Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Numerical study on ethylene-air continuous rotating detonation in annular combustors with different widths

Wei-jie FAN

Cite this as: Wei-jie FAN, Wei-dong LIU, Hao-yang PENG, Shi-jie LIU, Jian SUN, 2022. Numerical study on ethylene-air continuous rotating detonation in annular combustors with different widths. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 23(5):388-404. https://doi.org/10.1631/jzus.A2100448

Physical model and numerical method

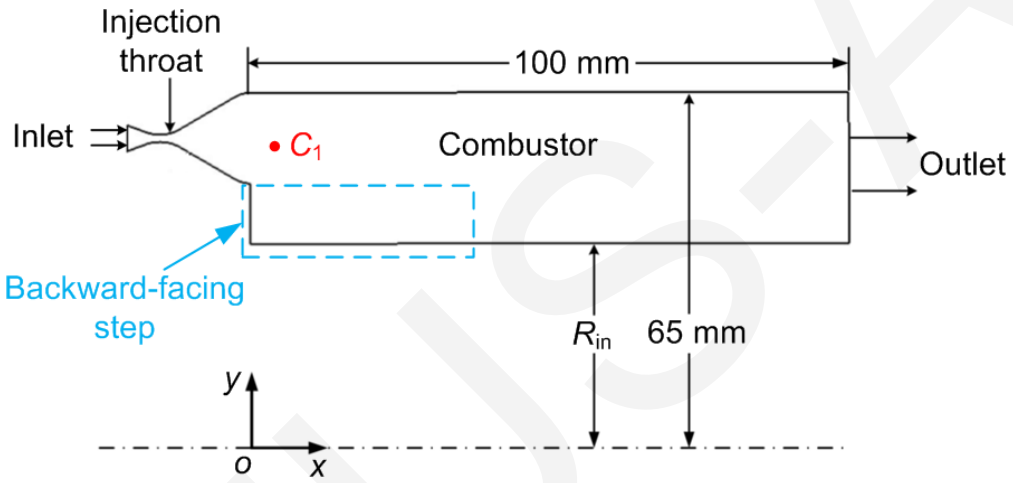

Fig. 1 Cross-sectional schematic of the CRDE combustor

- A stoichiometric ethylene-air mixture is injected axially into the combustor through an annular slot. The throat width of the slot and the length of the combustor are 1.2 and 100 mm, respectively.
- Three-dimensional Reynolds-averaged Navier-Stokes (RANS) controlling equations are solved by the transient implicit density-based solver.

