Politechnika Krakowska im. Tadeusza Kościuszki

Karta przedmiotu

obowiązuje studentów rozpoczynających studia w roku akademickim 2019/2020

Wydział Inżynierii i Technologii Chemicznej

Kierunek studiów: Inżynieria Chemiczna i Procesowa — Profil: Ogólnoakademicki

Forma sudiów: stacjonarne — Kod kierunku: I

Stopień studiów: II

Specjalności: Engineering of Technological Processes (IPT, IOZE)

1 Informacje o przedmiocie

Nazwa przedmiotu	Biochemical reactors engineering
Nazwa przedmiotu w języku angielskim	Biochemical reactors engineering
Kod przedmiotu	WITCh ICHIP oIIS D1 19/20
Kategoria przedmiotu	Przedmioty specjalnościowe
Liczba punktów ECTS	4.00
Semestry	1

2 Rodzaj zajęć, liczba godzin w planie studiów

Semestr	Wykłady	Ćwiczenia	Laboratorium	Laboratorium komputerowe	Projekt	Seminarium
1	30	0	0	0	30	0

3 Cele przedmiotu

Cel 1 Understanding the principles of processes occurring in biochemical reactors of various types.

Cel 2 Broadening the knowledge about mathematical modeling of mass transfer processes.

Cel 3 Broadening the knowledge about numerical methods used in calculations of biological reactors.

Cel 4 Developing ability to solve mathematical models with use of specialized computer software.

Cel 5 Developing ability to compare technological solutioons and to propose modifications for improvement of process efficiency.

4 Wymagania wstępne w zakresie wiedzy, umiejętności i innych kompetencji

1 Courses: Mathematics, Chemical engineering, Chemical reactors engineering, Numerical methods.

2 Skills: Computer literacy; programming in selected high-level language e.g.: Fortran, basic knowledge of Matlab.

2 Wymaganie 2

5 Efekty kształcenia

EK1 Wiedza Understanding the principles of processes occurring in biochemical reactors of various types.

EK2 Umiejętności Ability to formulate mathematical models of processes occurring in basic types of bioreactors.

EK3 Umiejętności Choice of proper types and design of biochemical reactors for selected processes of industrial significance.

EK4 Umiejętności Skill in methods of solutions of nonlinear equations describing bioreactors with lumped state variables.

EK5 Umiejętności Assessment of steady states stability in continuous stirred tank bioreactors.

6 Treści programowe

Projekt		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
P1	1.Technological analysis of chosen biotechnological processes. In the project student is obligated to describe in detail individually chosen biotechnological process and perform its technological analysis. The description should take into account technological scheme, process conditions and species of microorganisms used. Additional element is to find kinetic equations of the process. Within a framework of technological analysis student interprets technological scheme, reasons the choose of bioreactor type and perform the assessment of process and products significance. The project also consists of: justification of choosing the process, conclusions and quoted literature.	10
P2	2.Kinetic analysis of chosen microbiological processes. The goal of the project is determination of kinetic equation of microbiological process occurring according to unstructured model. The basis for the determination of kinetic equation are experimental results, which student receives from the tutor. Task of student is both proposing the form of kinetic equation and determination of kinetic parameters in this equation. For the determination of kinetic constants it is necessary to use chosen minimizing method, and the choice should be justified. Within a framework it is also necessary to: elaborate numerical algorithm, create computer program, execute and describe calculations and draw conclusions. Additionally the project consists of list of quoted literature.	10

Projekt		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
P3	3.Evaluation of work conditions of cascade of two tank bioreactors with partial recirculation and determination of productivity and stability of cascade work in steady state. Biodegradation of toxic carbonaceous compound proceeded in a cascade of two continuous tank bioreactors with perfect mixing with partial recirculation of flow is the subject of the project. The task is to evaluate steady state of the cascade and to determine its stability. Kinetic parameters of the microbiological process and process parameters: concentration of substrate in feed flow of the cascade, residence time of liquid in the object, reactors volumes distribution coefficient and the degree of biomass recirculation are the data for the project. In order to calculate state variables determining steady state student needs to formulate the mathematical model of the cascade and convert to dimensionless form, and solve obtained set of algebraic nonlinear equations by using self-written computer programme or computing environment. The stability should be determined by calculating the eigenvalues of Jacobian matrix of right-hand sides of model equations. Writing own programme is the basis to increase the grade. The project consists of: derivation of the model and conversion to dimensionless form, way of reasoning and intermediate results, scheme of installation, conclusions and quoted literature.	10

Wykłady		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
W1	Technical and economical importance of biotechnological processes and bio-engineering. Classification of bioprocesses and their characteristics.	2
W2	Manner of stoichiometric equations notation. Application of stoichiometric equations for mass balances and kinetic equations.	2
W3	Rate of a microbiological process. Kinetic models of microbiological processes. Unstructured and structured models of microbiological processes. Kinetics of substrates utilization and biomass growth. Yield coefficients. Experimental methods in kinetic research of microbiological processes.	2
W4	Mass balances of batch reactor. Mathematical modelling of batch reactors dynamics. Design of batch reactors.	2
W5	Design of continuous flow bioreactors. Steady-state properties of continuous flow bioreactors. Single- and multi-substrate processes. Nonlinear characteristics of steady-states of tank bioreactors. Phenomenon of biomass washout and its influence on process safety.	4
W6	Modelling of biochemical cascades. Simple cascades without recirculation. Biochemical cascades with recirculation and thickening of biomass. Comparison of steady-state characteristics of cascades with single reactors. Influence of distribution of reactors volumes and recirculation of biomass on position of steady-state branches.	2

Wykłady		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
W7	Co-existence of different microbiological species in a continuous stirred tank bioreactor. Microbiological process with double trophic chain. Existence and significance of predator-prey processes on biodegradation. Steady-state and dynamic characteristics of continuous stirred tank bioreactor for predator-prey processes.	2
W8	Modelling method of bubble bioreactors, allowance for kinetics of mass transfer and hydrodynamics of two-phase and three-phase systems. Design of bubble bioreactors and fluidized bed bioreactors for aerobic processes.	4
W9	Methods allowing for presence of biofilm in bioreactors. Classification of biofilms and their models. Characteristics of bioreactors with wall growth.	4
W10	Characteristics of enzymatic processes. Enzyme immobilization engineering. Types, properties and method of membrane bioreactor modelling.	2
W11	Design solutions of biochemical reactors: tank bioreactors, column bioreactors for aerobic processes, plate column and fluidized bed reactors, airlift reactors. Membrane reactors for enzymatic processes. Hollow-fibre bioreactors.	4

7 Narzędzia dydaktyczne

N1 Ćwiczenia projektowe

N2 Wykłady

N3 Dyskusja

N4 Zadania tablicowe

N5 Konsultacje

8 Obciążenie pracą studenta

Forma aktywności	Średnia liczba godzin na zrealizowanie aktywności
Godziny kontaktowe z nauczycielem akademickim, w tym:	
Godziny wynikające z planu studiów	60
Konsultacje przedmiotowe	15
Egzaminy i zaliczenia w sesji	10
Konsultacje drogą elektroniczną	5
Godziny bez udziału nauczyciela akademickiego wynikające z nakładu pracy studenta, w tym:	
Przygotowanie się do zajęć, w tym studiowanie zalecanej literatury	10
Opracowanie wyników	10
Przygotowanie raportu, projektu, prezentacji, dyskusji	10
Sumaryczna liczba godzin dla przedmiotu wynikająca z całego nakładu pracy studenta	**120**
Sumaryczna liczba punktów ECTS dla przedmiotu	4.00

9 Sposoby oceny

Ocena formująca

F1 Ćwiczenie praktyczne

F2 Odpowiedź ustna

F3 Kolokwium

F4 Zadanie tablicowe

Ocena podsumowująca

P1 Projekt

P2 Egzamin pisemny

Ocena aktywności bez udziału nauczyciela

B1 Projekt indywidualny

Kryteria oceny

Efekt kształcenia 1

Na ocenę 3.0	Classifying biochemical processes. Defining a reaction rates of process following simple kinetic model. Knowlegde about kinetic parameters of microbial and enzymatic processes.
Na ocenę 3.5	Ability to describe properties of a cascade of biological reactors. Indication of the influence of the coefficient of volume distribution on steady-state properties of the cascade.
Na ocenę 4.0	Knowledge about construtional solutions for condution of aerobic microbiological processes. Ability to compare bioreactors of different types. Ability to evaluate particular solutions in technological processes.
Na ocenę 4.5	Description of modeling basics of batch and continuous bioreactors for microbiological processes following complex kinetics.
Na ocenę 5.0	Knowledge about steady-states properties of bioreactors of different types, including bioreactors with immobilized biomass. Describing basics of modeling bioreactors with immobilized biomass.
Efekt kształcenia 2	
Na ocenę 3.0	Ability to formulate a mathematical model of single-substrate process occuring in continuous bioreactor.
Na ocenę 3.5	Ability to formulate a mathematical model of single-substrate process with product inhibition occuring in continuous bioreactor.
Na ocenę 4.0	Ability to formulate a mathematical model of single-substrate process with substrate inhibition occuring in a cascade of continuous bioreactors with recirculation of biomass.
Na ocenę 4.5	Transofromation a model of single-substrate process with substrate inhibition occuring in a cascade of continuous bioreactors with recirculation of biomass to dimensionless form.
Na ocenę 5.0	Ability to formulate a mathematical model of single-substrate process with substrate-inhibition occuring in continuous bioreactor with recirculation of biomass, with developed predator-prey food-chain.
Efekt kształcenia 3	
Na ocenę 3.0	Indicatating key constructional elements of bioreactors and requirements for proper condution of a process.
Na ocenę 3.5	Indicating risks related with inadequate conduction of a process and manners ensuring process safety.
Na ocenę 4.0	Ability to propose specific constructional solution for given microbiological process.
Na ocenę 4.5	Knowledge about technological properties of batch bioreactors and continuous bioreactors for process with substrate inhibiton.
Na ocenę 5.0	Analyzing technological properties of bioreactors based on steady-states branches of processes following complex kinetics, also of predator-prey kinetics.
Efekt kształcenia 4	

