Design of Film Forming Rate Measuring Instrument based on Polyurethane Material

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Abstract

With the development and research of polyurethane materials, it has become widely used in the field of antibacterial, waterproof and moisture permeable, and medical. 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 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 it on the basis of it. By improving 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.

Keywords: Measurement instrument; Film formation rate; ATmega328P; BH1750

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 new film-forming rate measurement instruments involved in this design include specific light source, light-intensity acquisition sensor, microcontroller and data processing computer. When making the film, on the glass plate will be cast film liquid scraped into a film, into the container's solidification bath. The specific light source directly above the polymer cast film liquid, light intensity sensor is located directly below the container, the intensity of the projected light measured by the light sensor, light intensity sensor connected to the acquisition controller, the acquisition controller connected to the data processing computer[2]. The device by measuring the change of light intensity through the membrane during phase separation, the membrane curve is generated. The test instrument is compact, small in size, easy to use and more suitable for a variety of measurement environments.

2. The hardware structure design

2.1. Controller selection

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 environment by controlling lights, motors and other equipment[3]. It has no complex micro-computer underlying code, no difficult assembly, just simple and practical functions. In addition, it has a simple integrated development environment, great freedom and great scalability. Standardized interface models provide a solid foundation for their sustainable development. Developers have developed simple features and many application libraries, so we don't need to operate registers directly, so people who don't have a good MCU knowledge can use Arduino to do what they want.

2.2. Data acquisition sensor selection

This device using BH1750FVI chip, power supply voltage 3-5V, light intensity range 0-65535lx, sensor built-in 16bit AD converter, direct digital output, omit complex calculations, omitted calibration. Without distinguishing between 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. Using the standard NXP IIC communication protocol, the module contains communication level conversion and can be directly connected to the 5V microcontroller IO. The GY-30 module is shown in Fig.1.

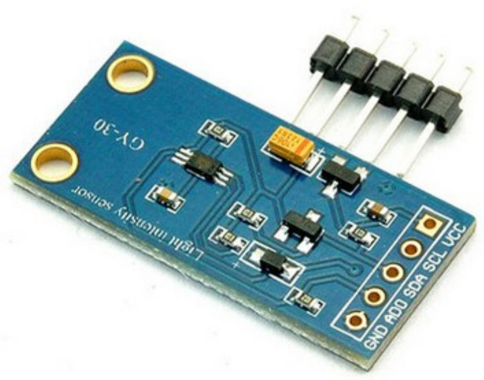

Fig.1. WIFI module

2.3. Development language

The C language is a process-oriented computer programming language that differs from Java, C++ and other object-oriented programming languages. The design goal of the C language is primarily to provide a programming 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. 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, derived from 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++. With its powerful operation ability, elegant syntax style, innovative language functions and convenient support for component programming, it has become the preferred language for NET development. Therefore, the upper computer used in this system is developed by C# language.

3. Hardware circuit design

The hardware circuit design of the system is mainly composed of 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.

3.1. ATmega328P microcontroller control module

This design uses the ATmega328P 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 transmitted by the outside world, 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 Fig.2.

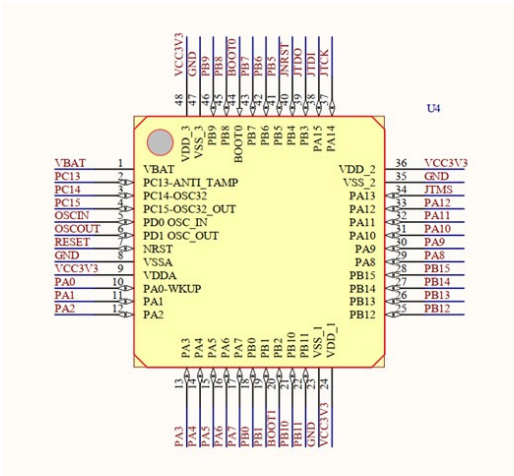

Fig.2. ATmega328P chip

3.2. Power circuit

In this design, we choose a RT9193 chip to power adapter, the main electric 12V through the transformer in the adapter to buck the pressure, and then through the bridge circuit to convert 12V into DC 5V output[5]. 5V voltage to the microcontroller, liquid crystal display module, buzzer module and other circuits to power.

