# 암모니아를 이용한 모형가스터빈 연소기에서의 저온 플라즈마의 효과

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# Effects of non-thermal plasma on ammonia combustion in model gas turbine

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One of the most significant issues is global warming mainly driven by human activity. To reduce greenhouse gas emissions, the Paris Agreement on climate change has demanded progressively strict emission regulations. Ammonia ($NH_3$) as an alternative fuel is a possible complementary solution since it is a flammable inorganic substance which does not produce $CO_2$ when burned. Thus, it has a much lower impact on global warming. However, ammonia combustion has some challenges that have to be addressed. First, ammonia has low flame speed and high ignition energy make it difficult to burn. Second, it presents low radiation intensity and low energy density. Moreover, the combustion of ammonia produces much emissions of $NO_X$ and unburned $NH_3$ which can lead to serious health problems.

As one of new technologies, non-thermal plasma (NTP) has drawn great attention because it can give an unprecedented opportunity for emission control and combustion stabilization [1-3]. In particular, dielectric barrier discharge (DBD) technique has been regarded as a promising candidate to generate non-thermal plasma. It has several advantages of relatively-low cost and lower power consumption than thermal plasma such as arc discharges.

Figure 1 shows schematic diagram of the experimental setup. The swirl combustor has a fuel nozzle with ten holes through which ammonia is supplied and a compressed dry air is also supplied through a ceramic mixing chamber. The DBD reactor has a circular ring made from stainless steel to control streamers.

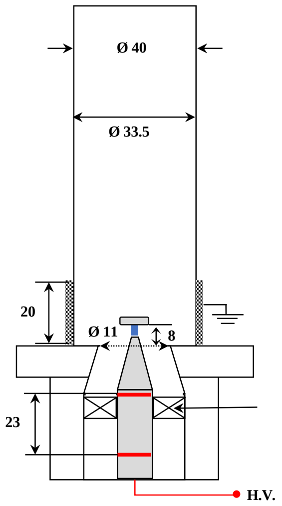

Fig. 1 Schematic diagram of the experimental setup.

The ring serves as a central electrode and a stainless steel mesh surrounding the outer quartz tube, a dielectric barrier, is a cylindrical electrode which is grounded.

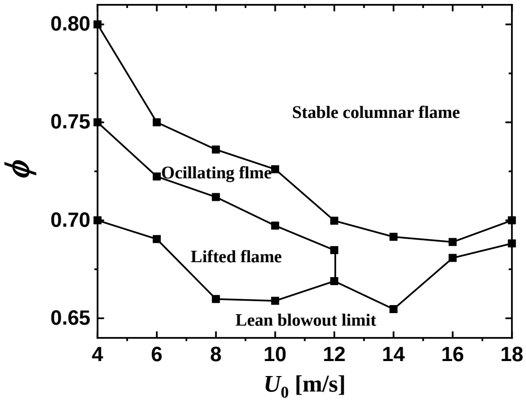

Fig. 2 Flame stability map with dependence on equivalence ratio ($\phi$) and mixture exit nozzle velocity ($U_0$) without applying non-thermal plasma.

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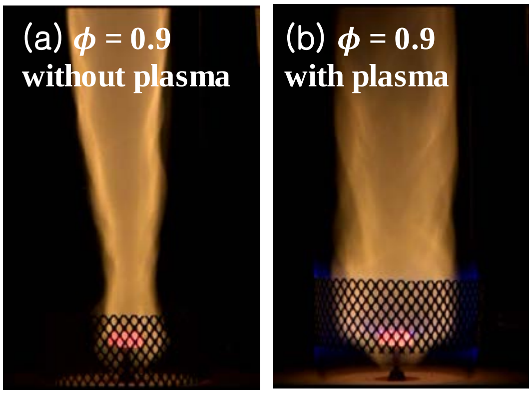

**Fig. 3** Representative flame images of columnar flame at $\phi$ = 0.9 (a) without and (b) with non-thermal plasma.

The flame stability map is presented as a function of equivalence ratio ($\phi$) and exit nozzle velocity ($U_0$) without applying non-thermal plasma in Fig. 2. There are three modes in flame: (1) a stable columnar flame, (2) an oscillating flame, and (3) a lifted flame. The stable flame is attached to the circular ring. The regime of stable flame is extended to lower $\phi$ as $U_0$ increases. When the $\phi$ reduces, the flame occurs oscillation. As the $\phi$ decreases further, the flame is lifted from the ring.

Figure 3 shows the representative images without NTP and with NTP at $V_{AC}$ = 7 kV, and $f_{AC}$ = 4 kHz. When a columnar flame is applied by NTP, the flame is significantly changed to a conical flame. Moreover, the oscillating flame does not occur for the flame with NTP. These results imply that the enhancement of combustion by the NTP can effectively stabilize the flames, leading to the extension of the lean blowout limit.

## 후 기

This research was conducted under the framework of the Research and Development Program of the Korea Institute of Energy Research (CD20200032). CSY was supported by Basic Science Research program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT (NRF-2018R1A2A2A05018901).

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