Na ocenę 3.0	Ability to solve mathematical model of continuous bioreactor with process following Monod kinetics.
Na ocenę 3.5	Ability to determine kinetic parameters of process following Monod kinetics
Na ocenę 4.0	Ability to transform the mathematical model of CSTBR for process following Haldane kinetics to dimensionless form.
Na ocenę 4.5	Ability to solve mathematical model of CSTBR with process following Haldane-Monod kinetics using numerical methods.
Na ocenę 5.0	Ability to solve mathematical model of a cascade of continuous bioreactors with process following Haldane-Monod kinetics using numerical methods.
Efekt kształcenia 5	
Na ocenę 3.0	Defining the Jacobi matrix and stability criterion.
Na ocenę 3.5	Ability to determine the Jacobi matrix of CSTBR for process following Monod kinetics.
Na ocenę 4.0	Determining the stability of CSTBR for process following Monod kinetics.
Na ocenę 4.5	Ability to determine the Jacobi matrix of CSTBR for process following Haldane kinetics and the stability of the reactor.
Na ocenę 5.0	Ability to determine the Jacobi matrix of a cascade of CSTBR for process following Haldane kinetics and the stability of the cascade. The cascade operates with recirculation of biomass.

10 Macierz realizacji przedmiotu

Efekt kształcenia	Odniesienie danego efektu do szczegółowych efektów zdefiniowanych dla programu	Cele przedmiotu	Treści programowe	Narzędzia dydaktyczne	Sposoby oceny
EK1	K2_W01	Cel 1 Cel 5	W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11	N1 N2 N3 N4 N5	F1 F2 F3 F4 P1 P2
EK2	K2_W02	Cel 1 Cel 2 Cel 3	P2 P3 W2 W3 W4 W5 W6 W7 W8 W9 W10	N1 N2 N3 N4 N5	F1 F2 F3 F4 P1 P2
EK3	K2_W04	Cel 1 Cel 2 Cel 3 Cel 4 Cel 5	P1 P3 W1 W5 W6 W8 W9 W10 W11	N1 N2 N3 N4 N5	F1 F2 F3 F4 P1 P2

Efekt kształcenia	Odniesienie danego efektu do szczegółowych efektów zdefiniowanych dla programu	Cele przedmiotu	Treści programowe	Narzędzia dydaktyczne	Sposoby oceny
EK4	K2_W02 K2_W06	Cel 3 Cel 4	P2 P3	N1 N4 N5	F1 F4 P1
EK5	K2_W01 K2_W09	Cel 1 Cel 2 Cel 3 Cel 4 Cel 5	P3 W5 W6 W7	N1 N2 N3 N4 N5	F1 F2 F3 F4 P1 P2

11 Wykaz literatury

Literatura podstawowa

[1] **I.J. Dunn, E. Heinzle, J. Ingham, J.E. Prenosil** — *Biological reaction engineering*, Weinheim, 2003, Wiley

[2] **J.E.Bailey, D.F.Ollis** — *Biochemical engineering fundamentals*, New York, 1986, McGraw-Hill

[3] **S.Aiba, A.E.Humphrey, N.F.Millis** — *Biochemical engineering*, New York, 1973, Academic Press

[4] **M.L. Shuler, F. Kargi** — *Bioprocess Engineering: Basic Concepts*, New Jersey, 1992, Prentice Hall

Literatura uzupełniająca

[1] **B. Tabiś, R. Grzywacz** — *Procesy i reaktory biochemiczne*, Kraków, 1993, Wyd. Politechniki Krakowskiej

[2] **J. Bałdyga, M. Henczka, W. Podgórska** — *Obliczenia w inżynierii bioreaktorów*, Warszawa, 1996, Oficyna Wydawnicza Politechniki Warszawskiej

12 Informacje o nauczycielach akademickich

Osoba odpowiedzialna za kartę

dr hab. inż. Szymon Skoneczny (kontakt: `yourmail@gmail.com`)

Osoby prowadzące przedmiot

1 dr inż. Szymon Skoneczny (kontakt: `skoneczny@chemia.pk.edu.pl`)

13 Zatwierdzenie karty przedmiotu do realizacji

(miejscowość, data) (odpowiedzialny za przedmiot) (dziekan)

Przyjmuję do realizacji (data i podpisy osób prowadzących przedmiot)

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