SUMMARY OF Ph.D. DISSERTATION

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Title

Numerical Study on the Dynamics of Cellular Structures in Gaseous Detonations

Abstract

This thesis examines two dynamics of cellular structures in detonation phenomena, transverse wave properties and the mechanism of soot track formation. The first part is concerned with one- and two-dimensional gaseous hydrogen detonations. Hydrogen is touted as a clean fuel waiting to replace fossil energy sources in recent years. The second part of the thesis is concerned with the soot track formation that has been unsolved for more than 40 years. Chapter 1 gives the background and the motivation of the thesis. Chapter 2 reveals the characteristics of longitudinal oscillations due to the interaction between the shock front and the reaction front. In Chap. 2, one- and two-dimensional detonation simulations are performed with a simplified reaction mechanism to compare their oscillations. Chapter 3 treats two-dimensional detonations with a detailed reaction mechanism to clarify the characteristics of transverse oscillations that play a prominent role in detonation propagation. According to Chaps. 2 and 3, transverse wave intensity is newly proposed for a guide to understand the mixture properties. It gives us the insight into control of detonation in safety engineering, and application in aerospace engineering. Chapter 4 proposes the mechanism of the soot track formation that has been widely applied to observe detonations. Mach reflection experiments record soot tracks. Features of the soot tracks in experiments would be explained in terms of shear stress variations in direction and magnitude created by a boundary layer adjacent to a soot foil. Numerical soot foils are redistributed by shear stress histories of three-dimensional air flow. The agreement of experimental and numerical soot foil lead us to suggest that the mechanism is also applied to detonation soot tracks. Chapter 5 gives conclusions of the thesis.