Engineering Tripos Part IIA Project, SG2: Bioreactor Control, 2022-23

Leader

Dr S Bakshi [1]

Timing and Structure

Thursdays 11-1pm and Mondays 9-11am plus afternoons

Prerequisites

2P6, 3F1 (desirable), 3G1 (desirable)

Aims

The aims of the course are to:

- To gain understanding of the relevant biological processes and process control in bioreactors
- To learn about the operation and calibration of the relevant sensors and actuators for monitoring and maintaining process variables
- To design an experiment to analyse the role of process variables on system performance

Objectives

As specific objectives, by the end of the course students should be able to:

- To use and calibrate sensors for cell density and temperature of the cell culture in a microbial bioreactor
- To regulate environmental variables (the level of oxygenation and temperature) and cell density for optimising growth of the culture
- To model and experimentally test microbial population growth under nutrient limited conditions at controlled temperature
- To implement and compare performance of open-loop and closed-loop control of cell density to regulate nutrient availability
- To design and perform an experiment to analyse the role of one of the process variable on the performance of the microbial system

Content

BACKGROUND:

Bioreactors are the key technology for bioprocess engineering. Primarily, bioreactors are used to keep cells (microbial or mammalian) under controlled conditions such that they can optimally perform the desired tasks. Example application include bioproduction of antibodies and vaccines, tissue engineering, or even nutrient production usign bacteria and algae.

PROJECT:

This project introduces you to some of the essential concepts of the bioprocesses in microbial bioreactors and how

to use sensors and actuators for monitoring and controlling the environmental variables to keep those bioprocesses operating in an efficient manner. You will also learn about sources of noise and drift in such bioprocesses and how closed-loop feedback control can be implemented for maintaining the process variables.

The project covers concepts of logistic growth of microbial populations, scattering based measurements of population growth over time and single cell imaging for calibration of such measurements, and how temperature, nutrient density, and oxygen level affect population growth. For process control, the project will cover chemostat and turbidostat modes of culture maintenance.

FORMAT:

Students will work in pairs. There are total 4 lab sessions. Each student will write interim reports by the end of weeks 1, 2, and 3 and a final report by the end of week 4.

ACTIVITIES:

Week 1: Get familiar with the various components of a bioreactor and calibrate cell density sensor of the bioreactor prototype using a standard optical density sensor and single-cell imaging
Week 2: Model and experimentally test population growth of bacterial cells in nutrient-rich media with optimum aeration and temperature
Week 3: Implement open loop and closed-loop control of culture density maintenance using dilution and explain the observed performance differences
Week 4: Design and perform an experiment to explore the role of different process variables (one variable assigned to each pair) on population growth and explain the observations

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

Last modified: 22/11/2022 20:15

Links
[1] mailto:sb2330@cam.ac.uk
[2] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations