ChESA 8th
Chemical Engineering on Science and Applications

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AIC 2015
UNIVERSITAS SYIAH KUALA

THE 8th CHEMICAL ENGINEERING ON SCIENCE AND APPLICATION (ChESA)
IN CONJUNCTION WITH
THE 5th ANNUAL INTERNATIONAL CONFERENCE SYIAH KUALA UNIVERSITY (AIC - UNSYIAH)

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WELCOME SPEECH FROM THE RECTOR

Assalamu'alaikumWr. Wb.
In the Name of Allah, the Most Beneficent, the Most Merciful
May the peace, the mercy, and the blessings of Allah be upon you.

Ladies and gentlemen, it is an honor indeed to open this conference, the 5th Annual International Conference (the 5th AIC) in conjunction with the 8th Chemical Engineering on Science and Application (the 8th ChESA) conference. On behalf of Syiah Kuala University or Unsyiah, I would like to extend a warm welcome to all participants and our speakers who are with us to make this a notable and exciting event.

This year, Unsyiah commemorates its 53rd anniversary. As part of the celebration, the university has held a number of events, including this interdisciplinary conference from September 9-11, 2015. At Unsyiah, we emphasize the excellence in education and research, and are also committed to innovation and technology. Today, we are facing more challenges in these spheres, therefore, as members of the academic community; we have a duty to find innovative research solutions for them. Hence, this conference is an excellent forum for experts, professionals, researchers, and students, to present, share, and discuss their knowledge and experiences with all of us. As a result, it is a privilege to host you, not just this year, but for years to come, to give and provide opportunities to contribute lasting and practical solutions to the challenges that confront us from time to time.

This conference includes keynote speeches, oral and poster parallel sessions on topics in the Food and Biochemical Engineering, Catalytic Reaction Engineering, and much more. The topics come from the belief to develop clean energy technology for community welfare. We thank our keynote and invited speakers for their contribution, time and support for this conference. Heartfelt appreciation goes to all the authors of the selected papers for their effort and hard work. I also thank the organizing committee of the conference for their exertion in making this event successful. I wish to encourage them to continue more events and other initiatives as well. To support and sustain important research linkage for dialogue and facilitate ideas exchange such as this will certainly generate many new discoveries in years to come.

Finally, I wish you a wonderful stay in Banda Aceh. Please enjoy our university's pleasant learning environment and our city's appealing offer in food and tourism. I am sure the committee of this conference extends their warm hospitality to make your brief stay positively memorable.

May God bless us all with the health to make this event a successful and enjoyable one!
Thank you.
Prof. Dr. Ir. Samsul Rizal, M.Eng
Rector of Syiah Kuala University

Message from the Chairman of AIC

Assalamu'alaikum Wr. Wb.

I take this occasion to cordially welcome all participants of the 5th Annual International Conference (or AIC) in conjunction with the 8th Chemical Engineering on Science and Application (or ChESA) conference. This conference is held in the heart of our campus, Syiah Kuala University or Unsyiah, Banda Aceh, from September 9 to September 11, 2015. Unsyiah, the home of 12 notable faculties and one school of postgraduate studies, is one of the major state universities in Indonesia. Its pleasant surroundings in a city with remarkable history are a spotlight for this congregation. We are assured that the 200 scientific participants contribute to productive discussions and exchanges that impact the success of this conference. Participants from 10 countries; Indonesia, Malaysia, Thailand, South Africa, Japan, Singapore, Taiwan, Germany, England, Australia countries have marked the conference to be in an international scope.

I would like to express my gratitude to the Research Institute of Syiah Kuala University or LembagaPenelitian (Lemlit) and the committee members for helping us with full force in organizing the conference. The conference and proceedings are a credit to a large group of people and everyone should be proud of the outcome.There are four plenary speakers covering the different areas of the conference. From science and engineering, there is Prof. Dr. Evamarie Hey-Hawkins from University Leipzig, Germany. From ChESA, there is Dr. Kazuaki Syutsubo from the National Institute for Environmental Studies (NIES), Japan. From life sciences, there is Associate Professor Dr. Ororat Mongkokporn from Kasetsart University, Thailand. And finally from social sciences, there is Professor Dr. Patrick Daly from National University of Singapore. Their talks cover the full range of the conference topics.

We are delighted with the vast responses of 166 submissions from researchers and practitioners. The knowledge bases that we are aiming to generate on the conferences topics are overwhelming due to the involvement of these experts from various fields of studies. Their papers are published in the proceedings to provide permanent records of what has been presented. The proceedings are divided into Life Sciences, Engineering, Social Sciences, and ChESA sections, and the 158 papers published here exhibit the current state of development in all aspects of important topics that are instrumental to all researchers in the field. They have succeeded in bringing together various aspects of developments and innovations in knowledge and technology that will benefit not only the academic community, but society itself.

It is hoped that this conference does not only provide a member meet, but also offer a common platform for academia and practitioners to discuss issues related to their field of studies. We also wish everyone a pleasant stay in Banda Aceh and have a taste of our best traditional culinary.

Thank you,
Prof. Dr. drh. Darmawi, M.Si

MESSAGE FROM THE CHAIRMAN OF ChESA

Assalammualaikum Wr. Wb.
Honorable Guests, Presenters, and Participants,

First of all, I would like to thank you for your valuable contributions to this conference that is conducted by Chemical Engineering Department of Syiah Kuala University. Our department is one of the largest department in Engineering Faculty. It was established in 1963 driven by a spirit to form a deparment to bring Acehnese to become educated, knowledgeable, and technocrate. Therefore, we try to give our best in contributing our ideas in the field of Chemical Engineering Science and Applications so that we can cooperate to improve our daily lives. We understand that it takes time to achieve the target; however, we believe one effort is much better than nothing.

I am also happy to inform that the committee is very lucky to have 5 Plenary and invited speaker Speakers, i. e. from Japan, Germany, and Indonesia, who supported us from the very beginning with their capabilities to try and personally come and meet you all.

This conference has collaborated with four international journals, i.e. Bulletin of Chemical Reaction Engineering and Catalysis, International Journal of Science and Engineering, and International Journal of Renewable Energy Development. All selected conference papers are then peer-reviewed to meet the highest standards of publication. The peer review of each manuscript is rigorous and concentrates on objective and technical concerns to determine whether the research has been sufficiently well conceived, well executed, and well described.

Finally, I expect all participants have memorable moment through this conference and enjoy your stay in Banda Aceh.

Thank you.
Sincerely,
Chairman of Committee
Dr. Nasrul Arahman, ST, MT

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Simulation of Continuous Bio-Reactor

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Abstract

Dynamic study of bioprocess system plays a central role in bioprocess control. It is in fact on the basis of the time required for the development of the knowledge process that the total design, analysis and implementation of monitoring and control methods are carried out. Within the framework of bioprocesses, the most natural way to determine the models that will enable the characterization of the process dynamics is to consider the material balance of major components of the process. This article will present simulation results of continuous bio-reactor. The mathematical models for the bio-reactor based on the material balance had been derived (Riggs and Karim, 2006) and would be adopted in this study. Those model were solved and simulated using Matlab. It is found that the dynamic responses of the bio-reactor due to a step change in feedrate are first order.

Key words: Simulation, bio-reactor, biochemical, fermentation

Introduction

Microbial fermentation is a process in which a population of micro-organisms are grown using certain nutrients under favorable surrounding conditions (temperature, pH, agitation, aeration, etc). It schematically corresponds to the transformation of substances (generally carbonaceous substrates) into products, resulting from metabolic activities of cells.

The main components of the reaction are as follows (Dochain, 2008):

- Substrates, denoted as S_i, which are necessary for the growth of micro-organisms, or even which are precursors of a compound to be produced. These substrates generally contain a source of carbon (glucose, ethanol, etc) and sometimes nitrogen (NO_3, NH_4, etc.) and phosphorus (PO_4, etc).
- Microbial biomasses, denoted as x_i.
- End products, denoted as P_i, for agri-foods (oils, cheese, beer, wines, etc), chemistry (solvents, enzymes, amino acids, etc), the pharmaceutical industry (antibiotics, hormones, vitamins, etc) or for the production of energy (bio-ethanol, biogas, etc.).

