Design and Research on New Track System for Machine Tool

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Abstracts: The kernel of this system is controlled by single-chip computer type 8031 to surveillance the real-time working state of bed. It can collect three-direction cutting-force, which are created at the same time and are called F_X F_Y F_Z by time-sharing. Three-direction cutting-force will be converted to the variable voltage through resistance strain gage , after amplification, filtering, anti-jamming, with single-chip computer sampling and holding、Analog-to-Digital conversion and control through multi-switch and then putting the results in the memorizer. The system is expanded with the function of print、display、keyboard and so on and enhanced the function of man-machine dialogue .

Keyboards: data acquisition real-time monitor single-chip computer

1 Introduction

During the industrial production, there are a large number of parameters ,such as pressure、temperature、speed and so on, needing for roving detection、data processing、analysis、record and alarm when the parameters are at a high pitch . The cutting force of the machine tool is one of the main parameters in industrial control targets. As far as this type of control objects is concerned, because of their grate changing rate, artificial observations had been used to regulate the relating parameters in the past with the low control accuracy and incapable of recording the data. This paper is adopted with the single-chip computer to monitor the working condition of the bed automatically to improve the control accuracy and the automation. Through the real-time analysis of a lot of parameters accumulated in the computer in advancing the trend analysis of the production situation, it will be convenient for the operational and managing personnel to decide and guide production.

This paper introduces a design and research on new track system for machine tool. The single-chip microcomputer used for real-time tracking, the machine tool is characterized by the simple structure, low prices and reliability and stability. With a good man-machine interface, normative data can be produced conveniently. The design and research on new track system for machine tool refer to sensors, electronic circuits, computers and other fields, which is the hot field currently [1] .

2 Summarization

This system that is named the real-time monitoring system of the three-direction cutting-force is composed of sensors、amplifiers、multi-switch、Analog-to-Digital converter and single-chip microcomputer 8031 [2] .The diagram of the system is in figure 1.

Because the working environment of the sensor is usually complex and poor during the system, the greater interference signal that is noise is produced in the two output lines of the sensor. Although the operational amplifier can suppress the common-mode signal which is input to the differential end directly, the suppression ability is rather worse. To ensure the measurement results, we choose the high-performance differential amplifier which is made up of n closed-loop operational amplifiers in the system, which has the good performance and simple hardware

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connection.

