

PROPOSED AUTOMATION OF TEA WITHERING PROCESS USING FUZZY LOGIC CONTROLLER

A dissertation submitted to the
Department of Electrical Engineering, University of Moratuwa
in partial fulfilment of the requirements for the
degree of Master of Science

by

JAYASUNDARA MUDIYANSELAGE INDIKA JAYASUNDARA



University of Moratuwa, Sri Lanka
LIBRARY
UNIVERSITY OF MORATUWA, SRI LANKA
www.lib.moratuwa.lk

621.3 "08"

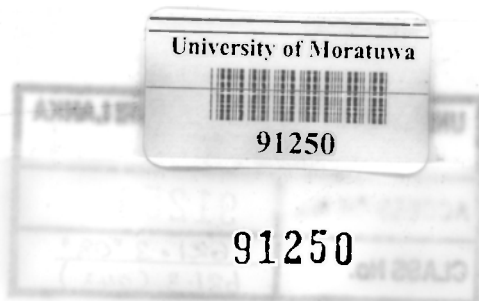
621.3 (043)

Supervised by:
Dr. Lanka Udawatta,
Mr. K.Raveendran.

91250

Department of Electrical Engineering
University of Moratuwa, Sri Lanka

February 2008



DECLARATION

The work submitted in this dissertation is the result of my own investigation, except where otherwise stated.

It has not already been accepted for any degree, and is also not being concurrently submitted for any other degree.

J.M.I Jayasundara

Date

endorse the declaration by the candidate.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Dr. Lanka Udawatta

UOM Verified Signature

K.Raveendran

CONTENTS

Declaration	3
Contents	4
Abstract	6
Dedication	7
Acknowledgement	8
List of Figures	9
List of Tables	10
1. Introduction	11
1.1 Background	11
1.2 Motivation	14
1.3 Objective	14
2. Tea Processing	15
2.1 Withering	15
2.2 Rolling	16
2.3 Fermentation	17
2.4 Drying	17
2.5 Grading and Packaging	17
3. Fuzzy Controller	18
3.1 Fuzzy logic History and Applications	18
3.2 Fuzzy logic in Industrial Automation	18
3.3 Multivariable Control	19
3.4 Structure of a Fuzzy Controller	20
3.4.1 Pre-processing	20
3.4.2 Fuzzyfication	20
3.4.3 Rule Base	21
3.4.4 Inference Engine	21
3.4.5 Defuzzyfication	22
3.4.6 Post Processing	22



4. Statement of the Problem	23
4.1 Preliminaries	23
4.2 Behaviour of Process Inputs	24
5. Proposed Solution	28
5.1 Methods and Techniques	28
5.2 Development of the Control Algorithm	36
5.3 The Fuzzy Inference System	38
5.4 Rule Base	40
6. Results and Analysis	45
6.1 Evaluation of the Proposed Control Strategy	45
6.2 Energy Saving Approximations	49
7. Application of the Proposed Method	53
7.1 Implementation	53
7.2 Configuring Fine Tuning and Commissioning	54
7.3 Practical Issues	54
8. Conclusions	55
8.1 Conclusions, Remarks and Discussion	55
8.2 Considerations for Future Research	56
References	57
Appendix	59



ABSTRACT

Tea processing is one of the major energy intensive food processing industries in Sri Lanka and the process “withering”, which is the first stage of the complete process, accounts for about half of the total electrical energy consumption in the tea industry. This process consumes electrical energy mainly to run the withering fans. The traditional methods of controlling withering process have proven to be very inefficient in energy point of view.

This study proposes a fuzzy logic based withering control methodology which will optimize the electrical energy consumption of the process while maintaining the quality of the processed tea.

Present process analysis was done with field experimental data and the performance of the proposed system was evaluated on Matlab[®] platform.

This proposed control structure can be implemented, modified and field tuned for optimization depending on the practical installation characteristics and expected to save a considerable amount of electrical energy in tea processing industry.





University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
To my wife Thilini
www.ho.mrt.ac.lk



ACKNOWLEDGEMENT

I would like to express thanks to my supervisors Dr. Lanka Udawatta and Mr. K.Raveendran for their continuing guidance, encouragement, and support throughout the course of my study.

My sincere thanks go to the officers at Tea Research institute of Sri Lanka, Thalawakelle, Faculty of Engineering, University of Moratuwa, for helping in various ways to clarify the things related to my work in time with excellent cooperation and guidance. Also I must thank the management and staff of Rotax Limited, for support and encouragement extended to me in making this study a success.

Finally, I should thank many individuals, friends and colleagues who have not been mentioned here personally in making this educational process a success. May be I could not have made it without your support.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk



LIST OF FIGURES

- Figure 3.1: Standard Fuzzy Logic Controller.
- Figure 4.1: Withering Trough Arrangement.
- Figure 4.2: Variation of Air Flow with Process Time.
- Figure 4.3: Variation of Chamber Pressure with Process Time.
- Figure 5.1: Fuzzyfication of Input Air Flow
- Figure 5.2: Fuzzyfication of Input Chamber Pressure
- Figure 5.3: Fuzzyfication of Input Relative Humidity
- Figure 5.4: Fuzzyfication of Input Chamber Temperature
- Figure 5.5: Fuzzyfication of Output Motor Frequency
- Figure 5.6: Fuzzyfication of Output Damper Angle
- Figure 5.7: Layout of the Withering Trough
- Figure 5.8: Fuzzy Withering Control System
- Figure 6.1: Comparison of Normal Process and Fuzzy Withering Controller Outputs
- Figure 6.2: Graphical View of Motor Frequency Pattern With Respect To Chamber Pressure and Air Flow Readings.
- Figure 6.3: Graphical View of Damper Angle Variation Pattern With Relation To Humidity and Chamber Pressure Readings
- Figure 7.1: Structure of the Proposed Control System
- Figure A.1: Motor Power Consumption with Time (At Constant Frequency)
- Figure A.2: Air Flow Vs Chamber Pressure

LIST OF TABLES

Table 5.1: Fuzzyfication of Input Air Flow

Table 5.2: Fuzzyfication of Input Chamber Pressure

Table 5.3: Fuzzyfication of Input Relative Humidity

Table 5.4: Fuzzyfication of Input Chamber Temperature

Table 5.5: Fuzzyfication of Output Motor Frequency

Table 5.6: Fuzzyfication of Output Damper Angle

Table 6.1: Matlab Fuzzy Inference Evaluation Results

Table 6.2: Electrical Energy Consumption of the Present and Proposed systems

Table A.1: Field Experiment Data

Table A.2: Air Velocity through Withering Bed.

Table A3: Withering Chamber Pressure Variation during the Process

Table A.4: Motor Power Consumption with Time



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk