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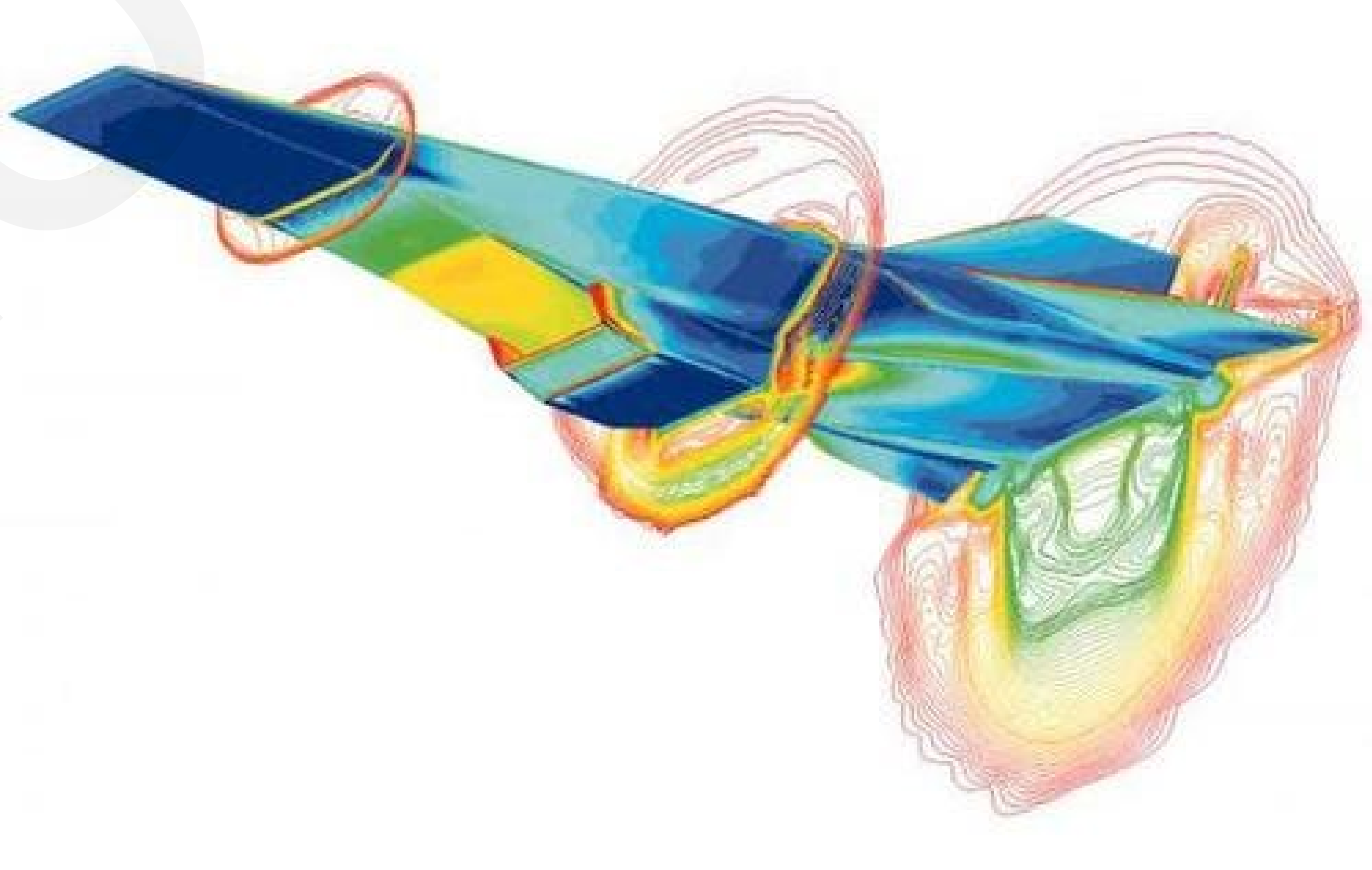
