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Remote Monitoring System Based on GPRS Technique for Polymerizer

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Abstract: In order to the make the production of PVC safety and efficiency, a remote monitoring system based on GPRS technique for PVC polymerizer was introduced in this paper, the overall structure of the device was designed, and the dissertation presented a new communication protocol of the communications terminal, monitoring center, and client-side based on CDT communication convention and polling communication convention, the advantages of which are integrated and disadvantages improved and in the design of monitoring and management system, using the structs+spring+hibernate architecture develop remote monitoring software, realized the real-time data display, remote control, historical data query, and other functions. Thus efficient and reliable data transmission was achieved, the remote dynamic monitoring on the real-time operation date and faults for different sets of PVC polymerizers was also realized. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Polymerizer, GPRS, Remote monitoring, Communication protocol, SSH (structs+spring+hibernate).

1. Introduction

In recent years, PVC industry develops rapidly in China, it is the most considerable work to maintain the stable operation and full capacity of polymerizer which play a very important role in PVC polymerization process. In order resolve this enterprise safety operation and environmental protection issues, the PVC need to be monitored. 60 % of operation problems can be resolved through the remote service which reduce the workload of field service for engineer in actual production, and the remote service system were cut by 20 % which has video output and by 10 % which has additional sensor [1].

A new type of mobile packet data bearer service (GPRS) based on GSM began to develop recently. It provides a way of linking between mobile subscribers and data networking technologies, then command and feedback information via Internet/GPRS in the form of IP packet, and realizes remote monitoring of the terminal equipment [2]. Compared to GSM, it has lower connection fee and higher resource utilization rate, higher transmission rate and shorter access time, and provides the technical support for polymerizer remote monitoring [3].

In this paper, the advanced GPRS wireless network communication was applied to the Polymerization kettle remote monitoring system, in the monitoring and monitored and controlling from monitoring center to polymerization reactor parameters (such as stir current, agitation speed, Mechanical seal temperature and so on) the C/S mode was used, that it can diagnose the faults for boiler accurately and timely. New tripartite communication protocol was proposed, the Information Interaction of client, the monitoring center and polymerization kettle was realized, it possesses advantages of both CDT communication

convention and polling communication convention, while avoid their shortcomings. in the design of monitoring and management system, using the structs+spring+hibernate architecture develop remote monitoring software, realized the real-time data display, remote control, historical data query, and other functions then the data of PVC polymerizer performance can be more accurate, timely, transparent, real-time remote monitoring can be more convenient and effective.

2. Overall Construction

The system consists of three parts: testing instrument of PVC, GPRS network, DTU data transmission equipment which Connects to a wireless network, monitoring center. Monitoring management center is divided into communication server, database server, and Web/application server, as shown in Fig. 1. The spot parameter acquisition module (lower computers) is mainly responsible for data collection, it can connection to DTU through RS232 (recommend standard 232, serial physical interface standard). DTU module in embedded wireless GPRS communication module and TCP/IP (Transmission Control Protocol/Internet Protocol) Protocol stack, it uses transparent transmission mode, which is equivalent to a Convertor between serial data stream and TCP/IP protocol. DTU communication server is equivalent to an information transfer station, it can perform duplex communication with Web/application server and database server. It has certain data processing ability as well. Web/application server is responsible for receiving and response from the terminal's request, at the same time provide the data query and treatment processing function for the system. Monitoring management terminal (namely Browser) is a system user oriented window, it can provide all kinds of monitoring implementation of the operation, management operation, related data query, statistical analysis and the man-machine interface of generate statistics analysis chart operation for maintenance operation personnel.

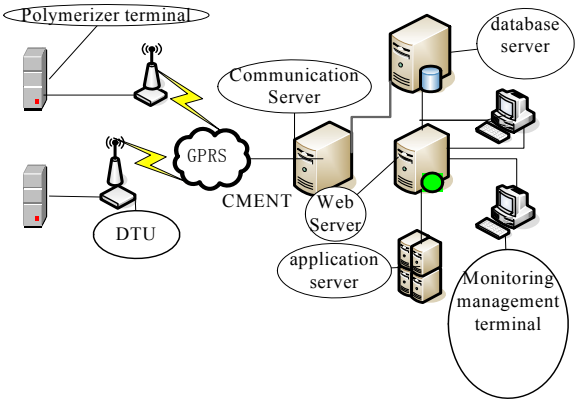


Fig. 1. Total structure of system.

