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Design and Implementation of Computer Aided Chemical Laboratory Control System

Jieshu Gao[a], Huachen Gao[b*]

[a]Yingkou Institute of Technology, Yingkou115000, China
[b]Shenyang Normal University, Shenyang110034, China
GaoHC516@163.com

The computer information technology continues to go deep into the chemical industry, which has brought convenience to the design, transformation and production control of the chemical industry. Thus a simple and effective system is urgently needed to maintain the information management of the chemical industry, so as to improve the efficiency of the experimental equipment and reduce the equipment loss. This paper analyzes the requirement of the computer control system of the chemical industry, undertakes the overall design of the control system with the centrifugal pump in the chemical laboratory of the scientific research institute as an example, and establishes a standardized and modern computer process control system for comprehensive chemical industry, including the storage and modification of centrifugal pump type information and centrifugal pump data information, which significantly improves the experimental efficiency and reduces the experimental loss.

1. Introduction

With continuous research and design, process modification, production control, plan optimization and supply chain optimization, the computer process control technology has been further widely used (Szilvási et al., 2017). The chemical industry is inseparable from computer information technology. After the combination of advanced process control technology and computer information technology in chemical industry, chemical data and real-time images can be integrated (Abilov et al., 1997). With more accurate maintenance and operation over the chemical industry, the computer control system improves the equipment efficiency, and saves the manpower and material resources (Petraglia et al., 2016). This is also very important for a chemical laboratory in a scientific research institute (Kimber et al., 2011).

By embedding the computer control system into the chemical laboratory, the visualized things can be transformed into language, thus a faster, better and more precise laboratory management can be achieved (Antony et al., 2011, Hoffman, 2015). The computer aided chemical laboratory control system provides a visualized operation management system, which combines computer technology with chemical equipment through language chips to realize remote control and simulation of equipment, including instrument display data acquisition module, pipeline and instrument flow chart module, data processing module, experimental curve drawing module and others (Souvatzis, 2014). In this paper, the chemical laboratory of scientific research units and computer technology are closely integrated through the overall design of the computer control system, database structure design and the design of each module based on the analysis of the requirement of the control system, which obviously improves the experimental efficiency and reduces the experimental loss.

2. Requirement Analysis of Control System

2.1 System requirement analysis

Computer technology is characterized by fast data computation, large amount of data storage, high accuracy in computing, and other advantages. Chemical industry is moving towards a continuous, large-scale and integrated development and its production process is increasingly complicated, which makes it inseparable

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from the computer control system (Ren et al., 2012). A large number of computer control systems are being widely used, and ordinary analog and control instruments have been unable to meet the requirements of modern enterprises. The commonly used computer control systems include supervisory computer control system (SCC), direct digital control system (DDC), data acquisition and data processing system, hierarchical computer control system and distributed computer control system, of which the most commonly used are direct digital control system and hierarchical computer control system (Palazzo et al., 2015).

