Multi-point scanning plastic film thickness detection system

Jiacheng Li [a], Chao Sun [b], Hanzheng Dong [c] and Maoyuan Li [d]

School of Shandong University of Science and Technology, Shandong Qingdao, 266590 China

[a] 962160138@qq.com, [b] 402630408@qq.com, [c] donghanzheng1259@163.com, [d] 690896261@qq.com

Abstract

The purpose of this design is to design a kind of the multi-point scanning plastic film thickness detection system based on capacitive sensors.At the same time,the system should ensure high-measuring accuracy,simple structure,low cost. This design includes the generation of scanning displacement and feeding system, sensors installation and fixed system, manual control system, etc.The system use screw transmission to complete the displacement and it can have a random measurement in X and Y directions.The capacitive sensor can also make a adjustment in Z direction.This design is focused on the following aspects:for examples,detailed understanding of contact or no-contact plastic film thickness mesurement method, analysising the advantages and disadvantages of online testing and online testing system; making multifaceted comparison of several commonly used plastic film thickness testing methods. Then, we make a plastic film thickness design scheme based on capacitive sensor. We make the program's design and the assembly mapping. Finally, finalize the selection and design of the circuit.

Keywords

Capacitive sensors, thickness of plastic film, multi-point scanning measurement.

1. Introduction

With the printing, packaging, insulation and photographic industries on the demand for high-quality film products more and more, the film industry has achieved rapid development in recent years. At present, there are up to thousands of film production lines in China, but some key technical problems in the measurement of film thickness and the uniformity of film thickness have not been solved yet. Therefore, accurate measurement of film thickness has been studied As well as the complete evaluation of measurement results have far-reaching significance.

2. Measurement system principle

Capacitive sensors have the advantages of good temperature stability, simple structure, high precision, fast response, wide linear range and non-contact measurement. In recent years, due to the continuous improvement of capacitance measurement technology, micron micrometer precision capacitance micrometer is a general product, capacitance micrometer technology as a high-precision, non-contact measurement means widely used in scientific research and production and processing industries. The most common form of capacitive sensor is a parallel plate capacitor.

Capacitance sensor thickness measurement principle shown in Fig.1

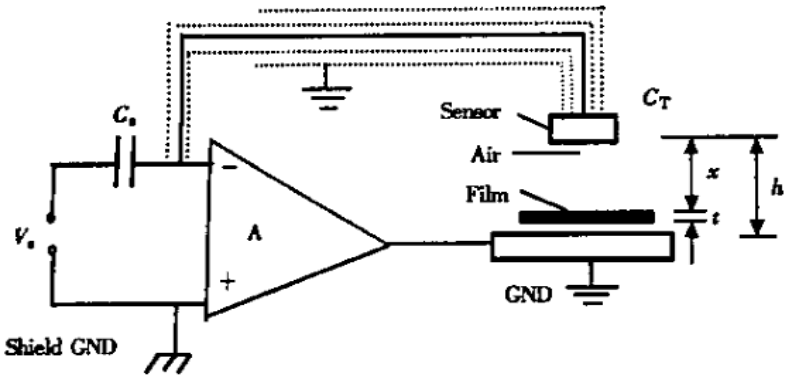

Fig.1 capacitance sensor thickness measurement principle

Set the sensor's effective area of the upper plate S; air dielectric constant ε=1; polar distance H; vacuum dielectric constant ε0; relative permittivity εa; plastic film thickness h; Sensor on the plate and the distance between the membrane x, high-input impedance amplifier measurement applied to the circuit, to form the form of feedback-type analog amplifier circuit. The output voltage is V0, the high-stability square wave signal Vs is 20KHz, the fixed capacitance at zero temperature coefficient is CS, and Ct is the capacitance of the sensor. The output and input of the expression:

$$V_0 = \frac{\left[\frac{1}{j\omega C_T}\right]}{\left[\frac{1}{j\omega C_S}\right]} V_s = -\frac{C_s}{C_T} V_S$$

Probe to the capacitance between the lower plate is:

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

Upper space capacitance:

$$C_1 = \frac{\pi \varepsilon_0 d^2}{4x}$$

Film space capacitance:

$$C_2 = \frac{\pi \varepsilon_0 \varepsilon_a d^2}{4h}$$

Lower space capacitance:

$$C_3 = \frac{\pi \varepsilon_0 d^2}{4(H - x - h)}$$

Substitute C1、C2、C3 into formula:

$$V_0 = -V_S C_S \left[\frac{4H}{\pi \varepsilon d^2} + \left[\frac{1}{\varepsilon_a} - 1 \right] \frac{4}{\pi \varepsilon_0 d^2} h \right]$$

From the above equation we can get the relationship between the output voltage V0 and the film thickness h:

$$h = k_0 V_0 + m$$

In the formula:

$$k0 = \frac{\varepsilon_0 \varepsilon_a \pi d^2}{4 V_S C_S (\varepsilon_a - 1)}$$

$$m = \frac{\varepsilon_a H}{\varepsilon_a - 1}$$

Because m,K_0 is a constant, fixed, so the output voltage change is proportional to the thickness of the film.

