The Effect of CO_2/O_2 Co-flow on Methane Jet Flame

Yung-Sheng Lien, Yueh-Heng Li , Yei-Chin Chao

Institute of Aeronautics and Astronautics
National Cheng Kung University, Tainan, 701, Taiwan, R.O.C

1 Introduction

For decades, the issues associated with burning fossil fuel is becoming an intensive global concern. The carbon dioxide emissions, which is generally believed to lead to the current global warming, contributed by the developed countries is expected to increase significantly more than 60% in 2020[1][2]. Burning fossil fuel could be the main source of carbon dioxide emission. Aside from fast development of renewable energy, the consumption of fossil fuel will still be the main energy source for the global economy to rely on in the next 50 years inevitably..

To reduce the impact of global warming, several effective methods have been proposed and intensively investigated, including: increasing energy efficiency and energy conservation, using low-carbon fuels, developing reliable renewables, etc. All these methods have the same purpose that is to down-size the amount of carbon dioxide emissions. However, the effect is yet to be evaluated extensively.

For modern combustion technology, zero-carbon emission may be achieved by using: post-combustion capture, pre-combustion capture, oxy-fuel combustion and in-situ capture and conversion in the combustion system [3~7]. Those technologies were developed for decaes. All these technologies capture, separate and store carbon dioxide from the combustion product gases. Among these methods, the oxy-fuel combustion receives special attention recently. For ease of sequestration of carbon dioxide from the combustion product gases, instead of air oxygen diluted with carbon dioxide is usually used inoxy-fuel combustion. The carbon dioxide in the product gases is recirculated for dilution to reduce the combustor temperature as well as to recirculate part of the waste heat. The research into the combustion characteristics of fuel burning in the environment of carbon dioxide diluted oxygen becomes a timely important issue.

2 Experiment Setup

In this study, a methane jet burner with coflowing of oxygen diluted with different percentages of carbon dioxide is used to simulate the oxy-fuel combustion. In the experiment, the jet burner consists of a rectified central methane (CH_4) fuel jet of 500-mmin length and

2.5-mm inner diameter and a30-mm inner diameter co-axial jet for oxygen and carbon dioxide of different concentration ratios and the jet burner system is placed in a confinement, as shown in Fig.1. The velocity of outlet fuel is 50 cm/sec. High-purity methane fuel from cylinder is used. Fuels and co-flow are metered by a rotameter and electronic flowmeters. All rotameter and mass flowmeters are calibrated carefully in advance. Oxygen and carbon dioxide are filtered and mixed in a mixing chamber before emerging from the burner tube. The flame shape and outlook are observed by using a digital camera (Nikon D80) in darkroom.

3 Results and Discussions

The purpose of this experiment is to understand the operational characteristics of flame in combustor. The temperature of combustor and flame conditions are the criteria of combustor design. Oxy-fuel combustion cause high temperature that will demage the burner or rise the cost of burner. On the other hand, low-oxygen combustion will bring out flame instability and extinguish. Those are unsuitable for designing a combustor. In the follow-on discussion, flame shape and oxygen concentration will be involved.

In diffusion flame, fuel and oxidizer diffuse to the flame front due to the gradients sustained by chemical reaction. The flame wouldn’t propagate into the oxidizer without fuel or into the fuel without oxidizer, so it is fixed to the interface. The oxygen (O_2) concentration is 21% in air. In this experiment, it using air for co-axial flow that means oxygen (O_2) concentration is 21% (Fig.3). So the concentration of oxygen (O_2) in this experiment will be more than 30% (oxy-fuel). There is very obviously the flame height becomes shorter when oxygen(O_2) concentration is increased. It can be explained by increasing the percentage of the oxygen (O_2) in co-axial flow will enforce the jet flame increasing burning velocity so the flame cone will become shorter (Fig.3).

4 Conclusions

The effect of CO_2/O_2 co-axial flow on methane non-premixed flame was observed at different oxygen(O_2) conncentration. When co-axial flow is air (oxygen concentration is 21%), jet flame will sustain at co-axial flow velocity below 32 cm/sec.

In CO_2/O_2 co-axial flow, CO_2 instead of N_2, the jet flame will not sustain until oxygen concentration is rose to 45%. It is that CO_2 has a much lower specific heat than N_2. So the jet flame will sustain in oxy-fuel situ-tation.

Consequently, lead CO_2 back to combustor is not only to reduce the CO_2 emission but also to low down the temperature of burner and keep oxy-fuel combustion stable.

