

**ANALYSIS FOR OPTIMAL POSITIONING OF KITCHEN
VENTILATION FAN**

By

TEZARA CIONITA

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in
Partial Fulfillment of the Requirements for the Degree of Master of Science**

December 2004

Abstract of thesis presented to Senate of Universiti Putra Malaysia in partial fulfilment of the requirement for the degree of Master of Science

STUDY ON THE OPTIMAL POSITION OF VENTILATION FAN IN TYPICAL KITCHEN AREA

By

Tezara Cionita

December 2004

Chairman : Associate Professor Ir. Nor Mariah Adam, PhD

Faculty : Engineering

This aim of the study is to determine the optimal position of ventilating fan in a kitchen. Experiments were conducted in a kitchen of a double-storey house at Subang Jaya and a constructed chamber inside Thermodynamics Laboratory, Universiti Putra Malaysia. The purpose of this study was to determine the best location for a kitchen exhaust fan and to prove the effectiveness of the use of fan. The experiment in Subang Jaya was based on the CFD (Computational Fluid Dynamic) result and the fan was moved to the midway above the window. The chamber at UPM had seven position of fan frames hence the fan could be removed from one frame to another to determine the optimum position to install the fan. Both experiments used CO₂ as tracer gas to measure the air exchange rate. CO₂ was injected into space in excess of 1000 ppm, and advanced to mixed with the air with the help of fan for ten minutes, before determining the value of air exchange rate. The data was taken every 5 minutes within 30 minutes to one hour. The Location of ventilating fan is crucial for effectiveness of contamination removal in

kitchen. From CFD and experiments, it is concluded that the best location for ventilating fan in the kitchen is mid-way above the window on external wall.

The result of the chamber at the lab showed that at height 3.6m the air exchange rate ranged from between 2.3 – 2.0 h⁻¹ for door fully opened and 2.1 -1.8 h⁻¹ for door closed. At height 3.0m the air exchange rate ranged from between 2.3 – 2.0 h⁻¹ for door fully opened and 1.9 – 1.7 h⁻¹ for door closed. And at height 2.5m the air exchange rate ranged from between 1.8 – 1.6 h⁻¹ for door fully opened and 1.6 – 1.5 h⁻¹ for door closed. Use of extract fan could increase the air exchange rate from 0.3, which was the obtained result from the measurement of the chamber in its original condition, when the fan off and the door is closed to 1.5 h⁻¹ which was the worst result obtained with the fan on when the measurement was taken with the door closed and at lowest height of the wall. That was an increase of 4 – 5 times. The best fan position is on the highest mid point for all wall height of 3.6m, 3.0m and 2.5m. The CFD trend and result for chamber at different heights showed that the best fan location is at the highest mid point of the wall. Those experiments proved that the result is consistent for both laboratory and site experiments.

Abstrak Tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian keperluan untuk ijazah Master Sains

**KAJIAN TERHADAP KEDUDUKAN OPTIMUM DARIPADA KIPAS
PENGALIHUDARAAN DI KAWASAN DAPUR TIPIKAL
Oleh**

Tezara Cionita

Disember 2004

Pengerusi : Profesor madya Ir. Nor Mariah Adam, PhD

Fakulti : Kejuruteraan

Kajian ini tertumpu kepada keberkesanan mengguna kipas pengalihudaraan di dalam ruang dapur. Ujikaji telah dijalankan di dalam ruang dapur sebuah rumah teres dua tingkat di Subang Jaya dan juga di dalam sebuah bilik ujikaji di makmal Termodinamik, Universiti Putra Malaysia. Tujuan kajian adalah untuk menentukan kedudukan terbaik bagi kipas penyedut udara (extract fan). Untuk kedua-dua kajian, CO₂ (carbon dioksida) dijadikan gas pengesan. CO₂ disuntik ke dalam ruang, dicampur selama sepuluh menit, kemudian disukat nilai kepekatan CO₂ bagi tujuan mendapatkan nilai pertukaran udara. Nilai kepekatan diambil setiap lima minit untuk tempoh 30 – 60 minit. Kedudukan kipas pengalihudaraan yang sesuai amat penting untuk mengeluarkan kontaminan daripada ruang dapur. Daripada Komputasi Dinamik Bendaalir (CFD) dan ujikaji, di atas dapat dirumuskan kedudukan yang paling sesuai adalah di tengah tingkap dinding luas.

Untuk bilik ujikaji pada ketinggian 3.6m, kadar pengalihudaraan berada pada julat 2.3 – 2.0 h⁻¹ untuk pintu terbuka dan 2.1 – 1.8 h⁻¹ untuk pintu tertutup. Pada ketinggian 3.0m,

kadar pengalihudaraan berada pada julat 2.3 – 2.0 h⁻¹ untuk pintu terbuka dan 1.9 – 1.7 h⁻¹ untuk pintu tertutup. Pada ketinggian 2.5m, kadar pengalihudaraan berada pada julat 1.8 – 1.6 h⁻¹ untuk pintu terbuka dan 1.6 – 1.5 h⁻¹ untuk pintu tertutup. Penggunaan penyedut udara dapat menaikkan kadar pengalihudaraan dari 0.3 hingga 1.5 h⁻¹, yang mana merupakan 4 – 5 kali peningkatan. Posisi kipas yang terbaik ialah pada titik tengah tertinggi pada dinding dengan ketinggian 3.6m, 3.0m dan 2.5m. Penggunaan CFD dan hasil percubaan pada bilik dengan ketinggian berbeza menunjukkan bahawa kipas paling baik diletakkan pada titik tengah tertinggi dari dinding. Percubaan telah membuktikan bahawa hasil yang didapati untuk percubaan dalam lab dan rumah percubaan adalah konsisten.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my advisor and chairman of the supervisory committee, assoc. Prof. Dr. Ir. Nor Mariah Adam, my supervisory committee Dr. Abdul Aziz Jaafar and Dr. Medyan Riza for constantly guiding and encouraging me throughout this study. Thanks a lot for giving me a professional training, advice and suggestion to bring this thesis to its final form.

