UNIVERSITI TEKNOLOGI MARA

STATIC AND DYNAMIC GRAPHS MODELING OF A BOILER SYSTEM

NOOR AINY HARISH

Thesis submitted in fulfilment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Computer and Mathematical Sciences

July 2015

AUTHOR'S DECLARATION

I declare that the work in this dissertation was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This dissertation has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Noor Ainy Binti Harish
Student I.D. No.	:	2005104441
Programme	:	Doctor of Philosophy (Applied Mathematics)
Faculty	:	Computer and Mathematical Sciences
Dissertation Title	:	Static and Dynamic Graphs Modeling of a Boiler System
Signature of Student	:	....
Date	:	July 2015

ABSTRACT

Fuzzy State Space Model (FSSM) is a novel inverse modeling technique used for optimization of input parameters in multivariable dynamic systems whereby the uncertainty of the parameters is considered and incorporated with the crisp state space models proposed in the modern control theory. The model is succesfully implemented to the state space model of a furnace system of a combined cycle power plant. In this study, FSSM is further implemented to the other state space model of a subsystem in the boiler namely superheater, reheater, riser and drum. Since graph theory is rich in theoretical results especially for studying interconnection among elements in natural and man-made system, therefore, graph representing FSSM is initially developed which is based on the graph theoretic approach. However, the graph of FSSM is found to be a static graph where not much analysis of the graph could explain the model of FSSM of a boiler. Thus, other concept namely Autocatalytic Set (ACS) was applied in developing a new graph which could explain a dynamic nature of a processes in the boiler system. Since combustion process and evaporation process are the main process occurs in the system, therefore two graphs representing interaction among the species in each of the process in the boiler are constructed. These results lead to the development of the third graph which represent a combination of the two processes in the boiler. Adjacency matrix for each of the graph is investigated and and its relation to Perron-Frobenious Theorem is established. Next, to obtain an explanation of the dynamic nature of the system, a Dynamic Autocatalytic Set Graph Algorithm (DAGA) is presented which succesfully explained the dynamics of the real processes in the boiler. The dynamic graphs found from the implementation of DAGA to the boiler system are then further investigated where connection of the graphs to fuzzy graph of type-1 are established. Basic characteristics of the dynamic graphs which was developed in this study have resulted in the derivation of some propositions and proven theorems.

ACKNOWLEDGEMENTS

IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

Alhamdullillah, praise be to Allah S.W.T for giving the continuous strength and determination to complete this study successfully. In order to complete this thesis, it requires a lot of contribution from others. I would like to express my thanks to all who have contributed, either directly or indirectly.

My deepest appreciation goes to my supervisors, Professor Dr. Razidah Ismail, Professor Dr. Tahir Ahmad, Associate Professor Dr Wan Eny Zain and Dr. Sumarni Abu Bakar, who had guided and pushed me to the right direction. Without their help and guidance, this study would not be materialized. Special thank, also, to the management team of FSKM, who had given me a lot of moral support, which indirectly, had encourage me to continue and struggling until the end. Advices and comments by my colleagues and friends had been a great help throughout my studies.

Finally, my deepest and heartfelt appreciation goes to my husband and my children for the patience and support during my studies. Their prayers, understanding and encouragement give me strength to finish this thesis.

Thank you very much.

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND AND RATIONALE

Mathematical modeling has been a source of pride for most mathematicians over the years. The ability to apply mathematics to predict and produce desired outcomes in conventional situations has been, is, and always will be great interest to man since the ability to control our environment is what gives us to control over our lives as a whole. The design of mathematical models for complex real-world system is essential in many fields of science and engineering. The need of new approach and philosophies in modeling and control of complex industrial systems are much influenced by recent advances in information technology, increased market competition, the demand for low cost operation and energy efficiency. In the electricity industry for example, factors such as high pressure and temperatures affect the operational conditions and efficiency of large complex systems such as the power generation plants. These factors affect production and environmental costs Gonzalez, Garcia, Ramon and Roces (2006).

It is useful to decompose a large complex system such as the power generations plant into subsystems or components that can be analysed and understood separately. The physical structure of the system often suggests suitable subdivision. In analysing such system, it is essential to reduce the complexity of the mathematical expressions and to resort to mathematical software when dealing tedious computations involved in the analysis. Thus, the state space approach is the best suited from this viewpoint. This approach is based on time–domain analysis and synthesis using state variables. It is a unified method for modeling, analysing and designing a wide range of systems (Nise, 2008). In fact, the most important advantage of the state space representation is that the system dynamic properties are condensed in the model (Cao and Rees, 1995). The properties such as the stability and the dual concept of the controllability and observability of a system play the important role in the design of a control system (Ogata, 2010).