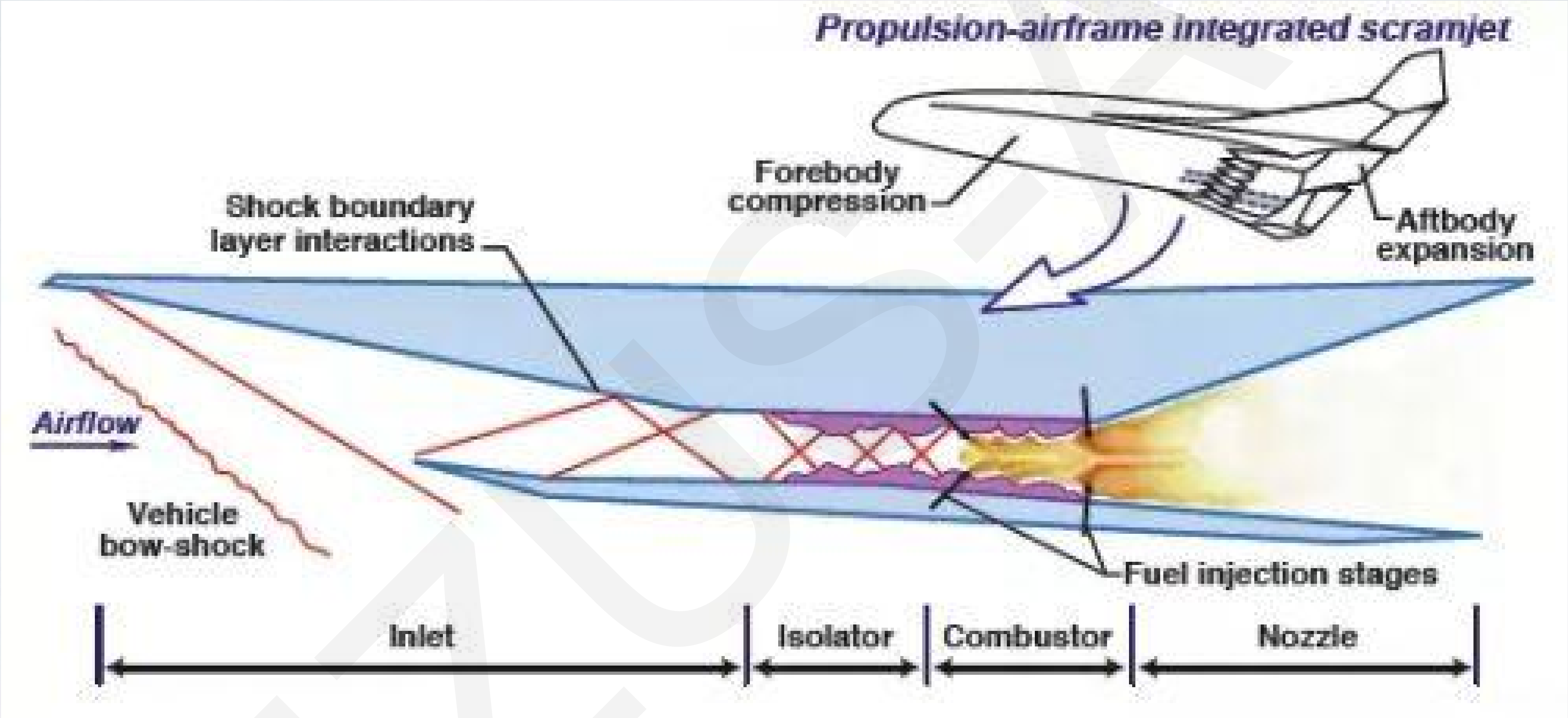
Numerical study on cavity ignition process in a supersonic combustor

