Predicting and Preventing Incipient Flameout in Combustors

Increases in acoustic signals could trigger rapid adjustments to prevent flameouts.

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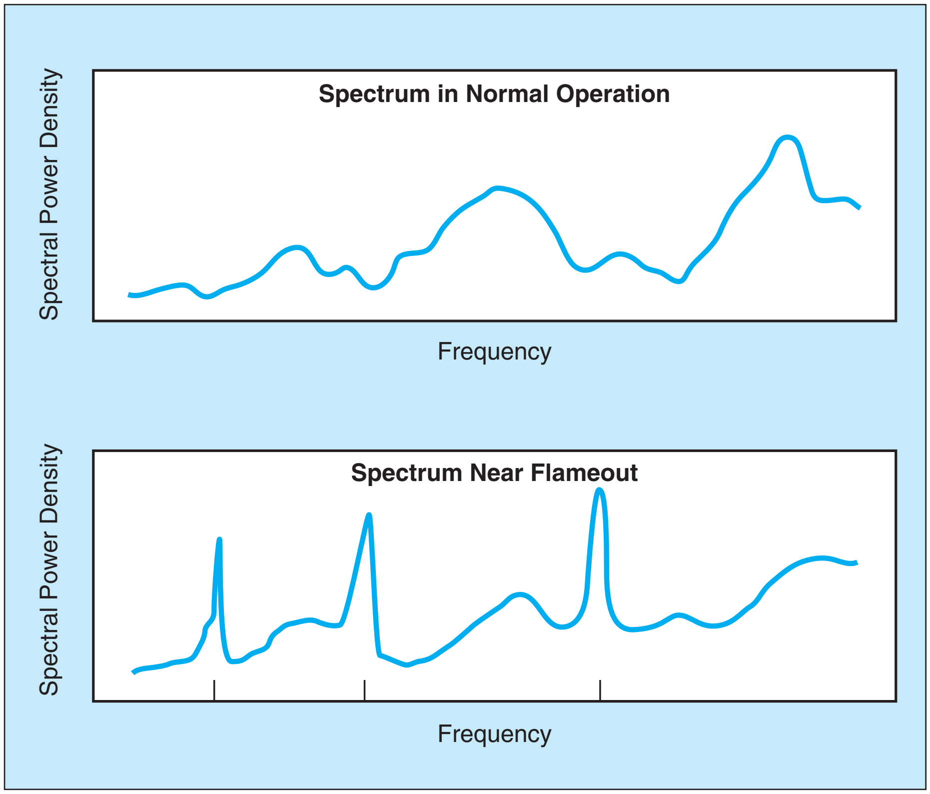
A method of predicting and preventing incipient flameout in a combustor has been proposed. The method should be applicable to a variety of liquid- and gas-fueled combustors in furnaces and turbine engines. Until now, there have been methods of detecting flameouts after they have occurred, but there has been no way of predicting incipient flameouts and, hence, no way of acting in time to prevent them. Prevention of flameout could not only prevent damage to equipment but, in the case of aircraft turbine engines, could also save lives.

For any combustor, excessive departure from optimum operating conditions can lead to instability that quickly ends in flameout. Of particular interest is that for a given temperature and pressure of incoming air, flameout can occur if the fuel/air ratio is too high or too low. In many cases, combustors are operated nearer their lean-mixture (low fuel/air ratio) stability boundaries.

Studies have shown that as a combustor approaches instability, pressure fluctuations increase sharply. One measure of such fluctuations that has been found to be especially useful is the ratio between the magnitude of pressure fluctuations (essentially, the acoustic pressure) and the time-averaged pressure. Alternatively, one could detect instability-related pressure fluctuations by detecting the sudden appearance of one or more acoustic spectral peak(s) at frequencies known to be associated with instabilities in the particular combustor (see figure).



Strong Peaks associated with instability appear in the acoustic spectrum of a combustor as it approaches flameout. The frequencies and amplitudes of the peaks depend on the combustor geometry and on temperature.

The proposed method is based largely on the foregoing observations. It calls for continuous monitoring and analysis of the acoustic pressure and several other key physical parameters that are indicative of the state of the combustion process. The instrumentation needed to implement the method in a typical installation would include the following:

- Meters to measure the flows of fuel and air into the combustor;
- Gauges to measure the pressures of the entering fuel and air;
- Thermocouples to measure the temperatures of the entering fuel and air;
- One or more thermocouple(s) to measure the temperature(s) at a key location or locations in the combustor;
- A microphone or other acoustic-pressure transducer;
- Analog-to-digital converters for sampling the outputs of the aforementioned sensors;
- A computer running special software for analyzing the digitized sensor outputs and responding as needed;
- Digital-to-analog converters to generate actuator-control signals for automated rapid responses; and
- Output connections to displays that would be read by human operators.

Through continuous monitoring of the temperatures, pressures, and flow rates, the instrumentation system would provide information that would enable a pilot, power-plant operator, or other responsible person to set the flow rates of fuel and air for safe operation. Upon detecting a sudden large increase in acoustic pressure, the system would act, much faster than the human operator could, to make a temporary adjustment in the fuel/air ratio to prevent flameout. For example, if the combustor was operating near the lean stability boundary, the system could respond by actuating a solenoid valve or fuel injector to increase the flow of fuel. At the same time, the system would generate a display advising the human operator of this action and suggesting an adjustment to restore steady safe operation.

This work was done by Richard Lee Puster of **Langley Research Center**. *Further information is contained in a TSP (see page 1).*
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