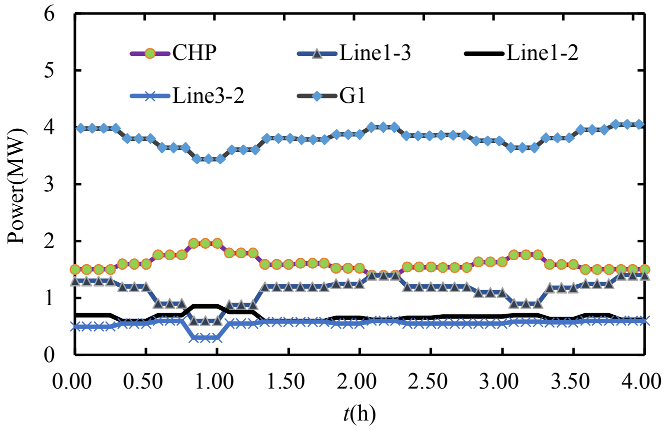

Fig. 4. Power distribution of power system

As can be seen from Fig. 3 and 4, the power balance of the power system is realized and the operation reliability of the power system is improved.

This paper examines the coupling modeling of an electrothermally coupled multi-energy flow system in accordance with the system's multi-time-scale properties. In order to increase the applicability of the model calculation and take into account the thermal dynamic process of the heating network of the heating system, a multi-time-scale dynamic model of the heating system is established. Calculations using a mathematical example show that electrothermal coupling can improve the system's anti-interference capability up to a point.

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NUMERICAL SIMULATION AND EXPERIMENTAL INVESTIGATION OF METHANE-AIR NON-PREMIXED STRONGLY SWIRLING COMBUSTION IN A NOVEL ASYMMETRIC SEMI-CONFINED COMBUSTOR

H. W. Du, D. B. Zhao, X. H. Shi, J. T. Feng, Y. F. Ji, T. T. Li, F. Y. Zhang, X. S. Duan

Department of Energy and Environment, Inner Mongolia University of Science and Technology, China

Supervisor K. Li

In this paper, a novel asymmetric non-premixed combustor with well-defined geometric boundary is provided to enhance air/fuel mixing and improve flame stability. A comprehensive numerical model, which coupled with large-eddy simulation using a modified Sub-grid scales kinetic energy model and second-order moment combustion model using a simplified four steps chemical reaction mechanism, for non-premixed combustion in a semi-confined space is established. The results show that four isolated vortices characterized by the features of strongly rotating and tangential shear stress are formed in the corner region of combustor. With the increases of inlet gas velocity, the flame blow off do not happen and the average temperature in the combustor remain mostly uniform low and well distributed. Combustion intensity, vortex structures

forming and shedding which involves turbulent mixing, chemical reaction and flame propagation is affected by the strongly swirling flow field structure.

Keywords: numerical simulation, experimental investigation, vortex flow, non-premixed combustion, rapid mixin.

In this paper, based on the well-characterized swirl burners or chambers (Khaleghi [et al.], 2015, Dyke, 1984; Gabler [et al.], 1998; Vijayan [et al.], 2010), we designed a novel vortex combustor where methane and air are injected in the transverse and alternative directions at a certain inlet velocity respectively. Combustion products are exhausted in the vertical direction. Vortex flow as a means to stabilize non-premixed gaseous flames in the combustor are investigated. A lab-scale combustor with chamber radius as small as 30 mm is fabricated in Inner Mongolia University of Science and Technology (IMUST). The system is based on the concept of asymmetric whirl combustion, which has illustrated unusual stability characteristics for macro-scale combustor at very well conditions. The large eddy simulation method based on a improved SGS kinetic energy model is used to evaluate the characteristics of combustion. Detailed computational study of the three-dimensional (3D) reacting flow fields as well as experimental analysis was performed to investigate the combustion characteristics. Results further verify the favorable temperature distribution and flow pattern of the asymmetric whirl combustion concept.

The experimental platform for the novel combustor is schematically shown in Fig. 1. The whole system is exposed to the standard ambient air with temperature 300 K and pressure 1.0 bar. It is consisting of a thermometer, PLIF, PC, combustor and two precision flowmeter. Air is delivered at 5 bars from a compressor, equipped with a pressure gauge and regulator. Fuel (methane) is supplied at 2 bar from a pressurized tank. Two digital high-precision flow meters from Cole-Palmer are used to measure the flow rate of fuel and air. The air flow rate was measured by a mass flow rate. Stretchy plastic plumbing is adopted to connect the combustor chamber with the fuel-air supply system. A LaVsion digital PLIF system is installed perpendicular to the outlet plane of the combustor to execute direct photographs for the flame. The wall temperature is measured by OKAZAKI thermometer which is mounted at different positions on the wall. The accuracy of the thermometer is ±0.1 °C. The design of the combustor has been illustrated in Fig. 2.

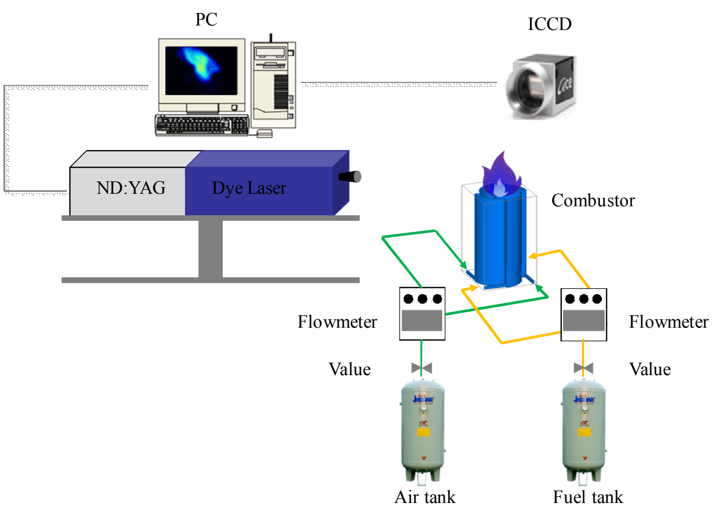


Fig. 1. Experimental setup

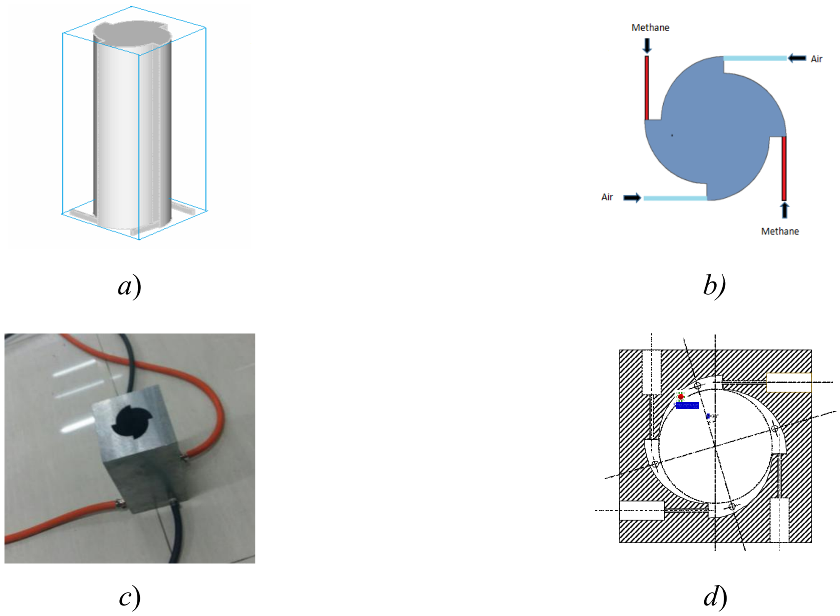


Fig. 2. The design of combustor

Non-premixed methane/air combustion in a novel asymmetric combustor with the equivalent radius of 30 mm was experimentally and numerically investigated. Negative pressure existing in the main flow and corner region of combustor respectively is beneficial to store heat energy and stabilize flame. Isolate vortex flow in each corner region has a function of drag reduction. With the increase of Reynolds number, the vortex in a corner region disappeared gradually. The existence of a wall self-cooling phenomenon obviously shows that the temperature ranges from 300 K to 400 K in the Z ≤ 55 mm region, and the highest temperature is about 1150 K in the whole combustor. The wall temperature was measured using a high precision thermocouple under the specified reacting flow conditions. With the increasing mass flow rate of air, the wall temperature increased. The effect of air/fuel inlet velocity on CO2 emissions was investigated. Large-eddy simulation technique was adopted and second-order moment combustion model was used for modeling combustion by using UDF functions of Ansys Fluent 14.5. Several wealthy observations and conclusions are obtained:

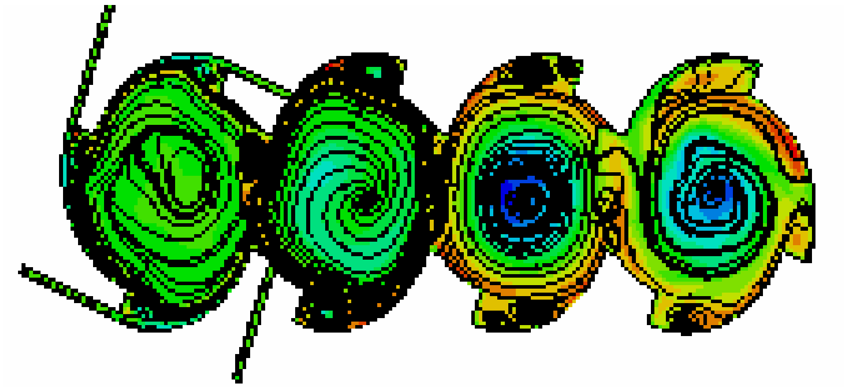
1. There are multiple wake recirculation regions in each corner of the combustor when is low. With the increase of Re of inlets, the recirculation region in the corner are compressed, the lengths are shortened and the wake recirculation zones disappear gradually. Besides, with the increase of axial distance, the stagnation point of each recirculation region moves forward and gradually ruptures.

2. Well air-fuel mixing performance is achieved in this combustion device. It can lead to the lower combustion temperature, and reduce the emissions of NO_x effectively by using such combustion system and technology. The results indicate that a new low emission combustor was presented.

3. Flame is full of the whole combustor than other vortex combustor. The average combustion temperature in the combustor decreases with the increase of Re. The maximum temperature in the main combustion zone is about 1100 K, approximately consistent with the experimental value. The wall cooling phenomenon can be observed on the bottom of combustor. The temperature is range from 300 K to 400 K in the Z ≤ 55 mm region.

4. The tangential velocity presents the centrosymmetric double-peak structure along the radial direction and keeps approximately consistent with Rankine Vortex law of mo-

tion. Mainstream and cornered backflow cause negative pressure areas respectively which is beneficial to the storage of heat and active centers as well as the stability of the flame. As shown in Fig. 3, the process of recirculation in a combustor using streamlines. These streamlines indicate the path that a fluid particle would follow. The mixture flows axially after the reaction and it diffuses away from the center.



(a)Z=5mm, 65mm, 125mm,185 mm(left → right)

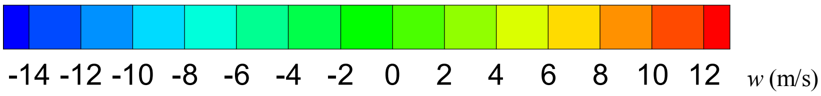


Fig. 3. Streamline with axial velocity in different cross section

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