3. The Data Flow of Remote Monitor System

Fig. 2 is the data flow diagram remote of monitoring system, Specific data flow is as follows:

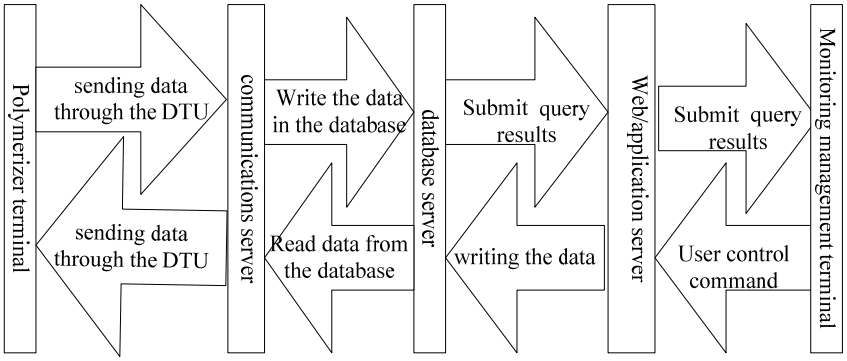


Fig. 2. Date flow.

1) The collected data which include equipment status information and monitor real-time data from Polymerization kettle sent to the communication server by DTU every half an hour. These data include polymerizer agitation current, stirring speed, mechanical seal temperature, mechanical seal pressure, Mechanical seal oil liquid level alarm, polymerization kettle operating pressure, polymerization kettle operating temperature, polymerization kettle reducer vibration value, reducer temperature, the motor temperature, bearing temperature, monitoring time and so on. Communication server received data from the polymerizer terminal, process it and then write the corresponding database data in the table.

2) DTU communication server timing read and remove the database control command and data table Settings. Then the server send the data which did not handled to the corresponding field data acquisition module, timely control field equipment.

3) Web application server read the alarm data table of the database according to the set time, and then sent alarm data which has not dealing with immediately to the monitoring management terminal, inform the related personnel at the same time.

4) In the monitoring management terminal, the staff connect Web application server at the browser mode, and release query and control command. Server analyze data the accepted orders is, then perform the corresponding operation, such as reading and writing database, processing formation data, etc.

4. Design and Implementation of Every Module in the System.

4.1. DTU Data Transmission Unit

DTU namely data transmission unit, which is equivalent to a converter between serial data stream and TCP/IP protocol conversion. It embedded wireless GPRS communication module and TCP/IP protocol stack and uses transparent transmission.

In this system, the diagram of DTU hardware block as shown in Fig. 3.

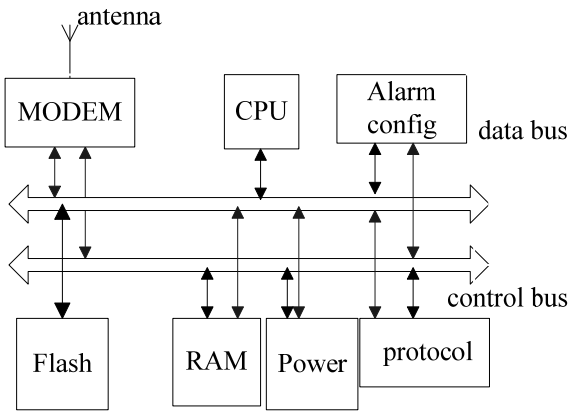


Fig. 3. Hardware schematics of DTU.

The main hardware chip: CPU uses ARM S3CA510B, communication module uses MC35 (Siemens GPRS Modem), it is a GPRS wireless communication module which Siemens company produces. With double frequency EGSM900 and GSM1800 (GSM Phase2 +), supports voice, data, short message, fax; the working current is only 360 mA, idle current for 15 mA for GPRS data transmission; the data upload speed can reach 21.4 kbps, download speed is as high as 85.6 kbps, the user can interact with MC35 for command and data through the AT command and MC35, MC35 connects with users through main and auxiliary channel of RS232. Its main advantage is the permanent online, fast data storage and faster data transmission speed. It is very suitable for polymerizer remote monitoring system whose real time data requirement is high and data transmission is big at the same time [4-6].

