

Interactive Terminal Technology for Safety Detection of Chemical Boilers

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The technology of interactive acquisition terminal for boiler remote monitoring is discussed. Utilizing information acquisition technology and communication transmission technology, the boiler remote monitoring terminal is optimized, which is interactive, real-time and feedback, and well coupled with the boiler remote monitoring system. At the same time, the terminal evaluates the operation status of the boiler through the detection of the boiler parameters (temperature, height, air pressure) and compares with the preset parameters to determine whether the early warning should be carried out. The results show that, compared with traditional terminals, the optimized acquisition terminal can wake up in time, signal pathways are diverse, and the boiler status can be calculated and judged online. At the same time, the acquisition terminal occupies a small amount of system resources, so the operation speed is due to the traditional terminal. Therefore, the acquisition terminal can send the boiler information to the system better, faster and more accurately, and effectively evaluate the boiler status through feedback information.

1. Introduction

Boilers are widely used in modern industrial production, where they primarily respond to energy conversion. However unfortunately, the boiler pertains to an energy-extensive type, and is subjected to various factors. There is still a big gap needed to be filled in the energy efficiency. Once the worker fails to operate it in accordance with prescribed procedure, it is very likely that an accident will occur. For this purpose, the safe operation and management of industrial boilers deserve to be studied intensively. In general, industrial companies will improve the safety of boiler operation by installing the additional sensors and monitoring systems, but fewer can configure a field monitor instrument with multiple functions where some parameters are displayed intuitively. In the absence of it, this makes it difficult for managers to timely understand the working conditions of the boiler, in the other ways, which will pull down the thermal efficiency.

For this purpose, the remote surveillance technology developed based on the web-based and the Internet of Things technologies can effectively meet this challenge. It timely acquires various operating parameters via the sensors and data network, and displays the real-time status parameters of boilers for the field firemen with the interactive human-machine interface, including the advice about boiler safety and energy efficiency operations, all of which will be sent to the remote surveillance platform after programming using the information technology code.

2. Literature review

Interactive acquisition terminals are widely used in various fields, and in recent years more and more people from all walks of life in China pay attention to them. Information and Communication Technology (ICT) has improved education widely in China, transforming traditional teaching into an interactive one. A new evaluation model is built to measure teaching efficiency in an "ICT-enabled classroom", an evaluation model named "TPOCME Deep classroom" is designed through ongoing five iterations. It includes six dimensions, which are higher-order thinking, classroom participation, openness of educational system, cooperative learning, meaningful learning and effectiveness of technology use (named TPOCME). This model helps educational researchers and teachers gain a comprehensive understanding of ICT in education (Li et al., 2018). To study

a bibliography acquisition approach to verify the bibliography from the integrated system and the metadata from the digital object identifier (DOI) content negotiation proxy, a framework using DOI content negotiation proxy is developed as context for the entering of the bibliography. Then, to simplify the service interface and support many kinds of bibliographic formats, the independent BibModel and its template-based model transformation engine are presented to support rich bibliographic records (Ma and Yang, 2014). Cloud-based video solutions are proposed to meet many technical challenges in the real world. However, the data security is a vital problem, especially about video data. Therefore, to ensure the data security, an architecture is proposed to mine the huge amount 3D video data and a model, called Key Encryption Model, is designed to protect the privacy video data. The result proves that transmitting the encrypted video is feasible and the outlook in this field is also pointed out (Xu et al., 2015). A system called supply-chain pedigree interactive dynamic explore (SPIDER) is proposed as a platform for the public and governments to explore the information in each part of the food chain and provide easy implementation of HACCP into the food industry. SPIDER is a secure and global platform to verify, inspect and investigate food effectively and efficiently. In this system, some artificial intelligent techniques, case-based reasoning, rule-based reasoning, fuzzy logical and neural network are used for automatic updating, to analyze data and to manage data. Finally, a simulated case is also studied to show the operation and the results of the system (Wang et al., 2013).

