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Research Article

A Design of Polyurethane-Material-based Film Forming Rate Measuring Instrument

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ABSTRACT

The polyurethane materials have been widely used in the field of antibacterial, medical, waterproof and moisture permeable. Therefore, this paper mainly studies on the determination of the film formation rate of polyurethane, and designs a film formation rate measuring instrument based on the Atmega328P single chip microcomputer and BH1750 light intensity measurement chip. This design compares the advantages and disadvantages of the currently widely used film formation rate measuring instrument and improves its multiple sensors into a high-precision main sensor. Measurement requirements are reduced, and the size of the instrument is also reduced, making it easier and more portable. Moreover, it can be used not only to measure the film formation rate of polyurethane, but also to determine the film formation rate of other materials.

1. Introduction

Polyurethane microporous films are widely used in daily life as high-end or special fabrics due to their optical transparency, strong ductility, durability, ease of processing, and water permeability [1]. The film-forming rate of the casting film in different coagulation baths is different, and the film-forming rate has a significant effect on the membrane pore size and other indicators. At present, the instruments used to measure the film formation rate are manually measured by humans, which results in large errors and inaccuracy.

The presented new film-forming rate measurement instruments include specific light source, light-intensity acquisition sensor, microcontroller and data processing computer. When making the film, on the glass plate the cast film liquid is scraped into a film and the container's solidification bath. The specific light source is directly set above the polymer cast film liquid, light intensity sensor is located directly below the container. The intensity of the projected light is measured by the light sensor, light intensity sensor is connected to the acquisition controller, and the acquisition controller is connected to the data processing computer [2].

The device measures the change of light intensity through the membrane during phase separation, thus the membrane curve is generated. The test instrument is compact, small in size, easy to be used and more suitable for a variety of measurement environments. It can be used not only in the film forming rate measurement experiment, but also in other experiments that need to measure the light intensity.

2. The hardware structure design

2.1. The controller

Arduino is a convenient, flexible and easy-to-use open source hardware product with rich interfaces, including digital I/O ports, analog I/O ports, and support for SPI, IIC, UART serial communication. It can sense the environment by connecting sensors and feed power and affect

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environment by controlling lights, motors and other equipment [3].

It has no complex micro-computer underlying code and difficult assembly. In addition, it has a simple integrated development environment, freedom and scalability. Standardized interface models provide a solid foundation for their sustainable development. Developers have developed many application libraries, so we need not operate registers directly, for those who don't have a good knowledge of MCU can also use Arduino to do what they want.

2.2. Data acquisition sensor

The GY-30 data acquisition module shown in Figure 1 uses the BH1750FVI chip, and has the power supply voltage 3-5V, light intensity range 0-65535lx, sensor built-in 16bit AD converter, and direct digital output, omit complex calculations, omitted calibration. Without distinguishing between the ambient light sources and close to the spectral characteristics of visual sensitivity, a wide range of brightness can be measured with high precision of 1 lux. By using the standard NXP IIC communication protocol, this module contains the communication level conversion and can be directly connected to the 5V microcontroller IO.

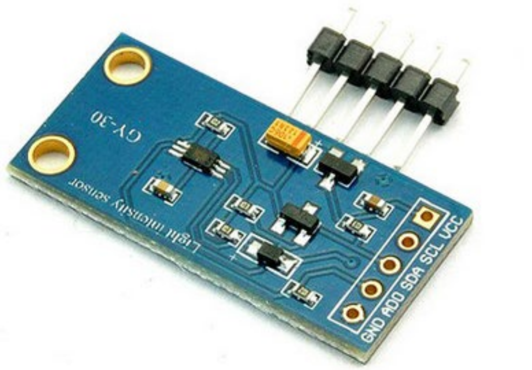

Fig.1. WIFI module

2.3. Development language

The C language is a process-oriented programming language that differs from Java, C++ and other object-oriented programming languages. The goal of the C language is primarily to provide a language that compiles in a simple way, handles low-level memory, generates only a small amount of machine code and runs without the need for any support from the operating environment. C is faster than assembly language in describing problems, reducing workload, improving readability, easy debugging, modification and porting, and the quality of the code is comparable to the assembly language. The C language is usually only 10%-20% less efficient than the target program generated by assembly language code. Therefore, the system is written in C language.

