Applied Science and Innovative Research
ISSN 2474-4972 (Print) ISSN 2474-4980 (Online)
Vol. 8, No. 3, 2024
www.scholink.org/ojs/index.php/asir

Original Paper

Research on Monitoring and Control System of Process Parameters in Biopharmaceutical Workshop

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Received: July 5, 2024 Accepted: August 4, 2024 Online Published: August 15, 2024

doi:10.22158/asir.v8n3p156 URL: http://doi.org/10.22158/asir.v8n3p156

Abstract

This paper integrates the application of process parameter monitoring, data acquisition and analysis technology and man-machine interface technology in biological medicine workshop. Through the research and application of these technologies, the accurate monitoring and control of process parameters can be realized, and the production efficiency can be improved. At the same time, it also introduces the design principle of interface, the optimization of operation interface and the design method of remote monitoring and alarm system, so as to provide better user experience and system security. This paper provides reference and guidance for the design and implementation of process parameter monitoring and control system in biological medicine workshop.

Keywords

biological drugs, Workshop, process parameters

1. Introduction

With the rapid development of the field of biopharmaceuticals, the monitoring and control system of process parameters in the workshop has become more and more important. Accurate monitoring and control of key process parameters is essential to ensure the stability and consistency of products in the production process. This paper aims to comprehensively study and apply the key technologies of the process parameter monitoring and control system in the biopharmaceutical workshop, including sensor technology, automatic control technology, data acquisition and analysis technology and human-machine interface technology. Through in-depth discussion of the principles and applications of these technologies, we can provide effective solutions for the accurate monitoring and accurate control of process parameters in the biopharmaceutical workshop, so as to improve the production efficiency.

2. Overview of Process Parameter Monitoring and Control System in Biopharmaceutical Workshop

2.1 Definition and Principle of Process Parameter Monitoring and Control System

1) Definition

Process parameter monitoring refers to the real-time and continuous monitoring and recording of key parameters in the production process to ensure the stability and accuracy of process parameters, so as to ensure the quality and consistency of products. The process parameters can be temperature, pressure, pH value, flow rate, speed, concentration, etc. these parameters can be monitored by sensors, instruments, equipment, data acquisition system and other technical means

2) Principle

Sensor technology: sensor technology is a technology that converts physical quantities into measurable electrical signals, through which the information of physical quantities can be obtained in real time and accurately. The working principle of the sensor is based on the relationship between the physical quantity and the change of a certain property. The common sensor principles include resistance, capacitance, inductance, photoelectricity, magnetoelectricity, acoustoelectricity, etc.

Data acquisition and processing: the monitoring and control system collects the data sent by the sensor through the data acquisition device, and preprocesses and corrects it. This includes filtering, smoothing and calibrating the data to ensure accuracy and reliability.

Control algorithm: the monitoring and control system uses advanced control algorithms, such as PID (proportional integral differential) control algorithm, to calculate and adjust according to the difference between the set value and the actual parameter value. The control algorithm will generate the corresponding control signal according to the size and direction of the error to keep the parameters within the expected range.

Feedback mechanism: the monitoring and control system adjusts the output of the control signal in real time by continuously feeding back the difference between the actual parameter value and the set value. In this way, the closed-loop control can be realized, that is, the control strategy can be dynamically adjusted according to the changes of actual parameters to maintain the stability and accuracy of parameters.

2.2 Importance of Process Parameters in Biopharmaceutical Workshop

The importance of the process parameters in the biopharmaceutical workshop lies in their influence on the product control and product performance in the production process. Biopharmaceuticals are a kind of complex drugs. The process parameters such as temperature, pressure, pH value and concentration in the production process are directly related to the stability, active ingredient content, purity and safety of the product. By monitoring and controlling these parameters, we can ensure the consistency, repeatability and compliance of the production process, so as to improve the stability and effectiveness of products, reduce the differences between batches, and ensure the safety and efficacy of biological drugs. Therefore, the accurate monitoring and control of the process parameters of the biological drug workshop is of great significance to ensure the products and meet the requirements of relevant laws and regulations.

Application of 2 sensor technology in process parameter monitoring of biological medicine workshop

2.3 Common Sensor Types and Principles

Temperature sensor: common temperature sensors include thermocouple, thermistor and infrared sensor. The thermocouple measures the temperature based on the voltage change caused by the temperature difference. The thermistor measures the temperature by changing the resistance value with the temperature change, while the infrared sensor measures the temperature by detecting the infrared radiation emitted by the object.

Pressure sensor: common pressure sensors include piezoresistive sensor, capacitive sensor and piezoelectric sensor. Piezoresistive sensor indirectly measures pressure by measuring the change of resistance value. Capacitive sensor uses the change of capacitance to measure pressure, while piezoelectric sensor uses piezoelectric effect to convert pressure into charge or voltage signal for measurement.

PH sensor: the pH sensor uses the potential difference between the glass electrode and the reference electrode to measure the acidity and alkalinity of the solution. The glass electrode responds to the change of hydrogen ion concentration in the solution, and the reference electrode provides a stable reference potential to obtain the pH value of the solution.

Flow sensor: common flow sensors include turbine flowmeter, electromagnetic flowmeter and ultrasonic flowmeter. The turbine flowmeter calculates the fluid flow rate by measuring the rotating speed of the rotating turbine. The electromagnetic flowmeter measures the induced electromotive force in the wire based on Faraday's law, while the ultrasonic flowmeter measures the fluid flow rate by using the time difference of ultrasonic propagation.

2.4 Application of Sensor in Temperature, Pressure, pH Value and other Parameters Monitoring

The temperature sensor is widely used in the fermentation process, cooling process and temperature control link in the biological medicine workshop process to ensure the temperature stability in the production process. The pressure sensor is used to monitor the gas or liquid pressure in the bioreactor to ensure appropriate reaction conditions and prevent equipment overpressure. PH sensor is used to monitor the acid-base balance of the medium, which has an important impact on the growth of microorganisms and the production of products in the fermentation process. Flow sensors are often used to monitor the flow velocity and flow rate of medium, solution and gas in the biological medicine workshop to ensure appropriate flow conditions.

2.5 Sensor Selection and Layout Strategy

1) Select the appropriate sensor type

According to the characteristics and requirements of monitoring parameters, select suitable sensor types, such as temperature sensor, pressure sensor, pH sensor or flow sensor.

2) Determine the number and location of sensors

According to the characteristics of the production process and the parameters to be monitored, the number and layout of sensors are determined. It is necessary to consider the spatial distribution of parameter changes, sensitive areas and actual operation requirements.

3) Accuracy and reliability of sensors

Select sensors with high accuracy and stability to ensure the accuracy and reliability of data.

4) Maintenance and calibration of sensors

Regularly maintain and calibrate the sensor to ensure its performance and accuracy. Check the status of the sensor regularly, and clean, replace or recalibrate as necessary.

5) Data acquisition and processing system

Select the appropriate data acquisition and processing system, which can receive and process the data sent by the sensor, and provide real-time monitoring and recording functions.

3. Application of Automatic Control Technology in the Process Parameter Control of Biopharmaceutical Workshop

3.1 PID Control Algorithm and Its Adjustment Method

PID control algorithm is a classical control algorithm commonly used in automation control, which is composed of three parts: proportional, integral and derivative.

Proportional control (P): the control signal is directly generated according to the size of the error, which is proportional to the error. Increasing the proportional parameter will improve the response speed of the system, but may cause overshoot or oscillation.

Integral control (I): generate a control signal according to the accumulated value of the error to eliminate the steady-state error. Increasing the integration parameter will increase the stability of the system, but may cause the response speed of the system to slow down.

Differential control (d): generate control signal according to the change rate of error to suppress the oscillation of the system. Increasing the differential parameter can make the system respond faster, but it may also introduce noise.

When adjusting the PID control algorithm, the parameters need to be adjusted according to the actual system characteristics. Common adjustment methods include manual adjustment, empirical rules (such as Ziegler Nichols rule) and adaptive adjustment methods (such as model reference adaptive control).

3.2 Architecture Design of Automatic Control System

Sensor: a sensor used to monitor key parameters, convert the parameters into electrical signals and send them to the controller.

Controller: receives the signal sent by the sensor and generates the corresponding control signal according to the preset set value and control strategy. Common controllers include PLC (programmable logic controller) and DCS (distributed control system), etc.

Actuator: perform corresponding operations according to control signals, such as regulating valves, starting and stopping equipment, etc.

Man machine interface: provide the interface for operating and monitoring the control system, such as display screen, computer software, etc., to facilitate the operator to set parameters and monitor in real time.

Data acquisition and processing system: used to collect, store and analyze the data sent by the sensor, and provide data report and historical data query functions.

3.3 Control Strategy Optimization and Feedback Mechanism

Control strategy optimization: optimize the parameters and structure of the control strategy through system modeling and simulation analysis to improve the response speed, stability and robustness of the system. Common optimization methods include model predictive control (MPC), neural network control and genetic algorithm.

Feedback mechanism: adjust the control signal through real-time monitoring and feedback parameter changes. If the parameter deviates from the set value, adjust the control signal according to the error size and direction to keep the parameter within the expected range. Common feedback mechanisms include PID control, fuzzy control and adaptive control.

