

سامية محمد مصطفى



شبكة المعلومات الجامعية

بسم الله الرحمن الرحيم



سامية محمد مصطفى



شبكة المعلومات الجامعية



شبكة المعلومات الجامعية التوثيق الالكتروني والميكروفيلم



سامية محمد مصطفى



شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات



يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



سامية محمد مصطفى



شبكة المعلومات الجامعية



بعض الوثائق الأصلية تالفة



سامية محمد مصطفى



شبكة المعلومات الجامعية



بالرسالة صفحات لم ترد بالأصل



S

CAIRO UNIVERSITY
FACULTY OF ENGINEERING

**AN INVESTIGATION OF MULTI FUEL TURBULENT
PREMIXED CONFINED FLAME STRUCTURE**

BY
MOHAMED SAID ATTIA SHEHATA
B. Sc. , M. Sc. Mechanical Power Engineering

A Thesis Submitted to
Mechanical Power Engineering Department
in Partial Fulfillment for the Degree of
DOCTOR OF PHILOSOPHY
in Mechanical Power Engineering

Supervisors

Prof. Dr. M. M. ELKOTB

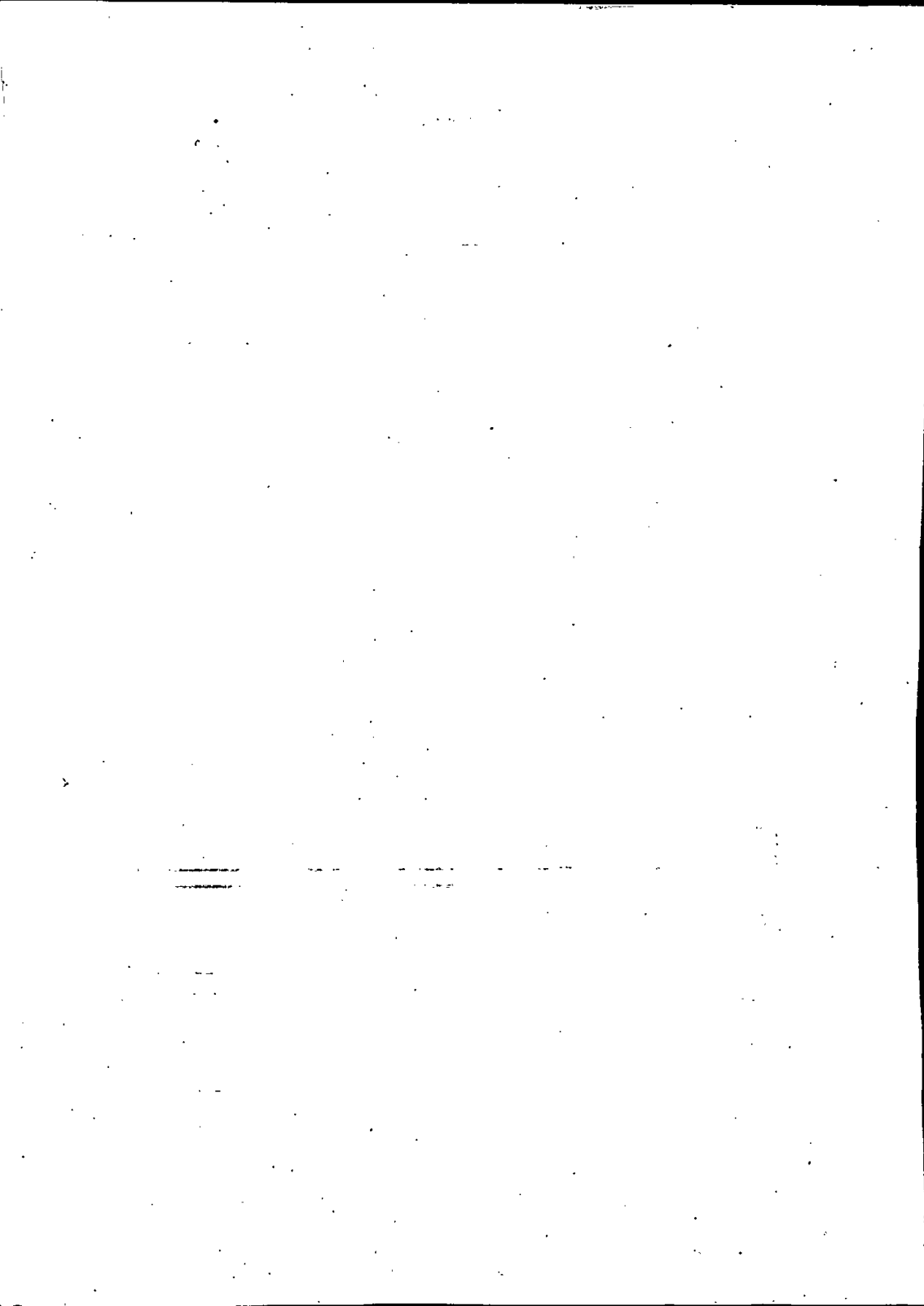
Professor of Heat Engines
Mechanical Power Engineering
Department
Faculty of Engineering
Cairo University

Prof. Dr. HINDAWI SALEM

Professor of Heat Engines
Mechanical Power Engineering
Department
Faculty of Engineering
Cairo University

Cairo 1993

B
17-21



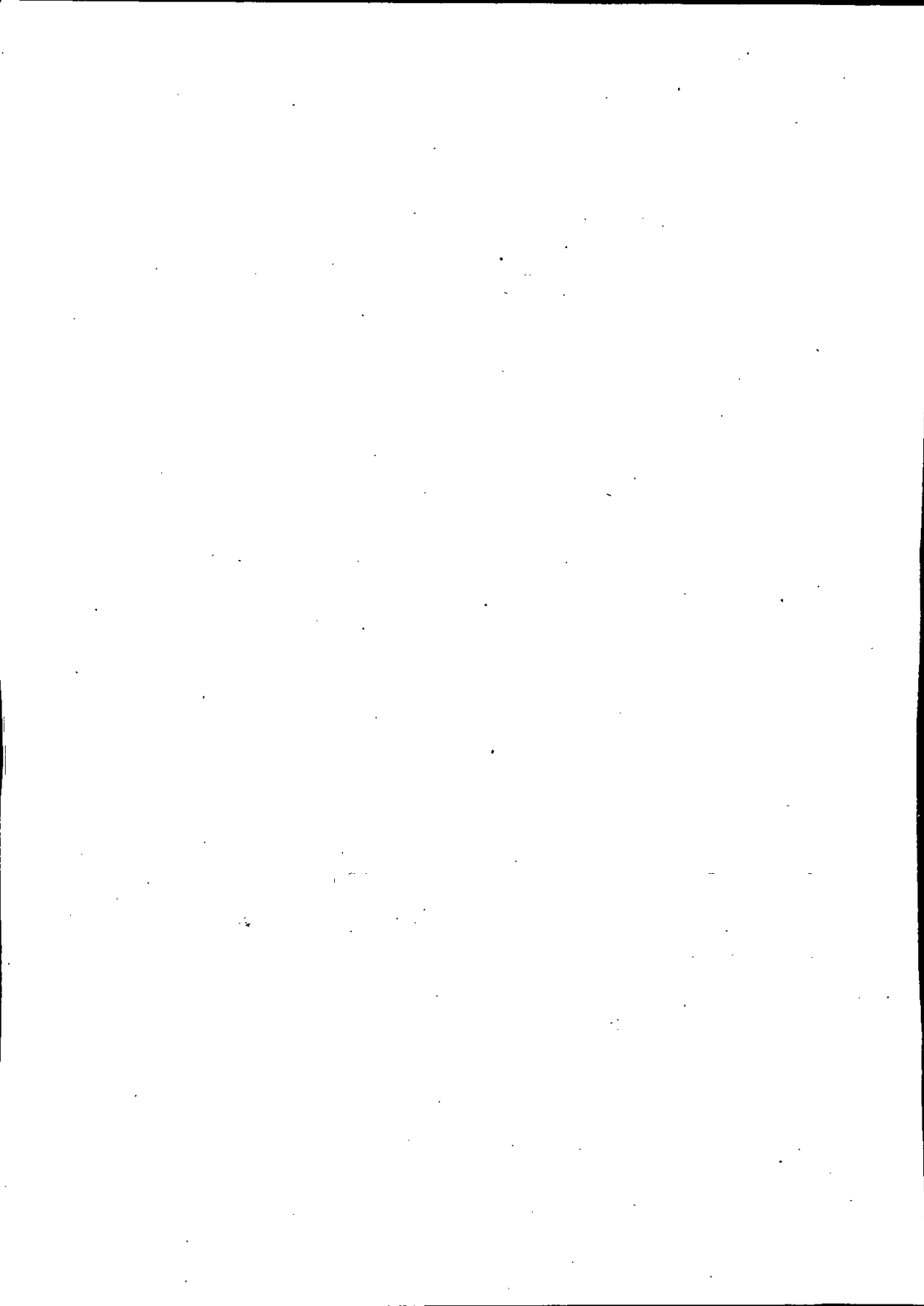
ACKNOWLEDGEMENT

I would like to express my deep gratitude to Prof. M.M.ELKOTB, Professor of combustion at Cairo university for his valuable supervision, helpful discussion, continuous and patient guidance and careful follow up.