In foreign countries, it also attracts great attention from scholars from all aspects. To develop an advanced monitoring system, an attempt is made by using Interactive Graphical Supervisory Control and Data Acquisition (SCADA) System (IGSS) software and Programmable Logic Controller (PLC) which integrate with a fertigation system to solve the problem. The results show that the project is able to control and supervise the fertigation system prototype process smoothly and the project operates in two conditions which indicate the water level in tank and detect the humidity in the soil, thus the user can supervise their plant without perforce to the site of planting area (Fauzi et al., 2016). In order to efficiently collect the interactive computer music data, how existing musical analysis methods can be converted into generative compositional tools that allow composers to generate musical structures in real time is described. Moreover, a compositional method based on generative grammars is put forward and the development of a compositional tool for real-time generation of Klumpenhouwer networks is described (Neuman, 2014). A model is designed to help sales representatives acquire customers in a business-to-business environment. Sales representatives are often overwhelmed by available information, so they use arbitrary rules to select leads to pursue. Preliminary tests are also made to test the quality of the model proposed and the results show that the model has rather good quality. It has two theoretical contributions: a standardized version of the customer acquisition framework is provided, and second, the iterative aspects of this process are pointed out (D'Haen and Van den Poel, 2013). Although many innovations exploiting web technologies have been suggested in distance higher education, very little original research exists investigating the impact of web - based learning environments on distance students' learning processes and outcomes. To close this gap, four sets of data have been collected in a distance - learning course: behaviour and usage data derived from the log files of an online learning environment; responses from a competence pre - and posttest that measures the competence gain of online and offline students; technology assessment data from the online students capturing their perception of the learning environment; and formal assessment data acquired from a written examination test. By analysing these data, insight into the effectiveness of online learning material compared with custom - designed textbooks for self - controlled distance study can be gained. Distance educators and open or distance universities may take the analysis results as a basis for the decision whether to migrate from textbooks to online learning materials (Krämer et al., 2015). To evaluate the effect of a robotic animal on behavioural and psychological symptoms of dementia in people with dementia living in long-term aged care, a sample of 380 adults with a diagnosis of dementia, aged 60 years or older living in one of the participating facilities will be recruited. Video data are analysed using Noldus XT Pocket Observer; descriptive statistics are used for participants' demographics and outcome measures; cluster and individual level are analysed to test all hypotheses and Generalised Linear Models for cluster level and Generalised Estimation Equations and/or Multi-level Modeling for individual level data (Moyle et al., 2015). Aiming at investigating the relevance, the needs and the implications of the data acquisition process by combining a focused review with an original research study, five categories of methodological approaches adopted for policy evaluation purposes with an explicit focus on the stated preference method given its behavioural peculiarity and robustness are critically compared. Stakeholder-specific data acquisition translates into the creation of multiple experimental designs, explicitly conceived for each stakeholder considered. A case study, intended to compare two alternative strategies for data acquisition, is analysed, which provides a quantitative measure of potential distortions in policy evaluation due to the adoption of a stakeholder-generic approach. The results show that a stakeholder-specific approach is needed not only when modelling but also in the data acquisition process (Gatta and Marcucci, 2016).

To sum up, the interactive acquisition terminals has been studied broadly. However, its application in boiler remote monitoring is not discussed. Therefore, based on the above findings, the application of interactive acquisition terminal technology in boiler remote monitoring is discussed.

3. Principle and method

The Web, also known as the World Wide Web (WWW), is an information service under the B/S framework provided by the Internet. It has many technical specifications and enables multifarious design technologies, such as HTML, scripts, and URLs, in which programmers can process data and write the code on applications. The Web-based technology integrates with advanced communication interface and data interaction technologies in the industrial field to allow managers to access relevant information and real-time operation status of industrial equipment at a remote terminal, based on processing data with multiple analysis modules in the system. With this system, the user can log in and access, manage, operate the information on the UI interface of the information platform via the browser.

The data acquisition terminal, as a conversion hub for signal acquisition and transmission of remote supervision system in the boiler, enables the acquisition, far East Tone and live set. On this basis, an interactive data acquisition terminal is then developed with extended functions such as field collection, remote transmission, animation education and knowledge inquiry. The firemen can have in hand to know well the real operating conditions of the boiler.

The interactive data acquisition terminal not only enables the field collection and remote transmission functions as the traditional equipment has, that is to say, it can transmit realtime data to the remote monitoring center where the managers can effectively oversight whether the boiler works normally. It also spports the human-computer interaction, that is, to display live animations, real-time curves, alarm reminders, operational knowledge and instructional videos as it has supervised. The configuration software of the collector used in this system is shown in Figure 1.