Results and discussion

Effects of combustor width on the CRD wave propagation process

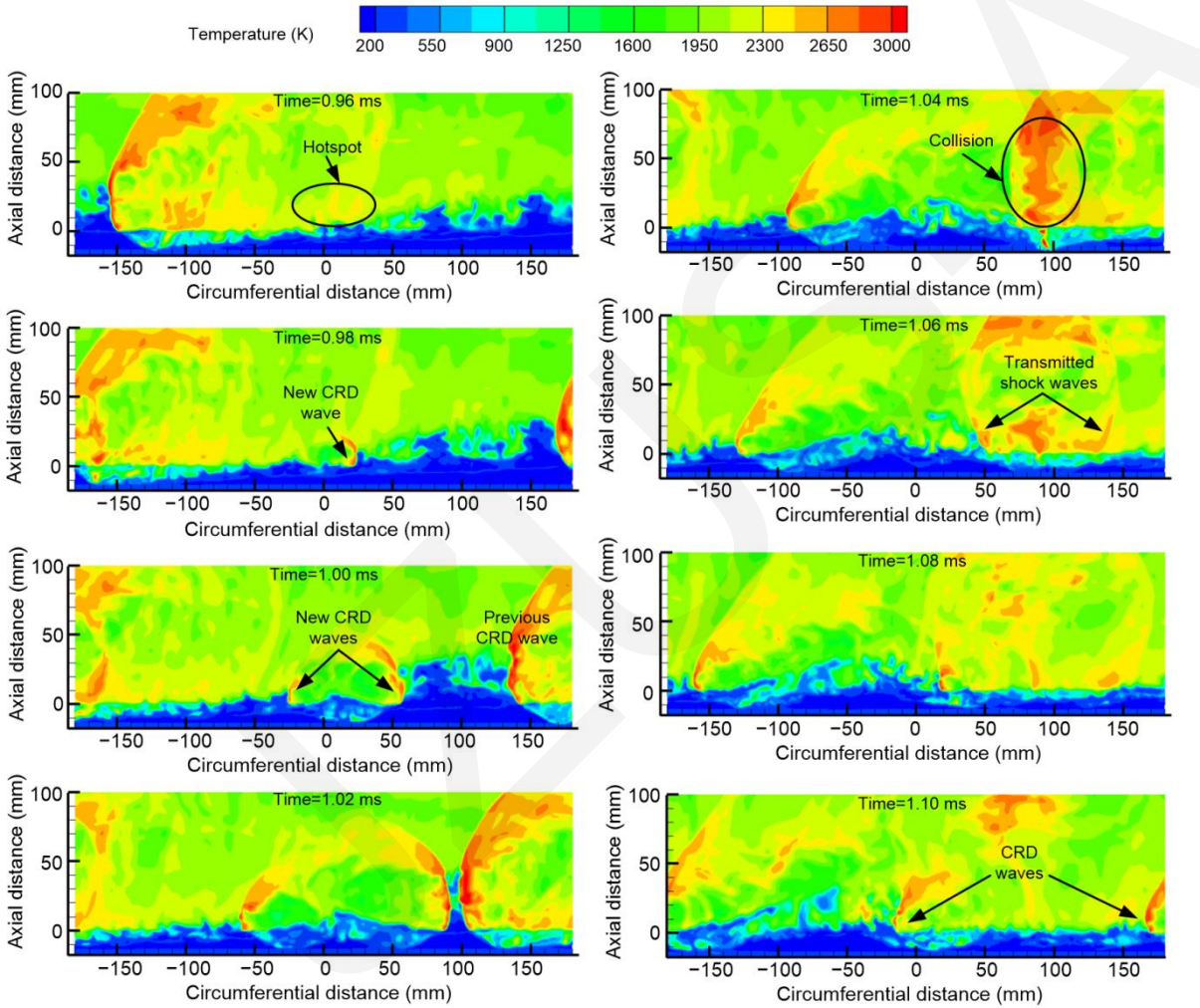

Fig.2 Unsteady multiple-wave propagation mode (*W*=15 mm)

