

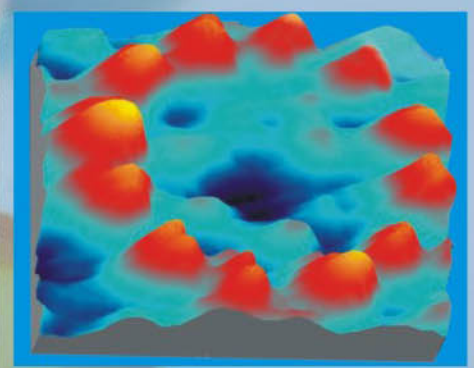
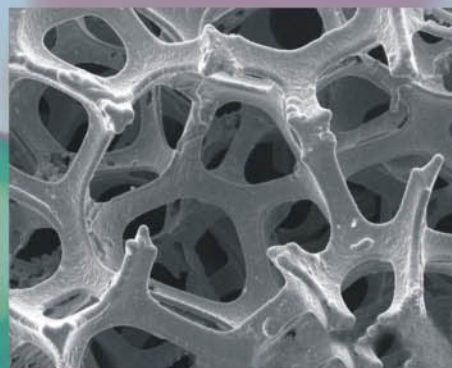


ISSN 2161-6213

From Knowledge to Wisdom

Journal of
Materials Science
and **Engineering**

Volume 1, Number 4, September 2011



**Structural Materials:
Properties, Microstructure and Processing**

David Publishing Company
www.davidpublishing.com

Journal of Materials Science and Engineering A

Volume 1, Number 4, September 2011 (Serial Number 4)



David Publishing Company
www.davidpublishing.com

Publication Information:

Journal of Materials Science and Engineering A (formerly parts of Journal of Materials Science and Engineering ISSN 1934-8959, USA) is published monthly in hard copy and online by David Publishing Company located at 1840 Industrial Drive, Suite 160, Libertyville, Illinois 60048, USA.

Aims and Scope:

Journal of Materials Science and Engineering A, a monthly professional academic journal, particularly emphasizes new research results in realm of materials science and engineering. Articles interpreting practical application of up-to-date technology are also welcome.

Editorial Board Members:

Prof. Preecha Yupapin (Thailand), Prof. M.V. Venkatasamy Reddy (Singapore), Prof. Guangmin Sheng (China), Dr. Starokadomsky Dmitro Lvovich (Ukraine), Prof. Xianbao Wang (China), Dr. Wenqi Luan (USA), Prof. Vijaya Srinivasu Vallabhapurapu (India), Dr. Emad Hassan Aly (Egypt).

Manuscripts and correspondence are invited for publication. You can submit your papers via web submission, or E-mail to materials@davidpublishing.com. Submission guidelines and web submission system are available at <http://www.davidpublishing.com>.

Editorial Office:

1840 Industrial Drive, Suite 160, Libertyville, Illinois 60048
Tel: 1-847-281-9862
Fax: 1-847-281-9855
E-mail: materials@davidpublishing.com; materials1934-8959@hotmail.com

Copyright©2011 by David Publishing Company and individual contributors. All rights reserved. David Publishing Company holds the exclusive copyright of all the contents of this journal. In accordance with the international convention, no part of this journal may be reproduced or transmitted by any media or publishing organs (including various websites) without the written permission of the copyright holder. Otherwise, any conduct would be considered as the violation of the copyright. The contents of this journal are available for any citation. However, all the citations should be clearly indicated with the title of this journal, serial number and the name of the author.

Abstracted / Indexed in:

Database of EBSCO, Massachusetts, USA
Cambridge Science Abstracts (CSA)
Ulrich's Periodicals Directory
Summon Serials Solutions
Chinese Database of CEPS, Airiti Inc. & OCLC
Chinese Scientific Journals Database, VIP Corporation, Chongqing, China

Subscription Information:

Print \$520, Online \$360, Print and Online \$680 (12 issues)

David Publishing Company
1840 Industrial Drive, Suite 160, Libertyville, Illinois 60048
Tel: 1-847-281-9862. Fax: 1-847-281-9855
E-mail: order@davidpublishing.com



David Publishing Company
www.davidpublishing.com

Journal of Materials Science and Engineering A

Volume 1, Number 4, September 2011 (Serial Number 4)