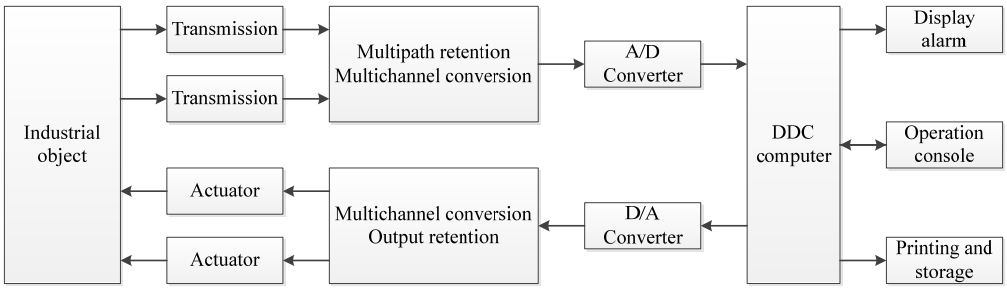

Figure 1: Direct Digital Control composition of the block diagram

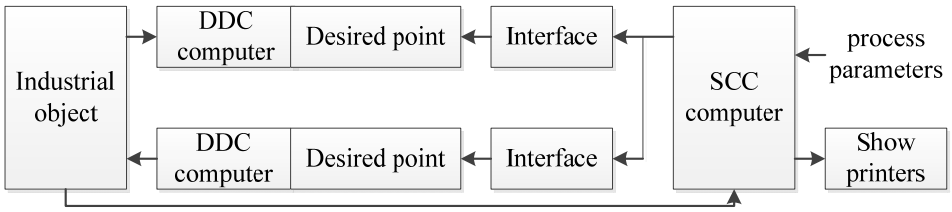

Figure 2: Direct digital and supervisory process computer control system

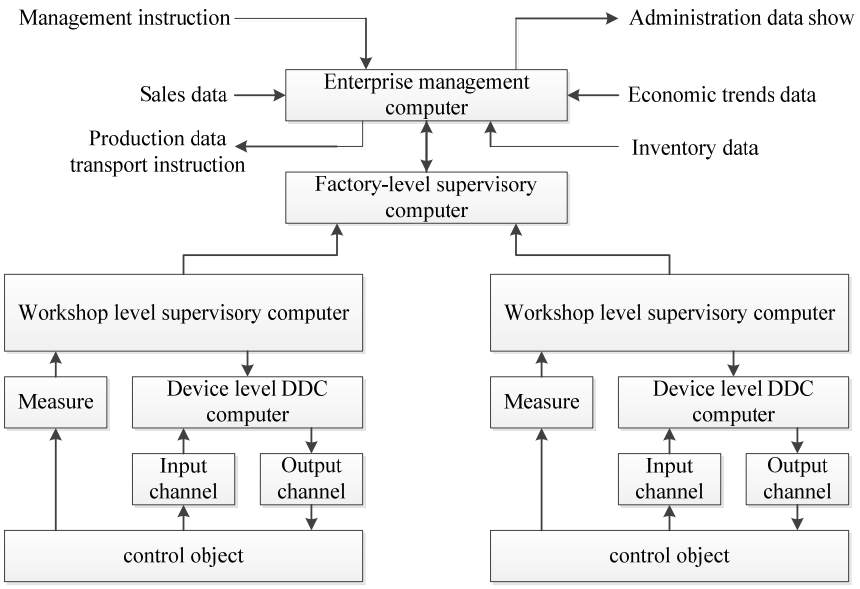

Figure 3: Hierarchical computer control system

As shown by the direct digital control system flow chart in Figure 1, the system calculates the test results of numerical analysis based on the pr- specified control algorithm, so that the state parameters of the controlled object can be continuously debugged, or each controlled parameter can be automatically adjusted in the controlled range of the given value of the object. Figure 2 shows the supervisory computer control system. A number of digital control systems can achieve comprehensive direct control over chemical production, and the additional supervisory computer control systems can achieve information transmission between SCC and

DDC. The supervisory computer control system will reconfigure the operation of the direct digital control system according to the optimized operation. As shown in Figure 3, the hierarchical computer control system realizes the control of enterprise management computer over centralized supervisory computer, the control of the centralized supervisory computer over hierarchical supervisory control computer and the control of the hierarchical supervisory control computer over the controlled object, through the hierarchical control and hierarchical feedback. And the direct digital control system is also used in the control and feedback process.

2.2 System feasibility analysis

With the improvement of people's accuracy and visualization, the performance of computer control system should also be enhanced. Therefore, it is necessary to ensure that the computer control system should have complicated control functions, simple monitoring operations, open information and shared data, flexible expansion, easy installation and maintenance, and reliability and stability (Limniou et al., 2009). Technically, computer control system sets up its database in server, which reduces repeated data reading and enhances the safety of the whole system, equipment operation and production efficiency of chemical industry. Moreover, the experimental data can be exchanged through the terminal, and the real-time update of the database, the running state of the equipment, the equipment loss, etc., can be monitored in real time, and researchers can interact through a computer terminal access system to reduce the frequency of contacting with dangerous chemical equipment. Economically, the realization of the computer control system can greatly improve the equipment efficiency, and reduce manpower and material resources, thus it is economically reasonable in the long run (Johnston et al., 2013). Therefore, the computer controlled chemical experiment system is feasible.

3. Overall Design of Control System

3.1 System architecture

In order to fully manage the system business and deal with various situations, data conservation and data closure, processing decomposition, processing numbering, balance of sub graph and main graph , and reasonable use of documents and other principles shall be followed in the designing the computer control system. As shown by the architecture of the computer control system in Figure 4, the backup server and database server are connected to the Web application server through the converter, which greatly reduces the burden of the server and increases the interactivity, and realizes real-time local update. This paper takes the centrifugal pump of chemical laboratory as an example to carry out the control design.

