

COMPUTER SIMULATION AND DESIGN OF COMPOSITE FIRE DOOR
UNDER ELEVATED TEMPERATURE USING MSC NASTRAN

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Dedicated to my beloved mother:

Wee Bee Hua

My elder brother:

Tan Hai Chen

My younger brother and sister:

Tan Hai Seng, Tan Hai Yin

and my supervisor:

Dr. Hishamuddin bin Alham

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ABSTRACT

Fire door is a very important part of fire protection. The conventional designs verified using furnace experiments are costly. There is a FEM software, MacNeal-Schwendler Corporation (MSC) Nastran that can greatly accelerate the numerical calculation of the transient heat transfer effect of fire door in the furnace. Therefore, this project has been carried out to analyse and design the fire door by using the FEM software, MSC. Nastran. The simulated result from the software has been verified with existing experimental results. Having confidence to the accuracy of the software, three computer designed composite fire doors were obtained with 1 hour and 2 hours rating according to the MSC. Nastran results. Detail of the design process and the materials selection are included in this thesis. The potential designs of fire door were suggested for future development since they have very good fire resistance. From the simulation, it was found that the insulation of the fire door rises with the increased of the thickness and the layers of the door, and also by using lower conductivity materials. It was also proven by simulation that a design using fiberglass or mineral wool fillet will result in a lower acceptable 2 hours fire rating with the additional advantage of reduced weight.

ABSTRAK

Pintu kalis api adalah sangat penting sebagai alat pencegahan api yang boleh menyelamatkan nyawa. Proses rekaan pintu kalis api menggunakan ujikaji pembakaran adalah mahal. Kini terdapat satu perisian komputer FEM, iaitu MacNeal-Schwendler Corporation (MSC) Nastran yang dapat mempercepatkan pengiraan matematik untuk suhu pintu kalis api yang berubah mengikut masa. Keputusan simulasi daripada perisian tersebut telah dibandingkan dengan keputusan ujikaji yang sedia ada. Dengan keyakinan kepada ketepatan perisian MSC. Nastran yang terbukti, tiga rekaan pintu api komposit telah diperolehi dengan kadar pemeringkatan 1 dan 2 jam. Proses rekaan terperinci terdapat dalam tesis ini. Rekaan pintu kalis api yang berpotensi ini dicadangkan untuk pengajian masa depan kerana ia mempunyai kebolehan kalis api yang sangat baik. Telah terbukti dari simulasi bahawa kebolehan kalis api bagi pintu kalis api meningkat dengan meningkatnya ketebalan, penggunaan bahan keberkondukan yang rendah dan rekaan yang mempunyai banyak lapisan. Simulasi juga telah membuktikan bahawa rekabentuk menggunakan kaca gentian atau kambi mineral wool akan mengakibatkan kadar api yang lebih rendah (2 jam) tetapi boleh diterima pakai apabila pintu yang lebih ringan diperlukan.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xii
	LIST OF SYMBOLS	xv
	LIST OF APPENDICES	xvi
I	INTRODUCTION	1
	1.1 Introduction	1
	1.2 Scope	1
	1.3 Objective	2
	1.4 Methodology	2
II	LITERATURE REVIEW	4
	2.1 Structural Fire Protection – Historical Progress	4
	2.1.1 Definition of Fire	7
	2.1.2 Physic of Fire	7
	2.1.3 Fire Safety and Fire Resistance	11
	2.1.4 Classification of Fire	11
	2.2 Definition of Heat	13

2.2.1	Forms of Heat Transfer	13
2.2.2	Conduction	14
2.2.3	Convection	15
2.2.4	Radiation	16
2.3	Introduction to Finite Element Method (FEM)	18
2.3.1	The Concepts of Finite Element Method	19
2.3.2	Implementation of FEA software	20
2.3.3	Introducing MSC. Nastran	20
2.3.4	The Seven Steps for Finite Element Analysis	22
	2.3.4.1 Conceptualization	22
	2.3.4.2 Create the Geometry	22
	2.3.4.3 Define Material and Property	22
	2.3.4.4 Meshing	24
	2.3.4.5 Apply Loads and Constraints	25
	2.3.4.6 Analyze the Model	25
	2.3.4.7 Post Processing	25
2.4	Fire Research Standards	26
2.4.1	Introduction to British Standard BS476	26
2.4.2	MS 1073: Part 2 1996 and Part 3: 1996	27
III	CONVERGENCE TEST TO GET THE OPTIMIZED MESHING SIZE	30
3.1	The Suitable Meshing Size	30
3.2	To Design a Convergence Test	30
	3.2.1 The Result From Manual Calculation	32
	3.2.2 Results From MSC. Nastran	34
3.3	Range of Element size	37
IV	VERIFICATION	39
4.1	Verification of MSC. Nastran Simulation	39
4.2	Verification with Existing Experimental Result A	40
	4.2.1 Running the Simulation with Existing Experimental Data	40
	4.2.2 Software Accuracy from Verification	45

