

الآية

بسم الله الرحمن الرحيم

(لَا الشَّمْسُ يَنْبَغِي لَهَا أَنْ تُدْرِكَ الْقَمَرَ وَلَا اللَّيْلُ سَابِقُ النَّهَارِ وَكُلٌّ فِي فَلَكٍ يَسْبَحُونَ)

سورة يس الآية (40)

DEDICATION

To my mother, father, grandmother and my aunt to my brothers
and my sisters to all my friends.

ACKNOWLEDGMENT

First and foremost, I am very grateful to my lord for giving me this opportunity to accomplish my thesis. Then, I would like to thank my supervisor assistant professor Awadalla Taifor Ali for his valuable suggestions, guidance and consistent support throughout this thesis. And I would like to thank Dr. Mohyedin Ahmed Abdelghder who helped me in this Thesis.

ABSTRACT

This study investigates the control of liquid level of flow control system. Proportional-integral-derivative controllers were used in this study as a control strategy. Optimum control setting has been determined and implemented by using Ziegler-Nicholls tuning method. Fuzzy logic control systems were introduced by (Lotfi Zadeh) to optimize the process control parameters in better way. In this thesis, a flow control system strategy been implemented with proportional-integral-derivative controller and then optimized with fuzzy logic controller (Mamdani-type fuzzy processing). The fuzzy logic control strategy shows the improvement in control specification like maximum overshoot, steady state error compared with PID control strategy.

The results show the superiority of fuzzy logic controller over comparing with proportional integral derivative controller.

مستخلص

تبحث هذه الدراسة في التحكم على مستوى السائل في نظام التحكم في التدفق. واستخدمت المتحكمة التناسبية – التكاملية – التفاضلية كاستراتيجية تحكم في هذه الدراسة . وتم ايجاد القيم المثلى لمعاملات المتحكمة باستخدام طريقه (زيكلر – نيكولاس). وادخلت انظمه تحكم المنطق الغامض من قبل (لطفى زاده) لاكتمال معاملات تحكم العمليات في افضل طريقه. في هذا البحث ، تم تنفيذ استراتيجية التحكم – التناسبي – التكاملي لنظام التحكم في التدفق ثم الامثل عن طريق متحكمة المنطق الغامض (معالجه الغموض من نوع ممدانى). اظهرت استراتيجية تحكم المنطق الغامض التحسن في مختلف معايير التحكم مثل اقصى تجاوز للهدف ، خطأ الحالة المستقرة لنظام التحكم في التدفق بالمقارنة مع استراتيجية التحكم التناسبي – التكاملي – التفاضلي .

هذه النتائج وضحت تفوق المنطق الغامض مقارنة مع التحكم التناسبي – التكاملي – التفاضلي .

TABLE OF CONTENTS

Title	Page
الآية.....	i
DEDICATION.....	ii
ACKNOWLEDGMENT.....	iii
ABSTRACT.....	iv
مستخلص.....	v
TABLE OF CONTENTS.....	vi
TABLE OF SYMBOLS.....	ix
List of ABBREVIATION.....	x
CHAPTER ONE: INTERDUCTION	
1.1 General.....	2
1.2 Problem Statement.....	2
1.3 Objectives	3
1.4 Methodology	3
1.5 Layout.....	3
CHAPTER TWO: THEORETICAL BACKGROUND	
2.1 Introduction.....	5
2.2 Fluid Characteristic.....	5
2.3 Bernoulli's Equation.....	6
2.3.1 Flow from a reservoir	6
2.4 Flow Control System.....	7
2.5 Servo Control System (actuator).....	8
2.5.1 Servo System Modeling.....	9
2.6 PID Controller.....	11
2.7 Ziegler-Nichols Tuning.....	12
2.7.1 The S-shaped method.....	12

2.7.2 Oscillation method.....	14
2.8 Routh's Stability Criterion.....	15
2.9 Fuzzy Logic.....	15
2.9.1 Foundation of fuzzy logic.....	17
2.9.2 Member ship function (MF).....	18
2.9.3 Fuzzy set.....	18
2.9.4 Linguistic variables.....	19
2.9.5 Fuzzy inference systems.....	19
2.9.5.1 Mamdani-type fuzzy possessing	19
2.9.6 Fuzzy rules.....	19
2.9.7 Fuzzy controller operation.....	20
2.9.7.1 the steps for classical design scheme	20
2.10 Structure of a feedback PID-like fuzzy controller.....	21
2.10.1 Fuzzy controllers as a part of a feedback system.....	21
2.10.2 PD-like fuzzy controller.....	22
2.10.3 PI-like fuzzy controller.....	22
2.10.4 PID-like fuzzy controller.....	23

CHAPTER THREE: CONTROL SYSTEM DESIGN

3.1 System Description.....	25
3.2 Fundamental Control Principle of Coupled-Tank System	26
3.3 Parameters of the Coupled-Tank System.....	28
3.4 Mathematical Modeling of the Coupled-Tank System...	28
3.5 Nonlinear Model of Coupled-Tank System.....	29
3.6 A linearised Perturbation Model.....	30
3.7 First Order Single-Input Single Output (SISO) Plant System	32
3.8 Second Order Single-Input Single Output (SISO) Plant System	33
3.9 Conventional System Design.....	35
3.10 Fuzzy System Design.....	38

CHAPTER FOUR: SIMULATION RESULTS

4.1 Performance with PID Controller.....	44
4.2 Performance with Fuzzy Controller.....	46
4.3 Time Response Specifications of Coupled Tank.....	50

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions.....	52
5.2 Recommendations.....	52
References.....	53

LIST OF SYMBOLS

$H_1 \& H_2$	Elevation of Coupled tank
α	Proportionality Constant
$A_1 \& A_2$	Sectional Area of the Coupled Tank Cross
Q_{03}	Flow rate of Liquid between Tanks
$Q_{i1} \& Q_{i2}$	Pump flow rate into tank 1 and Tank 2 respectively
$Q_{01} \& Q_{02}$	Flow rate of Liquid out of Tank 1 and Tank 2 Respectively
$q_1 \& q_2$	Small variations in each inflow in Q_{i1} , Q_{i2} Respectively
$h_1 \& h_2$	Resulting Perturbation in $H_1 \& H_2$ Respectively
$T(t)$	Motor Torque
T_d	Derivative Time
T_i	Integral Time
$U(s)$	Motor Input
$V(s)$	Motor Speed
$Y(s)$	Output Shaft Position
τ	Time Constant
K	System Gain
K_p	Proportional Gain
K_d	Derivative Gain
K_i	Integral Gain

TABLE OF ABBREVIATIONS

DC	Direct Current
FIS	Fuzzy Inference System
FLC	Fuzzy Logic Controller
Mf	Membership Function
PID	Proportional- Integral- Derivative
SISO	Single Input Single Output