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Title

Characteristics and Transition Structure of Triple Flame in Various Concentration Gradients

Abstract

Recently, the new concept of "partially premixed flame" is proposed. It is classified the middle of the character between premixed flame and non-premixed flame. This character is important in many practical cases, such as the flame base of a jet non-premixed flame, the flame edge at local extinction of a turbulent non-premixed flame and so on. In these cases, there are fuel concentration gradients in front of the flame edge. These concentration gradients sometimes three flame branches, lean premixed flame, rich premixed flame and non-premixed flame. These branches exit like an anchor, called "Triple Flame". Stabilization mechanism of this flame is one of the important source of controlling combustor, so many researcher pay attention to this character. Some kind of features of this flame were become clear but no one knows roll of this flame at the combustor because there was no unificative interpretation.

This thesis paid attention to the transition of the 2D-stationary Triple Flame structure changing in concentration gradients experimentally. We used rectangular burner that had 4-6 same sections. Methane-air mixture concentration was changed to realized a linear concentration profile at the test section. This experimental setup could stabilize 2D-Triple Flame. A mixture fraction gradient $(Z_{rich}-Z_{lean})/(x_{rich}-x_{lean})$ was defined as concentration gradient. Z_{rich} was the mixture fraction at a flammability limit of rich premixed flame. Z_{lean} was the mixture fraction at a flammability limit of lean premixed flame. x_{rich} and x_{lean} are the position of the flammability limit respectively. In this research, concentration gradient were set up $2.0m^{-1}<(Z_{rich}-Z_{lean})/(x_{rich}-x_{lean})<131.7m^{-1}$.

At the gentle concentration gradient, OH radical luminescence showed that reaction of combustion was active better than at the steep condition. This tendency was related to an assumed maximum calorific value that was combustion intensity. At $(Z_{rich}-Z_{lean})/(x_{rich}-x_{lean})<3m^{-1}$, the tendency of OH radical luminescence did not follow the tendency of assumed maximum calorific value. The flame was unstable in this range. We defined this range domain Ⅰ.

At the steep concentration gradient, non-premixed flame was formed near by rich premixed flame. PIV measurement and laser tomography showed that reaction of premixed flame changed actively at $(Z_{rich}-Z_{lean})/(x_{rich}-x_{lean})>75m^{-1}$. The Triple Flame of this range had different structure from normal one that was followed calorific value. Comparison between theoretical specific value of 1D-laminar premixed flame and experimental specific value of Triple Flame showed that combustion Intensity became strong. This was the evidence of flame interaction. We defined this range domain III.

At $3m^{-1}<(Z_{rich}-Z_{lean})/(x_{rich}-x_{lean})<75m^{-1}$, burning velocity of the triple flame was faster than burning velocity of theoretical equation which was considered flame stretch, Lewis number effect, flame curvature and so on. This was because of thermal interaction between premixed flame wing and non-premixed flame. Considering the temperature profile from local equivalence ratio along the premixed flame, there was heat transfer from non-premixed flame to premixed flame wing. This transfer became strong by increasing the concentration gradient so that combustion intensity became strong. We defined this range domain II.

After all, this experimental research divided Triple Flame in to three region at various concentration gradients and made clear of such characters and transition process. It is important for making new concept of combustor. Especially, these results showed that Triple Flame in domain II or domain III was useful for practical combustor because of the stability.