4.3	Verification with Existing Experimental Result B	46
4.3.1	Running the Simulation with Existing Experimental Data	46
4.3.2	Software Accuracy from Verification	48
V	DESIGNS	50
5.1	Designs of Multi-layers Composite Fire Door	50
5.2	Design A -Light Weight and Excellence Finishing Design	52
5.2.1	Conceptualization	52
5.2.2	Design Detail	52
5.2.3	Simulation and Result	53
5.2.4	Discussion and Suggested Design	61
5.3	Design B -Greatly Enhanced Fire Resistant	62
5.3.1	Conceptualization	62
5.3.2	Design Detail	62
5.3.3	Simulation and Result	63
5.3.4	Discussion and Recommendation	68
VI	GENERAL DISCUSSION, FUTURE DEVELOPMENT AND CONCLUSIONS	69
6.1	Discuss the Factors of Fire Door Quality	69
6.2	Enhance the Original Design	71
6.3	Simulation on the Uncommon Materials	71
6.4	Future Developments	72
6.5	Conclusions on the Objectives	73
6.6	Conclusions on the Findings	73
6.7	Limitation of the Research	74
	REFERENCES	76
	APPENDICES	79

LIST OF TABLES

TABLES NO.	TITLE	PAGE
2.1	Some landmarks in the history of structural fire protection (H.L. Malhotra, 1982)	5
2.2	Available properties in MSC Nastran	23
3.1	Calculated results from T_1 to T_5 until 2345sec	33
3.2	The simulation results from T_1 to T_5 at 2345sec for different element sizes	35
3.3	Error percentage with manual calculation as reference	38
4.1	Layers and materials found in cross section A, B and C	44
4.2	Layers and materials found in cross section D and E	44
4.3	Properties of the materials used	44
4.4	Simulated insulation time until 167°C of unexposed area	45
4.5	Properties of the materials used	47
4.6	The experiment and simulation results from 0min to 120mins and the error percentages of simulation	48
5.1	Properties of the materials for the designs	51
5.2	Temperature of unexposed area and SIRIM furnace (°C) from 0minute to 30minutes	57
5.3	Temperature of unexposed area and SIRIM standard from 31minute to 60minutes	58
5.4	Temperature of unexposed area and SIRIM standard from 61minute to 80minutes	59

5.5	Temperature of unexposed area and SIRIM furnace from 0mins to 66mins	64
5.6	Temperature of unexposed area and SIRIM furnace from 67mins to 130mins	65

LIST OF FIGURES

FIGURES NO.	TITLE	PAGE
2.1	The fire triangle and fire square	8
2.2	Flammable limits of gasoline	9
2.3	Flammable range comparison	9
2.4	Formulas of fire's chemical chain reaction	10
2.5	Thermal energy transfers from a "hot" region to a 'cold" region	13
2.6	Example of conduction	14
2.7	Illustration showing parameters in heat conduction equation	15
2.8	Radiation to a target from candle flame	17
2.9	The geometry is being meshed into small elements	19
2.10	Implementation of MSC Nastran in Finite Element Method	21
2.11	Models have been discretized to several elements certain size	24
2.12	Contour plot of a heat transfer simulation	25
2.13	Standard Temperature Curve of MS 1073: Part 2: 1996	29
3.1	The convergence test model	31
3.2	Schmidt Graph for $M = 2$ calculations	32
3.3	Conductions and the temperature at 2345sec in contour form	36

3.4	The temperature at 2345sec in contour form	36
3.5	Element size versus average error percentage	38
4.1	Two hours rated fire door tested with SIRIM standard in JUNE 2000	41
4.2	Cross section of a fire door	42
4.3	Cross section of the 1 hour and 2 hours rated fire door	42
4.4	Location of cross section A, B and C in 1 hour rated fire door	43
4.5	Location of cross section D and E in 2 hours rated fire door	43
4.6	Cross section of the fire door	46
4.7	The experiment and simulation results from 0min to 120mins	49
5.1	The design process	50
5.2	Cross section of the design	53
5.3	Contour output of mineral wool fillet cross section at maximum insulation time of 61mins	54
5.4	Temperature versus thickness from exposed to unexposed area (cross section of fibreboard sealed edge), at 2mins, 10mins, 30mins, 60mins and insulation of 65mins	54
5.5	Temperature versus thickness from exposed to unexposed area (cross section with mineral wool fillet), at 2mins, 10mins, 30mins, 60mins and insulation of 61mins	55
5.6	Temperature versus thickness from exposed to unexposed area (cross section with fiberglass fillet), at 2mins, 10mins, 30mins, 60mins and insulation of 54mins	55
5.7	Comparison of unexposed surfaces' temperature with SIRIM fire curve until 80min	60
5.8	Comparison of unexposed surfaces' temperature at maximum insulation time of 54min, 61min and 65min	60