Results and discussion

Effects of combustor width on the CRD wave propagation process

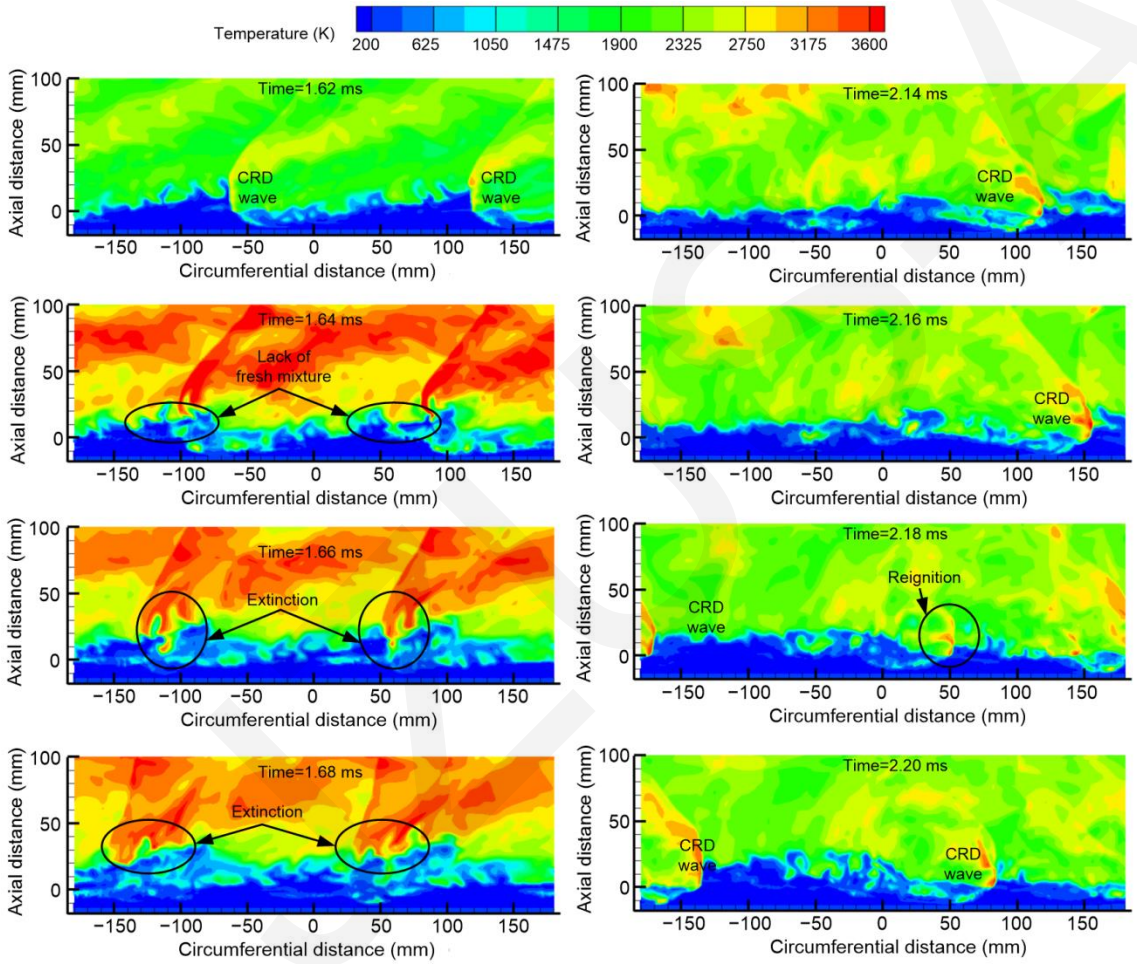

Fig.3 Extinction (a) and reignition (b) of the CRD waves (*W*=25 mm)