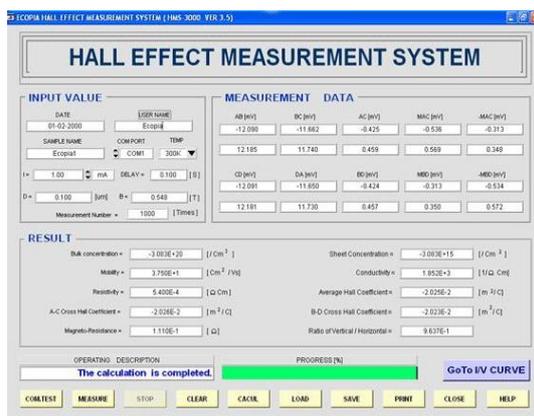


Figure 1: Configuration software for the collector device

The traditional interactive acquisition terminal consists of touch screen, industrial personal computer, power pack, PLC pack, communication device, terminal strip and power meter, etc., see Figure 2 for its framework. (1) The touch screen is 482.6 LCD TFT module, a resistive pressure type, with the resolution 4096*4096, and 35 million single touches. (2) The IPC is 1G DDR2 memory/160G hard disk, resistant to shock and vibration, and works stably at a high temperature. The operating system is WIN XP/WIN 2000/WIN 7. (3) The power pack is used to switch over the power source and supply power to the components at the terminal, including the bus switch, fuse, 24V and 12V power inverter. Among them, the fuse is used to cut off the fault circuit to protect the terminal against failure; the power inverter is used to switch 220V AC mode to 12V or 24V power supply, and supply power to the terminal components. (4) PLC pack is used to aggregate, encode and compute various types of signals, including temperature, analog, PLC host, switch and communication modules. Among them, the temperature module reserves 2 groups of 16 channels; the analog module reserves 6 channels; the switch module reserves 16 channels; there is 1 standard Ethernet communication interface. It can access to the external communication device via a Modbus communication protocol. (5) Communication devices are used for signal transmission, including DTUs, routers, etc. The specific circuit flow direction: the bus switch is energized and then connected to the AC/DC power inverter via the fuse. AC/DC power inverter converts AC power into 12V, 24V DC power sources to supplies power to various components

in the control cabinet. The power meter measures the real-time power consumption of the boiler; after each component is energized, signal acquisition, data transmission and human-computer interact with each other. The system uses the CAIMOREF GPRS FDTU module, see Table 1 for its hardware composition. The system adopts GPRS wireless communication mode to realize transparent transmission of data between the management platform and the collection terminal while monitoring, see Figure 3 for physical map of the CAIMOR GPRS DTU module.

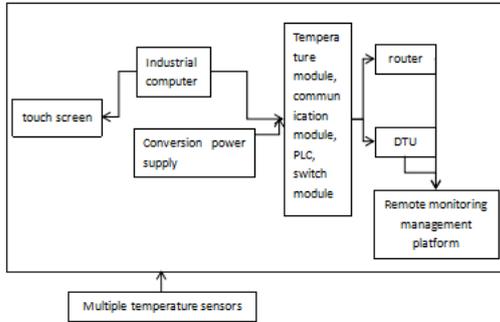


Figure 2: Structure design of traditional interactive acquisition terminal



Figure 3: Physical map of the CAIMORE GPRS DTU module

Table 1: Caim0ref gprsfdu module description

hardware	Description
ARM9 processor	MMU 200MPS memory management, 16KBDcache, 16KB lcache
SDRAM	32MB
FLASH	8MB
RS485 interface	
Control port	RS-232
Indicator light	Communication ACT, online online, power supply POWER
annex	Antenna, SIM card, power supply, voice interface, etc.

Flow of data signals: Signals such as temperature, pressure, flow and oxygen content collected by the field sensors are accessed to the terminal strip in the field control cabinet via the cables. Then, digital-to-analog signal conversion is performed via the PLC pack in the field control cabinet. A peripheral communication device transmits data to the Internet, so that data remote transmission is thereby implemented. The final online information is displayed on the touch screen via relevant software, thus implementing field supervision and human-computer interaction with the touch screen.