Bio-ethanol, as a clean and renewable fuel, is gaining increasing attention, mostly through its major environmental benefits. It can be produced from different kinds of renewable feedstock such as e.g. sugar cane, corn, wheat, cassava (first generation), cellulose biomass (second generation) and algal biomass (third generation). Sanchez and Cardona (2008) described the biotechnological production of bio-ethanol from different feedstocks. The agro-industrial wastes had been explored for their feasibility as culture media for the production of bioethanol (Bocanegra et al, 2015; Balat, 2011).

Previous research include kinetic study of batch ethanol production from sugar beet raw juice (Dodic at al, 2012). Continuous bio-reactors based on a CSTR are not commonly used in biotechnology industry although they are good candidates for the production of high volume products, such as, bioethanol. The design and development of continuous

fermentation systems have allowed the implementation of more cost effective processes. Tan et.al (2015) used a flocculating yeast Saccharomyces cerevisiae strain KF-7 to establish the continuous ethanol fermentation process to convert raw juice and thick juice of sugar beet to ethanol. Steady state and dynamic study in continuous bio-reactor but for gluconic acid production had been studied previously (Fatmawati & Agustriyanto, 2010). This paper describes the dynamic response of continuous bio-reactor for bioethanol production.

Methods

Figure 1 shows the CSTR system used in this study. Feed contains sugar as a substrate from corn or other grains (such as wheat, rice, barley etc) and nutritional salts to support for cell growth. The cells consume the substrate and produce the product and CO_2. An air blower provides oxygen to the cells. The exit gas is primarily composed of N_2 from the air, the unconsumed O_2, and CO_2 produced by the cells from the consumption of sugar. The cell concentration is measured by a turbidity meter, the substrate concentration is measured by an on-line HPLC analyzer. In industrial bio-process, filters are usually used for all streams entering and leaving the reactor to maintain sterile conditions although they are not shown in Figure 1.

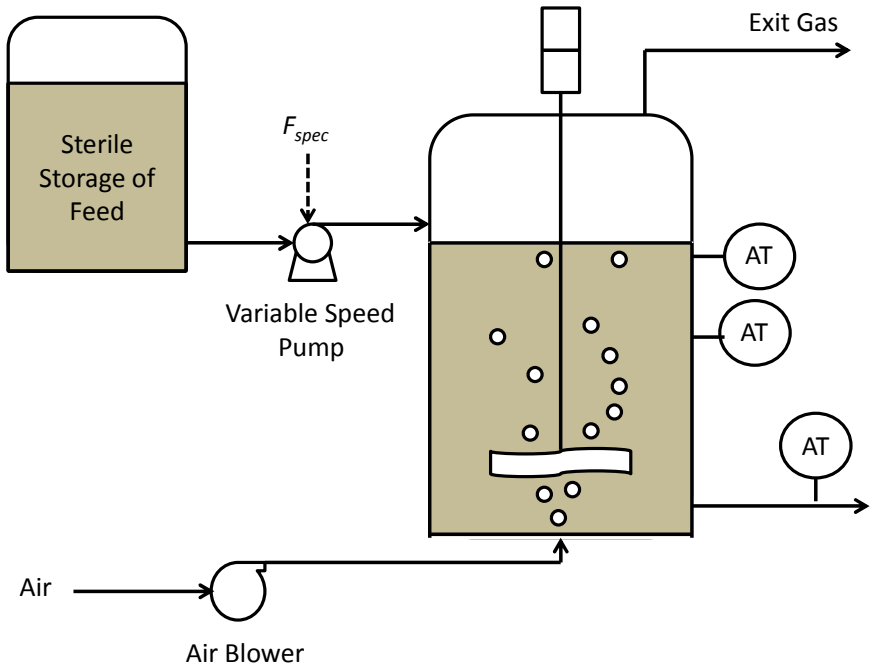

Figure 1. Schematic of the continuous bio-reactor used in this study

This bio-reactor is modeled by performing mass balances on the cells, substrate, and product (Riggs and Karim 2006). Assume Monod kinetics for the cell growth and that most of the substrate is consumed by the cells. The resulting process models are as follows:

$$\frac{dx}{dt} = -\frac{F_V}{V}x + «_{\max}x \quad (1)$$

$$\frac{dS}{dt} = \frac{F_V}{V}S_F - \frac{F_V}{V}S - \frac{1}{Y_{xS}}«_{\max}x \quad (2)$$

$$\frac{dP}{dt} = -\frac{F_V}{V}P + \frac{1}{Y_{xP}}«_{\max}x \quad (3)$$

The actuator is fast responding compared to the process dynamics; therefore the actuator is assumed to respond instantaneously. The sensors for the cell, substrate and product concentration are modeled separately based on the type of the sensor used in each case. Below are the model equations that represent the dynamic behaviour of the actuator and sensors:

Actuator : $F_V = F_{V,spec}$ (4)

Sensors : $\frac{dx_s}{dt} = \frac{1}{\tau_{TM}}(x - x_s)$ (5)

$S_s(t) = S(t - \theta_s)$ (6)

$P_s(t) = P(t - \theta_s)$ (7)

The process parameters and variables for this model are given in Table 1.

Table 1. Process parameters and variables (Riggs and Karim, 2006)

Symbol	Parameters and Variables	Values and Units
F_V	Feed rate to the reactor	Initally 1000 L/h
$F_{V,spec}$	The specified feed rate to the bioreactor	1050 L/h at t=13 h
K_s	Monod's saturation constant	0.1 g/L
P	Product concentration in the reactor	Initially 1.25 g/L
S	Substrate concentration in the reactor	Initially 25 g/L
S_F	Substrate concentration in the feed to the reactor	50 g/L
t	Time	h
V	Volume of the reactor	5000 L
x	Cell concentration in the bioreactor	Initially 0.25 g/L
Y_{xP}	Yield factor	0.2 g-cells/g-product
Y_{xS}	Yield coefficient	0.01g-cells/g-substrate
μ_{max}	Maximum specific growth rate	0.2/h
Θ_s	The sensor deadtimefor HPLC analyzer	30 min
τ_{TM}	The time constant for the turbidity meter used to measure the cell concentration	20 s

Those model equations were then solved and simulated using Matlab for input changes. The process transfer function in Laplace domain as follows can be obtained immediately:

$$\begin{bmatrix} \bar{x} \\ \bar{S} \\ \bar{P} \end{bmatrix} = \begin{bmatrix} G_1 \\ G_2 \\ G_3 \end{bmatrix} [F_v] \quad (8)$$

Results and Discussion

Figure 2 shows feedrate (F_V) step changes from 1000 to 1050 L/h at t = 13 h for 50 h simulation time. As can be seen in Figure 3, the concentrations of substrates increases linearly and the product concentration decreases linearly. Those results are consistent with previous findings (Riggs and Karim, 2006).