Results and discussion

Effects of the combustor width on the flow field characteristics

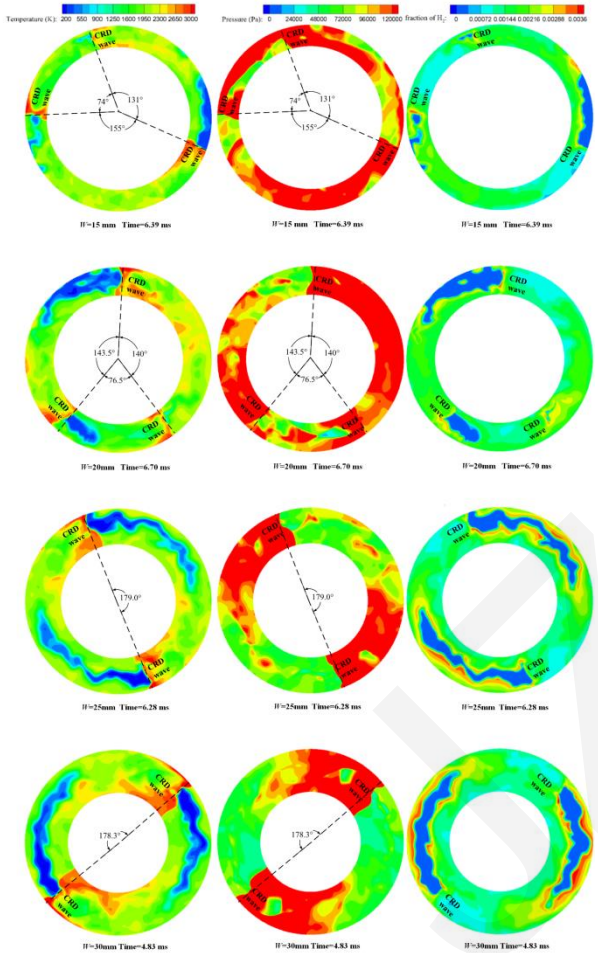

Fig.4 Contours on the x=10 mm surfaces

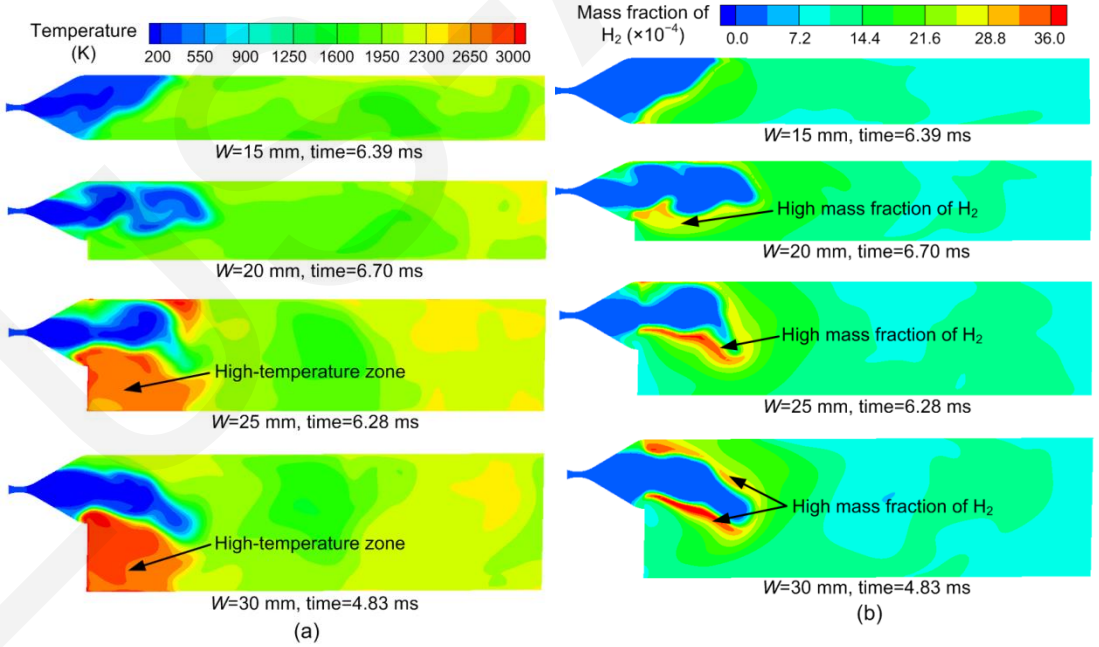

Fig.5 Contours on the radial-azimuthal surfaces in front of the CRD waves

Results and discussion

Effects of combustor width on the propulsive performance

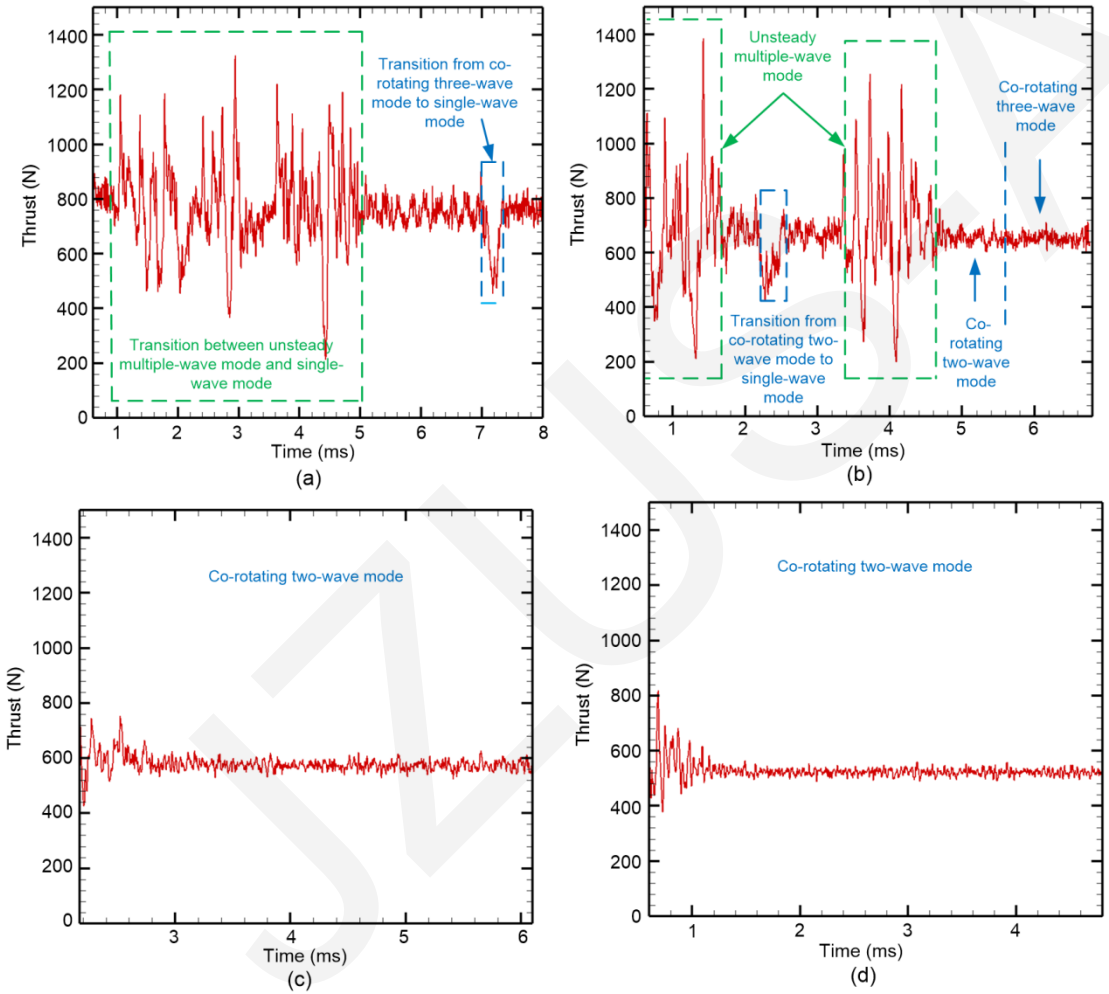

Fig.6 Thrust record curves of different combustors: (a) *W*=15 mm; (b) *W*=20 mm; (c) *W*=25 mm; (d) *W*=30 mm

Conclusions

- The critical combustor width to obtain steady prop-agation of the ethylene-air CRD wave is 25 mm. When the combustor width is smaller than 25 mm, an unsteady multiple-wave mode is observed and the CRD waves do not reach a long-term steady mode. As the combustor width is increased to 25 and 30 mm, the CRD waves can remain steadily and sustainably in a co-rotating two-wave mode.
- The average propagation velocity of the CRD wave increases as the combustor width is increased. The highest propagation velocity is obtained in the 30-mm wide combustor, reaching 1880.27 m/s, while the lowest propagation velocity is acquired in the 15-mm wide combustor at 1681.01 m/s.
- A high-temperature zone filled with primary detonation products is observed at the forepart. The high-temperature zone works as a pilot flame and preheats the propellants. This can greatly improve the detonation ability of the propellants and produce chemically active preliminary products.
- As the combustor width increases, the average thrust of the CRDE decreases while the stability of the thrust increases. With the increase in combustor width, the volume of the combustor increases and the combustion products flow more divergently. This results in a considerable pressure drop in the combustor and great kinetic energy loss in the circumferential and radial directions.