Key words:
ignition process, cavity,
supersonic combustor,
numerical study

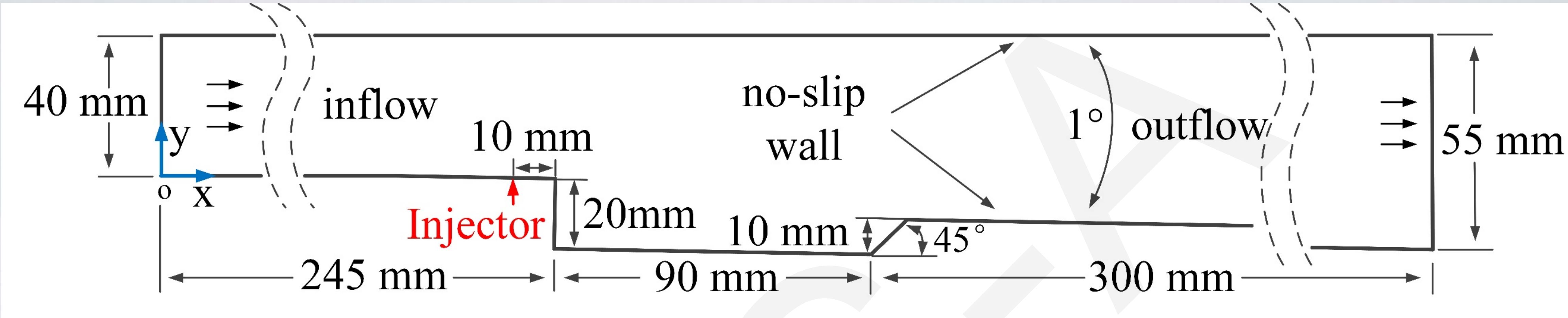


Introduction

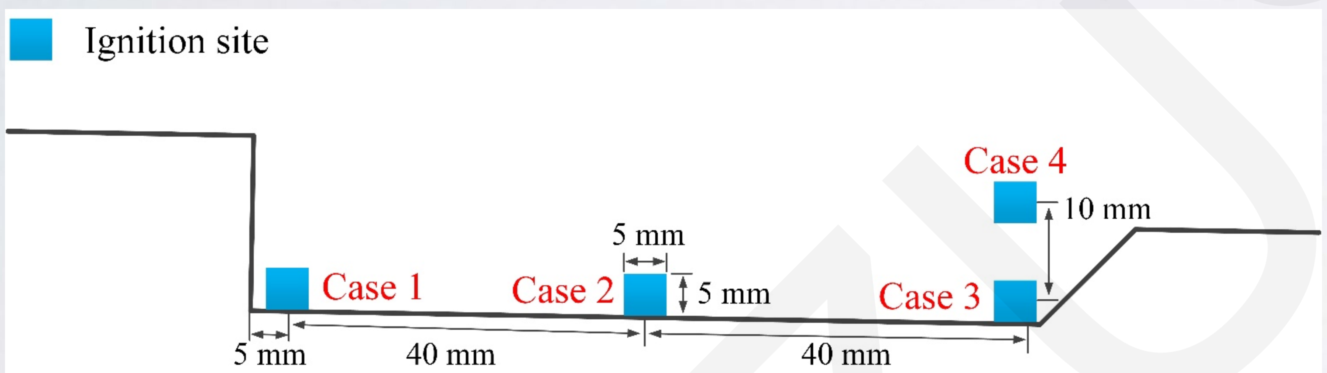


Due to the harsh supersonic flow and limited chemical reaction environment, successful ignition processes are still difficult to achieve even with a cavity flame-holder.

