters a problem, and there is also a corresponding alarm system to remind staff to repair it in a timely manner.

5.5. Safety protection

On this basis, a complete security protection mechanism has been established to ensure the safe operation of digital chemical plants. This safety protection mechanism is mainly reflected in the following aspects: firstly, ensuring that the robot returns to zero position after completing its work; The robot is controlled by CNC, and after completing the machining of the parts, it will automatically return to zero point. Meanwhile, robots controlled by CNC can effectively prevent collisions during operation. Secondly, repair the robots in the protective net. The workshop should conduct periodic inspections of the robotic arm to eliminate hidden dangers. These operations are all completed in protective nets, ensuring the safety of the production site. Thirdly, the programming of the NC system is done in the form of teaching, and the programming process can be verified by oneself. Fourthly, emergency alarms and emergency stop buttons have been installed in the security system. When problems arise, a buzzing sound will be emitted, and employees can press the emergency stop button to immediately stop the vehicle.

6. Analysis of robot digital workshop

In a digital robot production line, the layout of robots can be carried out in a "one to many" manner according to production needs and functions, thus forming a scientific digital production line. On the assembly line, there is a multi-production device controlled by a robot that completes tasks such as automatic handling, stacking, assembly, and inspection. Compared to traditional manual methods, digitization is the core of manufacturing processes. For example, in the entire process of product production and manufacturing, raw materials or semi-finished products will be inspected and enter a unified warehouse. At the same time, it will automatically generate the information flow of materials and connect with the production system of the enterprise. Under the control of the MES system, by receiving materials, the robot completes the extraction of materials while receiving them, and delivers them to the production line; In the assembly area, various parts are automatically assembled by robotic arms and intelligent equipment, and then transported to the automatic spraying area for spraying and drying; Finally, in the detection area, the robot detects the product and ships it to the warehouse, forming an information flow of the product. By using digital control, not only can the quality of products be greatly improved, but also the labor intensity of frontline staff can be reduced, and the production efficiency of enterprises can be greatly improved, with a certain degree of market competitiveness.

6.1. Material transportation under digital control

In digital workshops, AGV logistics systems are generally used for logistics transportation. Under the synergistic effect of laser guidance and sensors, driven by stepper motors, efficient collaboration among multiple production links such as robots, machine tools, and assembly lines is achieved, ensuring the accurate delivery of materials to designated sites. Sensors are installed at the placement positions of each material, which can effectively monitor the placement status of the materials. At present, the control programming of this material system is mainly achieved through PLC technology. The system can communicate in real-time with robots and related facilities, and can also display relevant information through the three color warning lights and display screens on the equipment.

6.2. Warehouse management under digital control

In warehouses that use the digital workshop production mode, digital management of goods is achieved by installing positioning devices on the storage positions constructed of angle steel, ensuring that pallets can be accurately positioned to various positions on the shelves. In addition to achieving precise positioning of the positioning equipment, corresponding sensors or other detection components need to be installed to monitor whether and how much material is present in each warehouse. Each warehouse has corresponding warehouse information and can be updated in a timely manner, so that warehouse management personnel can check it at any time and connect with the production system. In terms of automated material handling and transportation, the core facility of the stacker crane is mainly composed of several parts, including the lifting system, electrical control part, material placement platform, and moving parts. Driven by a servo drive motor, it can move along the guide rail and achieve precise positioning through sensors[9].

6.3. Workshop Control System in Digital Mode

The digital workshop production method operated by robots requires the assistance of control systems throughout the entire production and manufacturing process to ensure stable and reliable real-time communication between robots, intelligent facilities, and related equipment. Through this control system, monitoring of equipment operation, production progress, etc. has been achieved; The present invention provides a method for information communication between an assembly line control device and a warehouse through a display. At the same time, it can also achieve information exchange between multiple operating consoles and display real-time information on the display screen. In automatic production, if a device on the production line experiences an abnormality, the control console of other devices will display the status of the faulty device, and the corresponding alarm system will issue a warning to workers through sound and light methods. Based on the fault prompt information, it is possible to quickly and efficiently troubleshoot and restart production. Usually, the control system has a login management function. When people with different permissions log in to the system, the system will automatically record the login time and operation content, which is very helpful for production management personnel to have a good grasp of production progress and various change information in the production process[10].

6.4. Application of Digital Design

On this basis, a new model based CNC machining process design method is proposed. For example, in the production process of CNC machining, digital design units can be used to design parts such as gears, rotors, stators, and end caps, and then information communication can be carried out between the CNC system and DNC. In this way, the CNC system can complete the

formulation of process regulations for parts and the editing of CNC programs, and simulate the machining process using NC code. By utilizing digital design, the production process can be effectively simulated and analyzed, thereby detecting the rationality of the design, the orderliness and reliability of production and manufacturing, and preventing serious problems and causing huge losses after the product is officially put into use[11].

7. Conclusions

The entire working process of digital robots is quite intelligent, except for some things that require humans to do, all other things are done by robots. Through the above analysis, we can see that intelligent technology has been adopted in the production line, material transportation, warehouse management, workshop control, and safety protection of the robot digital workshop, achieving precise, efficient, and safe production. The digital workshop industrial intelligent manufacturing mainly based on robots has reduced production costs, reduced labor costs, and also improved production efficiency and quality, ensuring production safety. Therefore, its application and promotion value is high. Moreover, the industrial intelligent manufacturing mode of the robot digital workshop is a transformation of traditional production mode and a favorable factor in promoting the transformation of traditional industrial manufacturing mode. On this basis, this article proposes a new research approach and prospects future research directions. In the coming years, this new production method will be the dominant mode of enterprise production.

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