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.

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LIST OF SYMBOLS

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

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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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