Numerical Simulation of Multi-Dimensional Structure and Mach Reflection of Gaseous Detonation Waves *

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Abstract. When a detonation wave interacts with a wedge, the Mach reflection is occured. In this paper the DDT process of combustible gases and Mach reflection of detonation waves have been simulated numerically with a new CE/SE method. Simulated results are compared and verified with experiemntal results.

1 Model and Numerical Methods

In numerical simulation a two-step chemical reaction model (ZND model) is adopted for simlicity. In this model there are two steps: induction reaction and exothermic reaction respectively. They are expressed by proceeding parameters: α and β. At first α and β are 1.0, followed by decrease of α to zero, then β

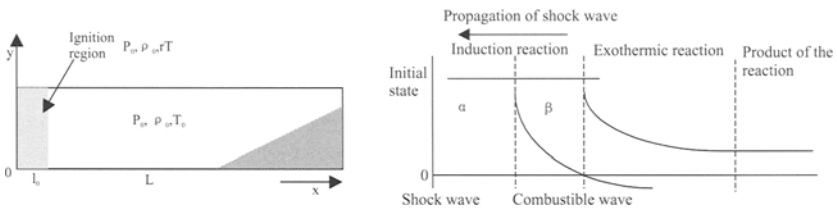

Fig. 1. Scheme of Mach reflection of detonation wave and two-step reaction model

decrease until the equilibrium state is reached. The scheme of two-step model is shown in Fig. 1. A new method of Space-Time Conservation Element and Solution Element(CE/SE method) is adopted to simulate the DDT process of combustible gases and Mach reflection of detonation waves on wedge with chemical reaction. It differes substantially in both concept and methodology from well-established methods: finite differece, finite volume, finite element and spectral method. This is first time to use CE/SE method to simulate the DDT process of combustible gases and Mach reflection of detonation waves with chemical reaction.

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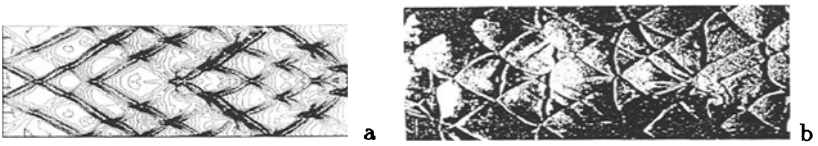

Fig. 2. Detonation cells in $2H_2 + O_2 + Ar$. a) Numerical simuation results; b) Experimental results

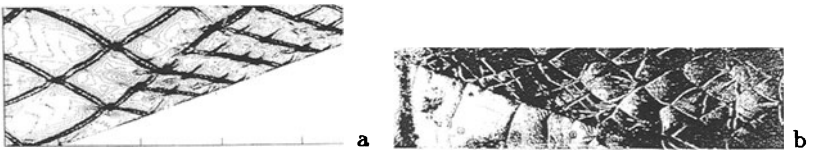

Fig. 3. Cellular structure produced by the Mach reflection of detonation waves in $2H_2 + O_2 + Ar$. a) Numerical simulation of Mach reflection; b) Experimental results of Mach reflection

2 Results

The simulated detonation cells of combustible gases and Mach reflection of detonation waves are shown in Fig. 2 and Fig. 3. The simulated results are compared with expeimental results. Following conclutions are given:

1. the Mach reflection of detonation waves differs totally from the Mach reflection of shock waves. Before and after Mach reflection of detonation waves there is a marked boundary line. Both side of the boundary line the size of cellular steructure is decreased with the increase of wedge angle and initial pressure of combustible gas.

2. the angle χ of the trace of triple point with wedge surface is decreased with the increase of wedge angle. Its change is not obvious with the initial pressure of combustible gases.

3. simulated results show that it is successful to adopt the CE/SE method in the chemical reaction flow of DDT process of combustible gas and Mach reflection of detonation waves. It has following adventages: simplicity of scheme; high resolution and small computational time.

References

1. M.A. Nettleton: *Gaseous Detonation*, (Chapman Hall 1987)
2. J. Meltzer, J.E. Shephered, R. Akbar, A. Sabet: 'Mach Reflection of Detonation Waves'. In: *Progress in Astronautics & Aeronautics*, AIAA, **153**, pp. 78–94, (1991)
3. S. Taki, T. Fujiwara: 'Numerical Simulation on the establishment of Gaseous Detonation'. In: *Progress in Astronautics & Aeronautics*, AIAA, **94**, pp. 186–200, (1984)
4. S.C. Chang: J. of Comput. Phys. **119**, pp. 295–324, (1995)