Effects of fluidic jet angle on detonation propagation in Rotating Detonation Engines

Zhenye Luan Yue Huang Zibo Zhao Han Peng
Xiamen University
Xiamen, Fujian, China

Abstract

In recent years, the potential benefits of applying rotating detonation engine (RDE) to modern propulsion systems to revolutionize current engines have generated significant interest, because RDEs have high thermodynamic efficiency, short burning time and relative mechanical simplicity. Most of the researches now focus on the propagation of detonation waves under premixed atmosphere, but in a practical RDE, local variations in reactant homogeneity and species concentration have significant impacts on the propagation of detonation waves. The detonation wave propagates in a non-premixed atmosphere, which have few researches yet. A numerical simulation in the paper is performed to study the effects of fluidic jet angle on detonation propagation in the RDEs.

The Reynold Average Navier-Stokes (RANS) equations are used as the governing equations in the paper. Turbulence model is Two-Equation k-ε model. Roe Riemann solver is used to construct inter-cell numerical upwind fluxes. The continuous TVD limiter is used for construct a second-order method in space. A $H_2/O_2/N_2$ reaction mechanism including 7 species and 7 elementary reactions is used.

The computational domain includes pre-detonation tube and combustor as shown in Figure 1. The left part is a pre-detonation tube filled with stoichiometric hydrogen and air with a length of 100mm and a width of 7.6mm. The right part is a combustor filled with air with a length of 140mm and a width of 62.5mm. The dotted lines and solid lines indicate outlet and adiabatic no-slip wall respectively. The red zone indicates an ignition zone that has high temperature and high pressure, the remaining zone in the whole computational domain is 0.1MPa and 293K.

Correspondence to: huangyue@xmu.edu.cn

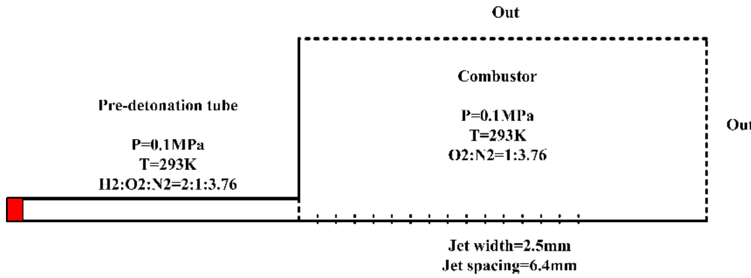

Figure 1. Schematic diagram of the computational domain

Figure 2 shows the comparison of speed between different injection angles. The dottled line indicates theoretical C-J speed, which is 1970m/s. The fluctuation of flame speed is due to the non-homogeneity of reactants caused by jets and the average flame propagation speed shows a downward trend as the injection angle increases. The jets larger than 90 degrees will hinder the propagation of the flame and cause a drop in flame speed. The jets less than 90 degrees will increase the energy of unburened gas and accelerate the local flame propagation speed.

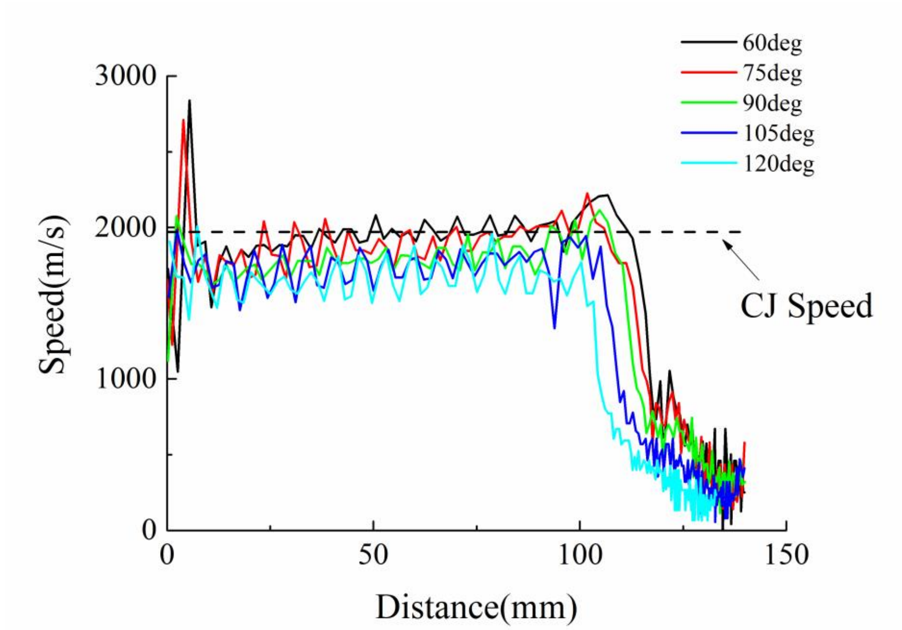

Figure 2. Comparison of flame speed within different injection angles

Figure 3 shows the sequence diagrams when the flame enters into the chamber to study how the flame propagates with multiple 60-degrees jets. The discontinuous flame front is caused by the jets. The decoupling of the combustion and the pressure wave on the combustion chamber can be observed, which is due to the insufficient fuel near the reaction front. Detailed analysis of more phenomena and other angles of work will be reflected in the work that follows.

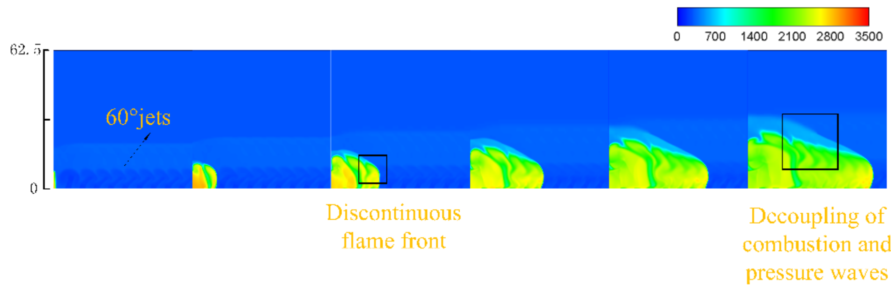

Figure 3. A sequence diagram of temperature with 60-degrees jets