XX Fluid Mechanics Conference KKMP2012,
Gliwice, 17-20 September 2012

PULVERIZED COAL COMBUSTION IN SWIRL BURNER IN CO_2/O_2 ATMOSPHERE

Piotr WARZECHA[1], Andrzej BOGUSLAWSKI[1]
[1]*Czestochowa University of Technology, Institute of Thermal Machinery, Czestochowa, Poland*
e-mail: warzecha@imc.pcz.czest.pl, abogus@imc.pcz.czest.pl

Key words: oxy-combustion, pulverized coal, swirl burner

Nowadays it is important to reduce emission of greenhouse gasses to the atmosphere during the combustion process. One way to reduce the emission is to introduce the alternative energy sources such as renewable energy sources or nuclear power. However, so far renewable energy sources cannot cover all the energy consumption and therefore a conventional methods using fossil fuel are used. Coal plays an important role in electricity production due to its large reserves. To reduce the emission during coal combustion one may carry out the combustion process in oxygen environment. This method is well known as an oxy-combustion (Buhre et al. 2005, Toftegaard et al. 2010). During oxy-fuel combustion, oxygen is separated from air (typically averaged of 95% purity of oxygen) and mixed with recycled flue gas (RFG). In oxy-combustion a lower emission of NOx is achieved by removing nitrogen from oxidizer. In this case as a combustion products become mostly CO_2 and water vapour. Flue gas is then purified and recirculated to the combustion chamber. Combustion process carried out in O2/CO2 mixture differes from air combustion. This is due to differences in CO2 and N2 properties such as higher density and higher heat capacity of CO2. In order to obtain adiabatic flame temperature similar to combustion in air, the proporion of oxygen passing through the burner should be about 30% higher than for air. The required amount of recirculated flue gases is about 70%. Attempts to burn pulverized coal in oxy-combustion technology in existing installations adapted for combustion in air bring problems with flame instabilities and weak degree of fuel burnout in swirl burners. Further development of oxy-fuel combustion technology can be supported by numerical methods – Computational Fluid Dynamics (CFD).

The paper presents results of numerical simulations of pulverized coal combustion process in swirl burner. In numerical simulation it is important to have fine mesh resolution in the region of the burner exit, where the flame is located. Mesh sensitivity tests have been done to ensure that the grid size has no influence on the results. Numerical simulations have been performed for the oxyfuel test facility located at the Institute of Heat and Mass Transfer at RWTH Aachen University (Toprov et al. 2006). The test rig is a vertical, cylindrical furnance with a length of the combustion chamber of 2.1m and an inner diameter of 0.4m. Pulverized coal enters combustion chamber together with the primary air. Mass flow rate of fuel and air are 6.5 kg/h and 17.6 kg/h respectively. Secondary air mass flow rate is 26.6 kg/h and is highly swirled with the swirl number of 1.2. Pulverized coal is simulated as a discrete phase with particle size distribution 0.9 – 123μm.

Figure 1 shows comparison of axial velocity, tangential velocity and temperature at axial distance of x=0.05m from the burner exit. Results obtained in Institute of Thermal

Machinery (IMC) were compared to experimental data (black circles) and numerical results of Toprov et al. (black lines). As it can be seen, results for both axial and tangential velocities give good agreement. Results for temperature distribution differs from experimental data. First the temperature is overpredicted up to the radius R=0.024 and then is higly underpredicted in the range of radius R=0.025-0.051m. This is also the case for results of group of Toprov et al. The reason for that could be combustion mechanism used in simulation. More work need to be done in this topic.

