Proper Orthogonal Decomposition (POD) Analysis of CFD Data for Two-Dimensional Cellular Detonations

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Work-in-Progress Abstract

Modal decomposition techniques are becoming standard post-processing methods in fluid dynamics to interpret either experimental or numerical data in term of the flow structures and characterize them spatially and temporally. These techniques reduce large amount of flow data into a set of spatial modes for building reduced model aimed to better understand complex flow evolution. In this study, Proper Orthogonal Decomposition (POD) is applied to high-resolution, two-dimensional, numerical simulation results obtained using the reactive Euler equations with one-step Arrhenius kinetics for examining compressible flow instabilities and understanding the underlying mechanisms on the dynamic of cellular detonation structure. CFD data computed using different values of activation energy E_a are analyzed. The results of such modal decomposition analysis help to identify events that contribute the most to the energy of the flow and any dominant or coherent features, ultimately to determine the hydrodynamic thickness of unstable cellular detonation based on the energy mode distribution. In such analysis, Mode 1 corresponds to the mean velocity field in the detonation structure in close agreement with the ensemble average. The higher modal structures describe the vorticity component and different degrees of hydrodynamic instabilities embedded in the two-dimensional cellular detonation wave.

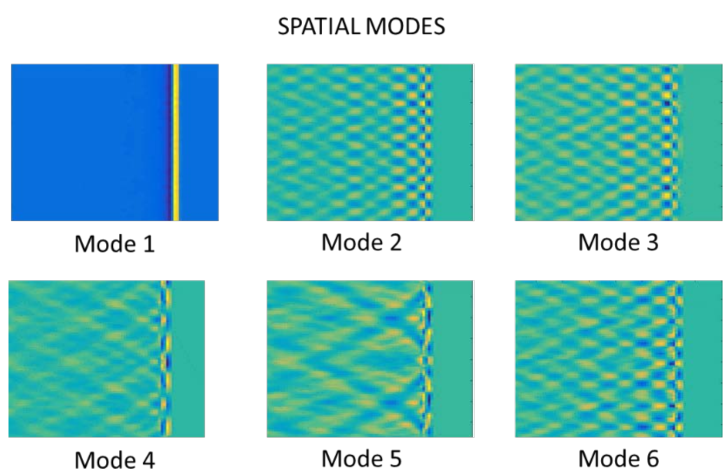

Figure. POD analysis of two-dimensional cellular detonation with E_a = 10