

UNIVERSITI TEKNOLOGI MARA

**PERFORMANCE ANALYSIS OF DIFFERENT
TUNING RULES FOR AN ISOTHERMAL CSTR
USING INTEGRATED EPC AND SPC**

AIMAN HAKIM BIN ROSLAN

B. Eng. (Hons) Chemical

May 2017

ABSTRACT

This report demonstrates the integration of Engineering Process Control (EPC) and Statistical Process Control (SPC) for the control of product concentration of an isothermal CSTR. The objectives of this study are to evaluate the performance of Ziegler-Nichols (Z-N), Direct Synthesis, (DS) and Internal Model Control (IMC) tuning methods and determine the most effective method for this process. The simulation model was obtained from past literature and re-constructed using SIMULINK MATLAB to evaluate the process response. Additionally, the process stability, capability and normality were analyzed using Process Capability Sixpack reports in Minitab. Based on the results, DS displays the best response for having the smallest rise time, settling time, overshoot, undershoot, ITAE and ISE. Also, based on statistical analysis, DS yields as the best tuning method as it exhibits the highest process stability and capability.

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and Most Merciful, I would like to express my deepest and utmost gratitude towards the Almighty for his blessing and provision which allowed me to complete this study smoothly and safely. Also, I would like to extend my thanks to Madam Siti Fatma Abd Karim for sharing her valuable advice and guidance throughout this entire journey. Surely, none of this could have been accomplished without her teachings. To my parents, whom have been the pillar of strength since the beginning, I owe every bit of success to both of them. Last but not least, I would like to thank my classmates of EH2208B for being the constant helping hand throughout our time together.

TABLE OF CONTENTS

	Page
AUTHOR'S DECLARATION	i-ii
ABSTRACT	iii
ACKNOWLEDGEMENT	iv
TABLE OF CONTENTS	v-vi
LIST OF TABLES	vii
LIST OF FIGURES	viii-ix
LIST OF SYMBOLS	x
LIST OF ABBREVIATIONS	xi
 CHAPTER ONE: INTRODUCTION	
1.1 Research Background	1-2
1.2 Objective	2
1.3 Problem Statement	3
1.4 Scope of Research	3
1.5 Significance of Study	4
 CHAPTER TWO: LITERATURE REVIEW	
2.1 Statistical Proses Control (SPC)	5-6
2.2 SPC Quality Tools	6-7
2.2.1 Control Charts	7
2.2.1.1 Subgroup	8
2.2.1.2 $\bar{X}$ -bar Chart	9-10
2.2.1.3 R Chart	11
2.2.1.4 I Chart	12
2.2.1.5 MR Chart	13
2.2.2 Histogram Chart	14
2.2.3 Normal Probability Plot	15
2.2.4 Process Capability Analysis	16-17
2.2.4.1 Process Capability Indices	17-18
2.2.4.2 Process Capability Chart	19

CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

In today's competitive market, many manufacturing industries are seeking ways to optimize process performance and improve product quality in order to maintain a successful operation. For this, two methods are commonly practiced, namely Engineering Process Control (EPC) and Statistical Process Control (SPC) (Duffuaa & Noman, 2004).

Variations are undoubtedly among the major concerns for every manufacturing industry. The concept of variation states that no two products will be perfectly identical even when extreme care is taken to ensure the products remain synonymous between one another (Mahesh & Prabhuswamy, 2010). Variations can be classified into two categories, namely common cause and special cause (Jiang & Tsui, 1999). Common cause variation contributes to more than 80% of product defect due to equipment failure, gradual deterioration, wear and tear, irregular scheduled maintenance and many more. These variations are natural and is inherent within the process, which makes it difficult to be completely eliminated. On the other hand, about 20% of the defect is due to special cause variation such as improper tuning, incorrectly adjusted machinery and wrong choice of material (Hossain, Choudhury, & Suyut, 1996).

Within the field of Chemical Engineering, reactors are looked upon as the "heart" of every chemical process. This is because of its important role in converting raw materials into specified products, which can be utilized by the general public. Continuous Stirred Tank Reactor (CSTR) is a common type of reactor that is commonly used in manufacturing industries. However, due to its complex and non-linear characteristics, control of product concentration is difficult to achieve and often requires an accurate model. (Kumar, 2012).