Model and Numerical Method



Geometry



Ignition sites

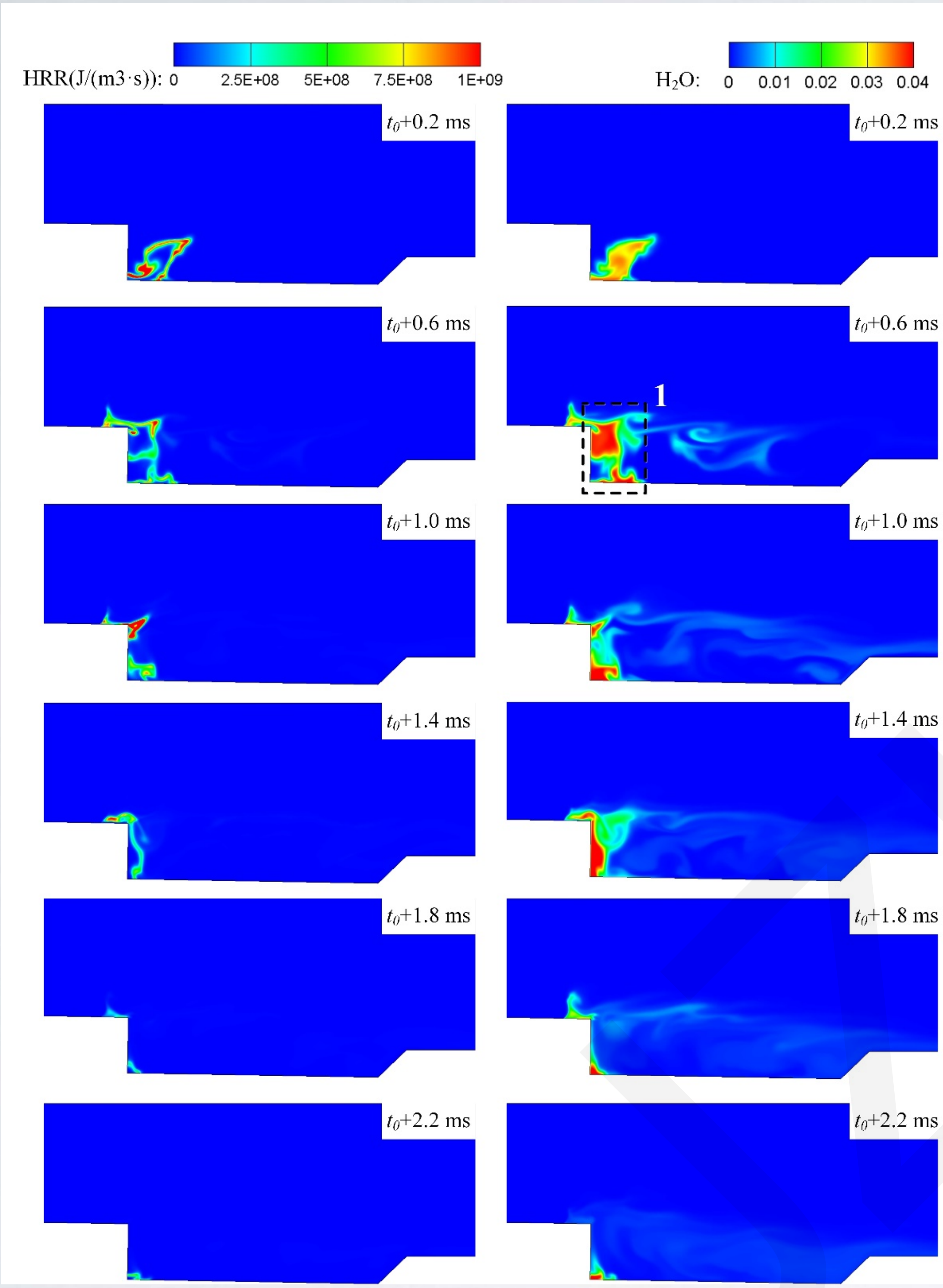
Boundary conditions

	Inflow	Fuel
Total temperature (K)	1530	300
Total pressure (Mpa)	2.6	1.5
Ma	2.92	1.0
Y_{O_2} (%)	23.3	0.0
Y_{H_2O} (%)	5.9	0.0
Y_{CO_2} (%)	9.6	0.0
Y_{N_2} (%)	61.2	0.0
$Y_{C_2H_4}$ (%)	0.0	100.0
ϕ		0.30
l	0.635 m	
Re	5.7×10^7	

