MODELLING OF COMBUSTION IN A SINGLE-BURNER BIOGAS FIRED COOKING STOVE

By

R.M.P.S. Bandara

This thesis was submitted to the Department of Mechanical Engineering of the University of Moratuwa in partial fulfillment of the requirements for the Degree of Master of Engineering in Energy Technology

Department of Mechanical Engineering
University of Moratuwa
Sri Lanka
February 2005

DECLARATION

"I certify that this thesis does not incorporate, without acknowledge, any material previously submitted for a degree or diploma in any university or higher educational institution in Sri Lanka or abroad and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text".

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R.M.P.S. Bandara

ABSTRACT

A variety of stoves are used for household cooking in Sri Lanka. Fuel-wood, Liquefied Petroleum Gas (LPG), Electricity, Kerosene oil, Biogas etc. are the common cooking fuels used. Combustion process in a cooking stove is a complicated phenomenon. It is very difficult to predict the distributions of temperature, flow properties and combustion product concentrations of the cooking stove. It is emphasized that a detailed understanding of the combustion process taking place in a cooking stove is essential for the development of better stove designs. Computational modelling is an efficient tool that could be used successfully in describing the combustion in cooking stoves. Modelling of combustion in a cooking stove that uses a gaseous fuel is comparatively easier than that uses a solid fuel, mainly due to the complexity of the combustion process that the solid fuel undergoes. On this basis present work is involved in the modelling of combustion taking place in a biogas fired cooking stove using *SOFIE*, a Computational Fluid Dynamics (CFD) code extensively used for fire modelling. The combustion flow field of the stove has been modelled using the k-ε turbulence model for turbulence and one-step reaction fast chemistry represents combustion chemistry. Simulations are conducted for the biogas cooking flame alone and also for the single-burner biogas fired stove with a square-shaped cooking pan. Temperature, density and combustion product concentration predictions have been made using simulations. The predicted temperatures are compared with the experimental measurements. The results generated could be used as a basis for further research in combustion in cooking stoves in order to develop better designs.

ACKNOWLEDGEMENT

I am highly grateful to Dr. Rohitha Weerasinghe, my Supervisor, for the invaluable guidance, assistance and encouragement given to me throughout the course of this event that contributed immensely to the successful completion of the research study. I also wish to thank Dr. Rahula Attalage, Head, Department of Mechanical Engineering (former course coordinator of M.Eng. Programme), Dr. Thusitha Sugathapala, the Course Coordinator of the Master of Engineering Programme in Energy Technology and Dr. Kapila Perera, Senior Lecturer in Mechanical Engineering, for the vital advice and instructions given to me at crucial stages of the research.

Special regards should go to Mr. D. D. Weerakkody, the former Director General, Mr. Percy Gunawardane, the former Director in Curriculum Development and Mr. Hubert Kalugampitiya, Director/Human Resources Development of the National Institute of Technical Education of Sri Lanka, Ratmalana for granting me duty leave to follow the programme without any obstructions and the encouragement given to me throughout. I also appreciate the contributions made by Mr. V R I Gunawardane, Mr. Yapa Karunaratne, Mr. Suraj Jayathilake and Mr. L. Ranathunga together with the academic and non-academic staff of NITESL.

I would also wish to thank Mr. Upali Wanigaratne for providing me with biogas for the experiments.

Finally, the support of my friends, Mr. Leslie Kumara, Mr. Himan Punchihewa, Mr Suranga Karawita, Mr. Saliya Jayasekera, Mr. Avantha De Silva, Miss Udeshika Lakmali, Mr. Ajantha Egodawatte and Mr. Janath Priyankara at University of Moratuwa is very much appreciated.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

NOMENCLATURE

D_f	Fin diameter (m)
g	Acceleration due to gravity (ms^{-2})
h	Heat transfer coefficient ($Wm^{-2}K^{-1}$)
k	Turbulent kinetic energy (m^2s^{-2})
k_f	Thermal conductivity of fin material ($Wm^{-1}K^{-1}$)
L	Length of fin (m)
m_{fu}	Time averaged mass fraction of fuel
m_{ox}	Time averaged mass fraction of oxidant
p	Thermodynamic pressure (Nm^{-2})
q_f	Rate of conduction heat loss from a long fin (W)
q_w	Wall heat flux (Wm^{-2})
T_e	Fin-end temperature (K)
T_f	Flame temperature (K)
T_o	Base temperature of fin (K)
T_p	Temperature at near wall point (K)
T_s	Sensor temperature (K)
T_w	Wall temperature (K)
T_∞	Ambient air temperature (K)
t	Time (s)
U	Velocity (ms^{-1})
Y_α	Mass fraction of species α

Greek Symbols

ε	Dissipation of the turbulent kinetic energy (m^2s^{-3})
ε_{th}	emissivity of the thermocouple junction surface
θ	Polar angle (rad.)
κ	Von Karman constant
μ	Mixture molecular viscosity (Nsm^{-2})
μ_t	Turbulent eddy viscosity (Nsm^{-2})
ν	Kinematic viscosity (m^2s^{-1})
ρ	Density of the mixture (kgm^{-3})
σ	Stefan-Boltzmann constant ($Wm^{-2}K^{-4}$)
σ_t	Turbulent Prandtl/Schmidt number
τ	Characteristic turbulent time scale (s)
τ_v	Spectral transmissivity
τ_w	Wall shear stress (Nm^{-2})
Φ	Azimuthal angle (rad.)