Portable interactive acquisition terminal consists of multi-function coulombmeter, routing inspection keypad, microprocessor, analog signal acquisition module, switch signal acquisition module, serial communication interface circuit, GPRS communication module, LED, data storage module, power supply module and the power source. This terminal structure is as shown in Figure 4 . The ARM microprocessor as a core control component of the system, uses a chip based on the ARM Cortex-M3 kernel. The analog signal acquisition

module adopts the 12-bit ADC integrated in the ARM microprocessor to implement a high-precision sampling with 16 channel analog data. Its function is to filter, isolate and amplify 4 ~20 mA input signals to avoid faults, distortion and interference possibly occurred during the transmission of acquisition signals. The switch signal acquisition module adopts the optocoupler isolation chip TLP181, and the isolated signals are directly accessed to the general I/O port of the ARM microprocessor to realize 16-channel switch signal sampling. It plays a function to safely isolate the switch signal as extracted. The multi-function coulombmeter is used to measure the total power consumption during the operation of boiler. It can send electrical parameter signals to peripherals via RS485 interface, for instance, real-time voltage, current, power, power factor. The data storage module uses a large-capacity SD card to facilitate the updating of the materials. The SD card is interfaced to the SPI of the ARM microprocessor via the SD card interface circuit. The touch display adopts a capacitive LCD touch screen as an integrated module connected with the ARM microprocessor via a general I/O interface, to timely display for firemen and perform human-computer interaction.

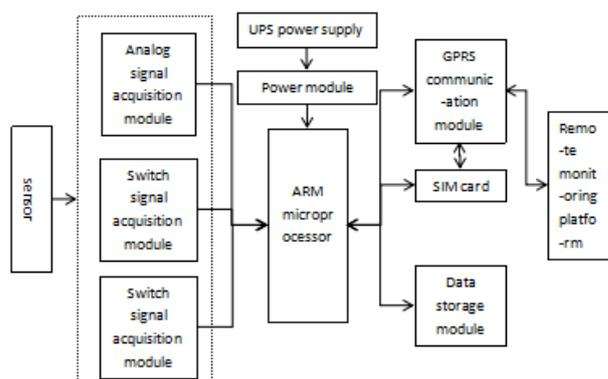


Figure 4: Portable interactive acquisition terminal structure

4. Results and analysis

Table 2: Comparison of technical performance of acquisition terminals

skills requirement	Traditional interaction	Portable interactive
Structural design	PLC and industrial computer are integrated in the control cabinet	Microprocessor constitutes integrated circuit board
Temperature acquisition channel	8	6
Pressure collection channel	1	1
Oxygen acquisition channel	1	1
Alternate channel	4	8
Switch signal acquisition channel	PLC and industrial computer	ARM microprocessor
Data acquisition and operation	PLC and industrial computer	ARM microprocessor
Data communication	broadband communication	Wireless communication
Data protocol	Wired communication	Wireless communication method
controlling software	Have	Have
Human interaction	No	Have
Online efficiency calculation	No	Have
Remote configuration	No	Remotely configure field collection terminal

The traditional interactive acquisition terminal mainly adopts external sensor, in conjunction with PLC and IPC, and integrates them into the control cabinet. Although the modular design and development cycle is short, the market compatibility is strong, and the maintenance is convenient, high cost, awkward configuration and the idle part of PLC control stump the marketing. The portable interactive acquisition terminal has rich interfaces, and features compact structure, high protection level, light weight and convenient installation, that is, it is convenient to be carried and installed in a wall-mounted mode, so that it is easy to marketing. As shown in Table 2, the performances of the two data acquisition terminals are compared. It is found that the portable interactive acquisition terminal integrates far more alternate channel for switch signal acquisition than the

traditional type, and can provide functions such as online efficiency computation, remote configuration, and the like.

5. Conclusion

As required by different functions, two types of acquisition terminals, the traditional and portable interactive types, that integrate field collection, remote transmission, animation education and knowledge inquiry are developed herein. They can not only send the operation parameters of tested boiler to the remote monitoring platform, but also interact with the firemen on the site, for example, the touch screen displays the measured parameters, troubleshooting and energy-saving operation guides to them, and with the human-computer interaction, it guides the firemen to effectively grasp the operating status, timely troubleshoot the operation failures, so as to make sure they will operate the boiler economically and safely.

The system can further integrate remote video surveillance technology, so that the monitoring platform can oversee various conditions of the operation in real time, thereby obtaining more useful information. It is also required to further analyze some features of other types of boilers in Wang industry (including fuel oil and gas fired boilers), and establish a remote supervision system for industrial boilers with a perfect system.

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