I am very grateful to the staff of Department of Mechanical Engineering, Faculty of Engineering, and the staff of Thermodynamics laboratory especially En. Syaifuddin, for all his helped during my experiments. And last, but not least I thank my parents for their support while completing this thesis.

APPROVAL

I certify that the Examination committee meet on 2004 to conduct the final examination of Tezara Cionita on her Master of Science in Mechanical Engineering thesis entitled “Study of The Effectiveness of Ventilating Fan in Kitchen’ in accordance with Universiti Pertanian Malaysia (Higher degree) act 1980 and Universiti Pertanian Malaysia (Higher degree) Regulation 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Prof. Madya Dr. A.M.S. Homouda
Department of Mechanical Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Prof. Madya Dr. Ir. Mohd. Sapuan Salit
Department of Mechanical Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Examiner 1)

Dr. Thamir Sabir Younis
Department of Mechanical Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Examiner 2)

Prof. Dr. Ir. Farid Nasir Ani
Faculty of Mechanical Engineering
Universiti Teknologi Malaysia
(Independent examiner)

GULAM RUSUL RAHMAT ALI, Ph.D.
Proffesor/ Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This Thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory committee are as follow:

NOR MARIAH ADAM, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

ABDUL AZIZ JAAFAR, PhD

Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

MEDYAN RIZA, PhD

Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

AINI IDERIS, PhD
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

TEZARA CIONITA

Date:

TABLE OF CONTENTS

	Page
ABSTRACT	ii
ABSTRAK	iv
ACKNOWLEDGEMENTS	vi
APPROVAL	vii
DECLARATION	ix
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF ABBREVIATION	xv
CHAPTER	
1. INTRODUCTION	1.1
1.1 Background of The Study	1.1
1.2 Kitchen Ventilation System	1.3
1.3 Statement of Problems	1.4
1.4 Objective	1.4
2. LITERATURE REVIEW	2.1
2.1 Introduction	2.1
2.2 Ventilation	2.2
2.2.1 Ventilation System	2.3
2.2.2 Fans	2.3
2.2.2.1 Fan Performance	2.4
2.2.3 Ventilating Fan Within House	2.6
2.2.3.1 Ventilating Fan in Kitchen And Bathroom	2.6
2.2.3.1.1 The Importance of Bathroom and Kitchen Fans	2.7
2.3 Studies Done Overseas	2.8
2.3.1 Air Exchange Efficiency in Residential Buildings	2.8
2.3.2 Experimental Study of Moisture Movement and Extractor Fan	2.9
2.3.3 Kitchen Ventilation Equipment	2.10
2.4 Heat Transfer	2.11
2.5 Measurement of Air Change Rates	2.13
2.5.1 Concentration Decay Method	2.14
2.6 Computational Fluid Dynamics	2.16
2.6.1 Work at CFD Codes	2.18
2.6.2 Problem Solving With CFD	2.20
2.6.3 Conservative Form of The Governing Equations of Fluid Flow	2.21
2.7 Summary	2.22
3. METHODOLOGY	3.1
3.1 Introduction	3.1
3.2 Determination of Kitchen Layout and Size	3.2

3.3	The Experimental at UPM	3.2
3.3.1	Design of The Chamber	3.2
3.3.2	Fan Location	3.4
3.3.3	Tracer Gas	3.4
3.3.4	Material For The Chamber	3.5
3.3.5	Construction of The Chamber	3.6
3.3.6	Setting Up The Chamber For Data Collection	3.6
3.3.6.1	Measurement Setting	3.6
3.3.6.2	Measurement of Indoor Air Quality	3.7
3.3.6.3	Airflow Rate Measurement	3.8
3.3.6.4	CO ₂ Rate	3.8
3.4	The Experimental Procedures	3.9
3.5	Kitchen in Subang Jaya	3.10
3.5.1	CFD Simulation (For The kitchen in Subang Jaya)	3.10
3.5.2	Fan Location	3.13
3.5.3	Setting Up The Kitchen For Data Collection	3.13
3.5.3.1	Measurement Setting	3.13
3.5.3.2	Measurement of Indoor Air Quality	3.14
3.5.3.3	Airflow Rate Measurement	3.15
3.5.3.4	CO ₂ Rate	3.15
3.6	The Experimental Procedures	3.15
4.	RESULT AND DISCUSSION	4.1
4.1	Result For Chamber in UPM	4.1
4.1.1	Initial Preparation	4.1
4.1.2	The Results for The Chamber Experiments	4.2
4.1.3	Sample Calculation To Obtain The AER	4.9
4.1.4	Sample Calculation To Derive The U Value	4.11
4.2	Result of Kitchen in Subang Jaya	4.13
4.2.1	Computational Fluid Dynamics	4.14
4.2.2	Field Measurement	4.22
4.2.2.1	Kitchen	4.22
4.2.2.2	Data of Subang Jaya Kitchen	4.23
4.3	Summary	4.25
4.4	Discussion	4.26
5.	CONCLUSION	5.1
5.1	The Experiment in UPM Chamber	5.1
5.2	Experiment in Subang Jaya Kitchen	5.3
5.3	Further work	5.4
5.4	Recommendation	5.4
	REFERENCES	R.1
	APPENDIX A	A.1
	APPENDIX B	A.2
	APPENDIX C	A.3