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The Design of Oxygen Concentration Electric Potential Detector

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Abstract:-View of the oxygen concentration electric potential detectors are widely used in domestic and foreign industry, but the measurement accuracy of domestic existence is not high, the sensor work condition is not stable, short life and other shortcomings, therefore improving the oxygen concentration potential detector has important significance for the development of industrial instrumentation automation. This paper is in-depth analysis of the structure and working principle of the oxygen concentration electric potential detector, and clarifies the instrument design features.

Keywords:-Zirconia, detector, Detector, SCM, oxygen

I. INTRODUCTION

The oxygen concentration electric potential detector is based on the difference of the oxygen concentration on both sides of the solid electrolyte to produce the concentration difference potential. Zirconia gas oxygen analyzer has a long-enduring and reliable performance because of the unique of reaction mechanism and chemical composition. Its applications from traditional high dust, high temperature gas mixture automotive and steel industry, extended to the fields of petrochemical, environmental testing, gas preparation, food health and scientific research [1].

In recent years, with the development of domestic technology. Domestic zirconia oxygen analyzer has an increasingly wide range of applications; it also has a very optimistic about the prospects for development. But in our country, zirconia oxygen analyzer is underdeveloped, which is showed that have unstable performance and low accuracy [2]. So develop a kind of high-accuracy, high-performance and high-reliable zirconia oxygen analyzer will bring significant economic and social benefits.

II. PRINCIPLE ANALYSIS

A. Analysis of the nature of the zirconia electrolyte

Zirconium dioxide is one of the most studied ceramic materials [3]. The zirconia has three crystal forms: monoclinic, tetragonal, and cubic phases. It shows monoclinic crystal at room temperature. Crystal transitions to the cubic crystal when the temperature was elevated to 1150°C, while about 7% of volume shrinkage. It becomes monoclinic crystal again when the temperature decreases [4]. If it repeatedly heats and cools, zirconia will be ruptured. In conclusion, the pure zirconia can not be used as measuring element.

If zirconia doped quantitative calcium oxide as stabilizer, zirconia will have a high cationic conductive. This is because in the zirconium oxide in the molecule, zirconium ions are positive tetravalence, oxygen ions are negative divalent, a combination of a zirconium ion with two oxygen ions. After adding Calcium oxide, since Calcium is positive divalent, it is only in conjunction with an oxygen ion, the oxygen ion hole has formed. At this time, if there is an applied electric field, it will formed current flow by oxygen ions occupy a hole movement. As shown figure 1.

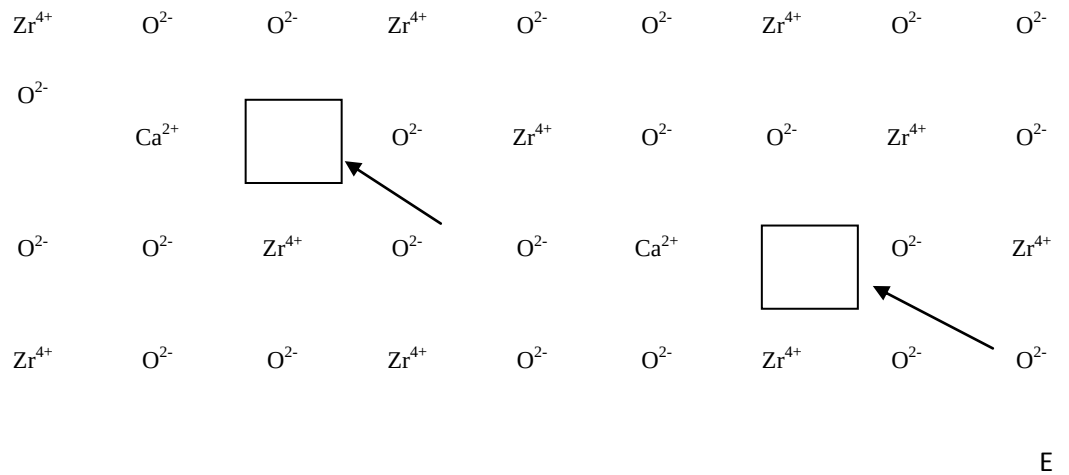

Fig. 1 The schematic diagram of the crystal structure of the solid electrolyte and the conductive mechanism

B. Principle of measurement

Figure 2 is the schematic diagram of concentration potential detection. Respectively sintered porous platinum (Pt) electrode in both sides of the zirconia electrolyte. A certain high temperature, it is a typical oxygen concentration cell when not simultaneously on both sides of the oxygen content of the zirconium tube. At this battery, air is reference gas, they are located in the inner and outer electrodes with flue gas. In actual oxygen probe, air flow through the outer electrode, flue gas flows through the inner electrode. When the flue gas oxygen content ΦC is less than the air oxygen content ΦA, 4 electrons from the outer electrode are captured by the oxygen molecules in the air to form two oxygen ions. Following electrode reaction occurs:

$$O_2 + 4e^- \rightarrow 2O^{2-}$$

Oxygen ions in the zirconia tube to quickly migrate to the flue gas side, opposite electrode reaction occurs on the inner electrode:

$$2O^{2-} \rightarrow O_2 + 4e^-$$

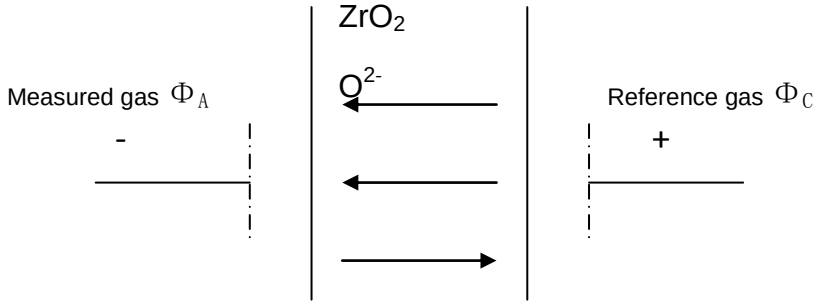

Fig. 2 The schematic diagram of concentration potential detection

As the oxygen concentration causes oxygen ions migrate from the air side to the flue gas side The resulting potential cause oxygen ions migrate to the air side from the flue gas side reverse, and it will generate a potential signal related to the oxygen concentration difference between the two electrodes when these two migration equilibrium. The potential signal in accordance with the Nernst equation

$$E=(RT/nF)\ln(\Phi_A/\Phi_C) \quad (1)$$

R—the ideal gas constant
F—Faraday constant
T—Zirconium tube absolute temperature (K)
Φ_A—The oxygen concentration of the air (The concentration of oxygen is 20.6%)
Φ_C—the concentration of flue gas
According to the equation (1), in certain high temperature conditions, a certain amount of the flue gas oxygen content would have a corresponding potential output. By utilizing this property manufactured measuring the oxygen content of the oxygen concentration difference potential detector [5].

III. HARDWARE DESIGN

The system selected main control chip AT89T51 of SCM [6]. The peripheral module as shown in Figure 3 shows, it includes A/D Converter, D/A Converter, LED Display, Keyboard, Signal Processing Circuit, Alarm Circuit and power-down protection circuit. The A/D converter selection ADC0809, D/A converter selection DAC0832 chip [7]. Design six buttons and six digital tubes to modification and display of parameters. It will be heating the resistance heater wire, if the temperature is lower than720℃. And the alarm circuit will be gave an alarm, if the temperature is higher than 820℃. In order to make the device safe and reliable, it builds a power-down protection circuit take Tl7705 chip as the core [8], the design also designed a WDT circuit to prevent program jump into an infinite loop. The output current is about 4~20mA.

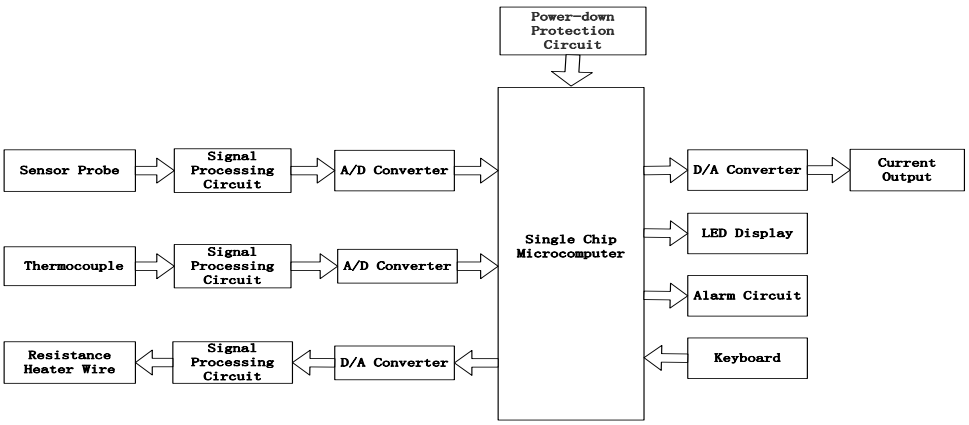

Fig. 3 Block diagrams of the hardware

IV. SOFTWARE DESIGN

Software design is corresponding for the part of the hardware. The software is designed with a modular design. A main program module as shown in Figure 4 shows [9], seven subroutine modules: data acquisition program, data processing program, the oxygen calculation program, display program, interrupt program, the temperature control and alarm program, serial-communication program.

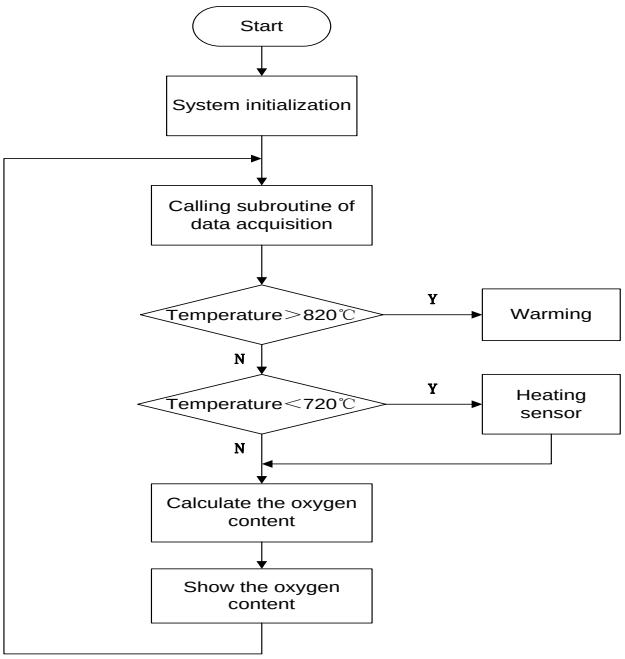

Fig. 4 Block diagrams of the software

In order to improve the accuracy and reliability of the measured, each data acquisition 4 times [10], remove the maximum and minimum values, took the average for remainder of the two numbers.

V. CONCLUSION

Oxygen concentration electric potential detector has a high degree of automation, improves measurement accuracy and stability, production efficiency, and has a broad application of prospects.

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