25th IMEKO TC4 International Symposium
23rd International Workshop on ADC and DAC Modelling and Testing
IMEKO TC-4 2022
Brescia, Italy / September 12-14, 2022

Research on online calibration method of refrigerator intelligent inspection line

Deng Bin[1] , Xu Hailong[2] , Ma Xuefeng[1] , Liu Jianbo[1] , Guan Zexin[1] , Wang Weizhao[1] , Wang Dalong[1], Sun Xiaoyan[1] , Jia Ru[1] , Sun Xiaojie[1]

[1] 1st Shandong Engineering Research Center of Reliability Evaluation for Electric Energy Metering Devices， Shandong Institute of Metrology ,250131, No. 28, QianfoShan East Road, Jinan,Shandong,China ,dengbin0105@sina.com

[2] 2nd Shandong Institute of Metrology and Science 250131, No. 28, QianfoShan East Road, Jinan,Shandong,China , 1070249558@qq.com

Abstract

In order to solve the problem of measuring and tracing the dynamic line and static line of the wireless intelligent detection line in the assembly line workshop of an enterprise, the on-line measurement method of refrigerator intelligent detection line was studied, and a set of on-line calibration device of refrigerator intelligent detector was established. The test results show that the on-line calibration device of the refrigerator intelligent detector designed in this paper can realize the minimum measuring AC power of 0.5 W and the lowest measuring temperature of -30 ℃. This measurement method solves the real-time online automatic calibration of the refrigerator intelligent testing line, as well as the real-time online measurement supervision of the measured data.

Keyword

wireless intelligent detection line
measurement traceability
online calibration device
refrigerator Simulation System
uncertainty

I. INTRODUCTION

With the continuous development of wireless detection technology, wireless intelligent detection line (dynamic line and static line), which is widely used in the automatic assembly line workshop of home appliance enterprises, and the wireless intelligent detection means are becoming higher and higher. The refrigerator wireless intelligent detector is a measuring instrument specially used to measure the metrological characteristics of refrigerators. It uses modern detection technology to realize real-time online detection, alarm, recording, data storage and query of the refrigerator production line, and can realize centralized control and online supervision of the wireless intelligent detection line[1].

However, when the wireless intelligent detection line (dynamic line or static line) is used for automatic detection, on the one hand, the tested refrigerator moves continuously along with the sliding spool conveyor belt of the production line, and the wireless intelligent detector of the refrigerator also moves synchronously. On the other hand, the production line workshop of the enterprise produces day and night, and the detection cycle of the refrigerator wireless intelligent detector is long, which is prone to the situation that the amount of detection data is out of tolerance, while the refrigerator with abnormal detection data may cause quality accidents. Therefore, it is necessary to carry out real-time online measurement and monitoring on the wireless intelligent detector of the refrigerator, solve the traceability problem of online measurement and detection of the detection line of a refrigerator manufacturing enterprise, and ensure the consistency and accuracy of the detection value of the intelligent detection line.

II. CALIBRATION METHOD

The online calibration of the refrigerator intelligent detection line is realized through the online measurement and monitoring platform. The working principle of the refrigerator intelligent detector is shown in Figure 1.

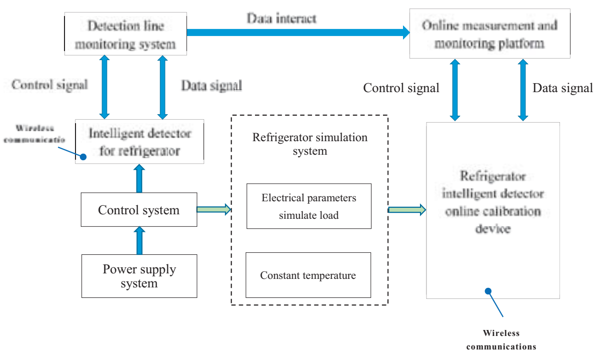

Fig. 1. Measurement schematic diagram

The refrigerator detection system is divided into an electrical parameter detection system and a temperature parameter detection system[2].

It collects the measurement data of the refrigerator detection line detection system and the online calibration device of the refrigerator intelligent detector in real time, collects and stores them in real time through the online measurement and monitoring platform, and then automatically analyzes, processes and queries the uploaded data. For the measurement of the electrical parameter detection system, the standard meter method is used to directly collect the measurement data of AC voltage, AC current, AC power, power factor, frequency and AC energy from the electrical parameter simulation load of the refrigerator simulation system.

The direct measurement method is adopted for the measurement of temperature parameter detection system, without considering the type of configured temperature sensor (thermal resistance sensor or thermocouple sensor), and the temperature parameters are measured through the simulated temperature field provided by the constant temperature device of the refrigerator simulation system. In practical work, the refrigerator intelligent detection system can provide AC power supply, directly detect the measurement performance indicators of the refrigerator, and the refrigerator can also be used as a simulated load.