4.2. Communication Protocol

There is now a large number of communication protocol composed by many different standards organizations across the world and technology provider through years of technology evolution and development [7]. They can be divided to circulating protocol (CDT protocol) and called mode protocol (Polling protocol).

In called mode specification, the monitoring center as a host to subsite sends relevant instruction, the substation answers questions respectively. Its characteristic is subsite must answer every question when receiving related instruction from monitoring center and the answer must be within the prescribed time, or it is understood that the communication failure.

Circulating statute is a protocol which subsite must send spontaneous continuous cycle date of field state to master station. The substation take the initiative to send the data to master station is its characteristic. It needs to be planned data format, data format with control word and information word is send according to the time sequence, the monitoring center must be accepted passively. This causes some faults. Such as it must take point-to-point transmission way, take up too much communication channel, the upload speed of state date upload and so on [8-9].

In the polymerization kettle wireless remote monitoring, in the polymerization kettle wireless remote monitoring, a new kind of communication protocol which combines the beneficial qualities of both polling protocol and CDT protocol is custom, in order to make data transmit effectively and reliably, and at the same time make protocol simple as far as possible and reduce the cost of hardware equipment effectively. Frame format as shown in Table 1.

Table 1. Custom frame format.

Frame header	Address bit	Functional position	Data bits	CRC	BBH

1) The monitoring center and DTU.

Control protocol: this protocol is made of remote data frames belong to descending data frame and response data frames belong to ascending data frame. Remote data control polymerization kettle remotely, changing polymerizer the current operation state, open or closed, is its function. It can also change every polymerizer parameters and alarm threshold. In this frame, frame head is written $l, representing the frame is an independent data frame. Address bits have two bytes of hex number, function sits has a byte of hex number whose number value is 01H, data bits occupy uncertain bytes of hexadecimal,

included one or more order which can change the current operating state of the polymerization kettle. Response data frame format is similar to remote data frame, response data frame head is #1 in order to distinguish.

Stateful protocol: this protocol is made of State detection data frames belong to ascending data frame and response data frames belong to descending data frame.

State data frame is used to detect current running state of a polymerization reactor. function bit is one byte of hexadecimal, value is FFH, corresponding state detection function; data bits occupy uncertain bytes of hexadecimal, corresponding to the length of the package, the information type, time date, information type and other related information, its role is checking the time when remotely control and remotely sensing for polymerization kettle. The monitoring center modifies the database state table according to the values of the states.

Response data frame is used to response the remotely sensing orders when polymerizer terminal received, it collect polymerizer field operation status data through the acquisition equipment. Upload to the data frame of the monitoring center. Address bits is a byte of hexadecimal in the data frame, value is empty; function bits is a byte of hexadecimal, value is 02H, data bits occupy uncertain bytes of hexadecimal, including mechanical seal temperature, polymerization kettle operating pressure, etc.

Fault protocol: they are consisted of the fault data frames through monitoring terminal's active upload belong to the ascending data frames. It upload the fault information actively when polymerizer field equipment operation anomaly, address bit whose function is transmitting the data to monitoring center is a byte of hexadecimal in the data frame. Value is empty; function bits is a byte of hexadecimal, value is 03H, data bits occupy uncertain bytes of hexadecimal, including the ascending fault data (motor fault, mechanical seal failure, polymerization kettle operating pressure temperature fault, deceleration machine fault, bearing and fan fault).

2) The monitoring center and the client.

Control protocol: when managers trigger the operation interface the button which represents one operation object of PVC, it is equal to send a control command to the monitoring center. The command and the above control protocol is similar, the function instead of 04H.

State agreement: the monitoring center send back the state date to the client timely, make management personnel easy to check, if the monitoring center receive the state changes form polymerizer, it update information to the client timely, the function bit is 05H.

Up to now, the munication protocol of a polymerization reactor network remote monitoring system is formed basically, the three side information transfer and interactive of polymerization kettle, the monitoring center and the client is realized.