Capacitive sensors to detect the thickness of plastic film system is the main point of multi-point scanning plastic film thickness detection system to achieve the form. If the capacitance changes, it is due to the capacitance sensor area, spacing or media has been changed. In the sensor between the two plates into the plastic film under test, the use of media thickness and constant changes, causing changes in capacitance to achieve the purpose of thickness measurement.

3. Mechanical structure design and circuit and control system

Motor drive through the role of the motor so as to achieve the purpose of driving the rolling screw pair. Fix the capacitance sensor with the clamp on the nut of the ball screw, so that the sensor can move horizontally with the nut, and achieve the vertical movement through the linear guide, so as to realize the synchronization in both X and Y directions Multi-point measurement, the basic realization of the mechanical part of the system. Capacitance sensor movement in the Z direction can be adjusted manually, adjust the sensor screw can be fixed. The base uses a dovetail rail design, and its connection at the design of the mobile slider, to ensure the stability of the mechanical structure.

Mechanical system assembly shown in Fig.2

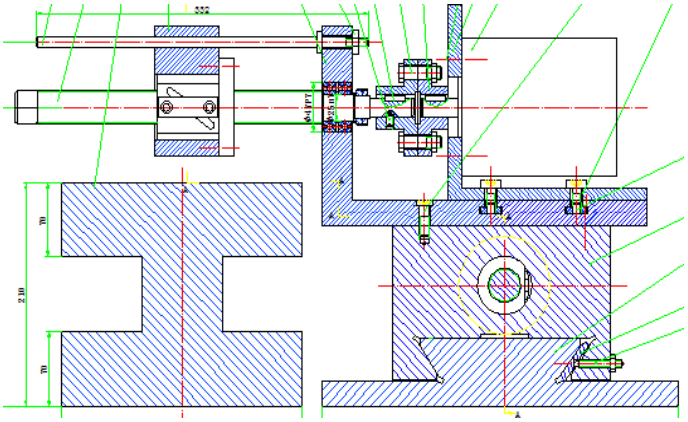

Fig.2 Mechanical system assembly diagram

Multi-point scanning plastic film thickness detection circuit system is the central part of the entire control system is responsible for signal conversion after the acquisition of information, the need for application of single-chip data processing, through the analysis of the function of the microcontroller, select the AT89S51 chip as the Test system, single-chip microcomputer, the use of stepper motor drive, the pulse signal sent by the microcontroller into a step angle, to control the stepper motor efficient and accurate rotation. The detection system uses a capacitive sensor. Capacitive sensors collected are analog signals, the need for A/D converter to convert the signal, the converted signal into the microcontroller system to achieve data storage and calculation. After comparing the function of related A/D converter, finally choose TLC549 as A/D converter of this detection system.

The overall circuit is shown in Fig.3

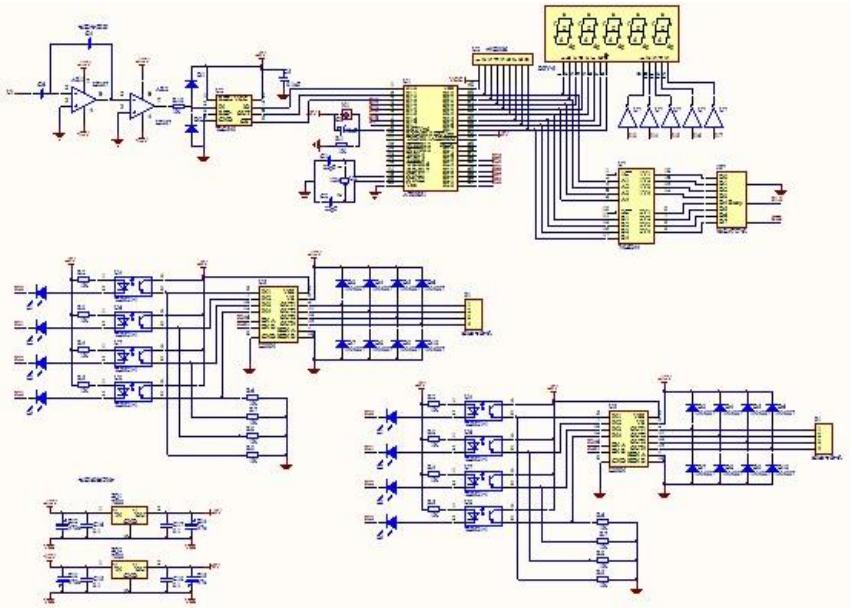

Fig.3 overall circuit

4. Conclusion

The use of multi-point scanning plastic film thickness detection system can be relatively accurate measurement of the thickness of plastic film. In the aspect of mechanical system, two motors are designed, the motor is controlled by the circuit, driven by the ball screw to move the capacitive sensor probe in the X and Y directions, and the screw can also be manually adjusted to adjust the probe in the Z direction Position, in order to achieve the plastic film scanning detection. Capacitive sensor-based multi-point scanning plastic film thickness detection system, effectively eliminating the shortcoming of other methods, can be a lot of promotion.

References

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