Southern Regional Engineering Conference
1-2 September 2012, Toowoomba, Australia
SREC2012-MMNoor-2

Numerical Investigation of Influence of Air and Fuel Dilution for Open Furnace MILD Combustion Burner

M.M. Noor[1,3,] Andrew P. Wandel[1]
[1]Computational Engineering and Science Research Centre,
Faculty of Engineering and Surveying,
University of Southern Queensland (USQ)
Toowoomba, 4350, Australia
Muhamad.MatNoor@usq.edu.au

T.F. Yusaf[2,3]
[2]National Centre for Engineering in Agriculture,
University of Southern Queensland (USQ), Australia
[3]Faculty of Mechanical Engineering,
Universiti Malaysia Pahang (UMP), Malaysia

Abstract—**Climate change and greenhouse gases (GHG) have become one of the priorities for today's intergovernmental issues. Reducing pollution and recycling the GHG are new challenges for the combustion community. The new technology Moderate or Intense Low oxygen Dilution (MILD) combustion is one of the best alternatives for high thermal efficiency and low pollution combustion. This paper discusses the modelling of MILD combustion in an open furnace using FLUENT. Exhaust gas recirculation (EGR) was utilised to increase the combustion thermal efficiency by the reuse of the heat in the flue gas. The combustion chamber is enclosed to capture the flue gas for EGR. The oxygen dilution and pre-heating of the oxidiser which are vital for operating in the MILD regime can be achieved by utilising EGR. The top of the chamber will be the opening for exhaust gas release. The ratios of EGR, fuel and air inlet velocity were numerically studied for their effect on achieving MILD combustion in an open furnace. Higher dilution ratios produce lower NOx emissions and more readily achieve the MILD condition..**

Keywords-spray MILD combustion, computational fluid dynamics, exhaust gas recirculation, turbulent, open furnace

I. INTRODUCTION

Energy supply is on progress of a transition from conventional form to more sustainable supplies. The energy production will increasing of greenhouse gases concentrations [1-4] and will effect on the climate change. The global temperature and the CO_2 concentration reported to increase significantly since the era of industrialization [5]. This is directly proportional with energy production and quality of life. The solutions to this problem included energy conversion improvement, carbon capture, transport and storage (CCTS) and the use renewable resources such as solar, wind, hydro, biomass and geothermal energy [6]. Besides that, combustion of fossil fuel projected at the year 2030 still account about 80% from global energy needs [7]. Transport fuel in 2030 remains dominated by oil (87%) and biofuels (7%), natural gas (4%) and electricity (1%) in 2030 [8]. Combustion of fossil fuel is still a very important source of energy and the efficiency and pollution emissions must be improved.

Moderate and intense low oxygen dilution (MILD) combustion is very suitable new combustion technology in order to reduce the pollution emission and increase the thermal efficiency [9-12]. This combustion also called flameless oxidation or FLOX [13-18], low NOx [19] and high-temperature air combustion (HiTAC) [20-21]. MILD combustion main requirement is oxygen dilution in the oxidiser and temperature mixture temperature is above the self ignition for the fuel or gas. The oxygen dilution and the heating of the oxidiser can be achieved by the used of exhaust gas recirculation (EGR) [20]. The EGR gas is in very hot temperature and almost zero oxygen will be heated the oxidiser and dilute the oxygen. The oxygen content from in the fresh air originally was 21% will reduce to as low as 3% depending on the ratio of EGR and fresh air. This is call EGR ratio.

II. CFD MODELLING

Computational fluid dynamics (CFD) is an important tool to explore MILD combustion. CFD was increasingly being used for the optimisation of gas burner [22] and industrial gas furnace [23-26] or coal combustion [27]. In this study, the CFD package ANSYS FLUENT 13.0 was used to model non premixed combustion, radiation, heat transfer and NOx emission in a diffusion flame biogas-air with a bluff-body burner. A governing equations used including mass, momentum, energy and species in addition to the turbulence transport and combustion model were discretized in the whole domain using the second-order schemes. The realizable k−ε turbulence model was used for turbulence model and discrete ordinate (DO) model [39] for radiation model. DO model is applicable to a wide range of optical thicknesses. The optical thickness for MILD combustion flames is not well defined makes DO model a good selection for the radiation model. This model solves a radiative transfer equation. Weighted sum of gray gas model (WSGGM) was used for the absorption coefficient which was conceptually developed in 1967 [40] and used for spray combustion [41] and gas furnace [42]. The WSGGM is having reasonable compromise between the oversimplified gray gas model and a complete model.

III. COMBUSTION EQUATION

Exhaust General hydrocarbon stoichiometric combustion equation

$$C_n\,H_m + \left(n+\frac{m}{4}\right)(O_2+3.76N_2) \rightarrow nCO_2 + \frac{m}{2}H_2O + 3.76\left(n+\frac{m}{4}\right)N_2 \qquad (1)$$

Stoichiometric combustion equation without EGR for low calorific value gas consists of 50% methane, 20% hydrogen and 30% carbon dioxide by mass fractions.

$$(0.5CH_4 + 0.2H_2 + 0.3CO_2) + (1.1O_2 + 4.14N_2) \rightarrow (0.8CO_2 + 1.2H_2O + 4.14N_2) \qquad (2)$$