4.3. The Design and Implementation of Remote Monitoring System

When the polymerization kettle in all kinds of state data transmitted to the main monitoring station timely and accurately, it requires master monitoring station released. Classified, summary analyzed, data storied and carry out. So database system and Web/application server system mainly includes data management, management of field devices and the system user management, etc. Management information structure diagram is shown in Fig. 4.

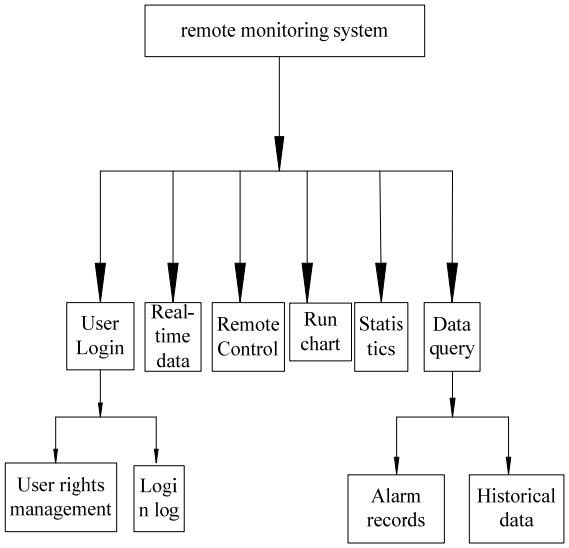


Fig. 4. Management information structure.

4.3.1. Database Design

Polymerizer remote monitoring system of database design 7 state data tables, including the SIM card information table, the user information table, monitoring information table, the alarm parameter table, the main menu table, and sub menu data table, it involves state data, mobile number, the default alert value, menus, task management, data and information which is the system needed. In the database each table should have correlation. In the data storage structure. Each data category in the data is corresponding to the ID of the alert table. In addition each of the data in the data table is sent by a DTU equipment. Therefore, it can judge the data came from according to SIM card number which is installed in DTU. And since each DTU SIM card number corresponds to one address, this address is corresponded to the address of the address table, so the data can be determined from the SIM card number. In system management storage structure, user information table (the user info) is given priority, the main menu table (menu) of the permissions corresponds to the table permissions of user information. The permissions of sub menu in table correspond to it table permissions of the main

menu, and MIDI in the submenu should be corresponded to the main menu. And then achieve a one-to-many relationship between menu and sub menu. So you can achieve user rights assignment and management user menu functions only through the user name.

4.3.2. Design and Implementation of System Function

Realizing the system function, firstly we must carry on the integration SSH framework, mainly including the integration of the Sping and hibernate, the main work is to modify the configuration file. In this we don't elaborate. then we introduces the realization process of WEB subsystem detailed according to the PO layer, DAO layer, business layer, the MVC layer, view layer (monitoring system interface) order.

PO is data persistence layer [9], each record in a database table is mapped into a objects of PO class through the object relational mapping. It is conducive to better handle in object-oriented programs. And each data table corresponding to the PO as follows, including a data table corresponding PO StatusData, the userinfo table corresponding userinfo of the PO class. The address table corresponding to the address of PO class, alarm table menu corresponding the alarm of PO class, menu table corresponding the menu of PO class, submenu table corresponding the submenu of PO class. After the Po class writing, you need to write a mapping file, which will map to the corresponding data sheet.

The DAO layer is a layer of data access object. It encapsulates to add, delete, change, check and other common operations of the business database, and it have transaction support to ensure the consistency of the data [10]. It simplifies the action part of the business processes. DAO including DAO component and DAO factory, every DAO components is usually responsible for a PO or a set of PO of database operations which is similar to business DAO components usually include interfaces and implementation classes. Add and delete to the database is defined in the interfaces, the method of implementation class implementing an interface definition of these methods. And DAO factory. It is to use the factory pattern to manage the DAO components through XML configuration. Spring put DAO components beans into corresponding business.