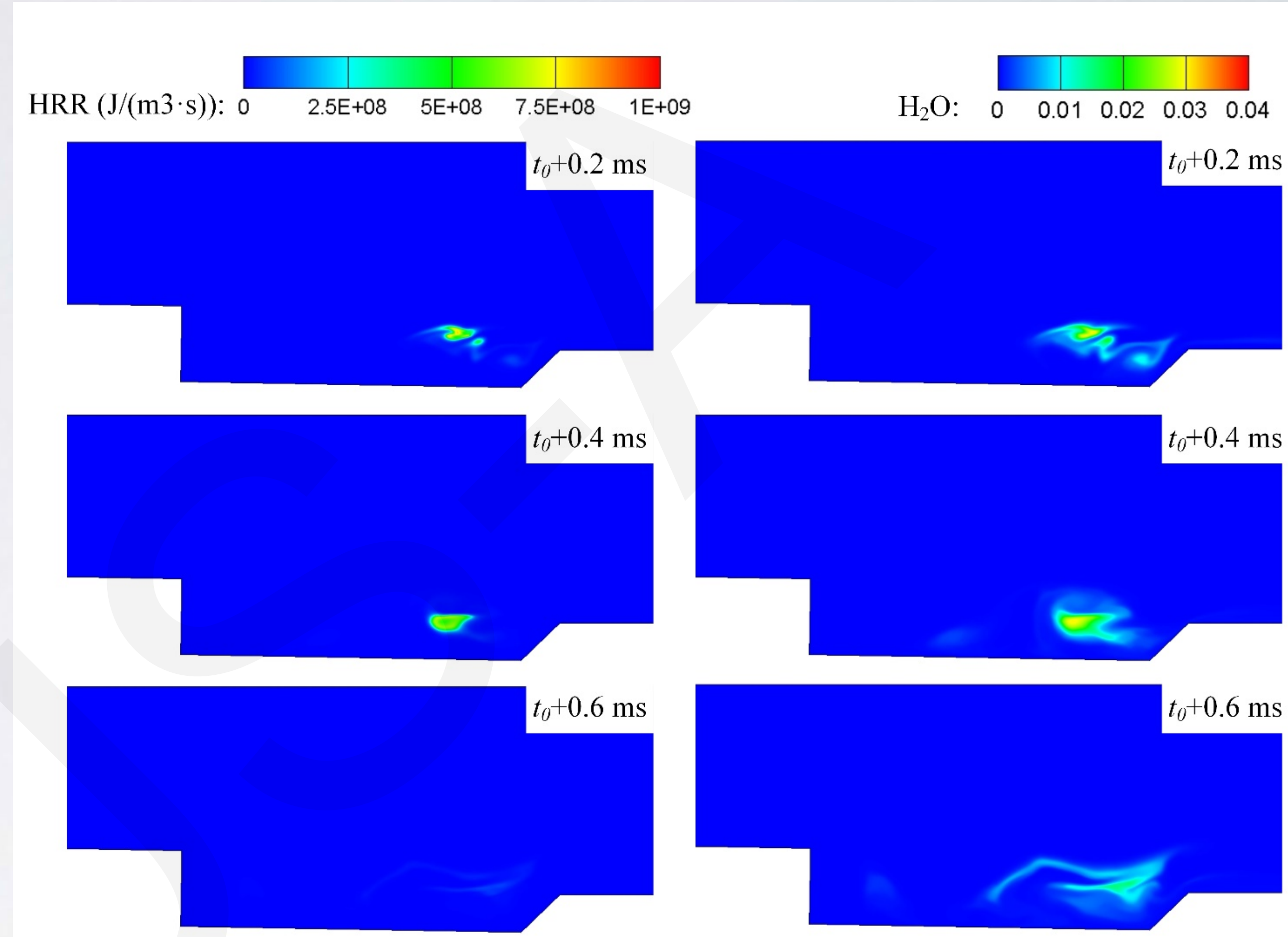
Simulation tool: OpenFOAM

Reaction mechanism: 35 steps ethylene chemical mechanisms (Dong et al., 2008)

