Plc-Based Aerospace Thin-Wall Part Processing Fixture

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Abstract. Incorrect clamping structure layout is easy to produce machining vibration, which leads to machining vibration and seriously affects the machining quality of workpiece surface, especially for thin-wall workpiece. In this paper, a structure which can adjust the clamping force at any time is designed to restrain the machining vibration of the workpiece, so as to improve the machining quality of the workpiece surface. The structure mainly solves the problem of adjusting the pressure plate by changing the force signal into micro displacement to automatically adapt to the pressure needed by the workpiece. Analyze the function of the structure, split into multiple modules, through the selection and design of these modules to meet the functional requirements, assemble each module to complete the structure design. The structure includes mechanical and control modules, and the push rod structure which can move up and down is used to adjust the pressure of the pressure plate. Because servo motor has feedback ability, servo motor control is selected and power is provided to push rod. In order to automatically adjust the pressure of the pressure plate, it is necessary to place a pressure sensor at the compression end of the pressure plate. The pressure sensor can feedback the pressure of the current workpiece in time, and then convert the electrical signal into a digital signal through the digital quantizer, so that the data can be processed. PLC processes the signal, and the function of PLC is as follows: it can set a value at will, can receive the digital signal of the pressure sensor and compare it with the set value, the difference is transmitted to the servo motor, and the servo motor selects forward or reverse to drive the push rod forward or backward, so as to realize the automatic adjustment of the pressure of the workpiece by the pressure plate. The correct assembly control class of these components needs the correct wiring mode, and the mechanical class needs to design the connection structure to ensure the connection between different components.
1. introduction

1.1. Research purpose and significance of adaptive platen
With the development of society, science and technology are progressing rapidly, and every small improvement will involve modern technology and get rid of traditional mechanical processing methods. The purpose of the adaptive platen device is to realize automatic processing and production, improve machining accuracy and work efficiency, improve production efficiency, and enable ordinary workers to invest in the production line and reduce production costs. In the process of machining the workpiece, the clamping force is adjusted independently with the change of the processing environment and processing requirements, so as to adapt to the production of various situations. The adaptive platen device makes the operator easy to master and can be used without training, reducing the labor intensity of workers, saving labor, improving work efficiency, reducing scrap rate, optimizing machine tool operating system, and improving mechanical performance stability and reliability.

Because the adaptive platen device is very easy to implement according to current science and technology, it also has high universality. By changing the force of the current workpiece at any time, the workpiece is prevented from being deformed by excessive pressure, and the pressure is too small and loose, which affects the processing quality. Especially in the processing of aluminum alloys, the adaptive platen device can play a huge role. Not only improves the machining accuracy of the workpiece, but also reduces the scrap rate of the workpiece. The production efficiency of the enterprise is greatly improved, the production cost is reduced, and an important step is taken for the production of zero waste in the future. This will also make our technology industry healthy, because we make up for the small loopholes in the development of science and technology, fully implement the achievements of scientific and technological development, and benefit the people.

1.2. Research Status of Adaptive Fixture
The graduate student of Chongqing Jiaotong University proposed a finger-like adaptive flexible fixture that improves the overall freedom of the fixture by a flexible mechanism, thus enabling many previously unfinished movements.

Qiao Caiyan from Northwestern Polytechnical University and others proposed an intelligent adaptive technology for aerospace product fixture design. Intelligent adaptive is due to the influence of geometric parameters of components or workpieces in fixture design on other fixture components. Generate corresponding geometric modification capabilities.

Professor Chen Bing of Northwestern Polytechnical University mentioned that adaptive clamping and clamping force optimization are mentioned in the article on adaptive fixtures for aero-engine thin-walled parts. The requirements for modern computer technology and intelligent machinery are high.

At present, the fixtures used by many enterprises in China have not been generally improved, and the average enterprise is still accustomed to using traditional special fixtures. The adaptive fixture is mainly used in the aviation field, and it cannot be applied to ordinary enterprises for some reasons.

2. Overall design of the fixture
There has always been a problem of poor processing for thin-walled parts in the aerospace industry. There are many factors that make thin-walled parts difficult to machine. Among them, the impact on the machining accuracy of thin-walled parts is greatly affected by force deformation, so the design of the fixture is very important to improve the machining accuracy of thin-walled parts. During the machining of the part, the force that the fixture pre-sets on the part will vary due to various factors.

In order to solve this problem, a platen clamp capable of adjusting the clamping force at will during the machining process is designed. Based on the principle of the platen clamp, the preliminary design uses a micro-motion device to adjust the pressure of the platen. There are many solutions for the power source of the micro-motion device: motor rotation; hydraulic cylinder; thermal expansion of special materials. The real-time data feedback is collected by the sensor for data processing, and finally the adaptive adjustment of the pressure plate is realized.
2.1. Composition and basic requirements of the clamping device

![Figure 1. The composition of the tightening device](image)

1—Sensor 2—Pressing Plate 3—Pushing Rod 4—Servo Motor 5—Connecting Member 6—Gear Box

2.1.1. Clamping device composition. The clamping device is composed of two basic parts

1. Powerplant
   - The clamping force generated by a person or some other device. The use of manual clamping of the workpiece is called manual clamping. The clamping force generated by some other devices is called motor clamping. Some of the devices that are often used are: hydraulics, vacuum, pneumatic electric and electromagnetic devices.

2. Clamping device
   - The clamping mechanism is generally composed of a clamping element and an intermediate transmission mechanism. The intermediate transfer mechanism is a mechanism that transfers the clamping force between the power unit and the clamping element.