The business layer encapsulation corresponding DAO components according to the actual business logic. Business component is divided into function defined interfaces and implementation classes. By system design we can see that the documentation part of the sub function of WEB system is static WEB pages, no business logic. And real-time data, remote control, run chart, history inquiry, statistics. Are part of the business of operating state of polymerizer data, permissions belong to user permissions table of business operation, alarm processing business is need to query and manipulate more tables, the user's business and management. Then layer of the business includes StatusDataService, JurisdictService, AlarmService, below the UserService StatusDataService, and we introduce the steps to write business class for example.

1) Real-time data: it saved all kinds of monitoring parameters in the database in real time, including polymerization kettle stirring current, stirring speed, temperature, mechanical seal mechanical seal, mechanical seal liquid level alarm, gas station polymerizer operating pressure, polymerizer temperature operation, the polymerization kettle vibration value of the gearbox, reducer temperature. The motor temperature, bearing temperature, monitoring time and so on. When the form show all the latest data from point in order to make the managers see all kinds of state data of polymerizer as soon as possible, after the communication socket receive data, it judge the source of the packet that it come from measurement control subsystem or reply packet control operation, otherwise it is known as abnormal packets, it must be the exception handling. If it accept the subsystem of data packets and the various states of polymerizer packet, it will need to troubleshooting firstly, if discover the unusual, it need to store in the database after alarming, if there is no exception, the data is stored in the database directly, then state data is displayed on the screen. It here is some failure. Workstations were used respectively to light alarm and send SMS alarm to relevant people in two ways according to the data, when the system judge that the data beyond the range of set value which collection, it means that there is abnormal situation, the system Pop up corresponding box, and then the user can see real-time fault time and fault types from the popup alarm confirmation screen.

2) Remote control: each parameter Settings for polymerizer can be specified 1 and change through the remote control. All kinds of parameter of Polymerizer which are commonly used domain values are shown in Table 2 below. Modified field devices enable new parameters immediately. Without restarting. Fault diagnosis is coming out after receiving status and then it found fault occurs, The all kinds of fault condition of the polymerization kettle are shown in Table 3 below, management personnel control menu simply start-stop of related polymerizer valves by software after analysis which were through the corresponding failure number and failure indication.

3) Run chart: there is a large amount of data produced in the statistical analysis, but because sometimes the data state variation is not large. It will make managers seem inconvenient, in order to facilitate management, we need to turn this data into images to make workers intuitive understand intuitively.

4) Historical query: it needs to remove the data stored in the database table to query the historical

data. Query history mainly consists of two aspects, one is the normal data query, the other one is alarm information query.

5) Statistics: it generates monitoring data reports and comprehensive operation data report, and divided into daily, monthly, half a year and annual reports. Report format can be customized according to user requirements. It can preview and print directly.

Table 2. Polymerization reactor active domain values of the parameters.

Parameter Number	Parameter Name	Parameter Unit	Parameter Field Values
1	Stir Current	A	Max175
2	Stirring speed	r/min	98
3	Mechanical seal temperature	℃	≤80
4	Mechanical seal pressure	MPa	1.5
5	Mechanical seal petrol stations Level alarm	No	The fuel tank 1/3
6	Operating Pressure	MPa	1.3
7	Operating Temperature	℃	56±1
8	Reducer temperature	℃	40—80
9	Motor temperature	℃	40—80
10	Bearing temperature	℃	40—80
11	Monitoring time	min	30

Table 3. Fault Type.

Fault Number	Fault Name	Fault Code	Fault Phenomenon	Fault Cause
1	Motor failure	0100	Motor failure; Table failure	Stir current exceeds 75 A.
2	Mechanical seal failure	0010	Mechanical seal is broken	Mechanical seal temperature exceeds 80 ^{0}C.
3	Operating pressure and temperature fault	0001	Load increase, more materials	Polymerization reactor pressure exceeds 1.3 MPa.

6) User right: in order to guarantee the security of the system, we have to classify users who use the system. Each type of user login to the system can complete the operation of the corresponding permissions.

MVC layer mainly intercept user access request [11], it invoke the corresponding business layer according to the request, and finally the business processing result to the corresponding WEB presentation layer.

The view layer is responsible for collecting user request, and returns to the layer which has results of user request. We choose JSP page which is commonly used, and use the Struct tag library to display and collect data. In your JSP pages. Any form of Java code is prohibited generally, but it will include some function which is written by Javascript language, the Javascript function can validate the data on the client, and it can provide some other rich function which reduces the burden of the server. Main function module of the interface diagram as shown in the Fig. 5 - Fig. 9 below.

