

UNIVERSITI TEKNOLOGI MARA

**NARX MODELLING FOR STEAM
DISTILLATION PILOT PLANT
USING BINARY PARTICLE SWARM
OPTIMISATION TECHNIQUE**

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ABSTRACT

A system identification in control engineering field is a mathematical model based on dynamic properties of the system. Previous researches have established that system identification received a significant attention and interest in broad disciplines due to the theoretical advancement, good predictive model, and performance accuracy. Existing research recognises the critical role played by the accurate nonlinear modelling for distillation column during the essential oil extraction process. The Nonlinear Auto-Regressive with exogenous input (NARX) is one of the most current widely used because of highly efficient, simple, accurate and outstanding results in the actual nonlinear system applications. In recent years, there has been an increasing amount of optimisation modelling research on time-varying nonlinear modelling in the actual nonlinear system applications which hasn't been explored for Steam Distillation Pilot Plant (SDPP) to date. The appropriate choice of the input signals for the nonlinear system is essential to obtain a good performance in the system identification since the widely used Pseudo Random Binary Signal (PRBS) was reported as an insufficient to reveal the nonlinearity behaviour. This study proposes a system identification of SDPP using NARX model. The model structure selection of polynomial NARX had been focused on Binary Particle Swarm Optimisation (BPSO) algorithm. The proposed NARX-based BPSO algorithm was implemented for both time-varying water and steam temperature from the SDPP. The time-varying data from this nonlinear system employed two perturbation input signals, PRBS and Multi-level Pseudo Random Sequence (MPRS). Several model's selection criteria such as Akaike Information Criterion (AIC), Final Prediction Error (FPE), and Model Descriptor Length (MDL) were investigated. Prior to analysing the efficiency of SDPP nonlinear models, the NARX-based BPSO model was checked based on the model validation. The performance comparisons were measured between these two PRBS and MPRS perturbation input signals for both water and steam temperature modelling. The findings reported the NARX models for water and steam temperature models demonstrated excellent outcomes through BPSO algorithm structure selection. The combination of BPSO algorithm and NARX model on the time-varying process produced higher accuracy (99.9999 %) with low Mean Square Error (MSE) (0.01 to 0.009), revealed the real feature of the nonlinear data and effectively captivated the nonlinear properties of the dynamic response. In addition, the results of this study indicated that the selection of MPRS perturbation input signal for the water (3 parameters) and steam temperature (3 parameters) dataset of the SDPP contributed to better modelling performance with the least number of parameters in the output models compared with PRBS signal (5 to 7 parameters).

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TABLE OF CONTENT

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENT	vi
LIST OF TABLES	x
LIST OF FIGURES	x
LIST OF SYMBOLS	xv
LIST OF ABBREVIATIONS	xvii
CHAPTER ONE: INTRODUCTION	1
1.1 Research Background	1
1.2 Problem Statement	3
1.3 Research Hypothesis	4
1.4 Research Objectives	4
1.5 Scope of Research	5
1.6 Significance of Research	5
1.7 Thesis Organisation	6
CHAPTER TWO: LITERATURE REVIEW	8
2.1 Introduction	8
2.2 System Identification	8
2.3 Linear Versus Nonlinear Modelling	9
2.3.1 NARX Modelling	10
2.4 Input Signals for Nonlinear System Perturbation	12
2.5 Time-varying Process Modelling	13
2.6 Nonlinear Modelling for Distillation Column	15
2.7 Small-Scale Binary Steam Distillation Pilot Plant (SDPP)	16
2.8 Optimisation Technique	18

2.8.1	Binary Particle Swarm Optimisation (BPSO)	20
2.9	System Identification Procedures: Model Selection and Validation	21
2.10	Summary of Literature Review	23
CHAPTER THREE: THEORETICAL BACKGROUND		25
3.1	Introduction	25
3.2	Perturbation Input Signal in System Identification	25
3.2.1	PRBS Perturbation Input Signal	25
3.2.2	MPRS Perturbation Input Signal	26
3.3	NARX Modelling	29
3.3.1	Polynomial Identification of NARX	29
3.4	Model Structure Selection: Binary Particle Swarm Optimisation	30
3.5	Model Estimation	34
3.5.1	Model Selection Criteria	34
3.5.2	Pre-processing Method	35
3.6	Model Validation	36
3.6.1	One-Step-Ahead (OSA) Prediction	36
3.6.2	Error and R-Squared	37
3.6.3	Correlation Tests	38
3.6.4	Histogram Analysis	39
CHAPTER FOUR: RESEARCH METHODOLOGY		40
4.1	Introduction	40
4.2	Plant Setup and its Instrumentation	40
4.2.1	SDPP Setup	40
4.2.2	Temperature Sensor	43
4.2.3	Signal Converter	45
4.2.4	Data Acquisition Card	47
4.2.5	Heating Power Controller	50
4.2.6	Software Interfacing Configuration	52
4.3	Voltage-Temperature Calibration	54
4.3.1	Voltage-Water Temperature RTD Calibration	54
4.3.2	Voltage-Steam Temperature RTD Calibration	56
4.4	Data collection	57