Contents

Technological Studies

- 457 **Nickel-Phosphorus Deposition on Pretreated Aluminium Alloys during Immersion in Electroless Nickel Bath**
Chike F. Oduoza and Enam Khan
- 472 **Effect of Silane Treatment on Weight Change and Mechanical Properties of Hydrothermally Aged Al(OH)₃ Particle/Vinylester Composite**
Tohru Morii
- 481 **Magnetic Field Effects on the Microstructural Variation of Electrodeposited Nickel Film**
Jamil Rabia, Hussain Tajamal, Shahid Saliha and Ansari Muhammad Shahid
- 488 **TiO₂-MCM-41 Thin Film Photocatalyst Prepared from Rice Husk Silica under Room Temperature**
Pummarin Klankaw, Chamorn Chawengkijwanich, Nurak Grisdanurak and Siriluk Chiarakorn
- 496 **EIS Study of Temperature and H₂S Concentration Effect on API 5LX65 Carbon Steel Corrosion in Chloride Solution**
Agus Solehudin, Isdiriyani Nurdin Wawang Suratno and Muljadji Agma
- 506 **Physical Properties Characterization of Fe-Deficient Mg_{0.9}Mn_{0.1}Fe_{2-x}O₄ Soft Ferrite by Citrate Precursor Method**
Nilar Lwin, Ahmad Fauzi Mohd Noor, Srimala Sreekantan, Radzali Othman and Aye Aye Thant
- 512 **Analysis of Cracks Resulting from Thermite Welding of Cathodic Protection**
Suban Marjan, Bozic Simon, Zajec Andrej, Cvelbar Robert and Bundara Borut
- 518 **Separate Observation with Polarized Electronic and IR Spectra of Hybrid Materials of Chiral Mn(II) Complexes and Azobenzene**
Takashi Akitsu, Rieko Tanaka and Atsuo Yamazaki
- 526 **In-vitro Cytotoxicity and Anti-microbial Evaluations of Silver Doped Titania Composite Coatings**
Shirin Ibrahim, Syazana Abu Bakar, Neelam Shahab and Mohd Radzi Mohd Toff
- 531 **Design and Transdermal Delivery of Indomethacin Nanosystem**
Catarina Pinto Reis, Felipe de Freitas Nunes, Catarina Rosado and Luis Monteiro Rodrigues

- 538 **Study on the Electrical and Thermal Properties of Carbon/Carbon Composite for Fuel Cell Bipolar Plate**
Weijen Chen, Shenghsiu Tseng, Yiluen Li, Mingyuan Shen and Mingchuen Yip
- 545 **NMR Imaging of Heavy Crude Oil for Softening Detection under Heat Treatment**
Morozov Evgeny V., Martyanov Oleg N., Volkov Nikita V. and Falaleev Oleg V.
- 552 **Influence of Temperature and Current on Hydrogen Evolution during Cathodic Polarisation of Al-Ga Alloys**
Jagoda Radošević, Lea Kukoč-Modun, Ratko Mimica and Igor Janjatović
- 556 **Influence of Y₂O₃ Addition on the Microstructure and Mechanical Properties of Mg-PSZ Ceramics**
Yamagata Chieko and Paschoal Jose Octavio Armani
- 562 **Effect of 5 GPa Pressure Heat Treatment on the Microstructure and Hardness of Cu-Al Alloy**
Yuefeng Wang, Qianyu Zhuang, Lin Qu, Weilong Lu, Jianhua Liu and Ruijun Zhang
- 566 **Effect of Mechanical Properties and Morphology of Sago Starch Filled UPR Composite**
Rahmah Mohamed, Rabi'ah Md Amin and Ahmad Faiza Mohd
- 572 **Implementation of Process Reaction Curve for Tuning of Temperature Control Parameters in a 10 L Stirred Tank Heater**
Yulius Dedy Hermawan

Theoretical Studies

- 578 **MAC Model for the Linear Thermoelasticity**
Igor Neygebauer
- 586 **Application of Radial Basis Function Learning Algorithm in Petroleum Engineering: Bottom-Hole Pressure Prediction**
Mehdi Mohammadpoor and Farshid Torabi
- 592 **Mathematical Models of Symmetrical Diffusive Layers in Porous Electrodes**
Andrey Vadimovich Shobukhov and Dmitry Sergeyeovich Maximov

Implementation of Process Reaction Curve for Tuning of Temperature Control Parameters in a 10 L Stirred Tank Heater

Yulius Deddy Hermawan

Department of Chemical Engineering, Faculty of Industrial Technology, Universitas Pembangunan Nasional "Veteran" Yogyakarta, Yogyakarta 55283, Indonesia

Received: April 27, 2011 / Accepted: May 12, 2011 / Published: September 10, 2011.