C# is a safe, stable, simple and elegant object-oriented programming language, and is derived from the C and C++. It inherits the power of C and C ++, while removing some complex functions (for example, no macros, multiple inheritance is not allowed). C# combines the simple visual operation of VB with the high efficiency of C++, and becomes the preferred language for NET development. Therefore, the upper computer used in this system is developed by the C# language.

3. Hardware circuit

The hardware circuit is mainly composed of the ATmega328P microcontroller control module, GY-30 light intensity acquisition module and key input module. GY-30 light intensity module is used to collect ambient light intensity information. The ATmega328P microcontroller control module is responsible for analyzing and processing the signals collected by the sensors, and then transmitting the data to the computer through a serial data transmission line. Simple structure, strong portability, and convenient for secondary update and modification is the advantage of the system.

3.1. ATmega328P microcontroller control module

The ATmega328P is used as the main control chip and the required drive chip operation of the crystal-vibration circuit, as well as the reset circuit [4]. The single-chip control module is mainly responsible for receiving the acquisition signal that is transmitted from outside, analyzing and processing the collected data, and sending control signals to the subsequent circuits to realize the control of each module. The ATmega328P chip is shown in Figure 2.

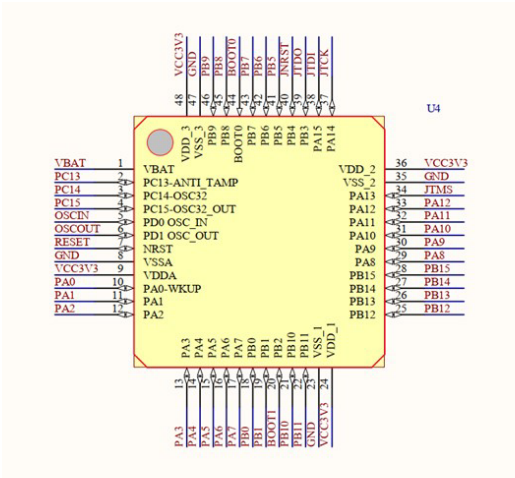

Fig.2. ATmega328P chip

3.2. *Power circuit*

The RT9193 chip is chosen to be the power adapter. The main electric 12V through the transformer in the adapter is to buck the pressure, and then through the bridge circuit to convert 12V into DC 5V output [5]. The 5V voltage is to the microcontroller, liquid crystal display module, buzzer module and other circuits as the power. The RT9193 chip is very small in size shown in Figure 3, and is suitable for our compact circuit board design. Although its rated power is only 1.5W, it is enough for our device.

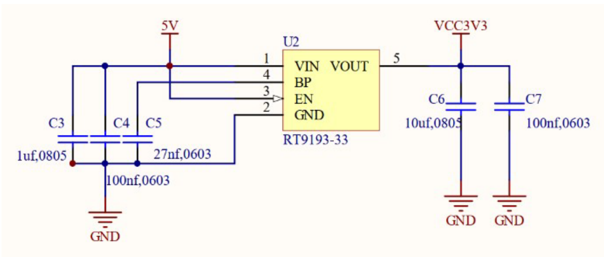

Fig.3. RT9193 regulation circuit

3.3. *Data acquisition circuit*

In this design, the GY-30 light intensity collector with bh1750fvi chip is used, which can measure the light intensity in the range of 0-65535 lux and has a large measurement range. The illumination intensity range used in our experimental environment is 100-1500lux, and the module fully meets the measurement requirements.

