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Industrial Bioreactors

Thomas Margret*

Institute of Advanced Management Studies, CA, USA

Introduction

Since exposure to variable environmental conditions has been demonstrated to cause changes in the metabolome, transcriptome, and population heterogeneity in industrially relevant microbes, gradients in industrial bioreactors have gained a lot of study attention. Key process factors including yield on substrate and productivity have also been found to be impacted by such modifications. As a result, comprehending gradients is critical from both an academic and an industrial standpoint. The influence of gradients must be quantified, which necessitates a thorough understanding of both fluid flow inside industrial equipment and microbial physiology. Environmental protection, healthcare, industrial biotechnology, and space exploration have all used bioreactors in various forms.

Description

The creation of novel bioreactor geometries and process control strategies, as well as the growth of the physical structure of the control system, was spurred by strong demand in the field. A hierarchical structure control system (HSCS) for bioreactors has been the dominant physical structure, with great efficiency and robustness since the introduction of digital computers to bioreactor process control. However, the HSCS's inherent flaws in bioreactors have necessitated the development of a more unified control system.

Aside from the development of new bioreactor geometrical designs, the corresponding control systems have also played an essential role in bioreactor development. Process control, monitoring, data gathering, and processing are the major roles of a bioreactor control system in general. The present study on bioreactor control systems can be divided into two categories, with some studies focused on bioreactor control techniques and algorithms, and others primarily investigating the physical structure of bioreactor control systems' instrumental organization. Because of the rapid advancements in sensors, equipment, and information technology, the development of a flat organizational control system (FOCS) for bioreactors based on parallel distributed smart sensors and actuators may give a more concise solution for bioreactor process control. The main focus of research on control strategies and algorithms used in bioreactor control systems is on issues such as monitoring parameters that cannot be directly measured, methods of effective and stable control based on process data monitoring, and the successful application of process data to improve future processes (such as dynamic bioprocess modeling). Control techniques, innovative optimization algorithms, and software frameworks for control systems have also made significant advances [1-3].

Human operation was required for early bioreactor control, which was based on workers' knowledge and long-term practical experience. Process monitoring and control of bioreactors has entered the era of automation with the development of sensor technology that allows on-line monitoring of numerous process parameters as well as the use of digital processors and actuators. Simultaneously, the HSCS for bioreactors was developed and refined during decades of use. The HSCS for bioreactors was created in two stages, the PLC stage and the DCS stage, from a technical standpoint. Three layers are commonly present in a traditional HSCS bioreactor. Process parameter monitoring and control equipment make up the bottom layer. Physical, chemical, physiological, and biochemical characteristics are commonly used in fermentation bioreactors. Specific functional sensors have been developed for some physical and chemical parameters such as temperature, pH, rotation speed, DO, pressure, liquid level, OD, and viscosity, and control of these process parameters can be carried out using traditional control strategies based on specific actuators. More complex monitoring capabilities, as well as advanced control techniques and algorithms, are frequently used for physiological and biochemical metrics like biomass, critical nutrient and metabolite concentrations, and gas composition. Industrial field computers, such as early PLC systems with a microprocessor module, make up the intermediate layer of a bioreactor HSCS [4,5].

Conclusion

The middle layer's functions include acquiring analog signals from sensors and converting them to digital signals (in some applications), recording process data, setting process parameters, running parameter control optimization algorithms, generating actuator actuation orders, presenting process data, and communicating with upper-layer computers or other PLC systems. In HSCSs for bioreactors, the middle-layer industrial field computer has functioned as a bridge for bidirectional data transfer. The core computers, such as a desktop computer, make up the upper layer of a bioreactor HSCS. The major functions of the upper-layer central computers are data management and obtaining process data from the industrial field computers (e.g., visualization of process parameter data for real-time administration and comparing and analyzing historical data of recorded experiments for process evaluation and development). The upper-layer central computer is the highest terminal of a single operational unit of a bioreactor control system, however for plants with a large number of bioreactor units, several upper-layer central computers can be connected via a local area network to form a bigger control system like DCS. The major functions of the upper-layer central computers are data management and obtaining process data from the industrial field computers (e.g., visualization of process parameter data for real-time administration and comparing and analyzing historical data of recorded experiments for process evaluation and development).

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***Address for Correspondence:** Thomas, Margret, Institute of Advanced Management Studies, CA, USA; E-mail: margretmolg20@yahoo.com*

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