Abstract: The use of Process Reaction Curve (PRC) method for tuning of temperature control parameters in a 10 L stirred tank heater has been studied experimentally. An electric heater was employed as a means to heat the liquid in tank and to maintain its temperature. In order to create a process reaction curve, an open loop experiment was done in laboratory. The electric heat load (q_e) was suddenly changed from 420 Watt (initial value) to 500 Watt (new steady state value) at time equals 2 min. As a result, the liquid temperature in tank rises from 31 to 32 °C at time equals 6 min. This open loop temperature response was then used for tuning of PID temperature control parameters; the tuning results are as follows: gain controller $K_c = 77$ Watt/°C, integral time constant $\tau_I = 300$ second, and derivative time constant $\tau_D = 75$ second. Furthermore, closed loop simulation using computer programming was also done to evaluate the resulted tuning parameters. The developed mathematical model of temperature control system in stirred tank heater was solved numerically. Such mathematical model was rigorously examined in Scilab software environment. As shown in closed loop simulation, closed loop responses in PID control were faster than those in P and PI controls.

Key words: Closed loop, open loop, PID control, process reaction curve (PRC), stirred tank heater, step input.

Nomenclature

C	controlled variable (°C)
$c_{p1,2,3}$	heat capacity of stream 1, 2, 3 (J/(gr. °C))
e	error (°C)
$f_{1,2,3}$	volumetric flowrate of stream 1, 2, 3 (L/second)
K	steady state gain of the process (°C/Watt)
K_c	proportional gain controller (Watt/°C)
M	manipulated variable (Watt or J/second)
q_e	electric heat/energy (Watt or J/second)
$T_{1,2,3}$	temperature of stream 1, 2, 3 (°C)
T^{SP}	set point of temperature (°C)
t_1	time at which $C = 0.283 \Delta C_s$
t_2	time at which $C = 0.632 \Delta C_s$
t_D	effective process dead time (second)

V liquid volume in tank (L)

Greek letters

ΔC_s	steady state change in controlled variable (°C)
ΔM	step change in manipulated variable (Watt or J/second)
ρ	liquid density (gr/L)
τ	effective process time constant (second)
τ_D	derivative time constant (second)
τ_I	integral time constant (second)

1. Introduction

Stirred tank heater is frequently used in chemical process industries. It can be utilized for examples as a mixing tank and/or a continuous stirred tank reactor. Since its operating conditions change as the disturbances enter the process, the main goal of the plant could probably not be achieved. Therefore, the plant engineers or operators should familiar with

plant's dynamic behaviors. Additionally, implementation of process control is also very important to operate the plant automatically.

The first activity that should be done before running the plant automatically at its desired conditions is tuning of controller's parameters. Feedback control parameters, such as, proportional gain controller (K_c), integral time constant (τ_I), and derivative time constant (τ_D), seriously affect the stability of the plant. However designed control system must be able to give a stable response in facing the disturbances. Therefore, it is important to study process dynamic and control.

There have been many contributions to the study of process dynamic and control. Temperature dynamic behavior in a horizontal stirred tank heater has been explored [1]. Application of On-Off control in a liquid tank has been done [2]. Tuning of level control parameters using Process Reaction Curve (PRC) and dynamic simulation in a liquid tank has also been done successfully [3].

The goals of this research are to tune temperature control parameters (PID Control parameters) in a 10 L stirred tank heater, and to examine the resulted control parameters through dynamic simulation. In order to achieve the aims of this research, this work was done in two parts, i.e., open loop experiment in laboratory and closed loop simulation using computer programming. PRC was chosen to tune temperature control parameters. The electric heat and the inlet temperature of the tank were selected as a manipulated variable, and a disturbance, respectively. A step input was chosen to make a disturbance, since it can be done easily in laboratory. The Scilab software was utilized to carry out dynamic simulation.

