The temperature and pressure Remote intelligent control system for biogas digester based on STM32

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Abstract. The application of biogas digesters in modern life has become more and more extensive. However, the current level of automation in biogas management was too low. and people are afraid of odor and dirty when operating biogas fermentation. In order to solve the shortage of modern energy and improve the safety and efficiency of biogas digesters, a temperature and pressure remote intelligent control management system based on STM32 for biogas digesters was designed. This system took STM32 as the main control chip, through the DS18B20 and PMS pressure measurement module for temperature and pressure measurement, combined with ESP 8266 01sWiFi module and cloud platform for data transmission communication and storage, and then displayed to the user by the QT software interface, the remote intelligent control of the biogas digester in the cloud was realized, so that the efficiency and safety management of the biogas digester were could improved. This management system of the biogas digester would promote the energy industry and sustainable development of human beings and facilitated rural revitalization.

1 Introduction

Energy is an important resource for national development, and also a guarantee for national industrial development and people's livelihood. With the shortage of non-renewable energy in China and the implementation of the rural revitalization policy, the promotion and application of biogas digesters has become an important way to ensure the energy supply of rural villages and towns [1]. The biogas digester using animal manure and crop straw fermentation can not only save energy and generate energy for cooking and boiling water in people's daily life, but also generate biogas for power generation. The biogas digester produced by the biogas digester can be used as organic fertilizer to save fertilizer and pesticide, which can not only improve the food safety of crops, but also promote and drive the development of rural aquaculture industry [2]. Therefore, the utilization of biogas digesters will provide vast fertile land for the development of rural areas and aquaculture. However, at present, the automation level of biogas management is too low, and people are afraid of odor

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and pollution when operating biogas fermentation. The biogas digester is sensitive to the internal temperature and pressure. Reasonable biogas digester temperature and pressure can quickly and effectively improve the working efficiency of the biogas digester, enabling people to use the biogas digester safely and effectively [3]. Therefore, how to effectively and intelligently monitor and regulate the temperature and pressure in the biogas digester is also the main problem. This paper proposes an intelligent temperature control and pressure control system for biogas digesters based on cloud platform technology, which can not only be realized; Realize the sharing of state information and data of the Internet of Things, and can also control pressure and temperature efficiently and high-quality, which is of great significance to energy conservation and low-carbon sustainable development [4].

2 Overall design architecture of remote temperature control system

2.1 Overall structure of the system

The system used STM32 as the main controller of the system, combined with DS 18B20 temperature and PMS pressure measurement module, LED display, Alibaba Cloud server, ESP 8266 01s Wi-Fi module and QT interface[5] , designed to form a remote intelligent biogas digester temperature control system. First, the DS18B20 temperature sensor and PMS pressure sensor are a sensing layer that collects the biodigester temperature and pressure analog signal and converts it into a digital signal to the main control STM32 chip. The STM32F103C8T6 acts as the central hardware, responsible for receiving and transmitting the signals required by each device, forming a central processing and provisioning. The Wi-Fi module built a bridge between the hardware and the user, had realized the interconnection between the user and the hardware device. Finally, there is the temperature and pressure control module we need. This temperature and pressure control module consists of triac voltage regulator module and an electric heating element, which consists of a voltage stabilization control box, and controls the conduction angle of the triac with PWM waves to control the output power. The overall structural framework of this system is shown in figure 1.

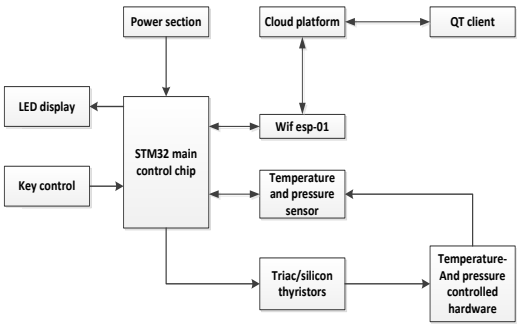

Fig 1. Overall structural framework of the system.

2.2 Overall program flow design of the system

The system programming process mainly includes MCU control, WiFi ESP-01s transmission module, button setting and display modules. First of all, the temperature and pressure sensor collects the temperature and pressure data of the biogas digester and transmits it to the MCU

for processing and judgment. if it is the target temperature pressure, it returns to the starting point, if not, sends a command to start the PWM output to adjust the temperature and pressure of the digester. The system program flow is shown in figure 2 below.

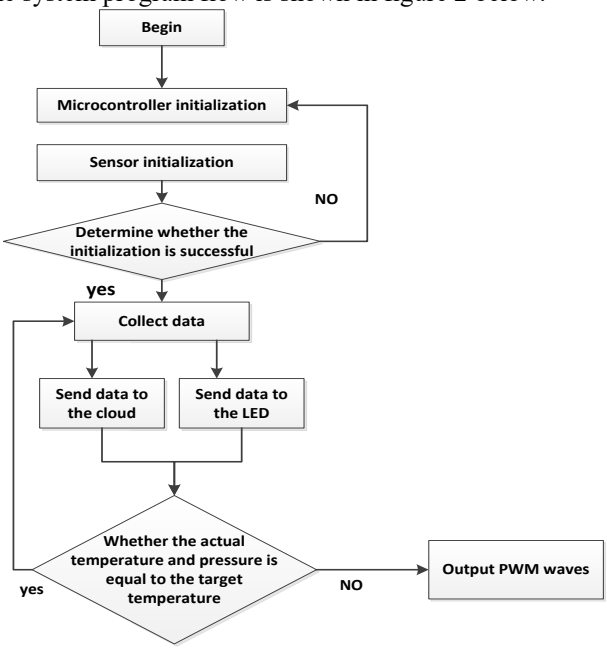

Fig 2. System program flow.