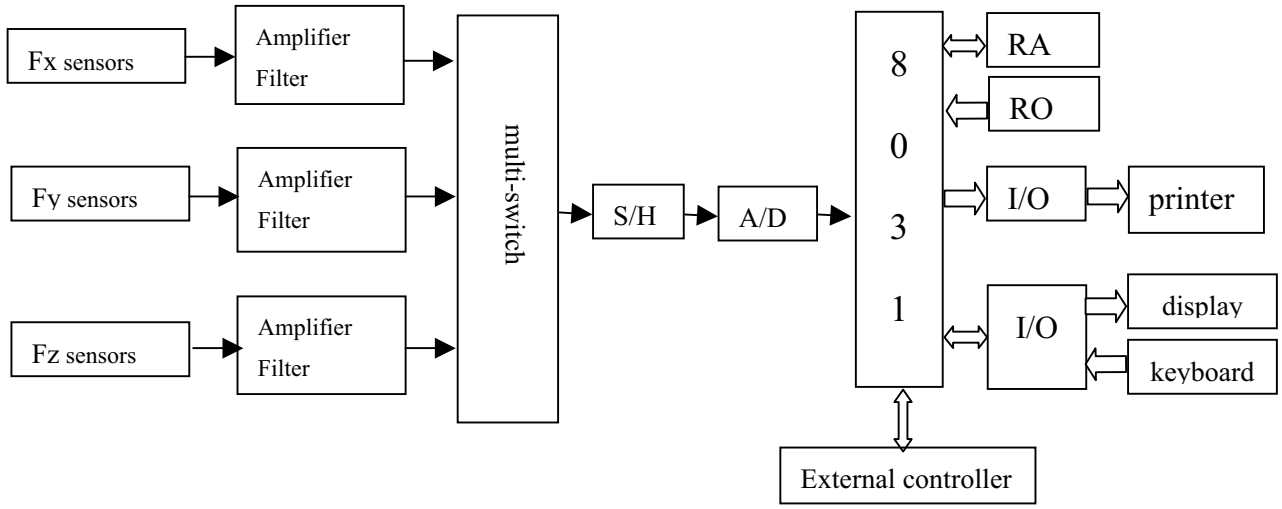

Fig.1 The diagram of the system

The three-direction sensors will make each power amplify and filter and then send into the converter. The power will be converted to the digital value. The device is required the largest Fz of the measurement is 450Kg, so the resolution must be less than 1/450, if we choose 8-bit Analog-to-Digital converter, the resolution of which is 1/256 that can not meet the requirement, so the 12-bit Analog-to-Digital converter is adopted, the resolution of which is 1/4096 that can meet the technical requirement. This system is used AD574 conversion chip, the resolution of which is 12.

In addition, the system has also been expanded with three pieces of chip that are used as the interface of the printer, which is RAM, ROM and 8155. The special interface chip 8279 provides the programmable interface of the keyboard and digital display[3]. In this paper, the choice of sensors and the analysis of the measurement principle are introduced in detail.

3 Choice of sensors and the analysis of the measurement principle

The resistance value varies correspondingly when the wire brings mechanical deformation under the action of outside force and this physical phenomenon is called the strain effect of the resistance wire. Resistance strain gage is one kind of the common sensors which is used to measure objects stress and distortion which produces deformation, which is a sensing component capable of converting the mechanical sample changes into the resistance changes, that is, using resistance strain gages as transition element which changes force into electricity. The principle of the strain effect of the resistance wire is as follows: suppose there is a metal resistance wire, the situation of the fore-and-aft deformation is shown in figure 2.

When the resistance wire does not accept the outside

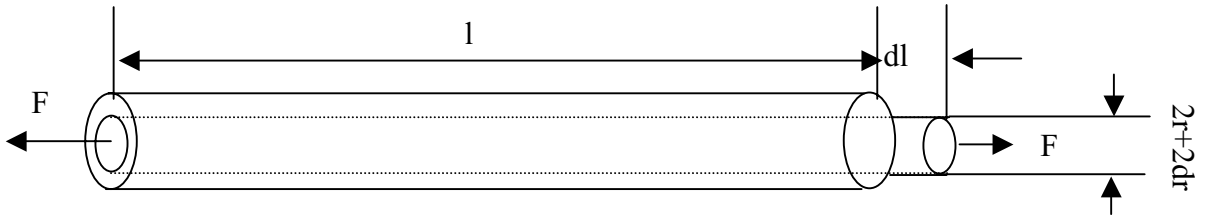

Fig 2. the diagram of resistance line faced

force that is F equals zero, the resistance value is:

$$R = \rho \frac{L}{S}(\Omega) \qquad (1)$$

In the formula, ρ stands resistivity while L stands the length of the resistance wire and S stands the resistance area of section（mm^2）.

Suppose the resistance wire accepts the outside force F and the acting force along the axial of the resistance wire is uniform stress, when the length changes, the area of the section changes ds and the radius changes dr and the resistivity changes $d\rho$.Because $\frac{ds}{s} = 2\frac{dr}{r}$, the change of the resistance dR is:

$$dR = \frac{\rho}{s}dl - \frac{\rho l}{s^2}ds + \frac{l}{s}d\rho = R(\frac{dl}{l} - \frac{ds}{s} + \frac{d\rho}{\rho}) \qquad (2)$$

We make both sides of the second formula divide R and the result is:

$$\frac{dR}{R} = \frac{dl}{l} - 2\frac{dr}{r} + \frac{d\rho}{\rho} \qquad (3)$$

We make $dl / l = \varepsilon x$ that is the axial relative elongation which is the axial strain micro-variable, which indicates the change of the unit length because of the load.