Results



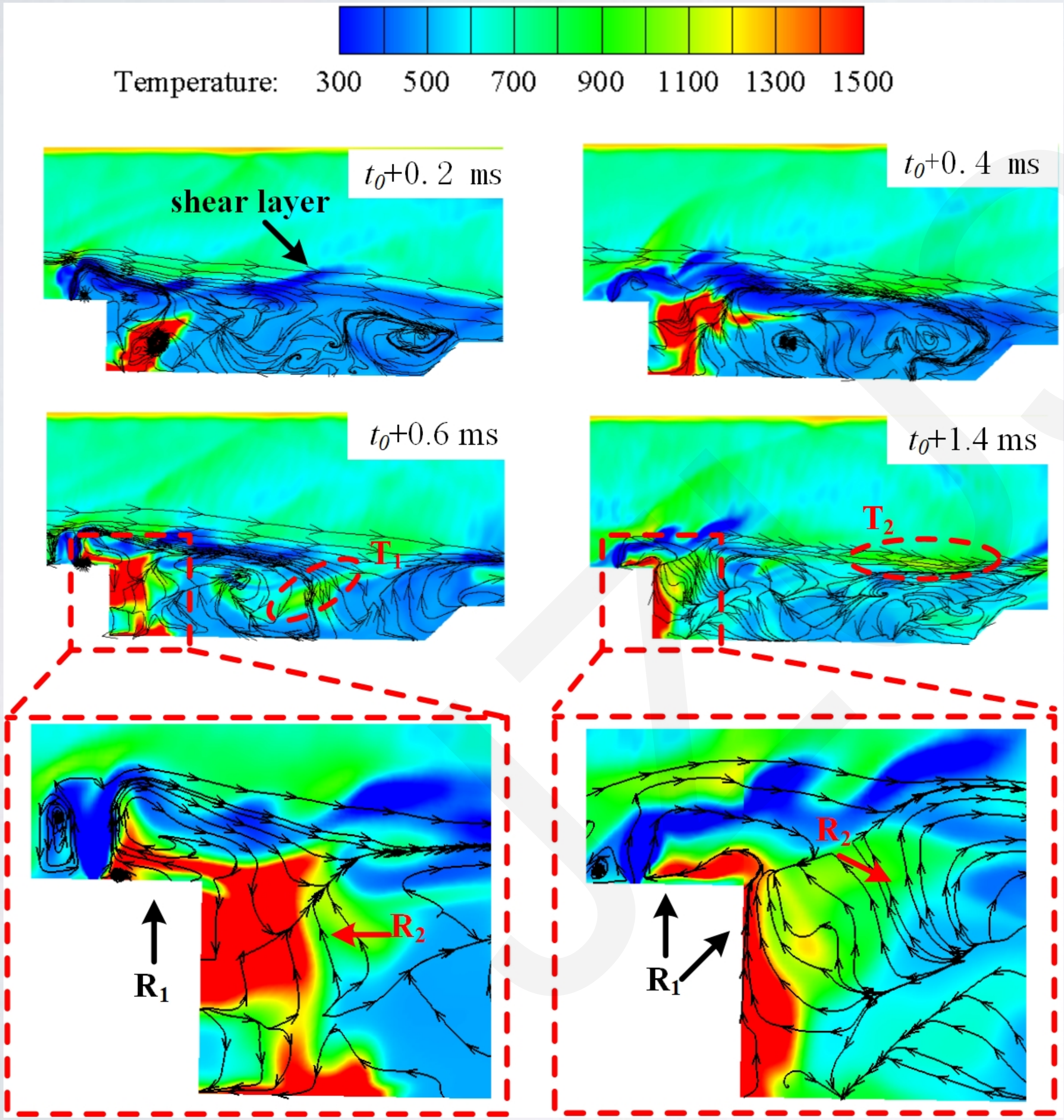
Dissipation extinguishing mode (Case 1)



Blow-off extinguishing mode (Case 4)

