SUMMARY OF Ph.D. DISSERTATION

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Title Study of an Industrial Dry Low NOx Gas Turbine Combustor with an Automatic Gaseous Fuel-Distributing Supply Mechanism

Abstract

The objective of this research is to apply the automatic fuel-distributing supply mechanism to gas turbine combustors with lean premixed combustion, and investigate the fuel distribution characteristics and the combustion performance, and establish the new gaseous fuel supply technology for gas turbine combustors with lean premixed combustion.

In order to realize combustion stability at low loads and low NOx at high loads for gas turbine combustors with lean premixed combustion, it is adopted to control of the number of firing burners and the fuel flow rate for each burner, and to stable flame by a pilot burner. But, If the control of the fuel flow rate is not proper at the loads where the burner operation changes, the combustion becomes instable. In order to solve the problem, an automatic fuel-distributing supply mechanism was contrived. Gaseous fuel is automatically distributed to the main and the pilot combustion regions according to the loads by an interaction between the gaseous fuel jet and the combustion air flow. It is probable to avoid the instability of combustion without any supplementary control at the loads where the burner operation changes, because the fuel flow rate of each combustion region changes correlatively. At low loads, more fuel is supplied to the pilot region than to the main region and consequently the combustion becomes stable. At high loads, more fuel is supplied to the main region than to the pilot region, so that the rate of lean premixed combustion increases and low NOx combustion is realized. In this reach, the feasibility of a dry low NOx gas turbine combustor with the automatic fuel distributing supply mechanism was evaluated.

The 1st chapter is an introduction. The present condition and the problem of the lean premixed combustion technology of the gas turbine combustors were explained. And it was mentioned about the principle and the characteristics of the automatic fuel-distributing supply mechanism contrived newly in this research.

In the 2nd chapter, the CFD simulations and combustion tests was explained. The fuel distribution characteristics and the combustion performance of a prototype combustor with the automatic fuel distributing supply mechanism were investigated. The fuel distribution based on the mechanism actually occurred according to the load. However, NOx was not low enough at high loads, and combustion efficiency was not high below medium loads. Further, the pressure loss of the combustor was high.

In the 3rd chapter, the effects of specifications of the fuel-distributing module (the gap size, the injected fuel velocity and so on) on the fuel distribution characteristics were investigated, and the recommended specifications of an actual fuel-distributing module were educed. Further, the improved fuel-distributing module in order to decrease NOx at high loads was contrived, and the fuel distribution characteristics of the improved module were investigated. It was confirmed that the improved module had the effect of the uniformity of the equivalence ratio in the circumferential direction for an actual combustor, but conversely the effect of the increase of maximum equivalence ratio in the radial direction, which may lead to high NOx. And, it was confirmed that the fuel distribution characteristics using different gaseous fuel was correlated closely with the kinetic energy of injected fuel at the fuel injection nozzle, and the fuel distribution characteristics using different gaseous fuel became almost the same as that for original fuel by the simple modifications of the module.

In the 4th chapter, the prototype combustor described above was improved from the viewpoint of combustion performance. NOx at high loads was decreased by the improved fuel-distributing module contrived in the third chapter. The pressure loss of the combustor was decreased by enlarging the opening area of the combustor. Combustion efficiency at medium loads was increased by the three fuel staging and the inward flow at the exit of the fuel supply unit. Further, the combustion performance of the improved combustor in the pressurized condition close to an actual gas turbine became a utility level. Finally, the combustion performance in the actual shaped sectored rig was investigated, and the knowledge and the notice regarding the application to an actual gas turbine were mentioned.

The 5th chapter is a conclusion. The application of the automatic fuel-distributing supply mechanism to gas turbine combustors with lean premixed combustion avoids the instability of combustion at the loads where the burner operation changes. The combustion performance of the combustor with the mechanism became a utility level. Therefore, it is considered that this new gaseous fuel supply technology is available for actual gas turbine combustors with lean premixed combustion.