We make $dr / r = \varepsilon y$ that is the radial relative elongation which is the radial strain micro-variable. The relation of them is:

$$\varepsilon y = -\mu \varepsilon x \qquad (4)$$

μ is the Poisson ratio of the resistance wire material, which is ratio of the axial relative elongation and the radial relative reduction. μ usually is 0.3 to 0.5. The change of the measuring resistance is as follows:

$$\frac{dR}{R} =$$

$$\varepsilon x - 2\varepsilon y + \frac{d\rho}{\rho} = \varepsilon x + 2\mu\varepsilon x + \frac{d\rho}{\rho} = (1 + 2\mu)\varepsilon x + \frac{d\rho}{\rho} \qquad (5)$$

Both sides of the equation divide εx and we will get:

$$K_0 = \frac{dR / R}{\varepsilon x} = (1 + 2\mu) + \frac{d\rho / \rho}{\varepsilon x} \qquad (6)$$

K_0 is the strain sensitive coefficient of the wire which denotes that the unit axial strain of the wire brings the corresponding change of the resistance value. It can be known through the sixth formula that K_0 is composed of two items. The first is the sum of one and double μ, which shows the change of the resistance because of the change of the geometrical size. The other one is $\frac{d\rho / \rho}{\varepsilon x}$, which shows the change of the resistivity by the unit axial strain. It is also a constant to most metals and its value is quite small, so it can be neglected. Therefore:

$$K_0 = 1 + 2\mu \qquad (7)$$

It is can be seen that K_0 is a constant which can be obtained through the experiment and it is usually 1.6 to 2.

$$\frac{\Delta R}{R} = K_0 \varepsilon x \qquad (8)$$

We measure the change of the resistance after the load that is the relative change of the wiry resistance should be in the direct proportion with the axial strain.

If the unilateral radial force Fy is applied in the ring, the strain of the ring is different everywhere and the strain is zero where the angle with the acting force is 39.6 degree which is shown is figure 3(a). There is the maximal strain in the horizontal center line. If the resistance strain gauge is affixed here, there will be the best sensitivity. R1 and R3 suffer tensile stress while R2 and R4 suffer compressive stress.

If one side of the ring is fixed, the other side suffers the tangential force that is Fx which is shown in figure 3（b）, in this way, there is the maximal strain where the angle with the vertical center is 39.6 degree. If the resistance strain gauge is affixed here, there will be the best sensitivity. R5 and R7 suffer tensile stress while R6 and R8 suffer compressive stress.

