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Design and Application of Flexible Fixture

Li Hui,*Chen Weifang,Shi Shengjie

[a]*Nanjing university of aeronautics and astranautics,Nanjing,210016,China*

* Corresponding author. Tel.: +1-585-060-0139; fax:+0-000-000-0000.*E-mail address:*15850600139@163.com

Abstract

The flexible fixture has been applied in many areas because it can adapt to the workpiece shape and size change, such as aircraft integral structure parts manufacturing, and air surface parts manufacturing, aircraft assembly. Due to the use of flexible fixture, greatly reducing the manufacturing cost and improves the production efficiency. In this paper, the design of flexible clamping platform is studied and the application is showed in a case. Through comparing the simulated results, it is found that flexible fixture with the follow-up support has higher accuracy.

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*Keywords:*Flexible fixture, OPC, Multiaxis control, CAN bus, Finite element method

1. Introduction

Flexible fixture is being used with NC machine or machining center to clamp the different workpieces[0]. Flexible fixture is divided into two categories: one is the traditional flexible fixture, and the other is the modern flexible fixture with the innovative principle and structure[0 0]. The traditional flexible fixture is divided into the adjustable fixture and the modular fixture, and the modern flexible fixture mainly includes: phase change material fixture, adaptive fixture and modular program control fixture. Because of the low flexibility, the traditional flexible fixture can't meet the high compliance requirements in modern manufacturing. And modern flexible fixture system with its characteristics of high flexibility, reconstruction, expansion and high precision, has gradually become the mainstream.

For example, the United States, Spain and other countries lead in the modular program control fixture. And a number of flexible fixture system has developed. In 1991, Horst Witte Geratebau in Germany developed chemical module loading system[4]. During 1994 to 2001, the CAN company researches and develops the flexible fixture system based based on POGO unit, providing a flexible, agile solution which had been applied by a number of aviation manufacturing enterprise. In 1997, Northrop Grumman in American manufactured the gantry reconfigurable fixture system. In 2004, M.Torres in Spain developed a flexible tooling system called TORRESTOOL and a Longmen milling machine named TORRESMILL, which are both widely used in the production.

Parts of the aircraft manufacturing process are complex and various types. Although the large - scale structure of the aircraft manufacturing is being used widely, there are still a large number of small and medium sized components. The traditional tooling couldn't apply to the medium and small sized structures because of its complexity and uniqueness. So the reconfigurable modular flexible fixture could solve these problems.

In this paper, the main object is to design a flexible fixture platform which is composed of modular fixture unit.

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2. Composition of flexible fixture

To improve flexible, a flexible fixture platform adopts the modular design method, providing a series of the tooling modules, which can be reconstructed according to the processing characteristics of a workpiece.

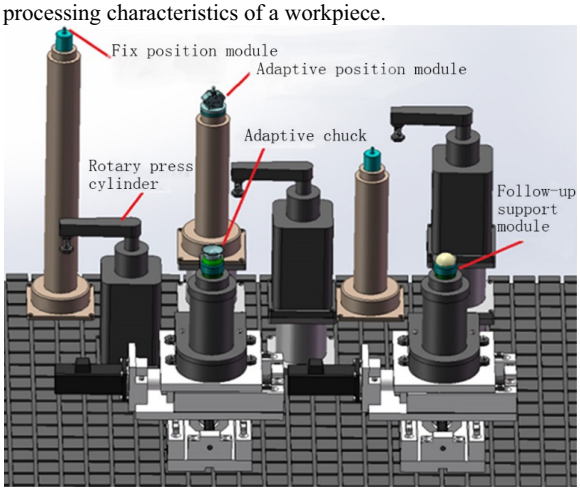

Fig.1 Flexible fixture module

Figure.1 shows the main modules of the flexible fixture platform, including: the fixed position module, the adaptive position module, the rotary clamping cylinder module, the adaptive sucker module, the follow-up support module and the auxiliary module. Fixed position module or adaptive position module is installed on the auxiliary module through a bolt for adjusting location height to realize the positioning and supporting function. Rotary cylinder clamping module also is installed on the auxiliary module through a bolt to adapt to the different clamping height. The self adaptation sucking disc or the follow-up supporting module is installed on the flexible supporting column to adsorb or the support the workpiece.

3. Design of the flexible fixture control system

Flexibility of flexible fixture system is mainly reflected in high reconstruction and high adaptability of system, as far as possible to improve tooling control system can be scalability. The key of tooling motion control system design is as far as possible to improve the scalability, stability and reliability of tooling control system. There are three ways to achieve multi axis motion control. 1. The servo motion control is based on CNC system; 2. The servo motion control is based on PC and motion control card; 3.The servo motion control is based on PLC pulse generating module.CNC servo system mainly used for CNC machine tools, has high control precision and can realize multi axis synchronization and linkage, as well as acceleration and deceleration functions. The cost of PC motion control card program is lower than it of CNC servo control program. The users should insert the motion control card into the PCI slot of the PC board, and then call the motion control function of the library function provided by the venter. The method is wildly applied, but the number of axis is limited, generally less than 8 axes.PLC pulse generating module control, which could collect more points, has the good stability. But the number of the pulse generating module can equip with each of the PLC is restricted. In order to control more

shafts, the way is to increase PLC. So the more shafts of control system, the higher cost.

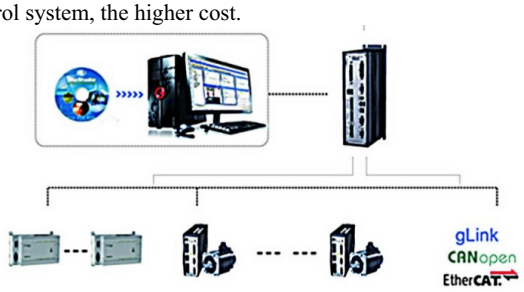

Fig.2 GUC-T multi axis controller system structure

Considering the flexibility and extensibility of flexible fixture, obviously, the traditional non bus control mode doesn't meet the requirements of the system control, so it is suitable to adopt the GUC-T multi axis motion control scheme. Although the hardware is able to achieve the expansion of the shifts, the software can't. When adding a support module, the software can't adapt to the reconstructed system and need to be overworte. After removal of a support module, the system will alarm, affecting the operation of other modules. The system is not distributed architecture, and the control commands of the controller control all point and axis. At the same time, the control plan calls for the shaft drive module and the I/O module support bus module, which will undoubtedly increase the cost of system.

The control scheme is improved in some ways, the bus node control layer added to motordrivermake the shaft back to zero or acceleration and deceleration. The control node layer receives and decodes control commands from the PC to execute the corresponding operations. The function of PC coordinates the axis position relationship rather than controlling the specific motions of shafts to coordinate communication system. In addition, abandon the high level bus protocol in the above program. The CAN bus control rather than the CAN open protocol applies to the program, because the CAN open protocol is too complex to be used in the program. According to the characteristics of the system, a series of protocols is developed to realize the interconnection of nodes which makes the bus load reach the lowest point. Due to the increase of the node control layer, the real-time performance of the PC controller is reduced, so the PC machine can be used as the host computer. On the one hand, the host computer sends and receives software through Ethernet and communicates with CNC system, on the other hand, it is used as the main role of the CAN network to coordinate the actions of nodes. The structure of the improved control system is shown in Figure 3.

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