I am very much indebted to Prof. HINDAWI SALEM Professor of combustion , Cairo university , for his encouragement and help in completion of this work .

I would like also to thank Prof. AHMED HUZAYYIN Dean of Benha Higher Institute of Technology for his help which greatly aided the finishing of this work.

Mohamed Said Attia Shehata.



ABSTRACT

Due to the great development in combustion systems and the increasing efforts to reduce the levels of gaseous emission, the combustion systems must be operated with high efficiency and low level of gaseous emission. The combustion efficiency and gaseous emission depend on the combustion rate and the mixing velocity of air and fuel. Because of a large number of combustion systems use the commercial fuel, many investigations have been carried out to study the different factors affecting the combustion efficiency. However, most of these studies have been carried out under predominantly one dimensional flow and using simple pure hydrocarbon fuels. Consequently, these studies do not simulate the conditions that exist in the practical combustors where flow and chemical kinetic effects are strongly coupled.

In the present study effect of Reynolds number, equivalence ratio, fuel type and their blends on turbulent premixed confined flames structure have been investigated. The experimental set up consists of a flat grid burner where liquid fuel is sprayed into preheated combustion air, vaporizes and strongly mixes with air prior to introduction into the combustion space through perforated plate flame holder. The combustion gases are sampled at different locations within the flame using a water cooled, stainless steel isokinetic probe and the gases samples are analyzed using gas chromatograph and infrared analyzer. Flame temperatures and gas velocities have been measured. During experiments, fuel to air ratio, air velocity and fuel type

have been varied. The effect of the fuel blending on flame structure has been investigated.

The optimum working conditions such as inlet mixture temperature, solidity ratio, optimum gas chromatograph operating conditions, check for no entrained air to flame during combustion from atmosphere and flame flatness had been carried out before any experimental results have been taken.

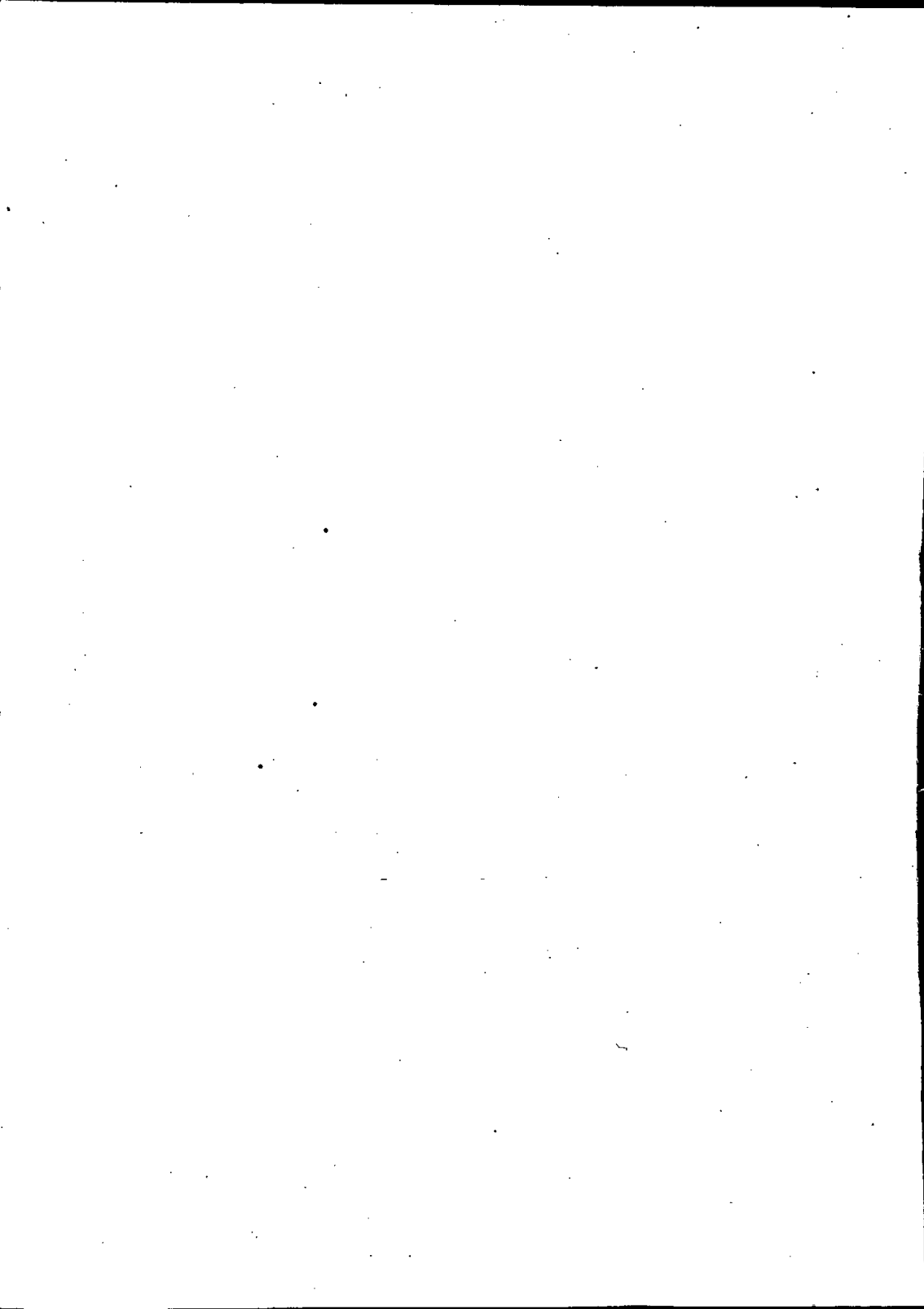
The experimental results show that, concentration, flame temperature and gas flow velocity in main and post flame zone have been affected by fuel to air ratio and inlet velocity. The effect in main reaction zone is greater than in post flame zone and for rich mixture than lean mixture, also, for light diesel than kerosene-air flames. Moreover, the adiabatic flame temperature can be calculated as function of mixture strength, fuel type and inlet mixture temperature. Fuel type affects flame structure through its effect on maximum flame temperature and radical concentration which consequently affect reaction rate.

