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The tuning methodology of a GE 7FA + e DLN-2.6 gas turbine combustor

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ABSTRACT

On the basis of a MARK-VI system, the tuning methodology for operation of a DLN-2.6 combustor was studied for the maintenance of a GE 7FA + e gas turbine at a Seo-Incheon combined cycle power plant. The DLN-2.6 combustor has a high level of yellow plume (NO_2 flue gas) and combustion vibration during the start-up mode (P_{out} = 20 ~ 30 and 40 ~ 45 MW) in comparison with the base mode (P_{out} = 100 ~ 160 MW). The objectives of the current study are to investigate one of the main factors for this high level of yellow plume and combustion vibration during the start-up mode and to suggest the operation strategy for the reliable working of a GE 7FA + e gas turbine. After analyzing the tuning data in a MARK-VI program, we conclude that the yellow plume is caused by the relatively rich mixture (ϕ ~ >0.5) in a PM1 nozzle at Mode 3 (P_{out} = 20 ~ 30 MW). In addition, the characteristic frequency of the combustion vibration was predominantly in the rage f_{char} = 120 ~ 140 Hz, which was related to the presence of a cold flow behavior in a PM3 nozzle at Mode 6B (P_{out} = 40 ~ 45 MW).

1. Introduction

Gas turbine engines composed of a compressor, combustor, and turbine have been developed and used for power generation and propulsion applications [1,2]. For stable operation and durability, non-premixed flame has been adapted as a combustion method for gas turbine combustors. This type of a flame, which was not premixed, was changed to a lean-premixed flame after passing though oil shock and the increased stringency of environmental restrictions over time. The lean-premixed flame has the advantages of more economic combustion, while emitting lower levels of air pollution [3]. However, the trade-off between fuel economy and low levels of thermal NOx has the problem of combustion vibration and combustion instability is still one of key issues affecting engine performance and maintenance. Combustion vibration is known to be caused by coupling between fuel or air-flow fluctuation and heat-release rate in a gas turbine combustor, which is related to strategies to reduce NOx emission [4].

The GE 7FA + e is a high-performance gas turbine for a power generation that has been developed by General Electric and has the generating capacity (P_{out}) of 180 MW. This gas turbine engine is composed of an Inlet Guide Vane (IGV) to control air-flow rate, a 15-stage compressor, a 14 can-type combustor, and a 3-stage turbine. For a combined-cycle thermal power generation, the GE 7FA + e gas turbine engine operates in connection with a starting motor, heat exchanger (HRSG; heat-recovery steam generator), and steam turbine.

A Seo-Incheon power plant is located in the west side of Incheon city, South Korea. This electric power plant is a subsidiary company of KEPCO (Korea Electric Power Company) and operates 8 GE 7FA + e gas turbines for a combine-cycle power generation. To reduce maintenance costs, the company is attempting to reduce NOx emission levels (involving a yellow plume; NO_2 flue gas) during the start-up mode and combustion vibration during the loading mode for the GE 7FA + e DLN-2.6 gas turbine combustor.

Due to the importance of the reduction of maintenance cost and pollutant emission, many researchers have investigated the tuning methodology or strategy of a gas turbine [5–11]. Najjar suggested the efficient methods for energy usage by utilizing combined-cycle gas turbine systems [5]. He carried out fundamental studies of combined systems including the closed gas turbine cycle, the organic Rankine cycle, repowering, integrated power and refrigeration, cryogenic power, and inlet air cooling. Kelsall and Troger studied the control technology of combustion instability in industrial gas turbines [6]. They reported the reduction of thermo–acoustic instability by using a damping device at a certain frequencies as passive control methods. Afran et al. developed the monitoring tool in a gas turbine combustor which is based on a heat flux sensor [7]. According their conceptual explanation, they used

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