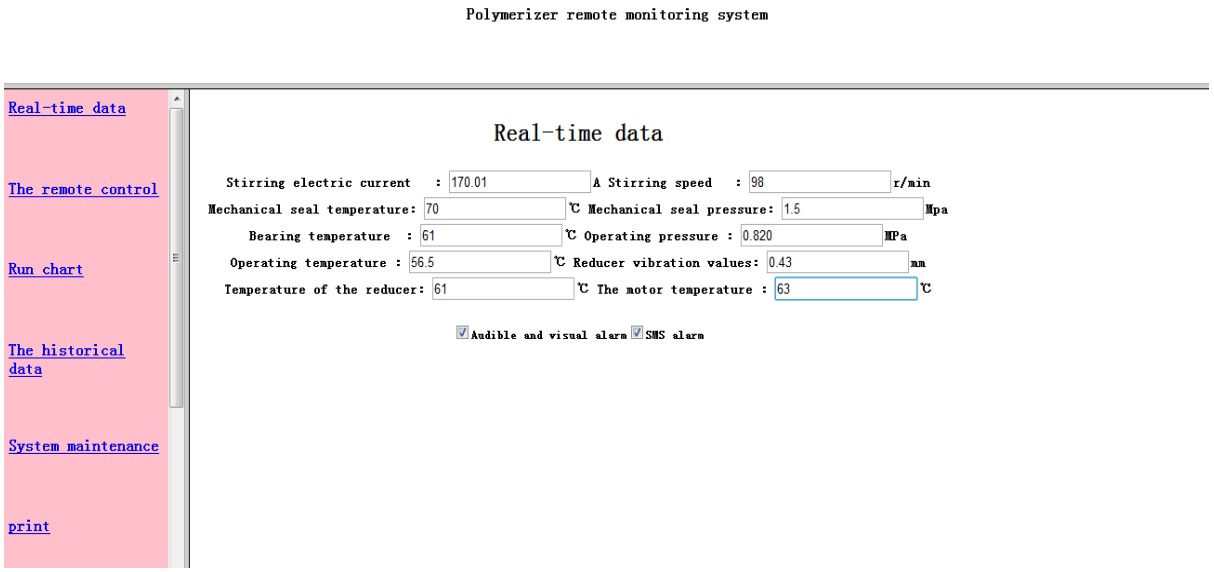


Fig. 5. Interface of real-time date.

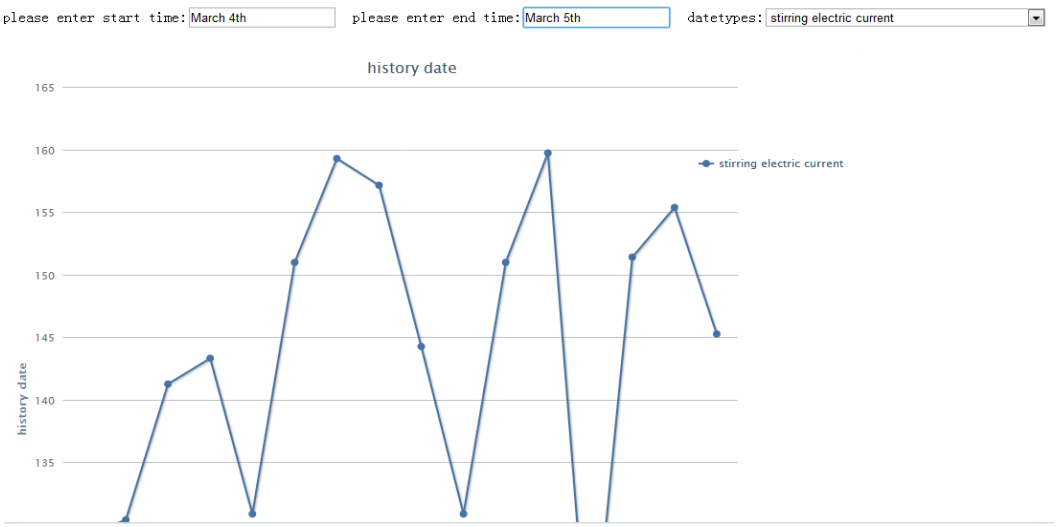


Fig. 6. Stirring current operation interface.

