HUMAN SPACEFLIGHT SYMPOSIUM (B3)
Interactive Presentations (IP)

Author: Dr. Xin Lin
China Academy of Aerospace Aerodynamics (CAAA), China, linxin_bit@163.com

Prof. Lianzhong Chen
China Academy of Aerospace Aerodynamics (CAAA), China, quarter724@sohu.com
Mr. Dongbin Ou
China Academy of Aerospace Aerodynamics (CAAA), China, oudongbin@sina.com
Prof. Yonghui Dong
China Academy of Aerospace Aerodynamics (CAAA), China, yhdong@189.cn
Dr. Fei Li
Institute of Mechanics, Chinese Academy of Sciences, China, Lifei@imech.ac.cn
Dr. Jinping Li
Institute of Mechanics, Chinese Academy of Sciences, China, jinping.li@foxmail.com
Prof. Xilong Yu
Institute of Mechanics, Chinese Academy of Sciences, China, xlyu@imech.ac.cn

EXPERIMENTAL AND MODELING INVESTIGATION OF CO2 DISSOCIATION IN MARS ENTRY CONDITION

Abstract

When a spacecraft enters the Mars atmosphere (96% CO2, 4% N2), there will generate a strong shock wave in front of the heat shield of a space probe. The knowledge of the chemical and physical processes occuring in the shock layer is extremely important in a number of applications, e.g., design and validation of thermal protection systems. Up to now studies, computations as well as experiments performed in shock tube have shown that one of the most important reactions is the dissociation of CO2: CO2+M=CO+O+M. Therefore, a thorough understanding of CO2 dissociation kinetics and radiation are extremely important in prediction of radiative heating environment and design of thermal protection systems for upcoming demanding missions.

In this paper, gas temperature and CO number density distributions behind a strong shock wave in simulated Martian atmosphere are simultaneously measured by combining the optical emission spectroscopy (OES) system and the tunable diode laser absorption spectroscopy (TDLAS) system. Experiments are performed in a hydrogen and oxygen combustion driven shock tube with diameter of 78 mm. With an aluminum diaphragm of 2 mm thick, the shock tube can produce a stable shock wave with velocity of 5.68 km/s. Through OES diagnostics, rotational and vibrational temperature data are obtained by analyzing the high temporal and spatial resolution experimental spectral of CN violet system, which is among the best molecules for temperature measurement for Mars entry. For TDLAS system, one CO absorption line near 2335.778 nm is used to determine the CO concentration distribution in the thermal equilibrium region.

Moreover, a thermochemical model, based on a two-temperature kinetic code, for studying chemical and physical processes is developed for Mars entry conditions. Comparisons between experiments and calculations show that the previously developed model is inefficient to reproduce our experimental results. These discrepancies mainly include the rise rate of the temperature immediately behind the shock wave, the non-equilibrium effects and the decay rate of the temperature following the peak location. During high-speed entry into Mars atmosphere, the dissociation of CO2 is the first chemical reaction to occur behind

a shock wave and it affects the whole chemical reactions. Therefore, we propose new CO2 dissociation rate coefficients based on our experimental data, showing the way towards a better description of the chemistry of the CO2-N2 mixture.