A study of the Influence by diluting Carbon dioxide to Methane Counterflow Flame

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The oxy-fuel combustion technology has received increasing attention nowadays due to an urgent clean combustion requirement. Oxy-fuel combustion is principally to burn the hydrocarbon fuels in oxygen/carbon dioxide condition instead of air condition (21%O₂+79%N₂). Carbon dioxide is recuperated from the flue gas, and considered as dilute gas in oxy-fuel combustion. Therefore, the product gas of oxy-fuel combustion will be simply carbon dioxide and water steam left. It benefits to integrate with the carbon capture and storage system (CCS) for accomplishing the goal of zero carbon emission. However, replacing nitrogen with carbon dioxide in hydrocarbon combustion would lead to ignition delay and combustion instability. Moreover, the laminar burning velocity in O₂/CO₂ condition would approximately reduce to 1/3-1/5 of that in O₂/N₂ condition.

Therefore, the objective of this study is to investigate the combustion characteristics of methane diffusion flames in various O₂/CO₂ conditions. The diffusion opposed-jet flame was used, as shown in Fig. 1. Figure 2 shows the diffusion opposed-jet flames in varied ratios of oxygen/nitrogen and oxygen/carbon dioxide condition. In case of 30% oxygen+70% diluents it appears that the flame thickness of methane diffusion flames is significantly different, as shown in Fig. 2(a) and 2(b). Principally, diffusivity of O₂ is lower in CO₂ (DₐO₂-CO₂=0.15 cm²/s) than N₂ (DₐO₂-N₂ =0.21 cm²/s). Besides, the flame illuminescence in O₂/CO₂ condition is much brighter than that in O₂/N₂ condition. It indicates the carbon dioxide does not simply play as diluents, but influences the chemical pathway. Therefore, the OPPDIF code of CHEMKIN Collection is used to investigate the chemical mechanism of two flames. Nevertheless, since the oxygen volumetric percentage is increasing, the flames in O₂/CO₂ and O₂/N₂ conditions are similar, as shown in Fig. 2(c) and 2(d). High oxygen volumetric concentration in oxidant side may eliminate the carbon dioxide effect in diffusion flames.

Keywords: Oxy-fuel combustion, Diffusion flame, Carbon dioxide.