論文 / 著書情報
Article / Book Information

題目(和文)	直接数値計算による乱流予混合燃焼の大域及び局所火炎構造に関する研究
Title(English)	Investigation on global and local flame structures of turbulent premixed combustion by direct numerical simulation
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	機械宇宙システム　　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（工学）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

To design high efficiency combustion devices for engineering applications, it is necessary to clarify the local and global flame structures of turbulent premixed combustion. Understanding these flame structures is of great importance for developments of turbulent combustion models that are used in industrial applications. However, due to difficulties in measurement of turbulent premixed flames in experiments, flame characteristics have not been well understood yet. Thanks to the developments in computational technology in recent years, direct numerical simulation (DNS) has become a useful tool for development and validation of turbulent combustion model and can provide an access to the details of turbulent combustion phenomena. In this study, DNS of hydrogen-air premixed flame under the pressure rising condition and methane-air premixed flames in thin reaction zones have been conducted considering temperature dependence of transport and thermal properties with a detailed kinetic mechanism to investigate turbulence-flame interaction and global flame characteristics. In chapter 1 'Introduction', importance of combustion technology is discussed briefly. Due to the usage of fossil fuels, environment problem such as global warming and economic issues due to the increasing prices of fossil fuels are reviewed. Background of turbulent combustion and simulation techniques are introduced. Finally, the objectives and outline of this thesis are presented. In chapter 2 'Direct numerical simulation of hydrogen-air premixed flames in a constant volume vessel', three-dimensional DNS of hydrogen-air turbulent premixed flames at relatively high Reynolds number in a constant volume vessel configuration is conducted considering the detailed kinetic mechanism to investigate the turbulence-flame interaction under pressure rising conditions. It is revealed that the Reynolds number based on Taylor micro scale increase with fluctuations as turbulent intensity decreases. The maximum wall heat flux is approximately proportional to the mean pressure after the flame impinges on the wall. It is clarified that the wall heat flux may be described as a function of mean pressure. It is also revealed that the pressure change in the vessel is quickly reflected in characteristics of the local flame structure. Local heat release rate, flame curvature and tangential strain rate could be scaled by the maximum laminar heat release rate of the corresponding pressure, the Kolmogorov length scale and the ratio of Taylor micro scale to turbulent intensity in the unburned side, respectively, even for the pressure rising condition. In chapter 3 'Direct numerical simulation of methane-air premixed flames in thin reaction zones', three-dimensional DNS of turbulent premixed planar flames propagating in homogeneous isotropic turbulence is conducted with GRI-Mech 3.0 mechanism which includes 53 reactive species and 325 elementary reactions to investigate local flame characteristics of lean and stoichiometric methane-air premixed flames classified into the thin reaction zones. It is revealed that at relatively high temperature region where heat release rate is around 0.50-0.60% that of laminar flame, very low concentrations of OH radicals are observed which could result in difficulties in OH planar laser-induced fluorescence (PLIF) measurement to identify flame front in experiments. Simultaneous CH-OH or CH_2O-OH PLIF measurements could be more accurate in the thin reaction zones. The statistical characteristics of local flame elements are clarified and compared with hydrogen-air flame in the thin reaction zones. The mean flame thickness increases 10% that of laminar flame in the stoichiometric methane flame. For the lean methane flame, mean flame thickness decreases 3%. For hydrogen flame, mean flame thickness decreases around 26%. In the thin reaction zones, it is revealed that the minimum curvature radius of the flame front is about twice of the Kolmogorov scale. The maximum tangential strain rate is about half the value that is observed in the flamelet regime. In methane flames, it is revealed that the mean value of reaction rates decrease about 20% that of laminar flame due to turbulence. These results show that turbulence significantly affect the reaction layers although the reaction rates possess similar profiles compared with those in the laminar flame. In chapter 4 'Fractal characteristics of turbulent premixed flames', fractal characteristics of hydrogen-air premixed flames in a constant volume vessel and methane-air premixed flames in the thin reaction zones are investigated. For the hydrogen-air turbulent premixed flame in a constant volume vessel, it is clarified that the fractal dimension of the flame surface does not show any dependence on pressure increase and the averaged fractal dimension is 2.24. For the methane-air turbulent premixed planar flames in the thin reaction zones, the fractal dimension increases as the flame develops and reaches about 2.5. It is revealed that the inner cutoff expression based on the ratio of the most expected diameter of coherent fine scale eddy, which is a universal fine scale structure of turbulence, to the laminar flame thickness can be used to predict inner cutoff of flame surface under pressure rising conditions and in the thin reaction zones. In chapter 5 'Conclusions', the conclusions from each chapter are summarized.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).