A. Electrical parameter calibration

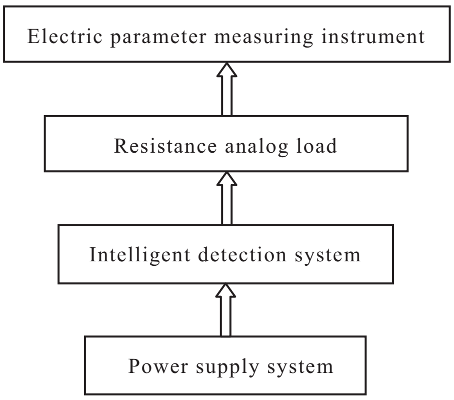

Fig. 2. Electrical parameter measurement

As shown in figure 2, standard table method which is adopted to calibrate AC voltage, AC current, AC power, AC energy and other electrical parameters. At least 5 calibration points are uniformly selected within the measurement range at 50 Hz to calculate the indication error of refrigerator intelligent detector.

The average value of the intelligent detector of the tested refrigerator is Y_x, the standard value of electrical parameter is Y_n , and the value error of the intelligent detector of the tested refrigerator is ΔY, and the value error calculation formula is as follows:

$$\Delta Y = Y_x - Y_n \quad (1)$$

B. Temperature parameter calibration

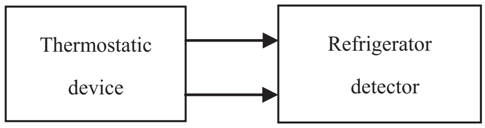

Fig. 3. temperature measurement

As shown in figure 3, with a standard temperature field method refrigerators intelligent detection system, the temperature parameters of calibration intelligent detector temperature sensor in the refrigerator in the constant temperature trough, set the thermostat temperature calibration point, control thermostat (second-class platinum resistance thermometer) temperature T_n, after being stable, record the display value detector T_x, calculation error of measurement.

$$\Delta T = T_x - T_n \quad (2)$$

III. DESIGN OF OF CALIBRATION DEVICE

A. Operating environment conditions

The operating environment requirements are as follows: Simulated ambient temperature from -25 ℃ to 40 ℃.

Data transmission: communication antennas of more than 4G can be installed independently. Communication antennas are not affected by refrigerator shielding and can normally send data.

Data monitoring: it can install communication interface such as RS485, and can monitor the running status of electrical parameters and temperature parameters of refrigerator intelligent detection system in real time, but it shall not affect its normal communication function.

B. Composition of calibration device

The measurement standard instruments are shown in Table 1.

Table 1. Standard of measurement

Name	Model	Range	Maximum allowable error or accuracy
Electric parameter measuring instrument	CL3112	ACA: 10 mA - 100 A	MPE: ±0.02%
		ACV: 1.5 V - 600 V	MPE: ±0.02%
		F: 40 Hz - 70 Hz	MPE: ±0.005Hz
Ac meter calibration device	JHP-20A	ACV: 10 V - 600 V ACA: 0.1 A - 20 A	MPE: ±0.1%
Standard platinum resistance thermometer	CST6602、CIMM1215	From -196 ℃ to 420 ℃	Second Class
Micro intelligent tank	CF40-A30	From -30 ℃ to 50 ℃	Volatility: ±0.05 ℃, Evenness:0.10 ℃

When the intelligent detection line of refrigerator is a static line, the calibration device is mainly composed of electrical parameter measuring instrument, AC meter calibration device, second-class standard platinum resistance thermometer, miniature intelligent slot, electrical parameter simulation load, etc.

In the actual running state, the measurement data of the online calibration device of the intelligent detector and the monitoring system are monitored in real time by the remote online measurement method.

When the intelligent detection line of refrigerator is a dynamic line, the measurement standard instrument in Table 1 cannot meet the realtime online measurement and calibration work. It is necessary to design a wireless transmission measurement and calibration device to carry out onsite calibration through the online measurement and detection platform.

C. Electrical parameters simulate load

The AC electronic load will consume the power of the power supply system in the actual calibration environment, which cannot meet the actual power consumption of each functional component in the calibration.Different power consumption of each functional component of refrigerator results in different load resistances[3-4].

Fig. 4. Simulated load test diagram

Based on the power consumption of refrigerator, a set of analog load resistances is designed to replace the refrigerator. It is used to detect the measurement error of electrical parameters of refrigerator detection system, as shown in figure 4.

In this scheme, 100 Ω, 250 Ω, 1 kΩ, 10 kΩ, 100 kΩ and other AC precision resistors are selected, and the AC precision resistors are used to design electrical parameters to simulate the load.

As shown in Figure 5,the rated power of each functional part of the refrigerator is 0.5 W, 5 W, 15 W, 50 W, 300 W and 500 W respectively.

