Effect of Mixture Flow Rate on Emission Characteristics of Laminar Premixed CH4/Air Flame with Changing Combustor Pressure

Hai-quan Ma*, Jae-hyeok Song*, Ki-joong Kang*, Gyung-min Choi**†, Duck-jool Kim **,

ABSTRACT

To investigate emission characteristics of laminar premixed CH4/air flame, combustion experiments were conducted at three flow rates (5.3L/min, 10.6L/min, 15.5L/min) with changing the combustor pressure(-30Kpa-30Kpa) .It was found that with increasing flow rate, NOx emission increased in high pressure condition, while decreased in low pressure condition; and the emission of CO decreased with increasing flow rate. For the influence of pressure, emission of NOx increased with increasing pressure regardless of flow rates, while CO emission decreased on the contrary.

Key Words : premixed laminar flame, changing pressure, emission index, mixture flow rate

Due to the increasing recognition of air pollution, the NO*x*(nitrogen oxides) and CO (carbon monoxide) emission during combustion process has been attracting more and more attention as the primary environmental concerns for a few decades. A partial premixed combustion system was used in this investigation, much work has been devoted to measurement and analysis of concentration of NOx and CO, and the solutions to reduce them. It was found that the fuel flow rate and surrounding air velocity affect the emission characteristics by a quite large level.

Induced flow system has been widely used in industrial instruments and home appliance, such as industrial boiler and gas dryer, to improve the heat transfer efficiency and prevent leakage. In induced flow system, the pressure fluctuates near, but mostly is lower than atmospheric pressure. Since changing pressure has a significant effect on flame temperature distribution and flame burning velocity, the emission characteristics is also influenced by variation of pressure quite a lot. However, there are only a few studies conducted in this field and the previous studies didn't focus on global pollutants emission. Therefore, in the present study, the objectives were to investigate the emission characteristics at low pressure. In this study, the variation of combustor pressure was form -30 to 30 kpa (gage pressure), the emission characteristics were investigated by temperature distribution, NOx and CO emission measurements.

Fig 1 shows the schematic diagram of the combustion system, in which the combustor pressure controlling part and premixed chamber are also included. The pressure of the combustor chamber was controlled by a blower installed at the upstream and a vacuum pump installed at the downstream. The blower provides blowing air while the vacuum pump provides suction force. The combustor pressure was expressed by a pressure index P*($P^*=P_{abs}/P_{atm}$)and gauged by a pressure transducer which was installed 100mm downstream from the main burner. To get pressure higher than atmosphere , control valve is adjusted to decrease the cross section of the pipe so that increase the pressure of

* 부산대학교 대학원 기계공학과
** 부산대학교 기계공학부
† 연락저자, choigm@pusan.ac.kr
TEL : (051)510-3072 FAX : (051)516-9598

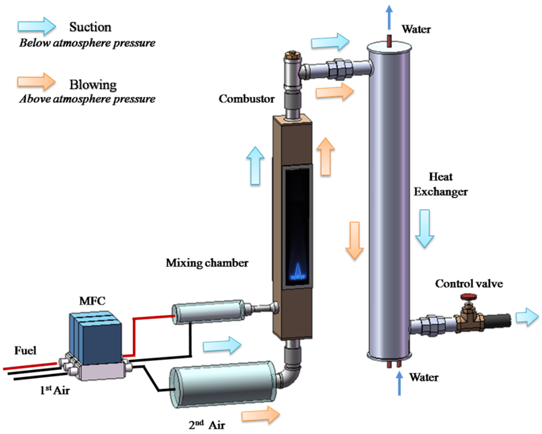

Fig.1 Schematic diagram of combustion system with pressure controlling system.

combustor chamber; the work frequency of the vacuum pump can be controlled by an inverter so to get a pressure lower than atmosphere. The exhaust gas after combustion was exhausted to the air after passing through the heat exchanger which was cooled by water.

Fig 2 shows the schematic diagram of exhaust gas concentration measuring system and sampling probe. Exhaust gases were sampled by a water-cooled gas sampling probe with a 1mm sampling hole, and the probe was installed on the top side of combustion chamber.

Methane gas (99.95%) was used as fuel, equivalence ratio was set at 1.0. The flow rate of mixture flow was 5.3L/min, 10.6L/min, 15.5L/min respectively, and the flow rate of co-flowing air fixed at 138.7L/min. Pressure index varied from 0.7 to 1.3.

Fig 3 shows the temperature distribution at half flame length cross section for each condition. It was observed that temperature increased a little or kept constant from the center of flame to the edge of reaction zone and decreased very rapidly as far away from the center and the temperature increased with increasing of flow rate.