2. Experiment

Fig. 1 shows an experimental apparatus setup. In this work, water was used as liquid to be heated in tank. As can be seen from Fig. 1, No.1 is a main tank that represents a stirred tank heater. The two feeds enter the

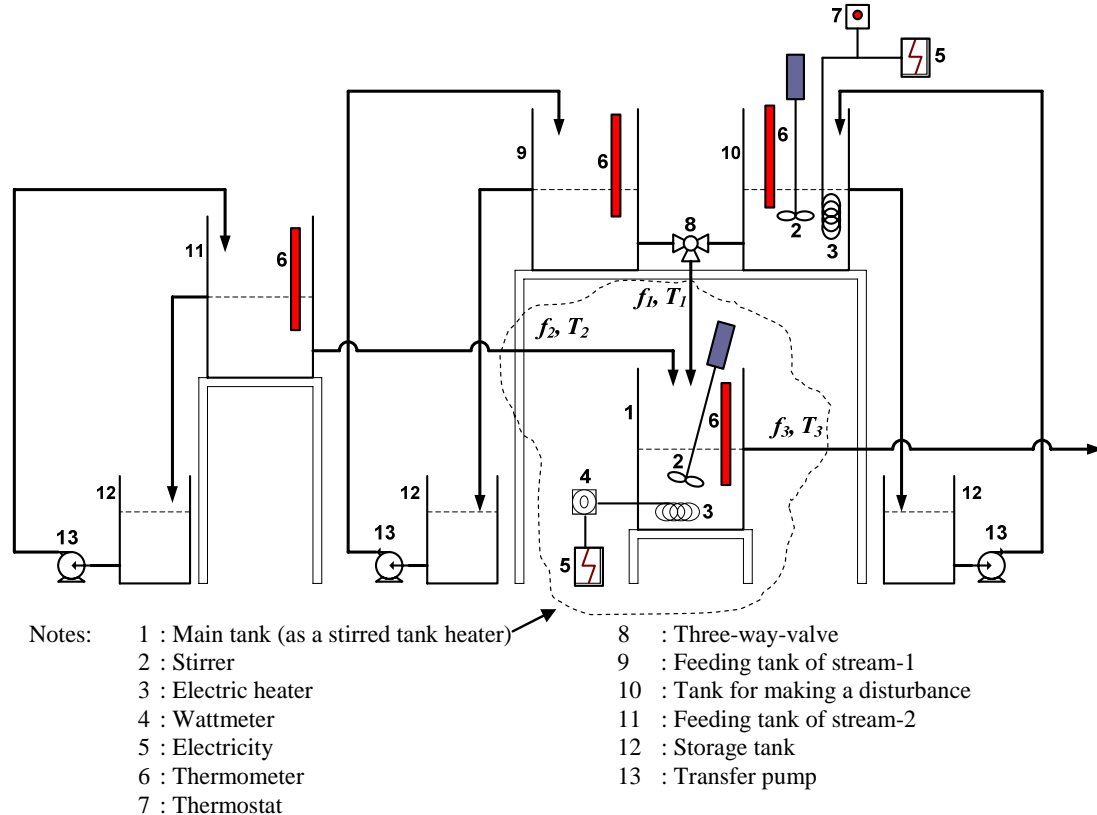


Fig. 1 Experimental apparatus setup.

tank with a volumetric flowrate f_1 and f_2 , respectively, and a temperature T_1 and T_2 , respectively. Since the system is designed overflow, the liquid level in tank is always kept constant. The water in tank is heated by an amount of heat q_e (Watt) which is supplied by an electric heater. A stirrer is employed to obtain uniform temperature in tank. The water density is assumed constant, the heat balance in Q model can be written as follows:

$$V\rho_{p3}\frac{dT_3}{dt} = f_1\rho_{p1}T_1 + f_2\rho_{p2}T_2 + q_e - (f_1 + f_2)\rho_{p3}T_3 \quad (1)$$

where heat capacity of water [J/(gr·K)] is a function of temperature:

$$c_p = 15.33 - 0.1161 T + 4.514 \times 10^{-4} T^2 + 8 \times 10^{-7} T^3 + 5.206 \times 10^{-10} T^4 \quad (2)$$

In normal condition, stream-1 and stream-2 come from the feeding tank No. 9 and No. 11 in Fig. 1, respectively. PRC experiment is done by changing the wattmeter (No. 4 in Fig. 1) to increase the electric heat load (q_e) rapidly. The liquid temperature response to a change in electric heat load is then investigated. The resulted response will similar with that response given by first order plus dead time (FOPDT) model. PID Control parameters are then tuned by fitting the resulted FOPDT as proposed by Smith [4]. After that, the heat load disturbance is made by changing the inlet temperature of stream-1, T_1 , suddenly. This is done by revolving the gate of three-way-valve (No. 8 in Fig. 1), so that stream-1 comes from the tank No 10 in Fig. 1, which is specifically prepared for making disturbance. Again, the liquid temperature response to a change in the inlet temperature T_1 is then investigated. These open loop experiments should be started from its initial (normal) conditions.

