Lean Blowout (LBO) Prediction Through Symbolic Time Series Analysis

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Abstract
Lean combustion is preferred in combustors for cleaner emission. But, the major problem in running the combustor in lean condition is the flame blow-out, due to lower burning velocity in lean condition. To sustain lean combustion, early prediction of lean blowout (LBO) is needed. This need calls for developing new strategies to predict LBO. This work is on development of strategies based on symbolic analysis of time series data obtained from the combustor. Optical signal (CH* chemiluminescence) based time series data has been captured from a laboratory scale dump combustor. Gaseous fuel has been used at different premixing regimes to run the combustor. The time series data obtained are partitioned to different cells to get symbol strings and subsequently generate a probabilistic finite state automata (PFSA). The constructed PFSA is called D-Markov machines. These machines have a deterministic algebraic structure and the states are represented by symbol blocks of length D or less, where D is a positive integer. The estimated state probability vector is found out on the basis of number of occurrence of each symbol over a time duration. A reference state vector is calculated at a condition that is sufficiently away from the state of LBO. For a given state, the deviation of the state vector from the reference vector can be computed and used as an anomaly measure for early detection of LBO. The problem of LBO prediction is posed in a pattern classification setting and the underlying algorithms have been tested on experimental data at different extents of fuel-air premixing and fuel/air ratio. It is found that, over a wide range of fuel-air premixing, performance of D-Markov machines, as LBO predictors, is better with $D > 1$ than those with $D = 1$.