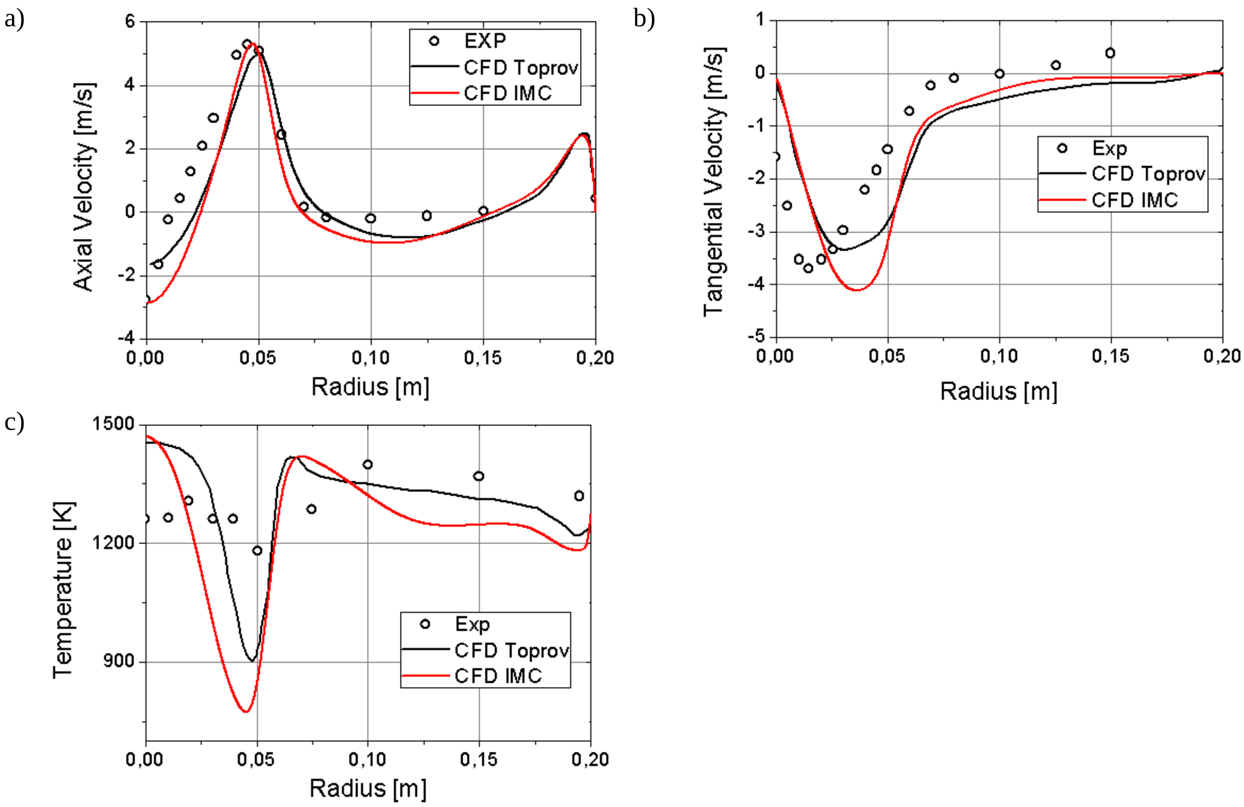

Figure 1. Axial velocity (a) tangential velocity (b) and temperature (c) at axial distance x=0.05m from the burner.

Acknowledgement

The work reported in the present paper has been suported by the research project SP/E/2/66420/10

References

Buhre B.J.P., Elliott L.K., Sheng C.D., Gupta R.P., Wall T.F., (2003): *Oxy-fuel combustion technology for coal-fired power generation*, Progress in Energy and Combustion Science, vol. 31, pp. 283-307

Toftegaard M.B., Brix J., Jensen P.A., Glarborg P., Jensen A.D., (2010): *Oxy-fuel combustion of solid fuels*, Progress in Energy and Combustion Science, vol. 36, pp. 581-625

Toprov D., Bocian P., Heil P., Kellermann A., Stadler H., Tschunko S., Foerster M., Kneer R., (2006): *Detailed investigation of a pulverized fuel swirl flame in CO2/O2 atmosphere*, Combustion and Flame, vol. 155, pp. 605-618