

The Development of Flexible Manufacturing Systems in Automotive Production Under the Background of Industry 4.0: A Descriptive Study

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Abstract: Taking Industry 4.0 as the background, this paper investigates the role of Flexible Manufacturing System in automobile production, introduces flexible systems from the application of CNC machine tools, manufacturing robots and computer control systems in automobile production, summarizes the existing technical barriers, and points out the feasible development direction.

Keywords: Industry 4.0; Flexible Manufacturing System; Automobile manufacturing.

1. Introduction

1.1. Research Background

Industry 4.0 is a division based on different stages of industrial development. Industry 4.0 is the era of revolution using information technology that is now underway. It can be found that the time interval between the emergence of each industrial revolution is shortening, so the requirements for technological updates are getting higher and higher. The characteristics of the era of Industry 4.0 are: (1) the individual needs of users can be met; (2) the production mode is highly flexible; (3) the level of decision-making has increased significantly; (4) the productivity and utilization efficiency of resources have increased significantly [1].

To achieve the above highly flexible requirements, flexible manufacturing systems must be used in production. Flexible Manufacturing System is composed of a unified information control system, material storage and transportation system and several Computer Numerical Control(CNC) equipment, can adapt to the transformation of processing objects intelligent automated electromechanical manufacturing system. This system can reduce the intensity of human labor to the greatest extent, ensure that the production organization process in the production process can be flexibly adjusted, and is suitable for diversified production needs of construction machinery products, and fully improve the overall efficiency of production. And can also start from the changing needs of the market, the use of flexible manufacturing system to adjust the production plan and production targets accordingly, to ensure that the production of construction machinery products can have good sales[2].

1.2. Research Objectives

In the context of the development of industry 4.0, the level of automobile production and manufacturing is one of the standards to measure whether the machinery manufacturing industry is modern. In today's automobile production, flexible manufacturing system is one of the indispensable parts, so the research on the application of flexible manufacturing system in automobile production has guiding significance for the development of automobile production under the background of Industry 4.0. This paper will study the flexible

manufacturing system used in the manufacturing process and control process of automobile production, find the defects from the existing technology, and provide guidance for the development of flexible systems in the future automobile production.

2. Manufacturing Section

2.1. CNC machine

With the development of the era of Industry 4.0, CNC technology is also constantly developing to more intelligent, linkage and intelligence, and in the automobile production industry, the manufacturing requirements for auto parts are getting higher and higher, and the precision of auto parts is getting higher and higher. Therefore, CNC machine tool technology can be applied in the processing of auto parts, through the application of this technology, improve processing efficiency and processing accuracy and quality, shorten the processing period, and effectively promote the intelligent and modern development of auto parts processing. [3] In the process of automobile production, it is necessary to use a variety of important parts, which are the foundation and core of vehicle processing and manufacturing, such as the chassis bears the power and pressure of the automobile engine and the processing accuracy and quality, which is directly related to the safety and stability of automobile operation. At present, there are many types of automobiles, and the requirements for various parts configuration are also high. [4] In the domestic auto parts manufacturing industry, the manufacture of key components such as engines, all-electric transmissions, high-pressure oil pump drive units, hub units, steering knuckles, axles, bearings, and automobile chassis requires a large number of CNC machine tools. Due to the advancement of contemporary CNC technology, many automobile manufacturing enterprises have begun to adopt driverless automated production lines, such as body front panel automatic production lines. This production mode is mainly through the cooperation of automation technology and data technology, and there is no need for workers to manufacture and process, and the quality of the manufactured parts is very high, and the welding speed is extremely fast. The precision of numerical control technology depends on the

interpolation technology, the higher the interpolation technology, the higher the precision.

2.2. Manufacturing robots

In addition to the application of CNC machine tools in the processing of automobile parts, the application of manufacturing robots in automobile production is also very extensive, such as the robot arm to assist automobile assembly. The industrial robot based on Programmable Logic Controller (PLC) is an important part of the existing industrial robot, the main working principle is: PLC mainly includes PLC controller, input module, output module, signal transmission module, control button and buffer switch. After pressing the work button, the action process of the manipulator arm starts, and the buffer switch in the control cylinder of the manipulator arm collects the action signal and feeds it back to the PLC controller through the signal transmission module; After the PLC controller completes the signal collection, it sends the control command signal to the control solenoid valve to drive the action of the linear moving cylinder and the rotating moving cylinder, so as to drive the robot arm into the specified working state [5]. LabVIEW is a common programming software for controlling robotic arms. It is a graphical programming language that uses ICONS instead of text lines to create application programs. Its VI code is composed of block diagrams with rich hardware interfaces, and program code can be directly applied to hardware through drivers. The robotic arm control based on LabVIEW can not only meet the higher control requirements of the robotic arm, but also simplify the program development process and improve the development efficiency [6]. Nowadays, the development of intelligent vehicles under the background of industry 4.0 is the center of gravity of the automotive industry, among which millimeter wave radar is an indispensable part of the advanced driver assistance system, in order to ensure the safety of the car form, it is necessary to conduct multiple performance tests in the production of millimeter radar waves. Building a real test platform is time-consuming and costly. Therefore, LabVIEW is used to carry out the performance test and functional test program of the intelligent vehicle MMwave radar test system, and CarMaker scenario simulation software is used to realize the functional test of mmwave radar [7].

