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Application of Virtual Instrument Technology in Condition-based Maintenance of Chemical Equipment

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This paper discusses the application of virtual instrument technology in condition-based maintenance of Chemical equipment, and provides technical support for power system automation. The status of Chemical equipment is analysed by virtual instrument technology, and the problems found are judged comprehensively to determine the fault point and location. At the same time, the condition monitoring system matched with virtual instrument is established to eliminate the faults more accurately and efficiently. The results show that virtual instrument technology can monitor the status of equipment in real time, determine the fault point effectively, predict the occurrence rate of the fault, and help the relevant personnel to repair. Therefore, virtual instrument technology has an objective application value in condition-based maintenance of Chemical equipment, reducing labour costs and equipment failure rate.

1. Introduction

The development of modern society requires more and more electricity, and the power system is developing towards large capacity, long distance and ultra-high voltage. Modern power system has many kinds of energy and complex network topology, which puts forward higher requirements for the safe and stable operation of power grid (Rozali et al., 2017; Zhang et al., 2017). The rapid development of information technology has put forward higher requirements for the operation status of the Chemical Equipment, so it’s also necessary to know the working status of the Chemical Equipment in time.
Therefore, in this paper, the online monitoring method of Chemical Equipment was analysed in a targeted manner, and combined with the importance of its CBM work, and the specific application of virtual instrument technology in the CBM of Chemical Equipment was also proposed, which provides the direction of automation development.

2. Literature review

The application of PC (personal computer) rapidly promote the innovation of test and measurement and automation instrument system, one of the most significant bit is the appearance and development of the concept of virtual instrument, a virtual instrument system is an industry standard computer or workstation with powerful application software, low cost of hardware (e.g., insert the card) and drive software, they together to complete the function of traditional instruments. Virtual instrument represents the fundamental change from traditional hardware - based measurement system to software - centered measurement system. Software-based measurement systems take full advantage of the powerful functions of computing, display and the Internet that are used to improve work efficiency. Virtual instrumentation technology is an instrument with visual interface based on computer by adding related hardware and software. It completely broke the traditional instruments can only be defined by the manufacturers, users can't change the situation, so that any user is flexible and convenient to use a mouse or soft key on the computer screen operation virtual instrument panel of "button" test work, and can according to the requirements of the different test through the window to switch different virtual instrument, or by modifying the software to change, increase or decrease the function of the virtual instrument system and scale. Virtual instrument has such advantages as "developability" and "expansibility", which make it have strong vitality.

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Virtual instrumentation technology was used to study the CBM crack monitoring system. The finite difference method was applied. Based on the three-dimensional geoelectric field of the vertical finite line source, the surface potential difference and the surface rupture anomaly range at different depths were calculated. The feasibility of the system was proven. The system exhibits satisfactory performance in coalbed methane wells in Jixian, Shanxi (Jia et al., 2015). Virtual instruments combine high-performance modular hardware with flexible software to perform a variety of experimental tasks. The research conducted sound field testing in the laboratory and built a dedicated platform for virtual instruments. Using the virtual instrument platform, the impedance characteristics of the transducer and the sound field of the phased array formed therefrom were measured. The results show that the mechanical positioning device can correctly locate the transducer and accurately control the excitation time of each transducer in phased array (Yao et al., 2016). A new test equipment setup and lab guidance was introduced to help students achieve these learning goals. The test equipment consists of two grain-oriented and non-grain-oriented electrical steel transformers, sensors, data acquisition boards, and PC-based virtual instruments (Martinez-Roman et al., 2014). A remotely operated high-voltage laboratory was established, the virtual instrumentation and information and communication technology (VI-ICT) facility, to increase student, researcher and industrial user interest in hands-on experiments on PD activity in high-voltage power equipment (Karmakar, 2017). The experiment was performed using an Endo-PaC (endoscope path controller).

