Exploring Solutions to Gas Turbine Combustion Pulsation Excursions with Big Data Techniques

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Currently, a set of gas turbine engines used in customer power plants is encountering power runbacks due to combustion pulsation excursions that are crossing an operating limit in fluctuating pressure amplitude. The occurrence rate is small and duration is brief, but any occurrence is disruptive to the power plant. The challenge is to look at the sources of environmental and operational variation to determine if there is a correlation between these pulsation excursions and controllable parameters that could reduce or eliminate the tendency of the turbine engines to exceed the operating limit. In simple terms, the goal is to identify the key variables that correlate with the occurrence of these pulsation excursions.

One month of data at 1 sec. resolution has been gathered for three different gas turbines. Each gas turbine has 18 individual combustion chambers. The dataset contains a wide range of control and environmental parameters that may correlate with the pulsation excursions of interest in frequency range 4.

Key Questions to Answer:

- What type of probability distribution best fits the data represented by the pulsation amplitudes in frequency range 4?
- What is the probability of having an excursion of magnitude:
    - Greater than 1.6 for more than 1 sec.? 5 sec.? 10 seconds? 1 min.?
    - Greater than 1.8 for more than 1 sec.? 5 sec.? 10 sec.? 1 min.?
    - Greater than 2.0 for more than 1 sec.? 5 sec.? 10 sec.? 1 min.?
    - Does the dataset show leveling of excursions?

- Do ambient temperature and pressure changes correlate with the excursions above 1.6?
- What combinations of parameters correlate with the pulsation excursions?
- When combining ambient temperature, airflow, IGV angle, fuel-temperature, what combination of parameters correlate with pressure excursions? Is this consistent between the three turbines?

Control Parameters include:

- Combustion Reference Temperature
- Combustion Mode (DLN Mode)
- Fuel distribution between combustion fuel injection circuits
- Power level of the gas turbine (this is largely controlled by power grid requirements)
- Compressor Pressure Ratio
- Compressor Discharge Pressure
- Compressor Pressure Ratio
- Inlet Air Heating Control Valve Position

- Inlet Guide Vane Angle (Surrogate for Airflow)
- Compressor Discharge Temperature
- Compressor Inlet Temperature
- Compressor Discharge Pressure

Environmental Parameters include:

- Compressor Inlet Temperature (represents ambient temperature)
- Ambient Humidity
- Barometric Pressure

Output Parameters:

- Pulsation Amplitude in each combustor frequency range 1
- Pulsation Amplitude in each combustor frequency range 2
- Pulsation Amplitude in each combustor frequency range 3
- Pulsation Amplitude in each combustor frequency range 4