3. Control Section

Nowadays, Manufacturing Execution System (MES) control system is widely used in automobile production plant. The Advanced Manufacturing Research Institute (AMR) in the United States defines MES as "the management information system for the workshop layer between the upper level plan management system and the lower level industrial control". It provides operators/managers with the execution of plans, tracking, and current status of all resources (people, equipment, materials, customer requirements, etc.).

In automobile production and manufacturing, MES system will implement dynamic data collection and monitoring in the entire production process from raw material purchase to finished product storage, thus meeting multiple management needs such as product traceability and assembly state monitoring [8]. The overall process of the order manufacturing mode under Industry 4.0 is as follows: the customer places a personalized order, the order information enters the management system, the system immediately synchronizes and coordinates the various departments upon

receipt of the order, and then generates a work sheet and plans a bill of materials. If the material inventory is insufficient, the system automatically issues a purchase order to the supplier and flows into the production process through logistics distribution. Factory processing is also an automated operation, real-time data during the operation, such as order completion progress, equipment failure, machine idle and other information will be synchronized in real time in the MES system, when any fault or hidden fault is found, the system will prompt supervisors and give solutions.

Not only can the processing process be coordinated in the MES system, but also the scheduling of employees can be input into the MES system. In the auto factory, employees generally need to rest for half an hour after working for 3 consecutive hours, and the MES system can record the workers' work market and remind them when they need to rest, reducing the possibility of accidents.

In addition, the digital twin is currently one of the more important enabling technologies for intelligent manufacturing, especially in today's era of technological change, the manufacturing industry, especially the automotive industry, can use the digital twin technology to achieve more flexible, more cost-effective, more cutting-edge, more close to the actual operation of the enterprise real-time scenario. A digital twin can be a vehicle component such as a chassis or a virtual version of a car, a method for manufacturing those products or an entire production line, or a factory or an end-to-end supply chain[9].

Both the MES system and the digital twin technology rely on the sensor to update the data in real time so that the system can make accurate judgments.

4. Prospects

The key technical requirement for the development of numerical control technology in the automotive field is to improve accuracy. There are the following operational measures to improve the accuracy of CNC technology: (1) The interpolation technology can be improved, from the initial two-axis linkage to now achieve six-axis linkage, but the six-axis linkage technology is not perfect enough, multi-axis linkage CNC machining in the linear interpolation of the CNC system and the actual tool trajectory inconsistency, resulting in nonlinear error. By establishing a nonlinear error model, the position of the maximum nonlinearity error is predicted. By analyzing the curve fitting degree and using the parabolic function method, the error model was further improved, and the influencing factors of nonlinear error were analyzed. The out-of-tolerance program segment is controlled within the error tolerance by adaptive linearization [10]. Reducing the standard deviation of the maximum nonlinearity error is an effective way to improve the interpolation technology and improve the accuracy of numerical control technology. (2) The software system can be upgraded. Because the technical level should be improved, the programming method is mainly manual mode, which also puts forward higher requirements for the comprehensive quality of programmers, not only to master the vehicle machining drawings, but also to clarify different parts shape, size, material and other data information, and then combined with the production process and processing process to compile the control program. In order to ensure the orderly operation of the control program, it is necessary to find the processing coordinate system and set the nozzle reasonably. Therefore, in order to give full play to the advantages of CNC

technology, it is necessary to integrate CNC system and automation programming technology, enterprises can introduce CAXA, Powermill and other programming software, and professional programmers complete the processing program writing based on the software. Under the support of software, programmers only need to master software operation methods and programming languages, post-processing work can be completed by software automation [11], but there are still special requirements for programmers, professional training is required, if the software can be upgraded more intelligently, then the programming errors caused by humans can be reduced.

For the control section (MES system and digital twin technology), improving the application range of sensors is one of the ways to improve the accuracy of the system. The processing process generally generates very high heat, and the accuracy of many sensors will be reduced in a high temperature working environment. And many sensors, due to size, can not be installed in the most need to monitor the processing station. Therefore, expanding the use of sensors can make the control system more accurate.

5. Conclusions

At present, Industry 4.0 has become a hot topic in the manufacturing industry and is the key outlet for technological innovation of every enterprise. Analyzing the automotive manufacturing system in the context of Industry 4.0 from the perspective of flexible manufacturing system, it can be found that flexible manufacturing system plays an important role in Industry 4.0. Innovation from flexible systems can enable the automotive manufacturing industry to achieve a qualitative leap.

At the same time, there are still many technical barriers to be solved in the flexible system in the automobile manufacturing system. For example, in CNC machine tools, the accuracy of interpolation still has a lot of room for improvement, and after improving the interpolation accuracy,

the manufacturing accuracy of mechanical parts will also be greatly improved.

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