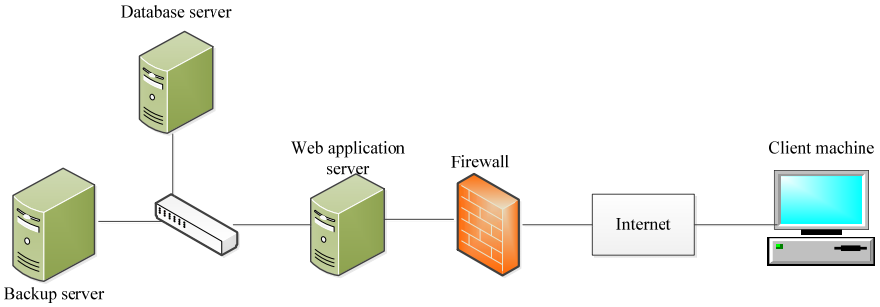

Figure 4: Computer control system architecture diagram

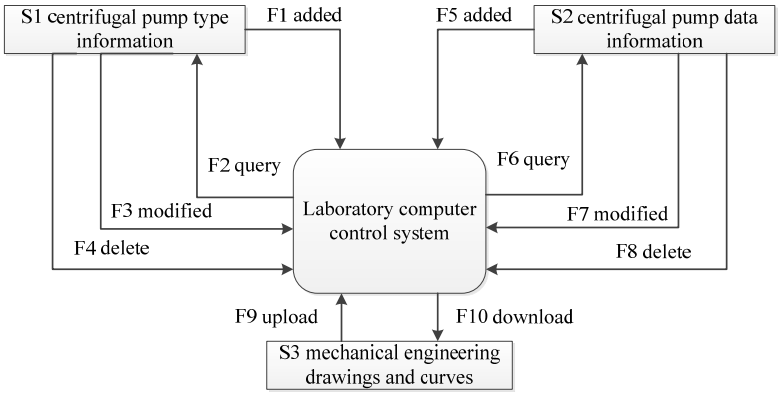

Figure 5: Laboratory computer control system data flow chart

As shown in Figure 5, the laboratory computer control system data flow chart, centrifugal pump type information and data information are added to the laboratory computer process control system for deletion and modification, and relevant information can also be inquired through the system.

3.2 Database design

The database design includes conceptual design and logical framework design. The conceptual design is implemented through statistics and information modeling and the E-R diagram. Figure 6 is an E-R diagram of the query relationship between the user and the pump type information, through which the user can query the scope of the pump type. The maximum and minimum flow, maximum and minimum lift, and other pump type information can be inquired through the login system interface system designed in this paper. The logical framework design is the data frame optimized for the conceptual framework model, which is the entity that links the E-R diagram. The centrifugal pump information is shown in Table 1.

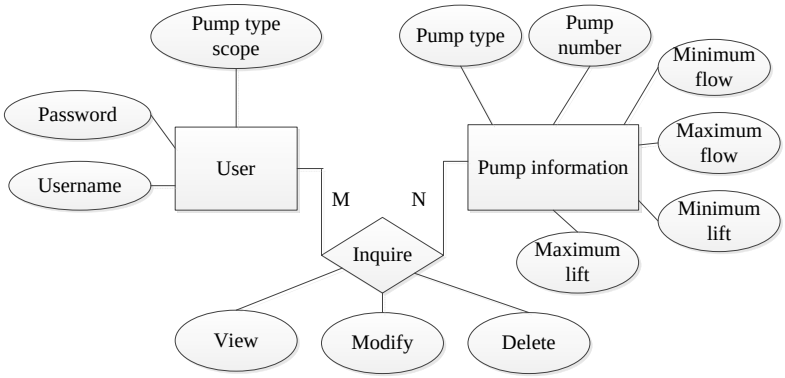

Figure 6: E-R Diagram of User and Pump Information

Table 1: Centrifugal pump information

Number	Field	Field Type	Empty	Primary key	Remarks
1	id	int	Yes	Yes	—
2	pump species	char	Yes	No	Centrifugal pump type
3	pump_no.	char	Yes	No	Centrifugal pump type number
4	min_F	char	Yes	No	Minimum flow
5	max_F	char	Yes	No	Maximum flow
6	min_H	char	Yes	No	Minimum lift
7	max_H	char	Yes	No	Maximum lift
8	min_T	char	Yes	No	Minimum temperature
9	max_T	char	Yes	No	Maximum temperature
10	adaptation	varchar	Yes	No	Scope of application
11	I.T.	char	Yes	No	Import time
12	I.N.	char	Yes	No	Import name

4. General Implementation of Control System

In this paper, the engineering architecture is designed based on the database and application forms of the chemical laboratory centrifugal pump, the real-time interaction between remote terminals and servers is achieved through network, and the remote control system is constructed, so that the database management information system and process control system for experimental device model of the chemical laboratory centrifugal pump is ultimately established. Figure 7 shows the login interface of the computer remote control system database, where there are different levels and different username levels. The system administrator can control the login information of other members, and the administrator also has the right to change the system background database and to query and change the experimental data.