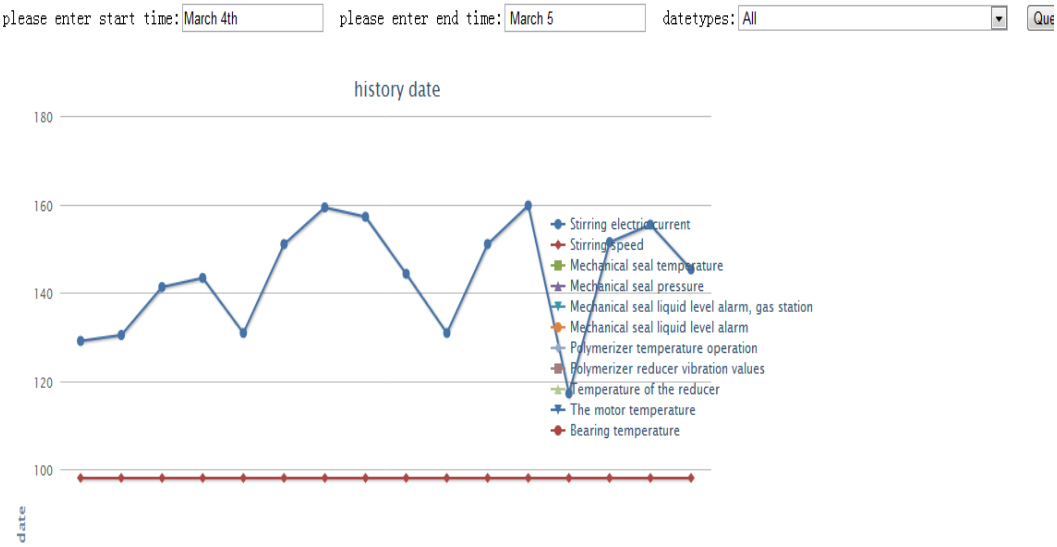


Fig. 7. All parameter variable operation interface A.