2.1.2. Basic requirements for clamping devices

1. The workpiece can also be held in a pair after positioning.
2. The clamping force should be stable and suitable. It is necessary to ensure that the vibration of the workpiece during the entire machining process is not large, and the workpiece does not cause too much clamping deformation. A stable clamping force reduces clamping errors.
3. The structure should be as simple as possible, and standard fixture parts should be used as much as possible; easy to operate, safe and labor-saving, easy to manufacture and maintain; good in use and processability.

2.2. Data collection

In order to achieve adaptive adjustment of pressure, real-time pressure acquisition of the pressure plate is essential. The application data acquisition system can record and store real-time parameters of the production site, improve information and means, improve product quality and reduce costs. A lot of dynamic information can be obtained through the application of data collection system in scientific experiments, which is of great help to the study of transient physical processes and one of the important means to solve scientific problems. In short, no matter where, timely data collection and processing can effectively improve the efficiency of production and processing, and thus achieve economic growth.

2.2.1. Data collection technology classification. Data collection can be effectively divided into four categories during production use:

1. Data acquisition based on general purpose small computers
   - The external signal is used to send the a/d converted digital signal and the collected signal to a small computer, and processing through the interface circuit, and then displaying the processing result or
inversely converting the output is its main function. This processing method has some features. For example, powerful software and hardware. All software and hardware resources can support the system through the microcomputer system. The application and configuration of the system software and hardware is relatively small, the system cost is high. It has the ability to develop independently.

2. Data acquisition based on single chip microcomputer

It is a data acquisition system consisting of a microcontroller and some peripheral chips. It has the following characteristics: The system does not have independent development capabilities. Therefore, the software and hardware development of the system must rely on development tools.

3. Data acquisition based on dsp digital signal microprocessor

Digital signal micro-processing is theoretically a form of single-chip microcomputer. Compared with ordinary microprocessors, dsp digital signal microprocessor has different structure. The basic difference is that dsp digital signal microprocessor has response and processing through sampling. The ability to simulate the data stream obtained by the signal.

4. Hybrid computer-based data acquisition

This is an architecture that has rapidly developed in the field of computer applications in recent years. It consists of a general purpose computer and a microcontroller connected via a standard bus. The MCU and its peripheral circuits are specially configured to meet the functional requirements of data acquisition, and the host computer undertakes tasks such as man-machine dialogue, large-capacity calculation, recording, printing, and graphic display.

2.2.2. Collection method. The composition of the acquisition system depends on the characteristics of the signal being measured. Try to achieve the system's performance requirements and minimum cost. According to this requirement, the acquisition system can be divided into the following methods.

1. Single channel data acquisition

Single channel data acquisition is: only one analog signal is acquired, as shown in Figure 2.

![Figure 2. Single channel data acquisition block diagram](image)

2. Multi-channel data acquisition

Its advantage is that when the number of channels increases, the maximum sampling frequency is not affected, and multi-channel signals can be collected simultaneously to maintain synchronization between signals. The disadvantage is high cost, large volume, multi-channel shared a/d conversion mode. The signal enters each sample-and-hold circuit, and then the multi-channel switch optionally sends each signal to the a/d converter for conversion. This conversion method is slower than the former method, and the signal of each channel is intermittent. When the sample-and-hold circuit is controlled by the same signal, not only the parameters of each channel can be collected at the same time, but also the synchronization relationship between the signals can be ensured. This method is mainly used for multi-channel signal acquisition and multi-switch mode, and does not require high acquisition. Frequency. The conversion speed of this method is slower than the above two methods, but it saves hardware. It is usually used to collect multi-channel slow-changing signals, such as temperature changes, strain signals, etc. When collecting multi-channel signals in this way, it is possible to collect various parameters at the same time.
2.2.3. Data collection requirements

1. Strong real-time
   Monitoring a large number of process data processing and real-time data for real-time processing and analysis of state parameters is the main work of this data acquisition system.

2. Good versatility, easy to expand
   Embedded systems can usually control different process parameters and multiple devices are core control devices. This requires the system to be as generic as possible, free to add extensions, such as the plc structure with extension modules.

3. High reliability
   This is the most important requirement in system design. Therefore, the choice of embedded systems, such systems have a high degree of reliability. In order to ensure the high reliability of the control system, the embedded system is required to have moisture-proof and dust-proof properties. Because the data acquisition system of this system is often installed in the actual working environment of the controlled object, not only the temperature and humidity change greatly, but also the dust is more and the corrosion is strong.

4. Short design cycle and low price
   Due to the rapid development of science and technology, various new technologies and new products have been invented. In order to meet the requirements of accuracy, speed and other performance, we should try to use low-cost components and shorten the design cycle.

   Considering the above aspects, computer selection is crucial as the core of the system. For data acquisition systems, plc is suitable for this design because of its small size, low power consumption, low cost, low price, and control functions. Important data collection and processing tools.

2.3. Structural design

The external meshing spur gear is used to connect the servo motor, and the third shaft gear is fixed by a cylindrical pin and a shaft, and the rear half of the shaft is formed into a screw structure, and a sliding screw transmission is used.

In order to solve the problem of connecting the servo motor to the push rod of the gear helical structure, I designed two connection structures for fixing the servo motor and the push rod. The specific structure is shown in Figures 3 and 4.

Figure 3. Connection structure 1
Figure 5. Physical map of structural unit with adaptive adjustment for platen
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Symbol table

| Symbol | Description | Unit |
|--------|-------------|------|
| $t$    | time        |      |
| $s$    | Fast moving speed | mm/sec |
| $PB$   | Pitch       | mm   |
| $\mu$  | Coefficient of friction | |
| $i$    | Transmission ratio | |
| $N$    | Rotating speed | rpm |
| $T$    | Torque      | N.m  |
| $\eta$ | effectiveness |      |