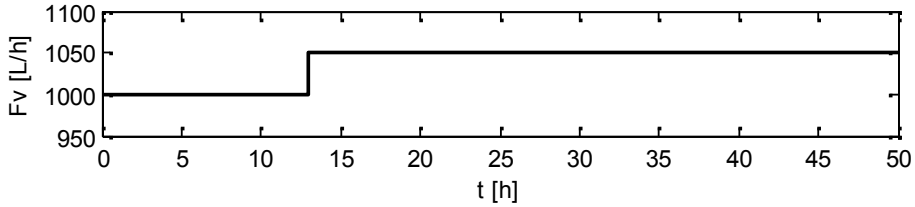

Figure 2. Step change of bio-reactor feedrate

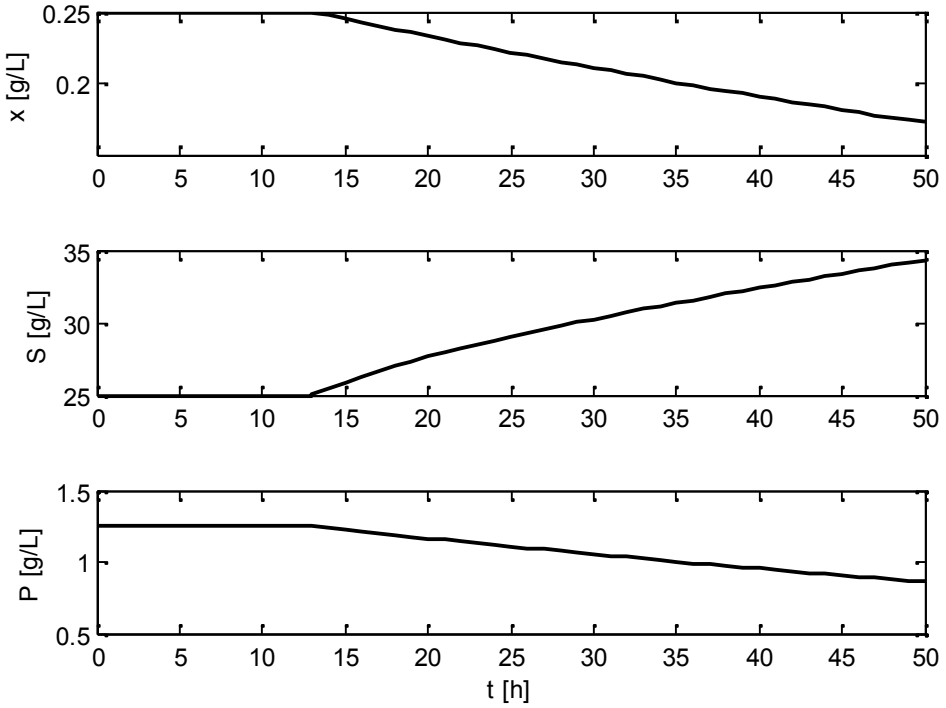

Figure 3. Dynamic response of the continuous bio-reactor to a step increase in feed rate

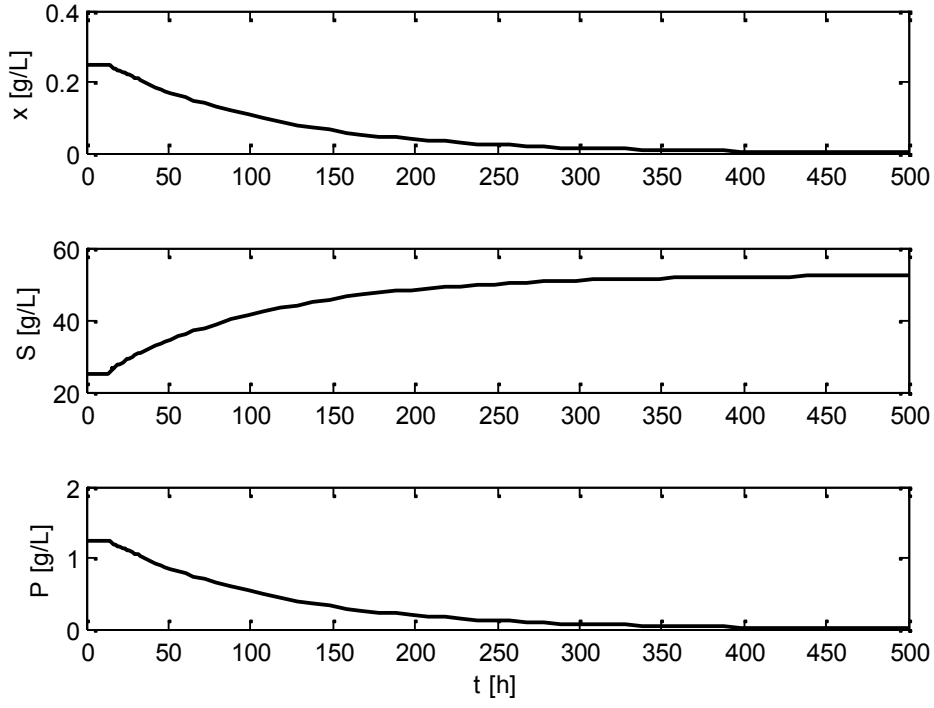

Figure 4. Dynamic response of bio-reactor for longer simulation time

As can be seen in Figure 4, which shows simulation results for longer time (i.e. up to 500 h simulation time), the process are actually first order (Marlin, 2000; Seborg et al, 2010). The first order process transfer function are as the following:

$$\begin{bmatrix} \bar{x} \\ \bar{S} \\ \bar{P} \end{bmatrix} = \begin{bmatrix} \dfrac{-0.005}{100s+1} \\ \dfrac{0.54813}{96.663s+1} \\ \dfrac{-0.025}{100s+1} \end{bmatrix} \left[\bar{F}_v\right] \qquad (9)$$

Conclusions

Dynamic study of a continuous bio-reactor for bioethanol production has been performed. It was found that the process actually follow first order dynamic behaviour. The gains and time constants of the first order process are shown in Eq (9).

Acknowledgements

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