A STUDY OF COMBUSTION INSTABILITIES IN THE DUMP COMBUSTOR WITH A BLUFF-BODY

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Combustion instability is very serious problem for the lean premixed combustion of gas turbine and liquid rocket engine development because it can even cause fatal damage or detonation (often, in liquid rocket engine) to the combustor and the entire system. Thus, improved understanding of the mechanisms of combustion instability is necessary for designing and operating gas turbine combustors. In this study, in order to understand the instability phenomena, an experimental study was conducted under the atmospheric pressure and ambient temperature. The combustor with a bluff body was used and pressure oscillation was measured by Piezoelectric pressure sensor under dump plane. On the other hands, numerical simulation was performed by FLUENT. The standard *k-ε* model was used for turbulence and the hybrid combustion model (eddy dissipation model and kinetically controlled model) was applied. After calculating steady solution, unsteady calculation was performed with forcing small perturbation on initial that solution. Then, self-excited pressure oscillation occurs and entire combustor system becomes unstable.
Pressure amplitude and frequency (~256Hz) measured by pressure sensor is nearly the same as those (~253Hz) predicted by numerical simulation. Reaction zone was positioned near downward plane of the bluff body and upward plane of that. Fig. 1 shows heat release contour and time lag effect of physical quantities. T_f is one period of pressure oscillation, and τ_{total} (= $\tau_1 + \tau_2 + \tau_3$) is 0.753, where τ_1 is 0.284T_f, τ_2 is 0.161 T_f, and τ_3 is 0.308T_f. This combustor shows consistency at the thermoacoustic criterion, because the time delay exists at the range of 0.75 $T_f < \tau_{total} <$1.25 T_f. The phase difference between the pressure and velocity is $\pi/2$, and that between the pressure and heat release rate is in excitation range described by Rayleigh, which is obvious that combustion instability for the bluff body combustor meets thermoacoustic instability criterion. Therefore, combustion instability results mainly from thermoacoustic instability in this experiment and numerical simulation.

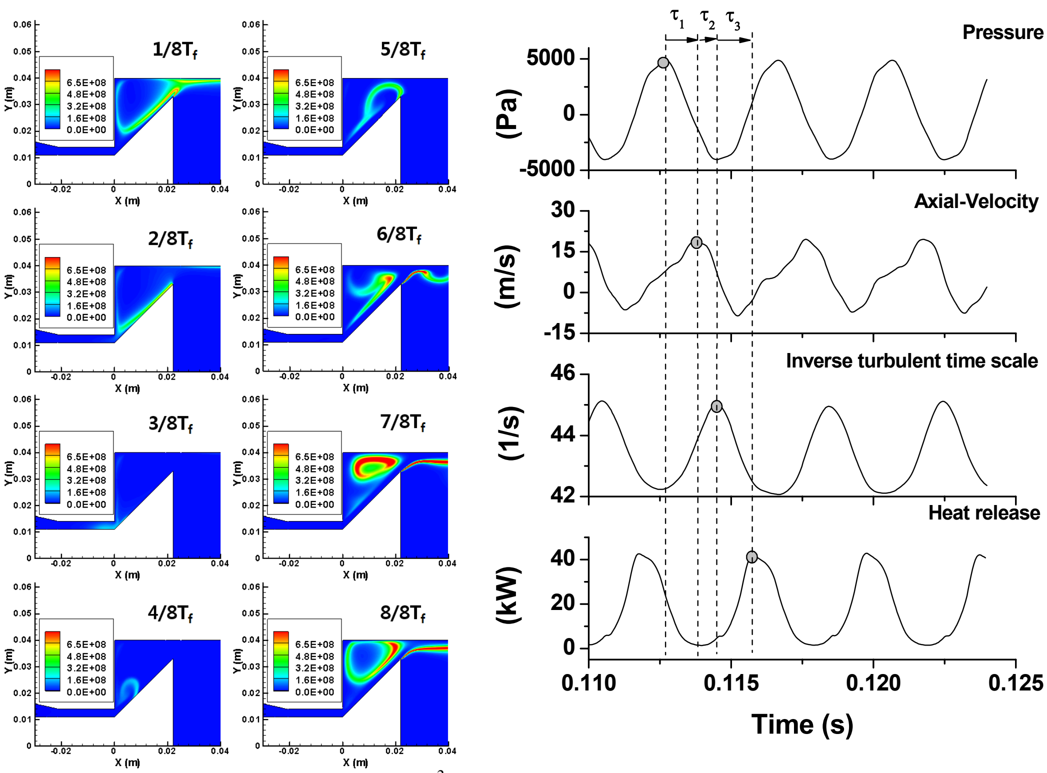

Fig 1. Time evolution of heat release (W/m^3) contour and time lag characteristic of combustion instability in the dump combustor with a bluff body.