5.9	Design of 7 layers fire door	63
5.10	Contour output of 7 layers cross section at maximum insulation time of 126mins	66
5.11	Temperature versus thickness from exposed to unexposed area at 2mins, 10mins, 60mins, 120mins and insulation of 126mins	66
5.12	Temperature of unexposed surface and SIRIM fire curve at maximum insulation time of 126mins	67
5.13	Temperature unexposed cross surface at maximum insulation time of 126mins	67

LIST OF SYMBOLS

T	-	Temperature ($^{\circ}\text{C}$)
l	-	Thickness (m)
A	-	Surface area (m^2)
k	-	Thermal conductivity ($\text{Wm}^{-1}\text{K}^{-1}$)
C	-	Thermal capacity ($\text{J.K}^{-1} \text{m}^{-3}$)
σ	-	Stefan-boltzman constant ($\text{W/m}^2 \text{K}^4$)
ρ	-	Density (kg.m^{-3})
ΔT	-	Time step (s)
q	-	Heat transfer rate (J/ms)

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	1 - The List of Material Properties I	79
A	2 - List of Material Properties II	80
A	3 - Dimensions for regular wooden door I	81
A	4 - Dimensions for regular wooden door II	82
B	1 - Delivery note of printed copy of MS standard	83
B	2 - Printed Malaysian Standards	84
C	1 - Example of standard dimensions for door sets	85
C	2 - Example of fire curve of MS1073	86
C	3 - Example of fire test apparatus	87

CHAPTER I

INTRODUCTION

1.1 Introduction

The number of fire accidents increases at almost every country every year. Fire causes losses of property and life. Hence, it is essential for a building to establish fire suppression system. More construction materials were invented and many of them have the ability to resist fire. Walls, ceilings, floors, doors and other parts of buildings which are fire resisting can prevent fire disaster. Besides preventing fire, a fire door also prevents smoke spreading to another room.

Today, Finite Element Method is becoming more widely used in fire research. However, this method needs large number of complex calculations which are time consuming for hand calculation. By using computer programs the process of Finite Element Method can be shorten in hours or even minutes for more complex analysis. For this research, a Finite Element Analysis software was used to run simulations of fire door under elevated temperature.

1.2 Scope

This research attempts to analyse and design fire door under elevated temperature using Finite Element Method. Generally, literature studies were done on

fire standard, heat transfer, fire door, fire test method and other related fields. Analysis of the fire door were executed. A Finite Element Method software, that is MSC. (MacNeal-Schwendler Corporation) Nastran was used to simulate the effect of high temperature of the fire.

Established experimental work were used as a verification tool. The temperature selected forms were determined and hence the limit was obtained. Consequently the output of the results was used for the analysis of the fire door.

1.1 Objective:

At the end of the project it is hoped:

- a) to generate the MSC. Nastran simulation of the effect of elevated temperature to the fire door.
- b) to verify the simulation result using existing experimental results.
- c) to design the model of fire door using finite element software.

1.2 Methodology

For the literature study, a search of information was made from the Internet, patents of fire door designs, reference books, journals and the patents database in the university. The literature study covered the fire door, SIRIM standard, ASTM E119 standard, BS standard, fire research, Finite Element Method and more. Information are rearranged and been compared to decide the analysis details.

The SIRIM (Standard and Industrial Research Institute of Malaysia) standard was utilized and MSC. Nastran software was used because of it's availability. The technical support department of SIRIM and the MSC. Software Corporation were contacted to obtain related information regarding the fire door research. Three

printed copies Malaysia Standard of Fire Resistant were bought from SIRIM and some free reference of MSC. Nastran was obtained through MSC. official website.

The MSC. (MacNeal-Schwendler Corporation) online forum is a resourceful platform for those using Finite Element Analysis in their research or jobs. Knowledge and experience are exchanged between engineers, researchers, lecturers and even students. The advices from the forum are helpful for the project.

Some of the fire protection companies for the fire research information and existing experimental results were obtained with the help of some friends. Although with terms and limitations, the existing experimental results were finally obtained from one of the companies which produce fire protection products in Malaysia.

Verification of the computer simulations are made with the existing experimental results. The suggestions of designs are chosen from the series of our fire doors designs tested with MSC. Nastran. The suggestions for further development and conclusion are as shown in the last chapter of this thesis.

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