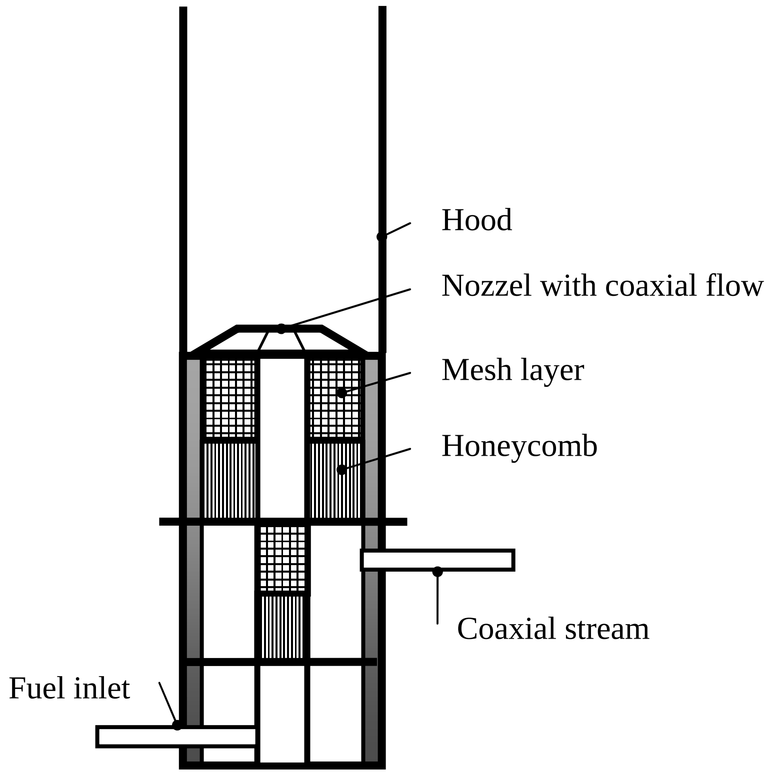

Figure 1. Burner's configuration

Figure.2 Photographic images of the various oxygen percentages in co-axial flow flame configurations

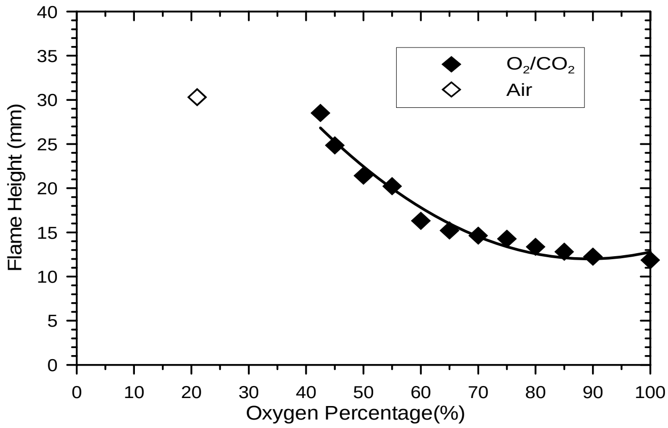

Figure 3 . Measured flame heights for varies oxygen.

References

[1] The Outlook for Energy: A View to 2030, Exxon Mobil, November. 2007.

[2] World Energy Outlook-2001 Insights: Assessing Today's Supplies to Fuel Tomorrow's Growth, IEA PUBLICATIONS, 2001.

[3] Dadhich, P.,"CO_2 Capture Technologies," Carbon Cature & Storage Technical Workshop, *India-Australia Coal & Mining Forum*-New Delhi,India, 2006.

[4]European Technology Platform for Zero Emission Fossil Fuel Power Plants(ZEP), http://zero-emissionplatform.eu/website/index.html,

[5]Office of Fossil Energy/Department of Energy, "Carbon Capture Research," http://fossil.energy.gov/programs/sequestration/capture/index.html, August 1,2005

[6]Zevenhoven, R., and Kohlmann, J., "CO_2 Sequestration by Magnesium Silicate Mineral Cabonaton by in Finland," Second Nordic Mini-symposiuum on Carbon Dioxide Capture and Storage, Goteborg,pp13-18,2001.

[7]Wisniewski, M.,Boreave,A., and Gelin, P.,"Catalytic CO_2 Reforming of Methane Over Ir/Ce.Gd.O_2", Catalysis Commum.,Vol.6,pp.596-600,2005.