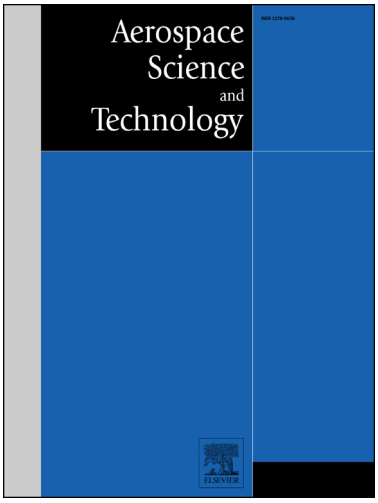
Accepted Manuscript



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PII: S1270-9638(16)31360-8
DOI: http://dx.doi.org/10.1016/j.ast.2017.04.027
Reference: AESCTE 4010

To appear in: *Aerospace Science and Technology*

Received date: 3 January 2017
Revised date: 10 April 2017
Accepted date: 26 April 2017

Please cite this article in press as: J. Hao et al., Assessment of Vibration-Dissociation Coupling Models for Hypersonic Nonequilibrium Simulations, *Aerosp. Sci. Technol.* (2017), http://dx.doi.org/10.1016/j.ast.2017.04.027

Assessment of Vibration-Dissociation Coupling Models for Hypersonic Nonequilibrium Simulations

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Abstract

The fidelity of three widely-used two-temperature vibration-dissociation coupling models, including the Park model (1988), the Macheret−Fridman model (1994), and the coupled vibration-dissociation-vibration (CVDV) model (1963), is numerically investigated via a comparison with state-specific results and existing shock tube data for oxygen flows. Under the hypothetical condition where a Boltzmann distribution corresponding to a vibrational temperature is assumed, it is found that the CVDV model with a proper parameter is capable of providing the most accurate results, whereas the Park and Macheret−Fridman models present similar prediction accuracy for which the nonequilibrium dissociation rate coefficients could be as much as three orders of magnitude lower than state-specific values. However, for actual postshock flows with intensive vibrational excitation and dissociation processes, the CVDV model still shows significant discrepancies relative to state-specific results and experimental data, presenting a much lower vibrational temperature and a higher degree of dissociation. The essential cause for the disagreement lies in the existence of non-Boltzmann

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