High precision auxiliary positioning system of drilling bit posture based on visual encoder

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Abstract: In order to obtain the accurate spatial position reconstruction of the drilling bit wear surface, a drilling bit posture measurement system based on visual encoder is proposed in this paper. A tool clamping device with adjustable posture is designed for 3D digital microscope to hold the drilling bit with outer diameter within 6-8mm. The adjustment of the spatial posture of the drill bit is completed by the cooperation of two rotating discs whose axes are perpendicular to each other. The shaft of the vertical rotating disk is consistent with that of the encoder, and its rotation angle is used as the reference and measured accurately. The experimental results show that the angle detection accuracy is 0.1 degree. The accurate angle information provides the basis for the machine.

1. Introduction
Contemporarily, the tool detection methods are generally classified as indirect and direct methods[1]. The indirect method is based on the detection of cutting force, temperature, vibration[2] or acoustic signal[3] and other signal characteristics or changes related to tool wear. The direct method is to collect images by industrial cameras, microscopes system and other devices, and use the image processing method to get the geometric size and other information of the tool image, which can be used as the basis to judge the condition of the tool. The advantage of the direct method is that it can directly observe the wear of the tool surface and obtain the geometric dimension information. However, when the microscope system or other visual acquisition system is used to obtain the tool image, there are some problems, such as the single posture of the observed tool, the difficulty of capturing, recording and reproducing the tool posture. Therefore, it is necessary to explore how to flexible adjust and detect the tool posture.

In recent years, the research on tool posture detection mainly includes optical projection method[4,5], laser scanning method, machine vision measurement method and laser diffraction method. These methods belong to non-contact detection. Although they can accurately detect the tool posture, but they cannot realize the flexible transformation of tool posture at the same time.

In order to solve the above problems, a high-precision encoder-based drilling bit posture auxiliary positioning system is proposed in this paper. A tool clamping device with adjustable posture is designed to realize the flexible transformation of tool posture. A new angle measurement method based on rotary encoder is used, which integrates the angle measurement part into the rotating disc. Compared with traditional methods, the method can simplify and reduce the structure of the device,
and has more stable mechanical characteristics. This paper will introduce the principle and composition of the system from the mechanical structure design and angle measurement based on encoder, and finally verify the feasibility of posture adjustment and detection function through experiments.

2. Functions of the system

In order to realize the function of holding the drilling bit stably and changing the posture flexibly, the mechanical structure of the two-dimensional rotating disks tool clamping device is designed. Among them, a new angle measurement method based on visual encoder is applied in the rotating disk, and an angle measurement device is designed.

2.1 Tool clamping and posture changing

Through the design of two different planes of the rotating disk, the clamping tool function can realize of angle posture transformation, and then the telescopic column is designed to realize the function of tool height adjustment, where the tightening screws are used to stabilize the clamping drilling bit. The overall structure is compact, as shown in Fig.1, the operation is very convenient, which can meet the experimental requirements.

2.2 Tool posture detecting function

Due to the limited space, a new angle measurement method based on image is used in the proposed system instead of the traditional rotary encoder. The image sensor is used to capture the image of a light spot rotating synchronously with the measured axis. By fitting the trajectory of the spot image, the angle of any position of the measured axis can be solved, so the angle measurement can be realized.

Based on the above method, we design an angle measuring device inside the small rotating disk. This method uses the non-focusing imaging of super close range, simplifies the structure of the device by omitting the parallel lens and focusing lens. Moreover, this method can solve the relative position of the spot disk and the image sensor as a parameter, therefore it can realize the accurate measurement under the condition of non-precision installation, which can greatly reduce the cost of the system and meet the measurement accuracy at the same time.
3. Posture detection experiment

In this system, the accuracy of angle measurement is verified by using the Omron optical rotary encoder E6B2-CWZ6C on the small rotating disk of the clamping device as the reference encoder. The encoder information is received by the digital display device to realize the real-time display of the drilling bit angle, and they are connected as shown in Fig.2.

![Fig 2. Posture monitoring structure](image)

The experiment is carried out by using machine vision technology with the KEYENCE 3D digital microscope system VHX-5000. The overall experimental environment of the system is shown in Fig.3, where the tool angle is 83.1 degrees. By acquiring 20 times of images and comparing the drilling bit posture detection results, it was verified that the visual encoder has a high accuracy of angle measurement with an accuracy of 0.1 degree, so this drilling bit posture detection system can realize real-time detection and display of drilling bit posture and has enough accuracy to meet the general experimental requirements.
4. Conclusions
In this paper, we designed a tool clamping device with adjustable angle and made a rotary visual encoder, and combined them into a drilling bit posture detection system. Through some experiments, it is verified that the system can realize the function of transforming the angle of the drilling bit, can accurately detect and display the angle of the drill bit, and solves the problem that the angle is single when the drill bit is observed, and is difficult to capture, record and reproduce.

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