4. Application of Data Acquisition and Analysis Technology in Process Parameter Monitoring of Biopharmaceutical Workshop

4.1 Real Time Data Acquisition and Storage Scheme

Sensor selection and layout: select the appropriate sensor type, and determine the number and location of sensors as required. Ensure that the sensor can accurately collect the data of key parameters.

Data acquisition system: select the appropriate data acquisition system, which can receive the data sent by the sensor in real time, and has stable and reliable communication and data transmission functions.

Data storage scheme: select the appropriate database or data storage system, which can store a large amount of real-time data and provide efficient data retrieval.

Real time data backup: ensure the safety and reliability of real-time data, establish data backup mechanism, and prevent data loss or damage.

4.2 Data Preprocessing and Anomaly Detection Methods

In the process parameter monitoring of biopharmaceutical workshop, preprocessing and anomaly detection of the collected data are helpful to improve the accuracy of the data.

Data cleaning: remove wrong, missing or abnormal data points to ensure data integrity and consistency.

Data smoothing: reduce the noise and fluctuation in the data through filtering and other technologies, and improve the stability and reliability of the data.

Data imputation: impute the missing data, fill in the vacancy, and make the data continuous and complete.

Anomaly detection: use statistical methods, machine learning algorithms and other technologies to identify and exclude abnormal data points to prevent the impact of abnormal data on the analysis results.

4.3 Data Analysis and Model Building Technology

Statistical analysis: use statistical methods to analyze data, such as mean, variance, correlation, etc., so as to understand the distribution law and relationship of parameters.

Trend analysis: through time series analysis and other technologies, study the trend and periodicity of parameters changing with time, and predict the future development trend.

Feature extraction: extract key features from a large number of data, such as peak value, waveform, frequency domain features, etc., to describe and distinguish different process states.

Model establishment: Based on the existing data sets, machine learning, artificial neural network and other algorithms are used to establish models to predict and optimize process parameters. These models can be used in real-time monitoring, fault diagnosis and optimization decision-making applications.

5. Application of Man Machine Interface Technology in Process Parameter Monitoring and Control System of Biological Medicine Workshop

5.1 Design Principles of Visual Interface

Easy to understand and operate: the interface shall be concise and clear, and the key parameters and status information shall be displayed graphically, so that the operator can quickly understand and master the system operation.

Consistency and standardization: the interface design should conform to user habits and industry standards, maintain consistency and standardization, reduce user learning costs, and reduce the risk of operational errors.

Customizability: provide personalized interface setting options, allowing users to adjust the layout, color and font according to their own needs, so as to improve user satisfaction and work efficiency.

Pay attention to visual hierarchy and highlight: highlight key parameters and alarm information by using appropriate color, font size and contrast, so as to quickly attract the attention of the operator.

Provide real-time data and trend analysis: the interface shall be able to display the data collected by the sensor in real time, and provide the trend analysis function of historical data to help the operator better understand the process status and change trend.

5.2 Operation Interface Optimization and Interaction Design

Interface layout optimization: reasonably arrange interface elements, make important parameters and functions easy to access and operate, and reduce cumbersome operation steps.

Shortcut keys and instructions design: provide shortcut keys and instructions to facilitate users to quickly perform common operations and improve work efficiency.

Feedback mechanism: feed back the user's operation results in time, and give clear prompts and guidance to avoid user's confusion and wrong operation.

Multilingual support: if the system needs to be used in different regions, multilingual support should be considered to facilitate the use of operators with different language backgrounds.

User training and technical support: provide training and technical support for new users to ensure that they understand how to use and operate the interface correctly.

5.3 Remote Monitoring and Alarm System

Remote monitoring: through the remote access and control system, the process parameters of the biopharmaceutical workshop can be monitored anytime and anywhere, and the process status and change trend can be understood in real time.

Alarm system: set appropriate alarm thresholds and rules. When key parameters exceed the set range, the system can automatically send an alarm to remind the staff to respond as soon as possible

Display alarm information: display the alarm type, time and related parameters on the interface for the operator to handle in time.

6. Concluding

With the continuous development of the field of biopharmaceuticals, the monitoring and control system of process parameters in the biopharmaceutical workshop has become increasingly important in ensuring the stability of the production process and product consistency. In this paper, sensor technology, automatic control technology, data acquisition and analysis technology and human-machine interface technology are integrated to reduce costs and ensure product stability. At the same time, the application of man-machine interface technology makes the operation interface more friendly and intuitive, and improves the operator's work efficiency and user experience. In the future, we can further study and apply emerging technologies, such as artificial intelligence and big data analysis, to further improve the level of process parameter monitoring and control system in the biological medicine workshop and promote the development of the biological medicine industry.

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