In order to evaluate the resulted PID Control parameters, closed loop simulation is carried out by means of computer. For closed loop dynamic simulation, a simple feedback control system is implemented to maintain liquid temperature in tank (T_3) constant by manipulating the electric heat (q_e).

Thus, the equation of manipulated variable can be written as follow:

$$q_e = \bar{q}_e + K_c e + \frac{K_c}{\tau_I} \int e dt + K_c \tau_D \frac{de}{dt} \quad (3)$$

where e is defined as:

$$e = T_3^{SP} - T_3 = \text{error} \quad (4)$$

The developed mathematical model of temperature control system in stirred tank heater is solved numerically with the easiest way of explicit euler. The free software Scilab is chosen to carry out the closed loop dynamic simulation. The closed loop responses of temperature control will then be explored in this work.

3. Results and Discussion

Steady state parameters of the stirred tank heater are listed in Table 1. Based on steady state material balance, the process time constant is found 133 seconds (2.2 min). Therefore the system is considered quite sensitive to the changes of input disturbances. Fig. 2 shows the process reaction curve of the influence of electric heat (q_e) on liquid temperature in tank (T_3). Electric heat is rapidly increased by an amount of 80 Watt at time equals 2 min; the temperature T_3 achieves its new steady state value of 32 °C at time equals 6 minutes. This temperature response (Fig. 2) is then fitted (by fit 3) [4] to obtain parameters of FOPDT as shown in Fig. 2. The tuning results of temperature feedback control parameters (P, PI, and PID) are listed in Table 2.

Table 1 Steady state parameters.

Variable	Steady state
Volumetric flowrate of stream-1, \bar{f}_1 (L/second)	14.870×10^{-3}
Volumetric flowrate of stream-2, \bar{f}_2 (L/second)	22.634×10^{-3}
Volumetric flowrate of stream-3, \bar{f}_3 (L/second)	37.504×10^{-3}
Temperature of stream-1, \bar{T}_1 (°C)	26
Temperature of stream-2, \bar{T}_2 (°C)	26
Temperature of stream-3, \bar{T}_3 (°C)	31
Electric heat, \bar{q}_e (Watt)	420
Liquid volume in tank, V (L)	5

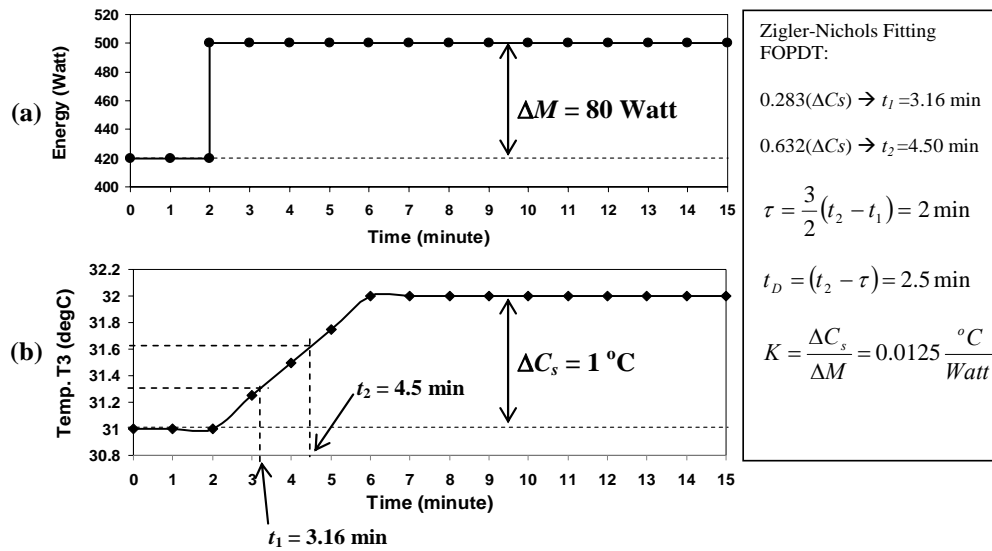


Fig. 2 Process reaction curve: temperature dynamic response to a change in electric heat.

