A DYNAMIC NEURAL NETWORK BASED MODEL PREDICTING OUTLET TEMPERATURE OF HEAT EXCHANGER

RESEARCH MANAGEMENT INSTITUTE (RMI)
UNIVERSITI TEKNOLOGI MARA
40450 SHAH ALAM, SELANGOR
MALAYSIA

BY :

ZALIZAWATI ABDULLAH
NOR HAZELAH KASMURI

OCTOBER 2012

2. Letter of Offer (Research Grant)

UNIVERSITI TEKNOLOGI MARA

PEMENANG Anugerah Kualiti Perdana Menteri 2008

Surat Kami : 600-RMI/ST/DANA 5/3/Dst (312 /2011)
Tarikh : 16 Jun 2011

Pn Zalizawati Abdullah
Fakulti Kejuruteraan Kimia
Universiti Teknologi MARA
40450 Shah Alam

Y. Brs. Profesor./Tuan/Puan

KELULUSAN PERMOHONAN DANA KECEMERLANGAN 06/2011

Tajuk Projek	:	A Multilayer Perceptron Neural Networks Model Of Heat Exchanger
Kod Projek	:	600-RMI/ST/DANA 5/3/Dst (312 /2011)
Kategori Projek	:	Kategori F (2011)
Tempoh	:	15 Jun 2011 – 14 Jun 2012 (12 bulan)
Jumlah Peruntukan	:	RM 9,000.00
Ketua Projek	:	Pn Zalizawati Abdullah

Dengan hormatnya perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan pihak Universiti telah meluluskan cadangan penyelidikan Y. Brs Profesor/tuan/puan untuk membiayai projek penyelidikan di bawah Dana Kecemerlangan UiTM.

3. Bagi pihak Universiti kami mengucapkan tahniah kepada Y. Brs. Profesor/tuan/puan kerana kejayaan ini dan seterusnya diharapkan berjaya menyiapkan projek ini dengan cemerlang.

4. Peruntukan kewangan akan disalurkan melalui tiga (3) peringkat berdasarkan kepada laporan kemajuan serta kewangan yang mencapai perbelanjaan lebih kurang 50% dari peruntukan yang diterima.

Peringkat Pertama	20%
Peringkat Kedua	40%
Peringkat Ketiga	40%

5 Untuk tujuan mengemaskini, pihak Y. Brs. Profesor/tuan/puan adalah diminta untuk melengkapkan semula kertas cadangan penyelidikan sekiranya perlu, mengisi borang setuju terima projek penyelidikan dan menyusun perancangan semula bajet yang baru seperti yang diluluskan. Sila lihat lampiran bagi tatacara tambahan untuk pengurusan projek.

Sekian, harap maklum.

"SELAMAT MENJALANKAN PENYELIDIKAN DENGAN JAYANYA"

Yang benar

MUSTAFAR KAMAL HAMZAH
Ketua Penyelidikan (Sains dan Teknologi)

5. Report

5.1 Proposed Executive Summary

Heat exchangers are widely used in industry both for cooling and heating large scale industrial processes. This process offers a complete line of thermal fluid heat transfer systems. Therefore, much energy is required to operate this unit. Neural network tecniques have been applied to many thermal problems, including the prediction of the steady-state and the dynamic behavior of heat exchangers. The neural network is used as a nonlinear process model to predict the future behavior of the controlled process i.e temperature outlet. The ability of neural network system to understand the behavior of this thermal process can lead to energy saving.

In this study, the multiple neural network model will be developed to describe the nonlinear dynamic behavior of the heat exchanger. It is based on fact that multiple neural network model often giving improved performance compared to single network systems in terms of their accuracy and generalization capability.

Experimental data will be collected from pilot plant heat exchanger equipped with Emerson DeltaV™ DCS in order to provide sufficient data processing to develop the model. The multiple multilayer perceptron neural network model of the heat exchanger will be developed in Matlab™ environment and the performance of the model developed will be assessed. Successful investigation will lead to availability of accurate models to represent the nonlinear dynamic behavior of heat exchanger that can be used in the development of advanced control system.

5.2 Enhanced Executive Summary

Heat exchangers are widely used in industry both for cooling and heating large scale industrial processes. This process offers a complete line of thermal fluid heat transfer systems. Therefore, much energy is required to operate this unit. Neural network tecniques have been applied to many thermal problems, including the prediction of the steady-state and the dynamic behavior of heat exchangers. The neural network is used as a nonlinear process model to predict the future behavior of the controlled process i.e temperature outlet. The ability of neural network system to understand the behavior of this thermal process can lead to energy saving.

In this study, a dynamic neural network model was developed to describe the nonlinear dynamic behavior of the heat exchanger. It is based on fact that dynamic neural network model provide better understanding between the nonlinear dynamical behaviors of the process with the neural network structure with presence of delays in the networks which improved the performance of the model in terms of their accuracy and generalization capability.

Experimental data were collected from pilot plant heat exchanger equipped with Emerson DeltaV™ DCS in order to provide sufficient data processing to develop the model. The multiple multilayer perceptron neural network model of the heat exchanger was developed in Matlab™ environment and the performance of the model developed was assessed. Successful investigation led to availability of accurate models to represent the nonlinear dynamic behavior of heat exchanger that can be used in the development of advanced control system.

5.3 Introduction

Many chemical processes in industries are inherently nonlinear due to the nature of the process itself. In many situations, the dynamic behavior of the process system is known to be nonlinear due to the complex thermodynamic relations or reaction kinetics of the processes.

Heat exchangers have been successfully employed for decades in the chemical industry in the most diverse sectors, such as the cooling and heating processes. This process offers a complete line of thermal fluid heat transfer systems which require much energy to operate. The heat exchanger system also has highly nonlinear features where small change in operating condition causes large changes in the dynamic performance [1]. It is also a clomplex process caused by many phenomena such as leakage, friction, temperature-dependent flow properties, contact resistance and unknown fluid properties [2]. Therefore, tight control system is required in order to obtain optimal performance of the heat exchanger and to minimize the energy consumption. Implementation of advance modelling in control system able to overcome these problems [3,4,5].

Conventional process control systems utilize linear dynamic models. However, the linear model fails to provide satisfactory performance especially when the process is operated away from the nominal operating region. For highly nonlinear systems, control techniques which are directly based on nonlinear models are expected to provide significantly improved performance. For the modeling of the nonlinear process, three different model structures can be used: white box models, also called fundamental models which are derived based on mass, energy and momentum balances of the process; empirical models which are derived from the input-output data of processes like neural networks, fuzzy models and block oriented models; and hybrid models which combine both the fundamental and the empirical model.

Neural network techniques are extensively used to model the nonlinear dynamic behaviour of chemical processes. One of the characteristics of modelling based on artificial neural networks is that it does not require the mathematical description of the phenomena involved in the process [6,7]. In addition, the neural network can provide powerful analysis properties such as complex processing of large input/output information arrays, representing complicated nonlinear associations among data and the ability to generalize or form concepts-theory [8].

Feedforward neural network become the most widely used form of neural network to represent the nonlinear dynamic processes. Currently, dynamic neural networks appear to be a very promising approach to model chemical processes since they provide better