Two extinguishing modes were obtained

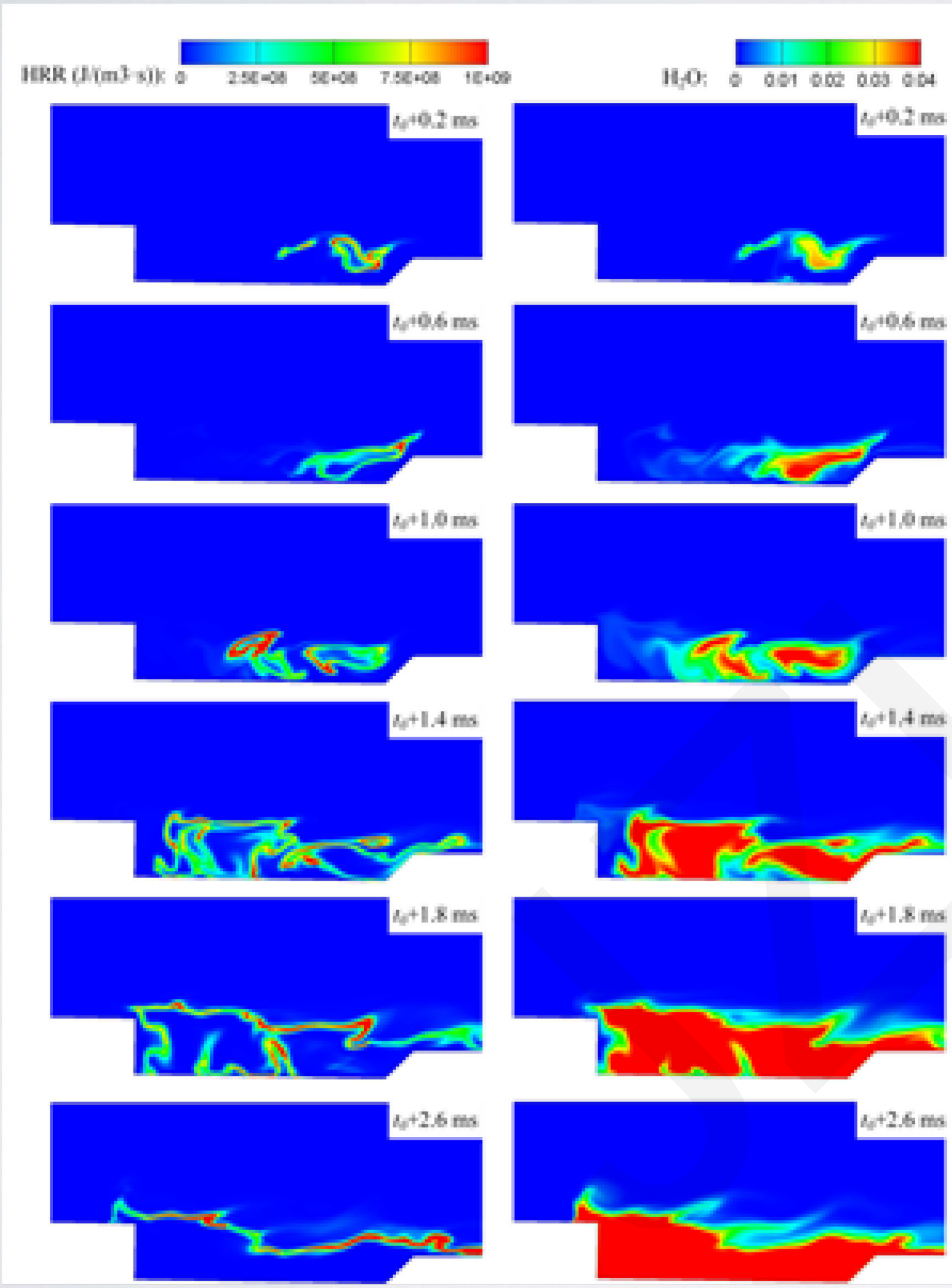
Mechanisms for the Dissipation extinguishing mode