3 Temperature and pressure control system hardware design and temperature regulation method

3.1 Hardware structure design of temperature and pressure control equipment

The hardware equipment of this system is a multi-functional temperature and pressure control box, and the box structure is divided into 3 parts, namely the placement area, the control equipment area and the intelligent control area. The placement is divided into three layers, which is convenient for storing more biological reagents, and each layer contains a fan, and in the box, the exhaust plate is equipped with a pressurized fan, which is used to place the circulation exchange of carbon dioxide and other gases in the environment inside and outside the layer and the adjustment of the air pressure temperature inside the box. The structure diagram of temperature and pressure control box is showing in figure 3.

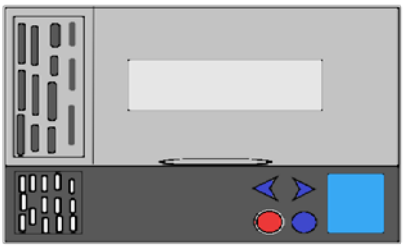

Fig. 3. Structure diagram of temperature and pressure control box.

3.2 Temperature and pressure control equipment temperature regulation mode

In this system, incremental digital PID temperature regulation is selected in the temperature regulation mode. PID control algorithms mainly include digital control and analog control [7]. Figure 4 shows the basic structure of a digital PID control system, where the roles of resistors, capacitors, and operational amplifiers are replaced by computer software operation.

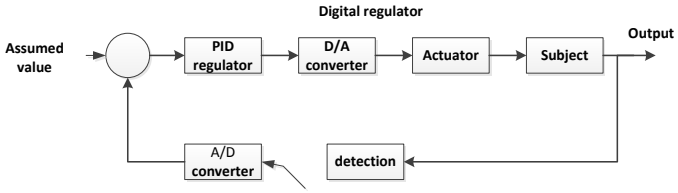

Fig. 4. Block diagram of a digital PID control system.

Equation (1) below is the discrete output of the PID incremental control algorithm:

$$\Delta u(k) = Ae(k) + Be(k-1) + Ce(k-2) \tag{1}$$

4 Temperature and pressure control system software design and communication construction

4.1 Cloud platform construction

For remote storage and processing of data, combined with user needs, this paper selects Alibaba Cloud IoT Cloud Platform to build and develop it[9], and the following are the detailed steps for building this system cloud platform.

(1) First register an account and activate IoT Platform: Then open the console of IoT Platform to create a "temp" product.

(2) Continue to add devices according to the prompts, "temp" is to connect to the device, "temp_control" is to connect to the QT client for data transmission, These two devices communicate with each other, and single-chip microcomputer and QT communication can be realized.

(3) Set up and add device service functions to realize the connection of things.

(4) Create rules to realize data information exchange and storage between the cloud platform and remote devices, and realize the construction of the cloud platform.

4.2 QT software interface settings

QT is a cross-platform C++ graphical user interface application development framework developed by Qt Company in 1991.This system combines QT development to visualize system data, which is convenient for users to view and manage. The following are the main steps for developing the QT interface of this system.

(1) User subscription interface design: first carry out the page layout, and then carry out coding regulation to realize the basic functions of MQTT such as Connect, Publish, Subscribe, UnSubscribe, Disconnect, etc., and set the information area to display debugging information in real time.

(2) Design of temperature and pressure control display interface: the control interface is mainly composed of the main functions of "target temperature and pressure", "real-time

temperature and pressure" and "start" button. The start button is the start button for temperature and pressure regulation.

5 Test validation

This system used stm32 master chip, cloud platform and QT client. Combined with PID incremental control algorithm, the temperature and pressure of biogas digester are monitored and controlled in real time. After testing, the system functions can operate normally and stably and reach the expected functions. The following figure 5 show the temperature curve diagram under the control of PID increment algorithm.

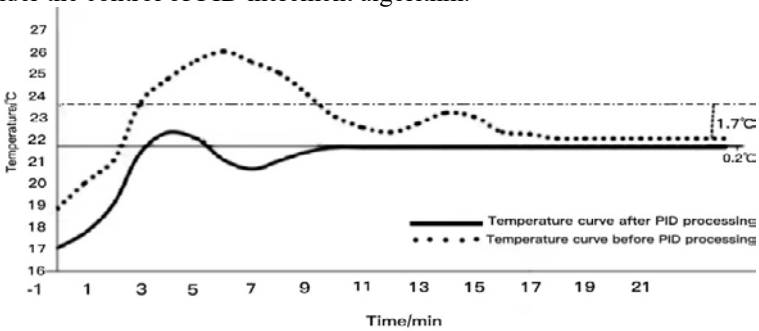

Fig. 5. Temperature curve of the PID control.

6 Conclusion

This system used STM32 master chip, cloud platform and QT client. Combined with PID incremental control algorithm, the temperature and pressure of biogas digester are monitored and controlled in real time. The biogas digester temperature and pressure control system combined with cloud platform technology, whith alized the remote intelligent monitoring and management of biogas digester by users. The application of this system greatly improved the efficiency and safety of biogas digester, and provided more intelligent and digital development direction and path for our national rural revitalization. The intelligent and digital temperature control management system has great potential for development in the rural and aquaculture industries now and in future.

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