The simulator incorporates a custom software animated path surgical scene that simulates the axes and handles of the steerable instrument. Performance was evaluated in terms of task completion time, path length of virtual instrument travel, motion smoothness, collision metrics, subjective workload, and personal preferences (Wang et al., 2015). Remote laboratories were increasingly used in the classroom to complement or replace hands-on labs. Therefore, it was very important to understand the value of learning. A repeated quantitative study was used to evaluate these resources. The teaching performance of virtual instrument systems in real-time remote laboratories was investigated (Garciazubia et al., 2017). Users of atomic force microscopy (AFM) often use the functions built into a single instrument to calibrate the spring constant of the cantilever beam. The study describes a virtual instrument for calibration of a cantilever beam of an atomic force microscope (Internet-based initiative). With this virtual instrument, users from all laboratories can immediately and quantitatively compare their calibration measurements to other calibration measurements (Sader et al., 2016). Tychkov et al. studied the development of a LabVIEW environment for a non-invasive arterial pressure virtual instrument. A virtual device was employed. The device mimics the operation of a non-invasive sphygmomanometer (Tychkov et al., 2015). A LabVIEW Virtual Instrument (PAC_Fit.vi) was developed to efficiently simulate and analyze probe proximity curve data from scanning electrochemical microscopy (SECM). The virtual instrument (VI) was available for free download and can be used to determine the absolute probe height above the substrate, measure the rate constant of irreversible electron transfer on the substrate, and perform a simulation of the SECM proximity curve. VI was applied to the analysis of the dynamic properties of an aluminum alloy (AA2024-T3) substrate immersed in an acidic solution. Among them, the activity of the substrate increases with time due to the dissolution of the passivation oxide layer. At approximately 1 hour of soaking time, a 40-fold increase in the apparent value of K was observed (Jensen and Tallman, 2013). Pitting corrosion, a type of local corrosion, causes premature failure of industrial equipment and fluid leakage through perforation (Martinez et al., 2014).

In summary, virtual instrument technology has obtained certain research and application in different fields of various industries. The study consists of two central parts. The first was the study of traditional methods and the formation of test pits, and the second was the development and application of virtual instruments. To quantify the pitting phenomenon, two alloys for aerospace were used: carbon steel UNS G1000 10 and aluminium alloy UNS A96061. Part VI was developed on the LabVIEW 2010 software using a graphical system design approach. The image acquisition library was applied to analyze plaques equivalent to pits. Therefore, virtual instrument technology was applied to the overhaul of the state of the Chemical Equipment. It provides technical support for power system automation.

3. Methods

The Chemical automation system is developed on the basis of computer technology and network communication technology. The secondary equipment for protection, control, measurement and monitoring, which was originally separated in the Chemical, constitutes a monitoring system through the communication network to complete the automatic operation of the Chemical. On-line monitoring of power system equipment is a multi-directional, multi-point measurement complex system that includes not only the measurement of basic electrical quantities such as voltage, current, frequency, power, phase angle, etc., but also that of many non-electrical quantities such as temperature, pressure, vibration, etc., then data is analysed, compared, and judged to form the final decision.

3.1 Monitoring system design

Chemical is a whole for the unified coordination of a variety of equipment. Generally, various separated power devices include power transformers, circuit breakers, current transformers, voltage transformers, power cables, reactors, disconnectors, and lightning arresters. Therefore, many parameters need to be monitored, as shown in Figure1 and 2.