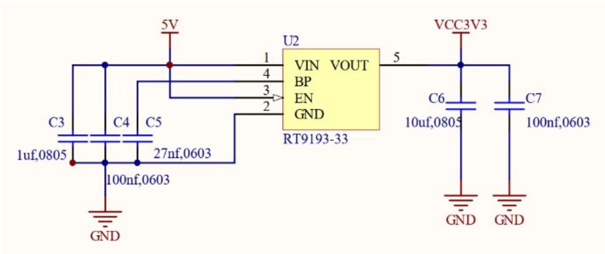

Fig.3. RT9193 regulation circuit

3.3. Data acquisition circuit

In this design, 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. 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. And 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.

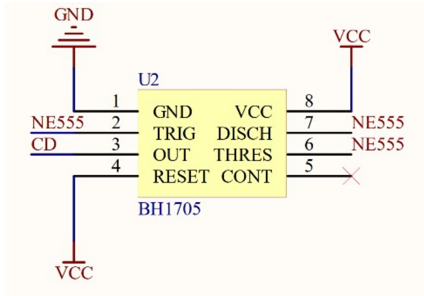

Fig.4. BH1705 chip

4. Experimental report

4.1. Experimental process

After the film formation rate tester and the computer are connected via a USB cable. Open the computer-side test software, first select the communication port connected to the instrument 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. Then place the sample to be tested in the corresponding position, click "Start Measurement", the tester starts to work, as the test time increases, the film formation rate curve gradually appears, and when the curve is stable, click "Stop Measurement". 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, the liquid film 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, that is, the film formation curve. This curve reflects the initial transmittance and end transmittance of the solidified liquid film and the time interval used, and 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.

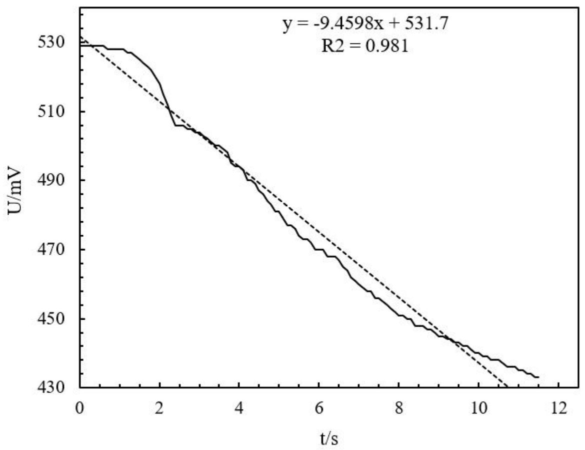

Fig.5. Distilled water bath curve

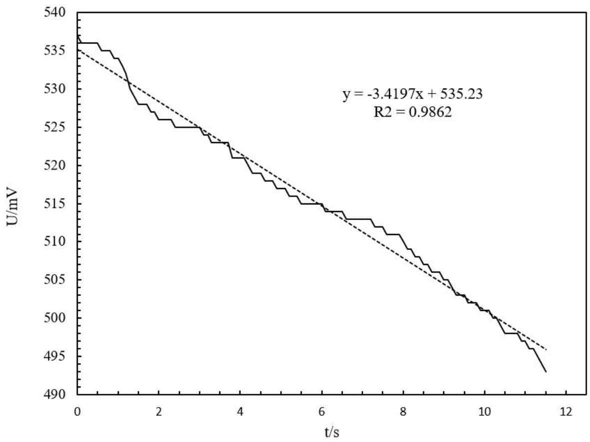

Fig.6. Methanol water bath curve

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.

Acknowledgements

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References

1. Ma Ye, Xin Lian, Tan Huaping, et al., Chitosan membrane dressings toughened by glycerol to load antibacterial drugs for wound healing, *Materials science & engineering, C, Materials for biological applications*,2017, pp.81.
2. Eykens L, De Sitter K, Dotremont C, et al., Membrane synthesis for membrane distillation A review, *Separation and Purification Technology*, 2017, 182: pp.36-51.
3. M. Caruso, R. Miceli, P. Romano, G. Schettino, C. Spataro, F. Viola, A low-cost real-time monitoring system for PV plants based on ATmega 328P-PU microcontroller. *Proceedings of the 2015 IEEE International Telecommunications Energy Conference*, Osaka, 2015, pp. 1-5.
4. B. Lu, X. Wu, H. Figueroa, A. Monti, A Low-Cost Real-Time Hardware-in-the-Loop Testing Approach of Power Electronics Controls, *IEEE Transactions on Industrial Electronics*, 2007, 54(2): pp. 919-931.
5. Y. Jang, S. Cho, B. Kim, J. Sim, H. Park, A low-power LDO circuit with a fast load regulation, *Proceedings of the 2016 IEEE Asia Pacific Conference on Circuits and Systems*, Jeju, 2016, pp. 47-49.