DESIGN AND IMPLEMENTATION OF GAS ULTRASONIC FLOWMETER SYSTEM BASED ON MAX35104

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Summary. *In the production, supply, storage and marketing of natural gas industry, gas measurement is a key link. Aiming at solving the problems in the current ultrasonic gas flowmeter, such as high-power consumption, low measurement accuracy and difficult data transmission, an ultrasonic gas flowmeter based on MAX35104 is designed and implemented. The system takes STM32F103 microcontroller as the control core, adopts the time difference method and uses high-precision timing chip, MAX35104, FUS-200A ultrasonic transducers and PT1000 temperature sensor to acquire instantaneous flowrate and temperature. It also connects LCD through FSMC ports as display module to realize local visualization interface generation, and realizes the function of remote monitoring on cloud server through the EC20, a 4G module, based on LTE communication protocol. In addition, the system has the function of real-time early warning, which is realized by preset threshold as well as the function of errors online diagnosis by analyzing the special state of hardware, which can diagnose the probe connection error, whether the chip working abnormally and the cloud server transmits correctly. With the continuous improvement of the measurement accuracy of the system, it is bound to play a positive role in the development of the natural gas industry.*

Keywords. *gas ultrasonic flowmeter, STM32F103, MAX35104, remote monitoring, errors online diagnosis*

Outline

Research background: Natural gas is one of the main energy sources in the world, with the advantages of clean, high heat generation and low price, and in the production, supply, storage and marketing of natural gas industry, gas measurement is a key link. However, the present problems such as high-power consumption, low measurement accuracy and difficult data transmission seriously restrict the development of gas flowmeter. Nowadays, the ultrasonic gas flowmeter based on the time difference method has been widely used in natural gas measurement with the advantages of high precision, large measuring range, etc.

Design principle: The time difference method [1] is the main design principle of the gas flowmeter system. The single channel ultrasonic gas flowmeter is shown in the figure 1.

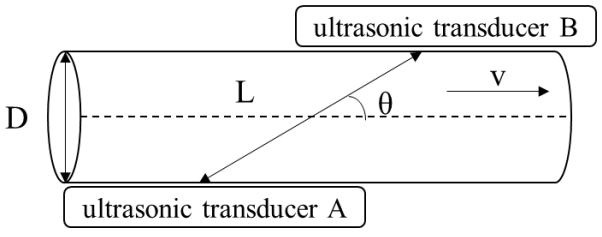

Fig1. single channel ultrasonic gas flowmeter pipeline

Among this, L is the measuring channel length, the distance between two ultrasonic transducers, D is the pipe diameter width, θ is the angle between channel and pipeline and v is gas velocity. It is easy to get the time of forward flow and backward flow, and the flowrate can be obtained by the simultaneous equation, which is independent of the current sound velocity, as shown in the formula (1).

$$v = \frac{L}{2\cos\theta}\left(\frac{1}{t_{AB}} - \frac{1}{t_{BA}}\right) \quad (1)$$

In general, it is necessary to modify the velocity according to the empirical formula. The instantaneous flow can be obtained by multiplying the corrected velocity with the pipe cross-sectional area. In case of multichannel, the flow of different channels needs to be weighted before the flowrate is corrected.

System Implementation: The hardware connection architecture diagram of the system is shown in the figure 2. STM32F103 and MAX35104 transmit instructions and data through SPI communication to obtain temperature and gas flowrate. 4G module connected with STM32F103 microcontroller through UART communication is used to realize the function of data transmission through clouds server based on LTE communication protocol. Integrating each module into a printed circuit board (PCB), and it will reduce the number of electronic components greatly, and improve the performance and convenience of the product.