Table 2 Tuning results of temperature controller in A 10 L stirred tank heater (Based on Zigler-Nichols Fitting).

Type of feedback control	Proportional gain K_c	Integral time τ_I	Derivative time τ_D
P	$\frac{1}{K} \frac{\tau}{t_D} = 64 \frac{Watt}{^\circ C}$	-	-
PI	$\frac{0.9}{K} \frac{\tau}{t_D} = 57.6 \frac{Watt}{^\circ C}$	$3.3t_D = 8.25 \text{ min} = 495 \text{ sec}$	-
PID	$\frac{1.2}{K} \frac{\tau}{t_D} = 77 \frac{Watt}{^\circ C}$	$2.0t_D = 5 \text{ min} = 300 \text{ sec}$	$0.5t_D = 1.25 \text{ min} = 75 \text{ sec}$

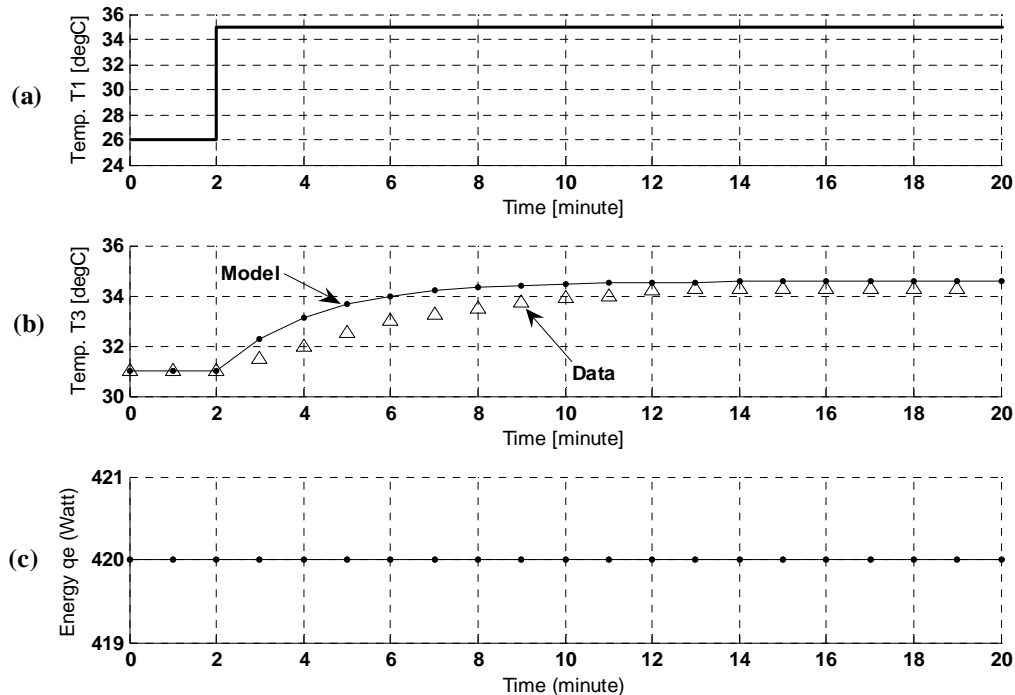


Fig. 3 The open loop responses to a change in the inlet temperature of stream-1 (T_1): (a) temperature of stream-1 (T_1), (b) liquid temperature in tank (T_3), (c) electric heat (q_e).