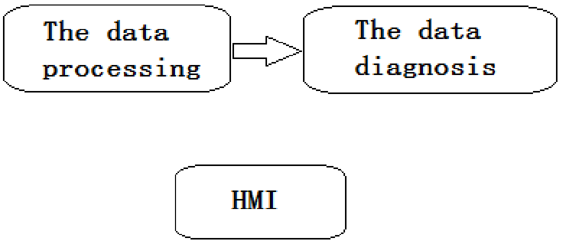

Figure 1: Processing decision system

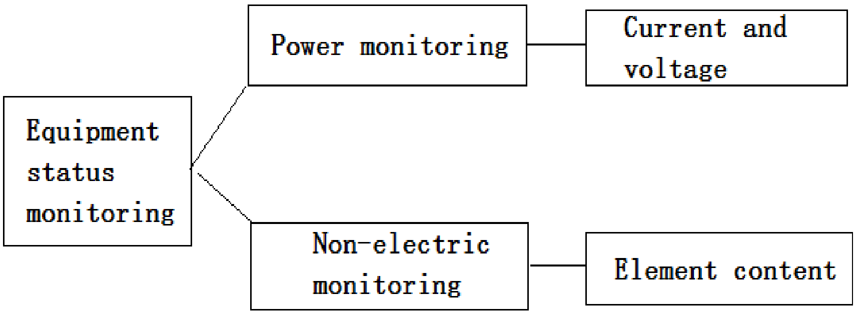

Figure 2: Power equipment monitoring parameters

The overall design of the online monitoring system can be divided into multiple units according to the actual equipment situation of the Chemical. For example, a multi-circuit Chemical can divide all equipment to be monitored on each line feeder into one unit. Each monitoring unit transmits information to the main control unit of monitoring system through an information processing module with an Ethernet interface and the Ethernet switch; then, the main control unit combines the database and the expert system to complete the operation of each monitoring parameter, and infers that the health status of operating device, which in turn, provides the basis for the maintenance decision system. Considering the anti-jamming and insulation of the signals, the data transmission between the monitoring units and the information fusion module in the design uses the optical fibre as the transmission medium. Thus, the information processing module in each monitoring unit also includes a photoelectric conversion circuit, which is responsible for converting the electrical signal into an optical signal and transmitting the information to the information fusion module.

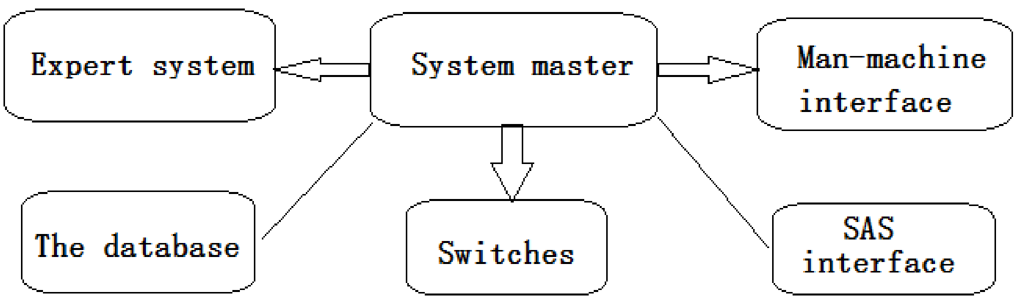

Figure 3: Online monitoring system

3.2 Information processing module

The function diagram of the information processing module is shown in Figure4.

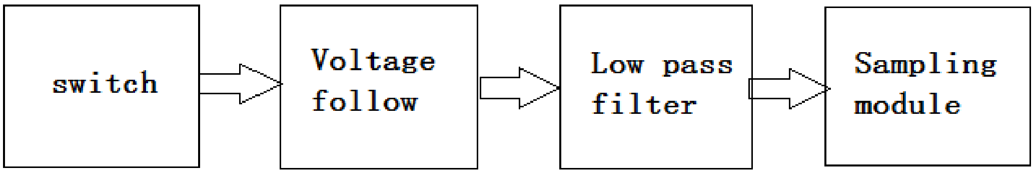

Figure 4: Monitoring unit information processing module function

Taking the monitoring parameters of the circuit breaker as an example, the signal processing module will receive the gas pressure, ambient temperature, gas humidity, coil current, breaking current, opening coil current, closing coil current, vibration, and starting position of various sensors, the number of breaking times and other power parameter signals. The information processing module can also receive signals such as pulse quantity and switch position, which are collected by the switch quantity acquisition module and transmitted by the optical fibre to the information fusion module via the optical fibre conversion interface.

3.3 System functions

The CBM of Chemical Equipment and related software is a relatively complicated system. Due to limited experimental conditions, the design of the entire system has not been implemented for field testing, but only partially realized under laboratory conditions. These include a sampling processing module of the monitoring unit, a communication interface information fusion module for data exchange, and a software system. It can complete the signal acquisition in the field, the synchronization of each monitoring unit and information fusion module, and the package transmission of sampling data etc. The main control computer realizes the acquisition of the field data and the output to the Chemical automation system through the Ethernet. At the same time, it can also achieve the implementation of the online monitoring minimum system through the Ethernet switch for the main practical functions that each module needs to complete.

3.4 System software design

The main control program is designed based on virtual technology, including the graphical operation main interface of the online monitoring system, expert system, database management, receiving and processing of field data, and communication with the remote-control centre. LabVIEW, one of the development tools for virtual instrument technology, is a graphical programming language and an industry standard graphical programming tool. Virtual instrument technology uses a combination of computer technology, intelligent test systems, and digital signal processing technology etc.