Figure 8 shows the chemical laboratory centrifugal pump information adding interface, which includes the pull-down menu of the centrifugal pump types, the maximum and minimum flow, maximum and minimum lift, maximum and minimum temperature and pump number and other information. By clicking the "submit" button, the new centrifugal pump information can be added, which will be completed after being verified by the system administrator. Figure 9 shows the query and modification interface for centrifugal pumps of the chemical

laboratory. First, after imputing the type and number of centrifugal pump into the interface, the corresponding pump can be found, then it can be modified in the modification box below. In addition to the management of the type information of the centrifugal pump, the system can also manage the data information of the centrifugal pump, including digital storage and modification of information.

The computer control system of the chemical laboratory is implemented by the code of the programming system. By debugging and testing the design and development of the whole system, the system is found to be safe and reliable, intuitive and easy to be read, easy to be tested, easy to be modified and maintained, etc. In order to ensure the safe and normal operation of the system, occasional real-time maintenance of the system shall be carried out according to the needs of the user.

Figure 7: Computer remote control system database login screen

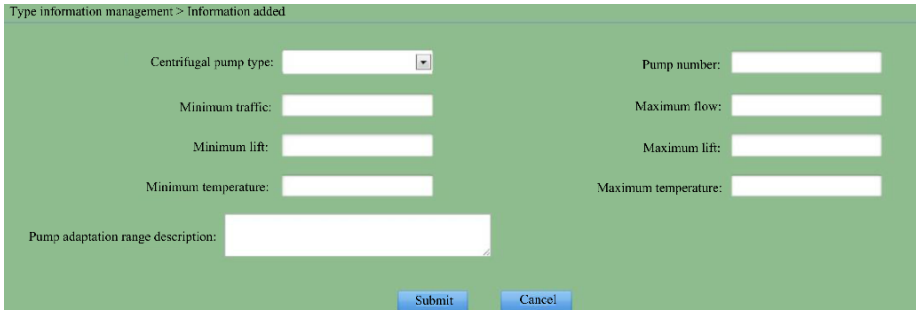

Figure 8: Centrifugal pump information in chemical laboratory Add page

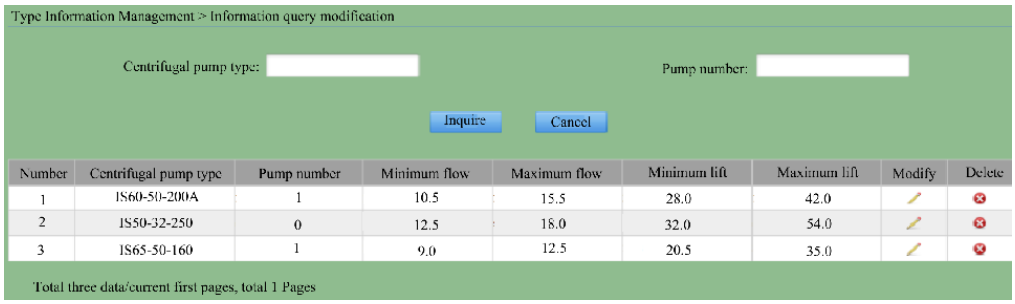

Figure 9: Centrifugal pump information to modify the query

5. Conclusions

Taking the centrifugal pump of chemical laboratory as an example, this paper has compiled a computer control system to facilitate the real-time data monitoring and analysis by the administrators and researchers. The specific conclusions are as follows:

(1) Direct digital control systems and hierarchical computer control systems are the most commonly used computer control systems, and direct digital control system is also used in the control and feedback of the hierarchical supervisory computer.

(2) The overall control system design includes system architecture and database design. The backup server and database server are connected to the Web application server through the converter, which greatly reduces the burden of the server and increases the interactivity, thus the real-time local update is achieved.
(3) To establish a database management information system and process control system of centrifugal pump experimental device model of chemical laboratory, can realize the management of centrifugal pump type information and centrifugal pump data information, including digital storage and modification of information.

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