Evaluation of flow structure in gas turbine combustor models by PIV

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Keywords: PIV, Combustor, RQL, flow

Purpose

For the gas turbine combustor, regulation of emissions is becoming severe every year. In order to clear regulation, the new combustor is suggested [1-2]. One of the solutions for realizing the new combustor is to apply the Rich burn Quick quench Lean burn (RQL) system. The RQL system has some dilution holes to make it form good combustion condition. The RQL system can realize low emissions by mixing rapidly fuel and air. In the previous experiment, the results by using RQL model show that the performance of the RQL system is affected by the alignment of the primary dilution holes and the shape of the combustion zone in the model [3]. The shape of the combustion zone is changed by a flat plate named flow guide. The system performance is related with the flow characteristics in the model, however the experimental results of the flow has not been clarified. The authors perform the flow measurement by using PIV (particle image velocimetry) about the alignment of the primary dilution holes [4]. In this study, the flow structure and the turbulent intensity of the model with flow guide are observed by using PIV. Both models without flow guide and with it are tested for evaluating the flow structures and the turbulent intensity.

Methods

The experimental study has been carried out by using PIV (particle image velocimetry). The PIV is used to measure the mean velocity and turbulent intensity in the flow. The PIV (TSI: INSIGHT Version3.0) consists of Nd:YAG Laser (New Wave Research: Minilase III 50mJ) as a source of light, and CCD camera (TSI : PIVCAM 10-30 TSI Model 630046 1008pix.x1018pix.). The laser sheet is generated using a cylindrical lens with approximately 1mm in thickness. Oil particle with a mean diameter of 2.0 µm is used for the tracer particle. A final interrogation area size is 32x32 pixels and 50% overlapping. The pulse interval is set from 5µs to 10µs. The flow rate is set to 0.075m³/s. The flow rate is calculated from the orifice and manometer installed in the duct of the combustor model upstream. The fuel is not injected from the fuel nozzle. The measurement sections are three planes along direction of the flow and a vertical plane to the direction of the flow. The x axis is set to a direction of the main flow. The y axis is set to horizontal direction. The z axis is set to vertical direction. The origin is set on bottom of the primary dilution hole.

Results and Conclusion

The differences in the flow characteristics in the combustor models are discussed with the experimental results. The combustor models without and with flow guide are tested. For both of the models, the flow is measured by using PIV. The flow structures in both of the model are compared with each other. The conclusions are followings:
1) The flow guide can affect the formation of the swirl flow near the nozzle exit. The swirl motion is formed in the model without the flow guide. The radial flow is formed in the model with the flow guide.
2) The flow along the flow guide is observed in the result with the flow guide.
3) The flow in the primary combustion zone is different with the flow guide condition.
4) The turbulence intensity of model with flow guide becomes larger than that of the model without flow guide.

References