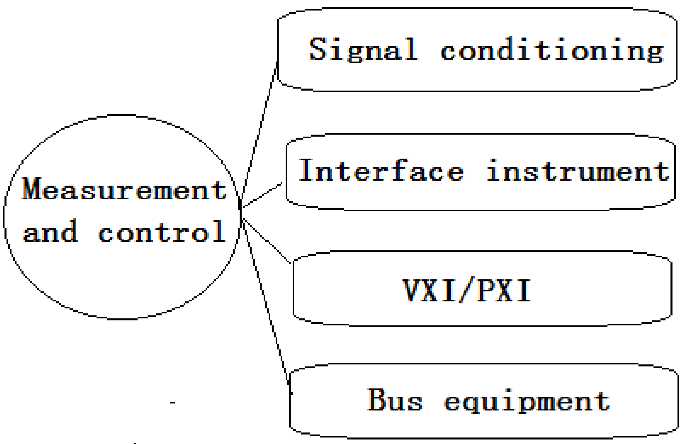

Figure 5: Virtual instrument system structure chart

The computer resources and hardware resources to perform specific functions are combined by software to integrate the powerful data processing capabilities of the computer with the measurement and control capabilities of the instrument hardware. The essence of virtual instrument is the deep integration of traditional instrument hardware and the latest computer software technology. It is an important technology in the field of computer-aided testing today. Its purpose is to realize and extend the functions of traditional instruments. In a virtual instrument system, the hardware is only to solve the signal input and output. Figure5 shows its system composition.
The typical hardware structure based on test system of virtual instrument is shown in Figure6. The sensor completes the conversion of the measured non-electricity signal, and after signal conditioning amplification, filtering, excitation, isolation, etc., the data acquisition card completes the A/D conversion of the signal; then, the signal processing and mathematical operation software package provided by the software is used for targeted processing

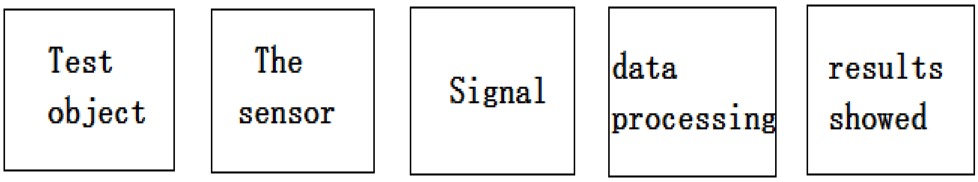

Figure 6: Virtual instrument hardware structure

3.5 Collaboration between the main control unit and the application layer of the on-site embedded measurement and control unit

The on-site monitoring unit and the main control unit are a unified whole, and the hardware is independent from each other, which is interconnected at the application layer and collaborated to complete related functions through the network information exchange. Both of them firstly complete self-test after start-up, and then the main controller sends a query signal, establishes a link connection through a handshake mechanism, and completes initialization coordination; finally, data transmission is performed. In the practice of measurement and control engineering, one of the most important advantages is the What You See Is What You Get (WYSIWYG) of interface editing. The front panel contains a large number of realistic controls, and users can also create custom controls. The window form of the front panel can also be displayed in different ways to meet different needs.

4. Results and analysis

The results show that based on virtual instrument technology and embedded technology, the distributed Chemical online monitoring system was studied, and the unified modelling idea of the online monitoring system for Chemical Equipment was proposed. Taking the information fusion unit in the online monitoring system of Chemical Equipment as an example, it indicates that CBM is the development trend of equipment maintenance. Online monitoring of equipment is an important basis for maintenance decision-making. Distributed online monitoring system with all equipment in Chemical as monitoring object has become one of the research directions. In addition, the possibility of applying virtual instrument technology in the online monitoring system of power equipment was also analysed. The graphical programming language was used to develop the online monitoring system master control software system, including database, expert system, communication management, and graphical monitoring operation interface. Partial implementation of the online monitoring system was performed. After the verification test under laboratory conditions, the results prove that it has a stable application value for further promotion in the future work.

5. Conclusions

In recent years, with the application of new sensing technologies, and the development of different technologies such as computer technology, communication network technology, artificial intelligence technology, etc., the condition monitoring and diagnosis of high-voltage equipment has made great progress. More online monitoring systems have been used on site. Intelligent primary equipment with communication capabilities is a key device in digital Chemicals, also called as digital process layer equipment. The operation of digital equipment will definitely have a profound impact on the development of online monitoring of Chemical Equipment today. This paper is also based on virtual instrument technology and embedded systems, focusing on the distributed online monitoring system of the entire Chemical Equipment, and strives to make breakthroughs in the future work in order to improve the efficiency of the Chemical.

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