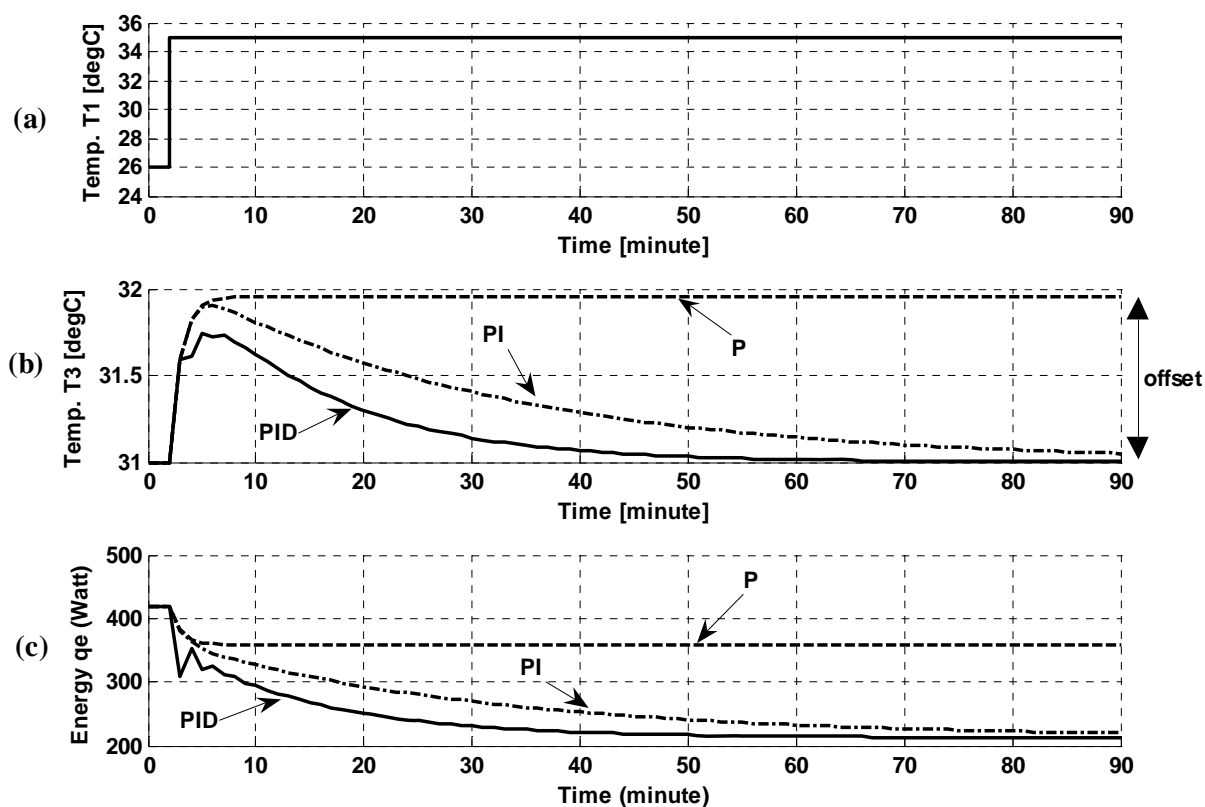


Fig. 4 Closed loop responses to a change in the inlet temperature of stream-1 (T_1): (a) temperature of stream-1 (T_1), (b) liquid temperature in tank (T_3), (c) electric heat (q_e)

Fig. 3 shows the open loop responses to a change in the inlet temperature of stream-1 (T_1). The inlet temperature T_1 is increased by an amount of 9 °C at time equals 2 min (Fig. 3a). Since the electric heat is constant (Fig. 3c), it is understandable that liquid temperature in tank (T_3) rises to a new steady state value of about 34.2 °C at time equals 10 min.

Closed loop responses to a change in temperature T_1 are illustrated in Fig. 4. As can be seen from Fig. 4, the temperature controller (P, PI, and PID) attempts to return temperature T_3 to its normal value of 31 °C. Temperature T_3 can be returned to its set point by both of PI and PID Controls. However P Control still produces an offset of 0.9 °C. Closed loop response of PID Control is fastest compared to P and PI Controls; Temperature T_3 can be returned to its set point at time equals 60 min.

4. Conclusions

This paper has discussed tuning of temperature

control parameters in a 10 L stirred tank heater. This research gave Proportional Integral Derivative (PID) control parameters as follows: gain controller $K_c = 77$ Watt/°C, integral time constant $\tau_I = 300$ second, and derivative time constant $\tau_D = 75$ second. According to the closed loop simulation results, PID Control produced the fastest responses compared to both of P and PI Controls. This study also reveals that by tuning the appropriate control parameters, stable responses can be achieved.