The design electrical parameters simulate the size of the load resistance, which is the rated power, rated voltage and rated current of the load resistance, as well as the influence of the temperature coefficient of the resistance value[3-4].

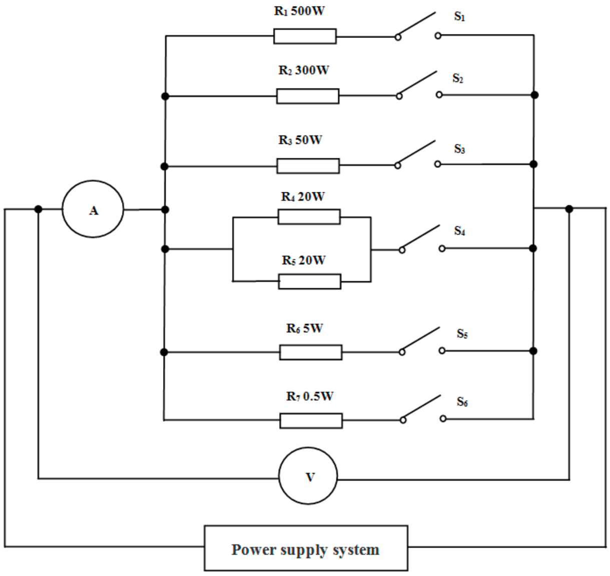

Fig. 5. Analog load resistance block diagram

D. Electric parameter detection system

The electric parameter measuring instrument is used to measure AC voltage, AC current, AC power, AC energy and other parameters,which is mainly composed of power supply,metering module, control module,display and communication module. The power module converts AC voltage to DC voltage that can be used by other modules.

The metering module divides the voltage signal through the resistance, converts the current signal into a signal for sampling through the current transformer and the sampling resistance.

Table 2. Design key components

Name	Model	Technical Index
Metering chip	RN7302	AC voltage, current, power and electric energy , MPE: ±0.1%
MCU	8101	Supply voltage: 2.5 V - 5.5 V, Frequency：32 MHz
LCD touch screen	SDWE080T67	Supply voltage:12 V
Crystal oscillator	HC-49SMD-3	Frequency 6 MHz， MPE: ±0.002%
Manganese copper shunt	FLQ-200-5-CK-110	Resistance：200 μΩ， MPE: ±0.1%
Resistance voltage divider	1206	Resistance：120 kΩ， MPE: ±0.1%
Resistance voltage divider	0603	Resistance：1.5 kΩ； MPE: ±0.1%
transformer	TC-X-195	Coil transformation ratio：135:22:20, Input voltage range：120 V - 320 V
Voltage module	W4726267	17 V / 220 mA ， MPE: ±0.1%

The metering chip completes the signal sampling and data processing. The control module mainly includes CPU, data storage chip, clock chip, etc. The display module includes a LCD driver chip. After receiving the data transmitted by the CPU, the driver chip drives the LCD to complete the display function.

The key parts selected in the design are mainly composed of electric energy metering chip, main control MCU, time base crystal oscillator, resistance voltage divider, current transformer, manganese copper shunt, liquid crystal, etc., as shown in Table 2.

The system control function is realized by single chip microcomputer.Since the measurement accuracy of the system is 0.1%, 16 bit A/D conversion is selected, and the linear error is better than 0.002%. The built-in self calibration circuit can be easily connected with the single chip microcomputer through the serial output interface.

At the same time, it has the characteristics of low power consumption, high precision and strong anti-interference ability. The current measuring circuit converts the measured resistance into the measured voltage, which is integrated into the single chip microcomputer through AD conversion. AC voltage measurement range: (10-300) V, AC current range: (0.1-20) A, active electric energy: (0-99999.99) kWh, measurement accuracy: 0.1%.

E.Temperature parameter detection system

The dynamic line of the refrigerator wireless intelligent detection line. In fact ,the refrigerator moves continuously along with the sliding spool conveyor belt, and the detection instruments andequipment also move synchronously.

The calibration device for temperature parameters should be designed with full consideration of the actual measurement environment.

Fig. 6. Key parts for temperature detection

As shown in Figure 6, the key components of the temperature parameter detection system are mainly composed of const-670 intelligent precision dry body furnace, dy-300s low potential transfer switch, daqm-4301 data acquisition, class A platinum resistance sensor,card DS18B20 temperature sensor, waterproof antenna and other key components.

Daqm-4301 data acquisition card connects DS18B20 temperature sensor or A-level platinum resistance sensor, 2-wire or 3-wire, 8-Channel 128 points, temperature measurement from -55℃ to 125 ℃, maximum allowable error of temperature measurement: ± 0.0625 ℃, communication baud rate: 1200 bps, 2400 bps, 4800 bps, 9600 bps, 38400 bps, etc.