Also, mathematical model for predicting concentration, flame temperature and gas velocity has been developed. In the present model under-relaxing finite-difference scheme for solving the governing conservation equations describing the motion of two dimensional, compressible turbulent and chemically reacting flow based on chemical kinetic approach have been used. The solution of finite-difference equations is accomplished by mean of tridagonal matrix algorithm. The turbulence parameters are determined by a variable density two equation $k-\epsilon$ model. At control volume near the confined tube wall node, modification for source terms and exchange coefficients have been carried out to suit the boundary conditions. The combustion model consists of eleven reactions, four steps mechanism for

commercial fuel containing seventeen chemical reacting species.

The experimental results have been used to validate the theoretical results for different equivalence ratio and Reynolds number for light diesel and kerosene-air flames.

The present results are important for developments of multi fuel combustors and air pollution.



CONTENTS

	page
ACKNOWLEDGEMENT	i
ABSTRACT	ii
CONTENTS	v
LIST OF TABLES	viii
LIST OF FIGURES	ix
NOMENCLATURE	xvi
CHAPTER 1 INTRODUCTION	1
CHAPTER 2 REVIEW OF PREVIOUS WORK	5
2.1 Introduction	5
2.2 Turbulent Flow Models	6
2.3 Influence of Combustion on Turbulence	11
2.4 Modelling and Measurements in Turbulent Premixed Flames	16
2.4.1 Velocity of chemical reaction	16
2.4.2 Chemical kinetics model	32
2.5 Discussion of Previous Work and Scope of Present Work	35
CHAPTER 3 EXPERIMENTAL SET-UP	38
3.1 Introduction	38
3.2 Experimental Set-up	38
3.2.1 Flame burner	38
3.2.2 Fuel system	43
3.2.3 Air and heating system	43
3.3 Measuring instruments	46
3.3.1 Sampling system	46
3.3.2 Gas chromatograph	46
3.3.3 CO and CO ₂ analyzers	51

	Page
3.3.4 Temperature measurement	52
3.3.5 Fuel, air and hot gases flow rate measurements	52
3.4 Effect of Solidity Ratio on Flame Structure	52
3.5 Effect of Inlet Mixture Temperature	58
3.6 Experimental Technique	62
3.7 Error Analysis	66
3.7.1 Systematic errors	67
3.7.2 Accidental errors	70
CHAPTER 4 EXPERIMENTAL RESULTS AND DISCUSSION	73
4.1 Introduction	73
4.2 Composition Profiles in Premixed-Air Flame	73
4.3 Effect of Equivalence Ratio on Flame Structure	84
4.3.1 Effect of equivalence ratio on concentration	84
4.3.2 Effect of equivalence ratio on flame temperature and gas flow velocity	95
4.4 Effect of Turbulence on Flame Structure	97
4.5 Effect of Fuel Type on Flame Structure	121
4.6 Effect of Fuel Blending on Flame Structure	135
CHAPTER 5 COMMERCIAL FUEL PREDICTION MODELLING FOR TURBULENT PREMIXED-AIR FLAMES	167
5.1 Introduction	167
5.2 Prediction Model	168
5.2.1 Governing equations	168
5.2.2 Chemical kinetic combustion model	176
5.3 Solution Procedure for Combustion Model	181
5.3.1 Finite difference equation	181