In the measurement process, it does not distinguish the environmental light source, and is close to the spectral characteristics of visual sensitivity. It can measure a wide range of brightness with high accuracy of 1 lux, and the response is more sensitive. Through the optimization design of the program algorithm, it can achieve the function of self-timing of the instrument, greatly reduce the error caused by manual measurement time, and make the data more accurate shown in Figure 4.

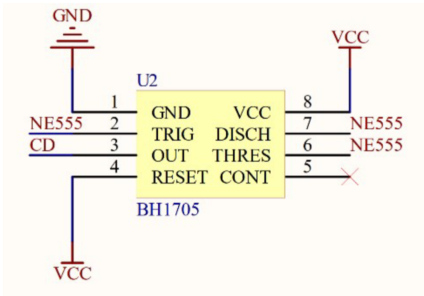

Fig.4. BH1705 chip

4. The experiment

4.1. *Experimental process*

(1) Connect the film formation rate tester and the computer via a USB cable. (2) Open the computer-side test software, first select the communication port connected to the instrument, so as to connect the computer and the instrument. And then select the acquisition speed required for this test, the rate range is 0-99 times per second. (3) Then place the sample to be tested in the corresponding position, click "Start Measurement", the tester starts to work. (4) As the test time increases, the film formation rate curve gradually appears. When the curve is stable, click "Stop Measurement". (5) Fill in the environmental factors of this test on one side, choose whether to remove the influence of ambient light according to the test needs, and finally click "Save Image" to generate a test report.

4.2. *Experimental result*

When the liquid film of the casting film liquid contacts the coagulation bath, the solvent on the surface and inside of the liquid film is extracted by the coagulation bath. Due to the precipitation of the liquid film, it gradually changes from transparent to white, so the intensity of the light transmitted through the liquid film decreases accordingly.

The start time of phase separation is the time when the transmission intensity starts to decrease. When the transmission intensity drops to a certain stable value, phase separation is considered complete, and the voltage value drops to a certain stable value. Over time, it gradually became stable.

This phase separation film formation rate tester is used to measure the change in light intensity transmitted through the film during the phase separation (the film formation curve). This curve reflects the initial transmittance and the end transmittance of the solidified liquid film and the time interval used. The collection time can be adjusted appropriately according to the extraction rate of different coagulation baths. Import the data into an Excel spreadsheet and set it as the relationship curve between time and light intensity change. For example, when polyurethane is formed into a film, distilled water and methanol are used as coagulation baths, as shown in Figures 5 and 6.

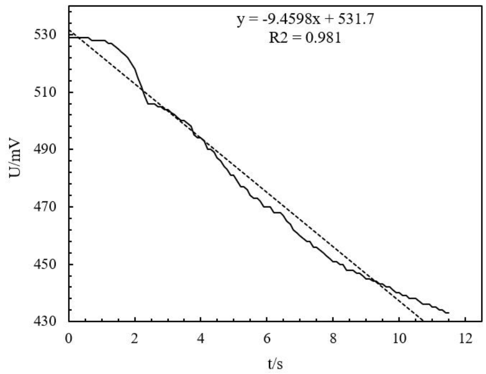

Fig.5. Distilled water bath curve

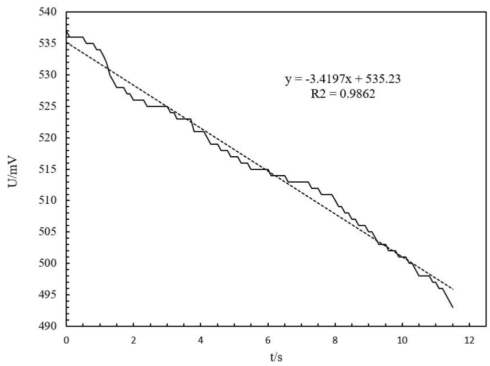

Fig.6. Methanol water bath curve

The absolute value of the slope can reflect the speed of the film formation rate of the process, that is, the greater the increase in the light intensity value during the same time period in the light projection curve, the faster the film formation rate of the system, the more solidified into the shorter the time taken by the film.

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Authors Introduction

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