It is completely similar that the resistance strain gages

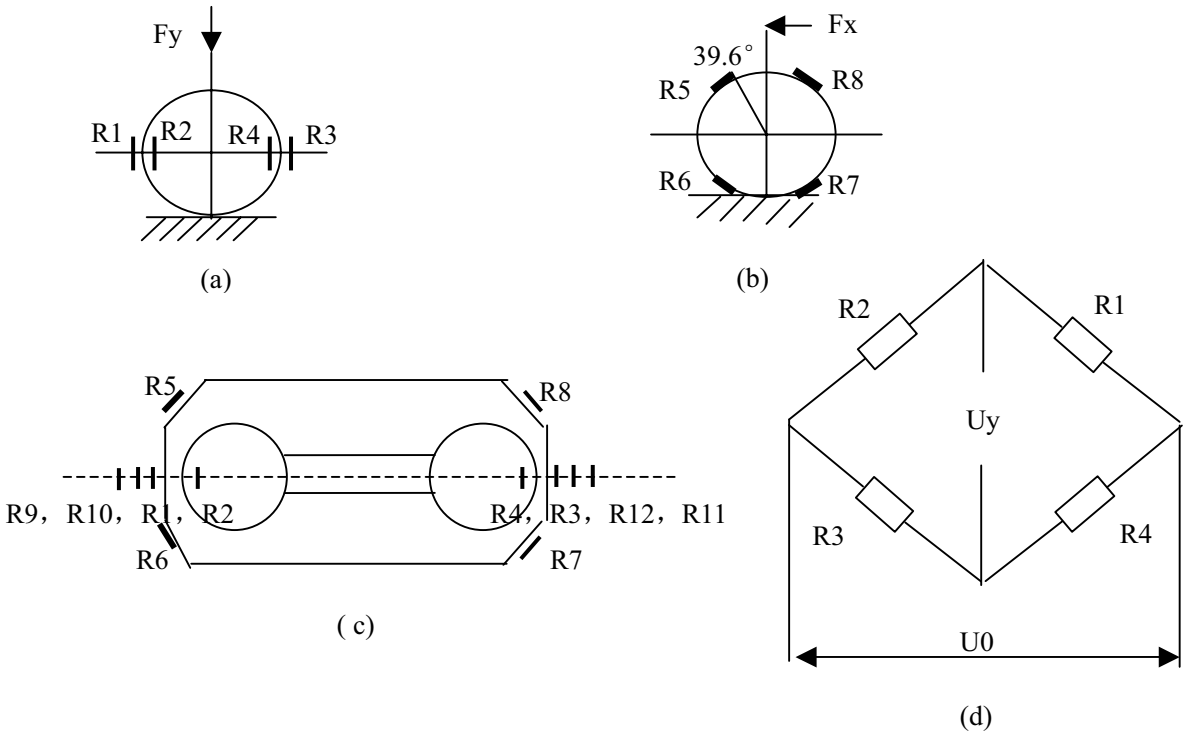

Fig 3. The diagram of measuring on three-direction cutting-force

R9 to R12 which are used to measure the main cutting force called Fz should be affixed to the horizontal center line.

In this way, when the resistance produces the corresponding changes because of the cutting, we can make use of the bridge to transform the resistance variation into the voltage variation. The bridge measurement is easy, furthermore, the accuracy and the sensitivity are upper. When the ring accepts Fy, Fz and Fx simultaneously, we make the resistance strain gages R1 to R4, R5 to R8, R9 to R12 buildup bridge separately which will be able to test Fy, Fx and Fz mutually non-interferential. The figure 3(d) shows the bridge circuit of one direction that is y direction.

Because the ring is not easy to clamp and fix, in fact, we use the octagonal ring to instead, which is shown in figure 3(c). The octagonal ring is also the common elastic component as the multidirectional ergometer. When the cutting tool is cut in the octagonal ring, according to the corresponding information produced by the direction and the size of cutting force, it can be cut accurately basing on the information.

Because the working environment of the sensor is usually complex and poor, the greater interference signal that is noise is produced in the two output lines of the sensor. To ensure the measurement results, we can choose the instrumental amplifier，which is also known as the data amplifier. The device is chosen AD521 which has the good performance and simple hardware connection.

Filter is a frequency-selective device, which makes the special frequency of the signal pass while reduces other ingredients greatly. In testing device, we can use the filtrating function of the filter to filtrate and eliminate interferential noise. The system is used first order Resistance-Capacitance low-pass filter to restrain interference.

In a microcomputer detection system, multi-channel analog switch with integrating in one chip and multi-model is used most widely, which is the standard and dual inline type structure, which is also small in size and easy to install.

When the input analog signal varies rapidly along with the time, we still need to connect a

sample-and-hold device in the input channel. There are two kind of working way that is the sampling way and the holding way, which is selected by the end of the control. The system is used LS398.

4 Conclusion

The design on new track system for machine tool is widely used in the industrial production, which is characterized by the simple structure, low prices and reliability and stability. With a good man-machine interface and the better real-time ability, it will be convenient to produce the normative data[4]. The system refers to sensors, electronic circuits, computers and other fields, which is the hot field currently. Nowadays, some scientific research institutes are doing this research and have made some achievement, but there are still some problems which need to be explored.

Acknowledgments

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