Fig 4 shows the emission index of NOx (EINOx) as a function of pressure index and flow rate. It's obvious that the EINOx value increased with increasing of pressure index regardless of flow rate, and the influence of pressure index on EINOx was weaker for small

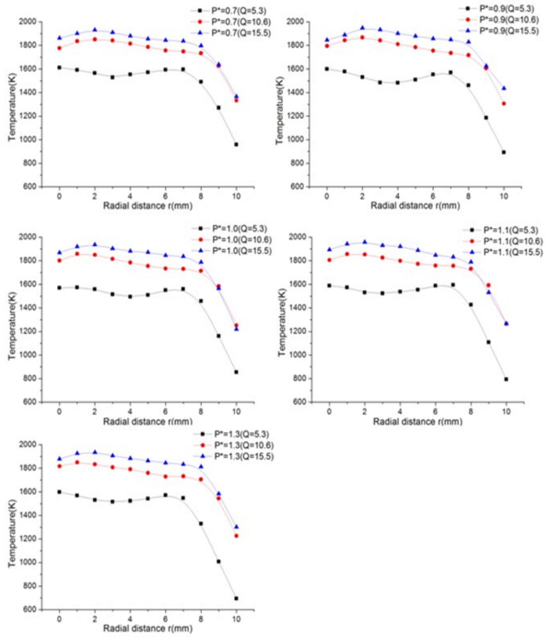

Fig.3 Temperature distribution of each mixture flow rate

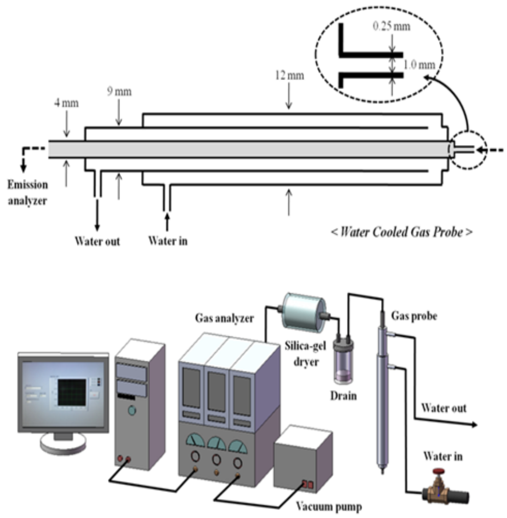

Fig.2 Schematic diagram of gas analyzer and sampling probe

flow rate than that of large flow rate. In high pressure part, large flow rate condition showed high emission of NOx while the situation was not the same for low pressure part.

Fig 5 shows the emission index of CO (EICO) as a function of pressure index and flow rate. Regardless of flow rate, the EICO value

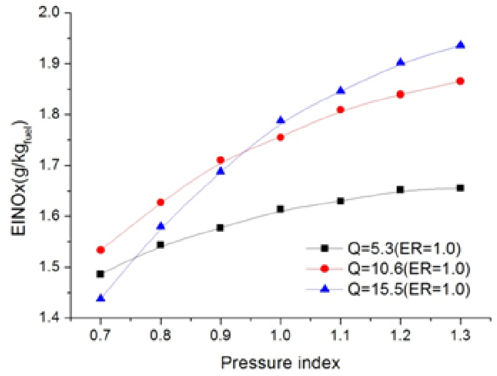

Fig.4 EINOx as a function of pressure index and flow rate

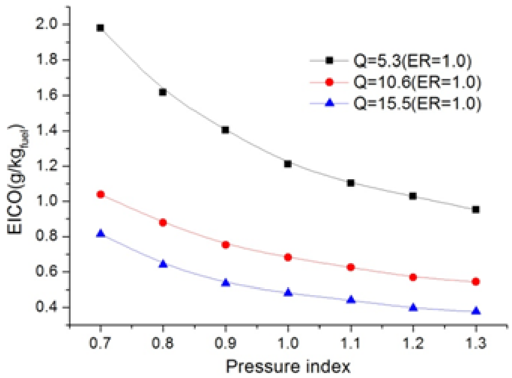

Fig.5 EICO as a function of pressure index and flow rate

decreased with the increasing of pressure index, and decreased faster in low pressure part than that of high pressure part. With increase of flow rate, EICO decreased.

Reference

[1] J. R. Kim, F. Akamatsu, G. M. Choi, D. J. Kim, "observation of local heat release rate with changing combustor pressure in the CH4/air flame", T*hermochimica Acta, Vol.* 491, 2009, pp. 109-115.

[2] M. A .Habib, M. Elshafei, M. Dajani, "influence of combustion parameters on NOx production in an industrial boiler", *Computers&Fluids,* Vol. 37, 2008 pp. 12-23.