DEVELOPMENT OF A BIOGAS COMBUSTION CFD MODEL FOR THE ANALYSIS OF TRACE EMISSIONS

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Degree of Master of Science

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Sri Lanka

September 2021

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Thesis submitted in partial fulfilment of the requirements for the degree Master of Science (Major Component of Research)

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Nürnberg, Germany.

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NOMENCLATURE

A/F	Air to fuel ratio
$(A/F)_{stoic}$	Air to fuel ratio in the stoichiometric mixture
λ	Equivalent ratio
$\dot{Q}$	Rate of heat transfer
$\dot{W}$	Power
h	Enthalpy
v	Velocity
g	Acceleration of gravity
$\dot{m}$	Mass flowrate
z	Elevation
ρ	Density
Y_i	Mass fraction of specie 'i' in the control volume
u_j	Velocity
D_i	Diffusion coefficient
R_i	Reaction source term
$M_{w,i}$	Molecular weight of specie 'i'
$\hat{R}_{i,r}$	Molar rate of creation/destruction of specie 'i' in reaction 'r'
N_R	Number of reactions
N_r	Number of chemical species in reaction 'r'
$C_{j,r}$	Molar concentration of specie 'j' in reaction 'r'
$\eta'_{j,r}$	Forward rate exponent
$\eta''_{j,r}$	Backward rate exponent
$k_{f,r}$	Rate constant
A_r	Pre-exponential factor of reaction 'r'
E_r	Activation energy for the reaction 'r'
R	Universal gas constant
T	Absolute temperature
E	Total energy
p	Pressure
q	Heat flux vector
τ	Viscous stress tensor
g	Gravitational constant
r	Total heat released/absorbed by reactions
u	Wind speed
u_r	Known wind speed at reference height
z_r	Reference height
ν	Kinematic viscosity
F	Sum of body forces (gravity)
F_c	Coriolis force
T_0	Reference temperature
β	Coefficient of thermal expansion
m	Mass
ω	Angular velocity of the earth
V	Tangential velocity
φ	Latitude of the location

ABSTRACT

Biogas is emitted from landfills, anaerobic digesters, and many other biomass sources. Emitted biogas is usually burnt in order to reduce greenhouse effect and to get energy. Burning of biogas emits several pollutants, mainly CO_2, NO_x and SO_2. Reducing the of emissions is very important in combustion. Emissions of combustion can be analysed experimentally or by computer simulations. Experiments are very accurate and expensive. Computer simulation is an economic way of analysing combustion systems. In this study emissions of biogas combustion are analysed with computer simulations.

There are several methods of reducing emissions in combustion such as excess air control, air staging, fuel Staging, flue gas recirculation etc. In this study, the effect of excess air in biogas combustion is analysed. The range of optimum equivalent ratio was found as 0.85-1.1.

Emitted gasses get dissipated in the atmosphere with the wind. The environmental effect from emissions of a 20kW industrial biogas burner in Colombo area was analysed using CFD simulations. Results show that the ground level is below environmental standard limits.

Keywords: Biogas, Combustion, Equivalent Ratio, CFD, Atmospheric dispersion

ACKNOWLEDGEMENTS

I am thankful to my supervisor Prof. Mahinsasa Narayana and co-supervisor Prof. Christoph Bayer for their encouragement, guidance, and time throughout my study. I should thank Dr. Niranjan Fernando for the guidance given on CFD modelling. I am also thankful to Prof. S. Walpalage, Head of the Department of Chemical & Process Engineering and Prof. A.A.P. de Alwis, Dean, Faculty of Graduate Studies, University of Moratuwa for enrolling me for the M.Sc. degree. I am thankful for National Research Council of Sri Lanka for the financial support and Europe Sri Lanka Capacity Building in Energy Circular Economy "EUSL-Energy" project for equipment grant. Finally, I should thank my parents, staff of University of Moratuwa and my colleagues as well for their supports.