Synchronization and Its Analysis in Thermoacoustic Instability Induced in Combustion

Jiazhong Zhang*[1]

[1]Xi'an Jiaotong University – School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an, China

Abstract

Combustion instabilities are complicated phenomena, involving much more singular or nonlinear behaviors, in gas turbines and ramjet engines. In particular, they become obstacle in the development of aircraft with higher performance. Among combustion instabilities, thermoacoustic instability is encountered frequently and characterized by rapid fluctuations of heat release, pressure, and large-amplitude oscillations of one or more natural acoustic modes of the combustor. It has been found that acoustic oscillations are excited by thermal sources, so the resulting phenomena are often referred to as thermoacoustic instabilities.
Following Navier-Stokes equations and nonlinear dynamics, a mathematical model involving vortex shedding is presented to study thermoacoustic instability. Then, the nonlinear dynamics, such as frequency hopping, synchronization, phase-locked, and Devil's staircases, are captured numerically with Galerkin procedure, and the influences of system parameters on the nonlinear dynamics listed above are further analyzed. More, some typical routes to thermoacoustic instability and chimera state in an interval are presented. Finally, the natures or mechanism of nonlinear behaviors are explained, in comparison with existing experiments, and hence some control methods are proposed and verified numerically.
As a conclusion, the results presented could give explanation of thermoacoustic instability occurred in combustion, and could be used to develop some available control methods.

Keywords: Thermoacoutics, Combustion, Instability, Synchronization, Phase, locked, Chaotic behavior, Bifurcation.

*Speaker