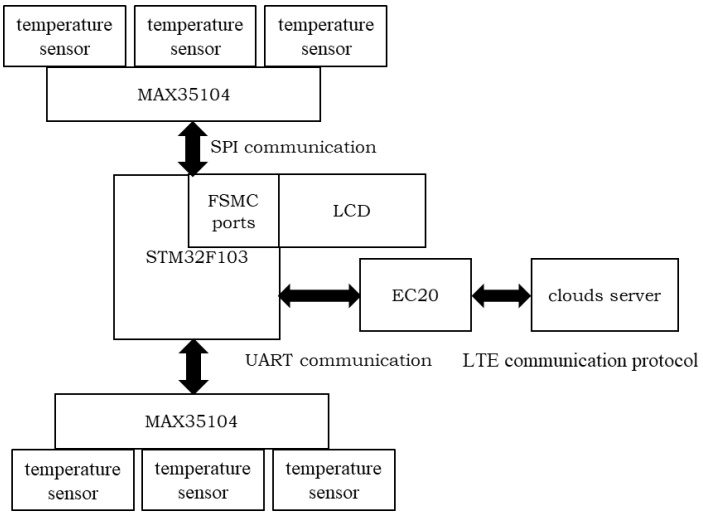

Fig2. system architecture diagram

The system mainly realizes five functions: data acquisition, real-time early warning, error online diagnosis, local and cloud server display. There are fixed gain amplifier, variable gain amplifier and band-pass filter in the MAX35104 [2]. The flight time can be obtained from the echo generated by ultrasonic transducers. The time difference, forward flow and backward flow can be easily calculated by the flight time. In the temperature measurement, the ratio of resistance can be calculated by the obtained flight time, and get the real-time temperature. The real-time flowrate can be obtained under atmospheric pressure. The system will alarm when the flowrate is too fast or too slow and the temperature is too high or too low by setting the threshold value. It can also diagnose the error online [3], such as the connection of 4G module, chip, ultrasonic transducers and temperature sensor, by analyzing the characteristic value generated by different states of hardware circuit. The local visual interface displayed by LCD and cloud interface displayed by clouds server through EC20 module based on LTE protocol can be realized as well.

Analysis and Prospect: A series of measurement values can be obtained by using different blowing equipment, and then the existing gas ultrasonic flowmeter and flowmeter calibration device can be used to calibrate the system to achieve high-precision measurement.

Reference

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DESIGN AND IMPLEMENTATION OF THE TURBIDITY REMOTE MONITORING SYSTEM BASED ON STM32F407 MICROCONTROLLER

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Summary. *Facing the developing trend of remote monitoring and real-time early warning of the monitoring system, based on FX -11A optical fiber sensor and the STM32F407 microcontroller, a turbidity remote monitoring system design is completed to monitor turbidity with high precision. According to Lambert-Beer Law and theoretical derivation, the relationship between the reference voltage and the measured voltage under the measuring facility was obtained. Based on this, two sets of experiments were designed by using a mixture of water and soil and 0-4000NTU Formazin solution to achieve the purpose of high-precision measurement of turbidity. Processing the experimental data with MATLAB software, the results shows that the system can monitor the turbidity, the correlation coefficient is as high as 0.9955, and the turbidity range of 400-1500 NTU can be monitored with an error of 3.5%. Take the STM32F407 microcontroller as the core controller in the system, and it is connected to Internet to realize the function of web server with Light Weight IP (LWIP) communication protocol. The value of turbidity can be transmitted to web server in real time with Server Side Include (SSI) instruction, and any device connected to Wi-Fi can realize the remote monitoring function through the router. The system function can realize the remote monitoring and real-time warning function of turbidity, which is in line with the developing trend of the monitoring system.*

Keywords: *remote monitoring, STM32F407, turbidity, high-precision, optical fiber sensor*

Outline

Research Background: During the sedimentation process of alumina smelting, when the various liquid layers of the sedimentation tank are unbalanced, there will be phenomena such as overflow and turbidity, which will affect the alumina production. Therefore, it is necessary to monitor the height of each liquid layer, which is monitoring the turbidity. The current measurement schemes are mostly for experienced workers to observe from small holes, or to perform real-time monitoring through probes and monitoring stations. This puts forward requirements on the workers' experience and restricts it in space. The development of a remote monitoring system will play a role in liberating labor. Due to the excellent physical properties of the optical fiber sensor, it can adapt to the high temperature and alkaline smelting environment.

Research Objectives: Based on the research background, the team put forward research objectives, which are to achieve high-precision measurement of turbidity and the design and implementation of a remote monitoring system.

Turbidity Measurement [1]: Take FX-11A fiber optic sensor, which has a Beam-emitting end, a Beam-receiving end and an analog voltage output end, as the turbidity monitoring sensor. The light emitting end will send infrared light, which can be absorbed and transmitted by the determinand. The transmitted light will be received by the receiving end and output in the form of