

Ain Shams University
Faculty of Engineering
Mechanical Engineering Department

FIRE SPREAD IN COMPARTMENTS

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By Engineer

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B.Sc., M. Sc.

A Thesis Submitted in fulfillment of the Requirements for the
Degree of Ph. D. in Mechanical Engineering

Under The Supervision

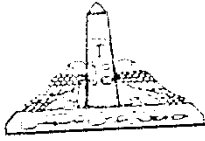
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STATEMENT

This thesis is submitted to Ain Shams University for the degree of Doctor of Philosophy in Mechanical Power Engineering in the Faculty of Engineering.

The work comprised in this thesis was Carried out by the author in the Mechanical Power Engineering Department, Faculty of Engineering, Ain Shams University, April 1993 to June 2000

No part of this thesis has been submitted for a degree at any other University.

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PREFACE

This thesis is submitted to Ain Shams University for the degree of Doctor of philosophy in Mechanical Engineering. The work included in this thesis was carried out by the author at the laboratories of Mechanical Engineering department, Faculty of Engineering, Ain Shams University.

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Hoping that this research will be useful for the developing countries and specially our beloved country, EGYPT.

ABSTRACT

The present study is an experimental and theoretical investigation of the thermal and environmental behavior in a compartment exposed to fire. The experimental model designed and constructed for this study represents a $\frac{1}{4}$ scale of a typical room in a building. This gives a rectangular base of dimensions of 1.0m $\times$ 0.75m with a height of 0.70m. The material used in the compartment is gypsum board. The compartment has two vents at opposite walls. They are situated at distances of 0.1625m and 0.405m from the ceiling to the center of the openings respectively. The heat release is obtained from a circular burner of 0.13 m diameter that used LPG fuel giving a constant heat rate of 2.53 kW throughout the study. Transient measurements were obtained for the temperature distribution both vertically and horizontally using bare wire thermocouple. The transient behavior of CO₂ is also monitored at different vertical locations. Parameters varied include burner location and the ceiling state i.e. whether it is plain ceiling or ceiling containing a beam as an obstruction to the ceiling jet flow.

Measurements showed that the thermal state inside the compartment reached a steady state after an interval of time that varied between 11 to 14 minutes for plain and obstruction ceiling respectively. However, much shorter times are required to reach constant carbon dioxide concentration values throughout. The steady state is defined as the time from ignition after which no change with time is monitored in the distribution of temperature and carbon dioxide inside the compartment. This is attributed to the effect of thermal inertia of the walls. Furthermore, measurements are taken to the amount of fresh air entrained into the compartment via the

III

lower vent. Also, the exit smoke temperature and oxygen profile are measured at the higher vent. The results show that the smoke stratifies in the higher layer of the compartment and the temperature decreases as the distance from the fire source increases. As the time elapses, the thickness of the higher hot layer increases. Generally, the overall temperature level in the compartment was found high in the case where the burner is located at the center of the compartment, higher in the case where the burner is next to one of the walls, and highest in the corner-burner case. As expected, the qualitative trend of the CO₂ measurements followed that of the temperature measurements.

The presence of obstruction to the flow in the ceiling through the addition of a beam did not alter the CO₂ profiles drastically. However, the time required to reach steady state in the presence of the obstruction is longer than that observed for a plain ceiling. This is an evidence of slowing effect of the beam that is beneficially may be used as a smoke barrier to give longer time for occupants to evacuate the enclosure that is subjected to fire.

The experimental results were used to validate a numerical model that is developed to simulate fire scenarios. Computer results of transient development were obtained for one minute after ignition for the plain ceiling in the case of corner burner. Comparison between theoretical and experimental results showed satisfactory agreement.

IV

	P.
ABSTRACT	1
CHAPTER 1	1
INTRODUCTION	1
CHAPTER 2	5
PREVIOUS WORK	5
2.1 INTRODUCTION	5
2.2 THE FLAMES AND PLUMES EMERGING FROM THE FIRE SOURCE	6
2.2.1 FLAME HEIGHT	6
2.2.2 TEMPERATURE AND VELOCITY DISTRIBUTIONS ALONG THE FLAME	15
2.2.3 AIR ENTRAINMENT INTO FIRE	20
2.3 CEILING JET	26
2.4 ROOM FIRES WITH COMBUSTIBLE MATERIALS.	29
2.5 THEORETICAL WORK	32
2.6 THE PRESENT STUDY	33
CHAPTER 3	35
DESCRIPTION OF EXPERIMENTAL AND MATHEMATICAL MODEL	35