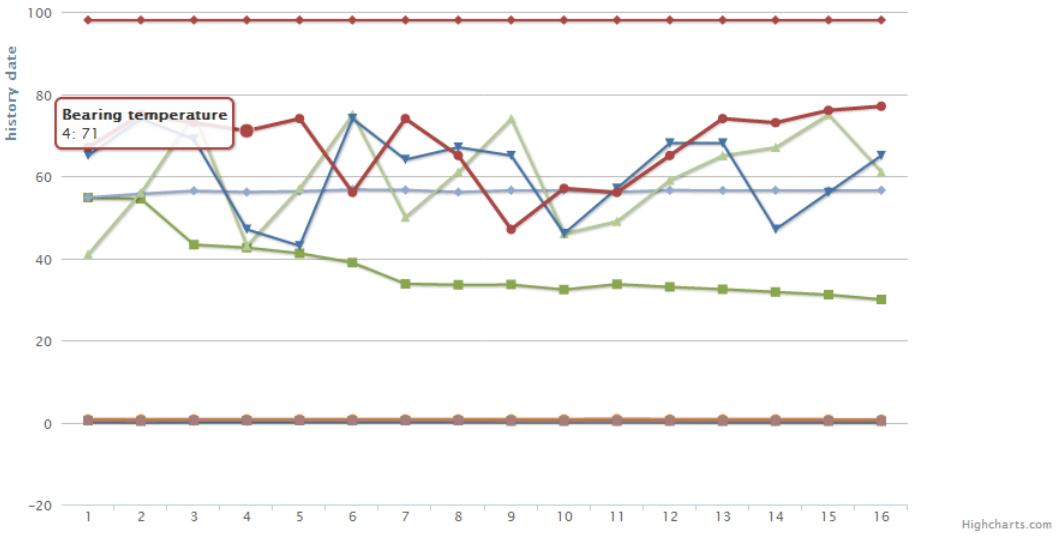
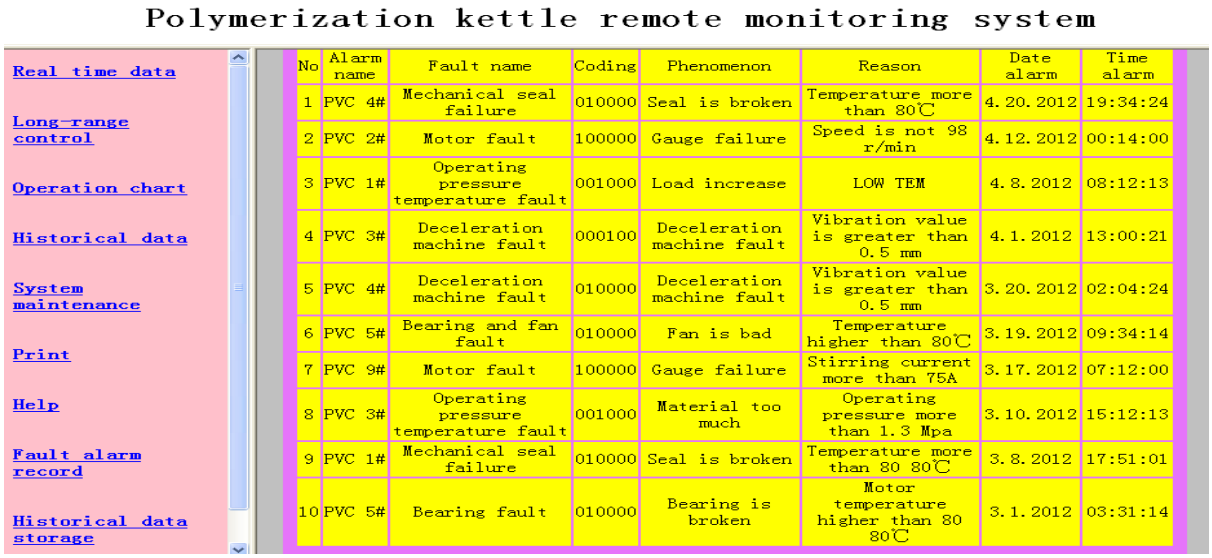


Fig. 8. All parameter variable operation interface B.



No	Alarm name	Fault name	Coding	Phenomenon	Reason	Date alarm	Time alarm
1	PVC 4#	Mechanical seal failure	010000	Seal is broken	Temperature more than 80℃	4.20.2012	19:34:24
2	PVC 2#	Motor fault	100000	Gauge failure	Speed is not 98 r/min	4.12.2012	00:14:00
3	PVC 1#	Operating pressure temperature fault	001000	Load increase	LOW TEM	4.8.2012	08:12:13
4	PVC 3#	Deceleration machine fault	000100	Deceleration machine fault	Vibration value is greater than 0.5 mm	4.1.2012	13:00:21
5	PVC 4#	Deceleration machine fault	010000	Deceleration machine fault	Vibration value is greater than 0.5 mm	3.20.2012	02:04:24
6	PVC 5#	Bearing and fan fault	010000	Fan is bad	Temperature higher than 80℃	3.19.2012	09:34:14
7	PVC 9#	Motor fault	100000	Gauge failure	Stirring current more than 75A	3.17.2012	07:12:00
8	PVC 3#	Operating pressure temperature fault	001000	Material too much	Operating pressure more than 1.3 Mpa	3.10.2012	15:12:13
9	PVC 1#	Mechanical seal failure	010000	Seal is broken	Temperature more than 80 80℃	3.8.2012	17:51:01
10	PVC 5#	Bearing fault	010000	Bearing is broken	Motor temperature higher than 80 80℃	3.1.2012	03:31:14

Fig. 9. Interface of fault alarm record.

5. Conclusions

For polymerizer industrial background and special needs, we blend in advanced wireless communication to the polymerizer remote monitoring, the overall structure and function of system is designed. The center and the monitoring center communication protocol are designed mainly. And the design of information management system based on SSH framework implementation is completed. Then the fault diagnosis system can be more convenient and accurate, it ensures the safe and stable operation of equipment, and it can meet the actual requirements.

Acknowledgment

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