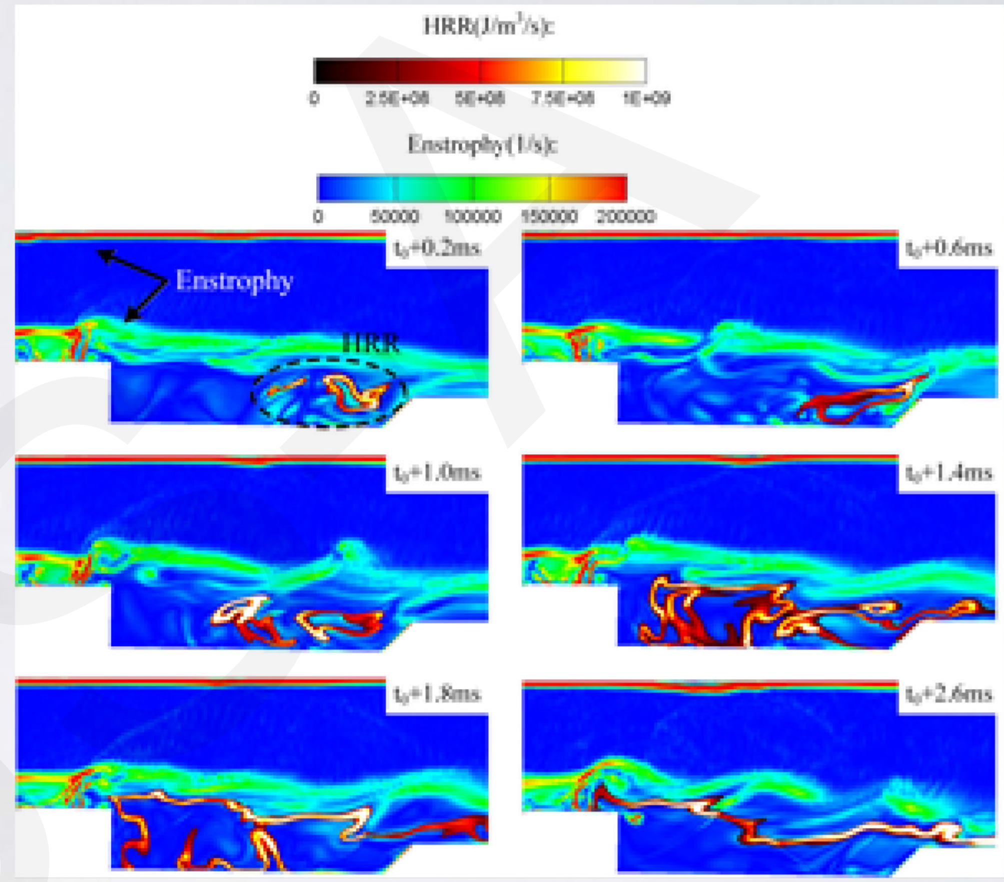


Due to the evolution of the flow stream, the high temperature region can be observed at the upstream of the cavity, and it can also be observed at the shear layer.

it can be concluded that the ignition energy in the high temperature region in case 1 and case 2 is dis-sipated by the flow stream evolution.

Successful cavity ignition process after ignition in the rear of the cavity floor (case 3)





The initial flame propagates towards the cavity front wall quickly after ignition and forms a large heat release region inside the cavity. After the initial flame propagates out of the cavity from the rear edge, the heat release region inside the cavity decreases gradually.

Conclusion

- The region in the rear of the cavity floor is an optimized ignition site with a favorable flow field environment and initial flame movement routine.
- Two extinguishing modes could be identified: blow out extinguishing mode and flow dissipation extinguishing mode.
- The initial flame movement routine is an important issue during the ignition process, including both moving towards a favorable flow field and forming a large heat release region.
- To ensure a successful ignition process, it is indicat-ed that both increasing equivalence ratio and opti-mizing the ignition site in the cavity are practical routes.