Acknowledgments

I appreciate the technical support on the use of free software SCILAB. Financial support from A2 Competitive Grant Program 2007, Department of Chemical Engineering, UPN "Veteran" Yogyakarta for this work is gratefully acknowledged. I also thank Ir. Drs. Priyo Waspodo, M.Sc and Siti Diyar Kholisoh, ST, MT of UPN "Veteran" Yogyakarta for valuable discussion.

References

- [1] Y.D. Hermawan, Y. Suksmono, P.B.S Chendikia, P.S. Agung, Temperature dynamic on horizontal stirred tank heater, seminar nasional teknik kimia "Kejuangan" 2007, Department of Chemical Engineering, Faculty of Industrial Technology, UPN "Veteran" Yogyakarta, 2007 B10-1-B10-6. (in Indonesian)
- [2] T. Khristiyanto, P.Y.B. Made, Application of on-off control and tuning of level control parameters in a liquid tank, Undergraduate Research Report, Department of Chemical Engineering, Faculty of Industrial Technology, UPN "Veteran" Yogyakarta, 2007. (in Indonesian)
- [3] W.A Andita, F. Syaerozi, The use of process reaction curve for tuning of level control parameters and dynamic simulation in a liquid tank, Undergraduate Research Report, Department of Chemical Engineering, Faculty of Industrial Technology, UPN "Veteran" Yogyakarta, 2007. (in Indonesian)
- [4] C.A. Smith, A.B. Corripio, Principles and Practice of Automatic Process Control, 2nd ed., John Wiley & Sons, Inc., USA, 1997. pp. 303-321.



From Knowledge to Wisdom

Journal of Materials Science and Engineering (A & B)

International Standard Serial Number: ISSN 2161-6213 & ISSN 2161-6221

Call for papers

Journal of Materials Science and Engineering (A & B) (ISSN 2161-6213 & ISSN 2161-6221) are collected and indexed by the Library of U.S Congress (<http://catalog.loc.gov>), an on-line inquiry can be triggered with the serial numbers: ISSN 2161-6213 and ISSN 2161-6221, as key words in "QUICK SEARCH" column. In addition, both journals are also retrieved by the following renowned databases:

- ★ Database of EBSCO, Massachusetts, USA
- ★ Cambridge Science Abstracts (CSA)
- ★ Ulrich's Periodicals Directory
- ★ Chinese Scientific Journals Database, VIP Corporation, Chongqing, China
- ★ Chinese Database of CEPS, American Federal Computer Library center (OCLC), USA
- ★ Excellent paper in ERIC

The *Journal of Materials Science and Engineering* is an international, scholarly, and peer-reviewed journal (print and online) published monthly by David Publishing Company, USA which was founded in 2007. It provides an international medium for the publication of theoretical and experimental studies and reviews related to metals, nonmetal, functional materials, composite materials, ceramics, macromolecule, superconductor, biological and biomedical materials, magnetism, glasses, polymers, electrical materials, fibers, nanostructured materials, and so on.

There are so many authors have published their papers in our journal all around the world. All papers considered appropriate for our journal are reviewed anonymously by at least two outside reviewers. In order to steadily improve the journal and provide a platform to present more academic achievements, the journal has been separated into 2 issues (Issue A and Issue B) from June 2011. *Journal of Materials Science and Engineering A* provides an international medium for the studies related to the properties, microstructure and processing of the materials, while *Journal of Materials Science and Engineering B* focuses on the functional solid-state materials. Both journals welcome contributions which promote the exchange of ideas and rational discourse between practicing educators and material researchers all over the world.

Submission of Manuscript

All manuscripts submitted will be considered for publication. Manuscripts should be sent online (<http://www.davidpublishing.com>) for our automatic paper submission systems or as the attachments to: materials@davidpublishing.com; materials1934-8959@hotmail.com; material.david@yahoo.com.

Address of Headquarters: David Publishing Company, 1840 Industrial Drive, Suite 160, Libertyville, IL 60048 USA

Tel.: 01-847-281-9862; fax: 001-847-281-9855 (USA).

E-mail: materials@davidpublishing.com; materials1934-8959@hotmail.com; material.david@yahoo.com



Journal of Materials Science and Engineering A
Volume 1, Number 4, September 2011

David Publishing Company
1840 Industrial Drive, Suite 160, Libertyville, IL 60048
Tel: 1-847-281-9862; Fax: 1-847-281-9855
<http://www.davidpublishing.com>
materials@davidpublishing.com, materials1934-8959@hotmail.com