Dy-300s low potential transfer switch is a 10 channel scanning switch. Its switch contact thermal potential is lower than 0.4μV.Computer program control can be realized through RS232 or RS485 interface.

Const670 intelligent precision dry body furnace, temperature control from -40 ℃ to 160 ℃, allowable temperature control error:±0.014 ℃, temperature fluctuation:±0.005 ℃,axial uniformity: 0.035 ℃.

Using the wireless network communication function, this paper selects A-level platinum resistance sensor or DS18B20 temperature sensor for design. Under the dynamic test conditions, the data information of thermocouple or platinum resistance is sent to the data acquisition system through the program-controlled scanning switch. Using the serial port communication technology, the data information is read, analyzed, processed and stored by the computer.

F.Metering monitoring platform system

As shown in Figure 7,The measurement and monitoring platform system realizes the real-time data acquisition of electric parameters and temperature parameters based on data analysis, and can realize the data acquisition of AC voltage, AC current, electric energy, etc., and monitor the measurement data of the intelligent refrigerator detector[5].

Fig. 7. Metering monitoring platform system

The measurement and monitoring platform system will upload the data for processing, including error calculation, display, early warning, alarm, etc.

The measurement and monitoring platform is connected to the Internet in 4G mode, and the underlying data interaction protocol based on TCP/IP is directly connected to the cloud server. The collected data is received and processed by the front-end service integrated in the cloud server, and stored in the cloud database to ensure the continuity, accuracy and effectiveness of the data. The application layer platform adopts B/S architecture, the mainstream springboo framework, supports database cluster technology, and has the ability of big data analysis.

IV. TEST DATA ANALYSIS

This calibration method is used to calibrate the dynamic line of refrigerator wireless intelligent detection line in a refrigerator manufacturer.

Table 3. Experimental data

AC power			Temperature channel T1		
Display value	actual value	*U* (*k*=2)	Display value	Actual value	*U*(*k*=2)
0.499 W	0.501W	0.003W	-30.0℃	29.8℃	0.2℃
4.98W	5.01 W	0.02W	-10.0℃	-9.9℃	0.2℃
14.97W	14.99 W	0.02W	0.0℃	0.1℃	0.2℃
49.98W	50.03 W	0.05W	10.0℃	9.9℃	0.2℃
200.1 W	200.3W	0.2W	30.0℃	29.9℃	0.2℃
499.8 W	500.2W	0.5W	/	/	/

Refrigerator intelligent detector model:KF2010-X1.Maximum allowable error: ±1%. Table 3 shows the test data of the power parameters of the dynamic line and the temperature parameters of the temperature channel T1 of the refrigerator wireless intelligent detection line.

According to the test results, the calibration method can meet the requirements of dynamic line quantity traceability of refrigerator wireless intelligent detection line.

The uncertainty of AC power mainly comes from the standard uncertainty components introduced by the maximum allowable error of the electrical parameter measuring instrument, the maximum allowable error of the AC regulated power supply, the measurement repeatability of the tested intelligent detector and other factors[6].

The uncertainty of temperature parameters is mainly derived from the standard uncertainty component introduced by the maximum allowable error of the second-class standard platinum resistance, the uniformity and fluctuation of the temperature field in the constant temperature tank, and the measurement repeatability of the temperature indicator and controller.

V. CONCLUSION

In this paper, through the research on the on-line calibration method of refrigerator intelligent detection line, we have established the on-line measurement calibration device of refrigerator intelligent detection line.

After many field tests and analysis of test data, it shows that the design scheme in this paper meets the online real-time measurement and calibration of the refrigerator wireless intelligent detection line (dynamic line and static line) of a refrigerator manufacturer, and solves the problem of quantity traceability of the enterprise refrigerator intelligent detector.

REFERENCES

[1] Xia Enpin,Qi Xin, "Research on standard of free embeddedstandard refrigerator",China standardization, vol.577,No.2,Feb. 2021,pp.77-80.

[2] Zhang Sen,Sui Feng, "Development of temperature calibration device with fixed-point method", Chemometrics, vol.28, No.4, Jul. 2019, pp.107-110.

[3] Zhang Xiaobin,"Study on constant power AC Electronic load", Power Electronics, vol.44,No.1,Jan. 2010, pp.81-83.

[4] Hao Zhikun, "Research on AC electronic load calibration technology", Journal of Astronautic Metrology and Measurement,vol.37,No.4,Aug. 2017 ,pp.54-60.

[5] Liu Deliang, Wei Guangjun, "Research on ignition time measurement of a missile based on FPGA", Computer measurement and control,vol.19,No.6, Dec. 2011,pp.1394-1396.

[6] Liu Fang,Tian MingXing, "Research on three-phase electronic load simulator", High Voltage Apparatus, vol.46,No.8,Aug. 2010,pp.22-25.