NUMERICAL ANALYSES OF CHEMICAL AND THERMAL STRUCTURE OF MICRO FLAMES

By

Eng. Mahmoud Ashraf Hussein Ali

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
MECHANICAL POWER ENGINEERING

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Key Words:
Micro diffusion flame; Laminar hydrogen flame; Heat recirculation; Flame burner interaction; Reaction mechanism

Summary:

The present study presents numerical analyses of chemical and thermal structure for different micro flames formed inside micro tube burner by studying the effect of changing fuel flow velocity, burner material and type of fuel. The present study is performed using ANSYS 17 CFD package to simulate eleven case studies. Reduced Deutschmann chemical reaction mechanism is adopted in this study.

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Table of Contents

Acknowledgment v

LIST OF TABLES iv

Nomenclature xi

Symbol Quantity xi

Greek Letters xi

Abbreviations xii

Chapter 1 Introduction 1

1.1.1 Energy density 1

1.1.2 Micro-satellite thrusters 1

1.1.3 Micro-air vehicles 2

1.1.4 Micro reactors 2

1.1.5 MEMS and communication systems 2

1.1.6 Energy density for various power sources 3

1.2 Scaling Parameters of Micro-scale Combustion 4

1.2.1 Length scale 4

1.2.2 Flame quenching diameter scale 4

1.2.3 Device scale 4

1.3 Development and Challenges of Micro-power Generation 5

1.4 Improving Micro-Combustors Efficiencies 6

1.5 Challenges in Fundamental Research of Micro-scale Combustion 8

1.6 Thesis Outline 9

Chapter 2 Literature review 10

2.1 Literature Investigating Combustion Characteristics of Non-premixed Micro-jet Methane Flame at Different Fuel Flow Velocities 10

2.2 Literature Discussing the Effect of Fuel Flow Velocity and Premixed Fuel on Thermal and Chemical Structures of Micro Hydrogen-air Jet Flames 17

2.2.1 Influence of fuel flow velocity on the flame height and OH radical concentration 18

2.2.2 Detailed flame structure formed inside the burner 19
2.2.3 Slight premixed effect 20
2.3 Experimental Study on the Unique Stability Mechanism via Miniaturized Micro Jet Diffusion Flames by Utilizing Preheated Systems 22
2.3.1 Role of burner as heat recirculation medium 26
2.3.2 The effect of slight addition of O_2 (at T_{air} =920k) 29
2.4 Scope of Current Work 31
Chapter 3 Modeling of Micro-Scale Flame 32
3.1 Description of the Adopted Experimental System 32
3.1.1 Cheng's Experiment Layout 32
3.1.2 Instruments used by Cheng .....**Error! Bookmark not defined.**
3.2 System Modeling 33
3.3 Governing Equations 33
3.3.1 Mass Conservation Equation (Continuity) 33
3.3.2 Momentum Equation 34
3.3.3 Navier-Stokes Equation 35
3.3.4 Energy Equation 35
3.3.5 Equation of state 38
3.4 Heat Transfer for solid 39
3.4.1 Conduction heat transfer for a solid 39
3.4.2 Convective heat transfer to solids 39
3.5 Reaction Mechanism 40
Chapter 4 Numerical Investigation Principles 44
4.1 Validation of ANSYS and Grid Sensitivity Analysis 44
4.1.1 The validation for ANSYS and grid sensitivity analysis using experiment of Cheng 44
4.1.1.1 Validation input data 44
4.1.1.2 ANSYS simulation results 47

4.2 Computational Domain Used in Current Study 57
4.3 Boundary Conditions Used in Current Study 58
Chapter 5 Results and discussion 59
5.1 Effect of Different Chemical Reaction Mechanisms 59
5.2 Thermal Structure of Micro-jet Flame under Different Burner Materials ... 67
5.2.1 Thermal structure of micro low fuel ejecting velocity flame 67
5.2.2 Thermal structure of micro high fuel ejecting velocity flame 71
5.3 Thermal and Chemical Structure under Different Fuels 74
Chapter 6 Conclusions and Suggested Future Work 76
6.1 Conclusions 76
6.2 Suggested Future Work 77
References 78
Appendix A: Deutschmann Reaction Mechanism 83
Appendix B: GRI-MECH 3.0 Reaction Mechanism 86

LIST OF TABLES

Table 1.1 Definition of micro-scale and mesoscale combustion using different length scales……5

Table 4.1: Series of grid simulations ……43
Table 5.1: Case studies……..57
Table 5.2: Reaction mechanisms……...57
Table 5.3: Maximum temperature for different cases…….....…….69
Table 5.4: Maximum solid tube temperature…...……..71
Table 5.5: Fuel types ……....72
Table 5.6: Maximum temperature for case (11) and case (12)…...……...……73

LIST OF FIGURES

Figure1. 1: Comparison of specific energy densities of lithium ion batteries with hydrocarbon and oxygenated hydrocarbon fuels as well as different engines [2]. 3

Figure1. 2: Temperature distributions of the swirling burner and heat recirculation burner 6

Figure2. 1: Schematic of the experimental system. [54] 11

Figure2. 2: Physic model, computation domain and boundary conditions. [54] 12

Figure2. 3: Direct images of micro-jet flames at different fuel flow velocities. (a: 18.3 m/s, b: 7.5 m/s, c: 2.5 m/s, d: 1.2 m/s). [54] 13

Figure2. 4: Variations of flame height and shape with fuel flow velocity. [54] 13

Figure2. 5: Variations of flame height with fuel flow velocity at different coflow air velocities. [54] 14

Figure2. 6: Flammable region of the micro-jet flame at different coflow air velocities. [54] 15

Figure2.7: The CH distributions of flames at different velocities by experiments (upper) and computations. (a: 5 m/s, b: 2.5 m/s, c: 1.2 m/s, experimental and numerical results are shown in the same scale) [54] 16

Figure2. 8: The OH distributions of flames at different velocities by experiments (upper) and computations (lower). (a: 5 m/s, b: 2.5 m/s, c: 1.2 m/s) [54] 16

Figure 2.9 :schematic view of computational domain and boundary conditions [55] 18

Figure2. 10: Effect of applied fuel flow velocity on the flame height (vertical lines stands for stoichiometric mixture fraction, ζ_{st} = 0.0284) and the distribution of mass fraction of OH along the axis. [55] 19

Figure2. 11: 2-D temperature and mass fraction of H-atom distributions for different fuel ejecting velocities ((a) uin = 2.5 m/s and (b) uin = 0.25 m/s) [55] 20

Figure2. 12: Comparisons of 2-D profiles of reaction rates [kgmol/m3s] (a–d), temperature [K] (e), and mass fraction of H2O2 (f) with/without O2 addition cases (left: 5% of O2 is added into the fuel flow, right: pure hydrogen is used as the fuel). [55] 21

Figure2. 13: Schematic illustration of experimental apparatus [56] 23

Figure2. 14: Direct photograph of the micro flames under three preheated air temperature conditions (T_{air} = 293 K, 570 K, 920 K) and various fuel flow rates [56] 24

Figure 2. 15: Definitions of the quenching distance (L_q) and the flame height (L_f) (Tair = 293 K) [56]..... 24

Figure2. 16:Relationship between minimum fuel flow rate and thermal conductivity of burner wall (Tair = 293 K) [56] 25

Figure2. 17: Relationship between the limiting value of fuel flow rate (V_{Lf}) and the imposed preheated-air temperature, T_{air} [56] 25

Figure2. 18: Relationship between the limiting flame height and the limiting quenching distance under all tested conditions considered in this study [54]..... 26

Figure2. 19: Typical temperature distribution of micro-flames under two preheated air temperature conditions ((I) Tair = 293 K and (II) Tair = 670 K) [56]..... 27

Figure2. 20Variation of conductive heat flux against the imposed fuel flow rate under three preheated air temperature conditions (Tair = 293 K, 500 K, 670 K) [56] 28

Figure2. 21: Temperature at the burner tip (left: T_w, right: T_w–T_{air}) [56]..... 29

Figure2. 22: Direct image of flames with/without the slight premixing effect at 920 K of preheated air temperature (a) w/o premixing and (b) 7.3% of O2 added to the fuel [56] 30

Figure2. 23: Effect of slight premixing on minimum fuel flow rate and flame luminosity at the extinction under 920 K of preheated air temperature [56]..... 30

Figure3. 1: Schematic diagram of UV Raman/LIPF system [57]..... 32

Figure4. 1: Coordinate system. 45

Figure4. 2: Grid system for (a)Case 1 simulation, (b) Case 2 simulation and (c) Case 3 simulation..... 46

Figure4. 3: N2 concentration variation with radial distance at X=50 mm..... 47

Figure4. 4: H2O concentration variation with radial distance at X=50mm..... 48

Figure4. 5: O2 concentration variation with radial distance at X=50mm..... 48

Figure4. 6: H2 concentration variation with radial distance at X=50mm..... 49

Figure4. 7: Hydroxyl radical concentrations (OH) variation with radial distance at X=50mm. 49

Figure4. 8: Temperature variation with radial distance at X=50mm..... 50

Figure4. 9: N2 concentration variation with radial distance at X=25 mm..... 50

Figure4. 10: H2O concentration variation with radial distance at X=25 mm..... 51

Figure4. 11: O2 concentration variation with radial distance at X=25 mm..... 51

Figure4. 12: H2 concentration variation with radial distance at X=25 mm..... 52

Figure4. 13: Hydroxyl radical concentrations (OH) variation with radial distance at X=25mm. 52

Figure4. 14: Temperature variation with radial distance at X=25mm. 53

Figure4. 15: N2 concentration variation with radial distance at X=5 mm..... 53

Figure4. 16: H2O concentration variation with radial distance at X=5 mm..... 54

Figure4. 17: O2 concentration variation with radial distance at X=5 mm..... 54

Figure4. 18: H2 concentration variation with radial distance at X=5 mm..... 55

Figure4. 19: Hydroxyl radical concentrations (OH) variation with radial distance at X=5mm. 55

Figure4. 20: Hydroxyl radical concentrations (OH) variation with radial distance at X=5mm. 56

Figure4. 21: LIPF-OH image and computed OH concentration..... 56

Figure4. 22: Schematic illustration of computational domain with boundary conditions.57

Figure5. 1: Comparisons of the computed and measured N2 and H2 concentrations at X=5 mm. 60

Figure5. 2: Comparisons of the computed and measured O2 and H2O concentrations at X=5 mm. 60

Figure5. 3: Comparisons of the computed and measured OH concentration at X=5 mm.61

Figure5. 4: Comparisons of the computed and measured temperature at X=5 mm. 61

Figure5. 5: Comparisons of the computed and measured N2 concentrations at X=25 mm. 62

Figure5. 6: Comparisons of the computed and measured H2, H2O and O2 concentrations at X=25 mm. 62

Figure5. 7: Comparisons of the computed and measured OH concentration at X=25 mm. 63

Figure5. 8: Comparisons of the computed and measured temperature at X=25 mm. 63

Figure5. 9: Comparisons of the computed and measured N2 concentrations at X=50 mm. 64

Figure5. 10: Comparisons of the computed and measured H2, H2O and O2 concentrations at X=50 mm. 64

Figure5. 11: Comparisons of the computed and measured OH concentration at X=50 mm. 65

Figure5. 12: Comparisons of the computed and measured temperature at X=50 mm. 65

Figure5. 13: Temperature distribution and radical concentration using Case (1) Deutschmann reaction mechanism and Case (2)GRI-MECH 3.0 66

Figure5. 14: 2-D temperature distributions for different burner materials; case (3) titanium, (4) stainless steel, (5) aluminum and (6) copper. Adopted fuel ejecting velocity 5 m/s..... 67

Figure5. 15: Flame structure near burner port; case (3) titanium burner, (4) stainless steel burner, (5) aluminum burner and (6) copper burner 68

Figure5. 16: Computational axial flame temperature at different burner materials along axial axis. Adopted fuel ejecting velocity 5 m/s 69

Figure5. 17: Computational temperature distribution of solid tube for different burner materials; case (3) titanium, (4) stainless steel, (5) aluminum and (6) copper. Adopted fuel ejecting velocity 5 m/s 70

Figure5. 18: Computational axial temperature of solid tube for different burner materials. Adopted fuel ejecting velocity 5 m/s 70

Figure5. 19: 2-D temperature distributions for different burner materials; Case (7) titanium, (8) stainless steel, (9) aluminum and (10) copper. Adopted fuel ejecting velocity 36 m/s..... 71

Figure5. 20: Computational temperature distribution of solid tube for different burner materials; Case (7) titanium, (8) stainless steel, (9) aluminum and (10) copper. Adopted fuel ejecting velocity 36 m/s 72

Figure5. 21: Computational axial flame temperature at different burner materials. Adopted fuel ejecting velocity 36 m/s 73

Figure5. 22: comparison between temperature distributions and radical concentration for case (1) and case (11)..... 74

Nomenclature

Symbol Quantity

c_p	Constant pressure specific heat, (J/Kg.K)
c_s	Solid material specific heat, (J/Kg.K)
g	Acceleration of gravity, (m/sec^2)
h	Enthalpy; heat transfer coefficient, (J/Kg)
K	Thermal conductivity, ($W/m.C^O$)
L	Length scale, (m)
M_α	Molecular weight of gas speciesα, (Kg/Kmole)
$\dot{m}_a$	Air mass flow rate, (Kg/sec)
$\dot{m}_f$	Fuel mass flow rate, (Kg/sec)
n_x	Number of grid cells in x-direction
n_y	Number of grid cells in y-direction
p	Pressure, (Pa)
R	Universal gas constant, (J/Kg.K)
Re	Reynolds number
T	Temperature, (K)
T_w	Temperature at the wall, (K)
t	Time, (sec)
x	(x, y, z) Position vector, (m)
X_α	Volume fraction of species α
Y_α	Mass fraction of species α

Greek Letters

∇	Gradient
λ	Wave length
μ	Dynamic viscosity
ρ	Density
σ	Stefan-Boltzmann constant

Superscripts and Subscripts

Δ	Change interval of any property
∞	Ambient property
f	Fuel property
flow	Flow property
g	Gas property
ij	Indicates two different Cartesian coordinates
w	Wall property
$\alpha_{x,y}$	Property for species α

Abbreviations

CFD	Computational Fluid Dynamics
HCCI	Homogeneous Charge Compression Ignition
MEMS	Micro-Electro-Mechanical Systems
SSME	Space Shuttle Main Engine