A New Aerosol Shock-Tube Facility for the Study of Mixtures with Large Hydrocarbons

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A new shock-tube facility for the study of gas and condensed-phase measurements is discussed. The facility was constructed for use at the Doha, Qatar campus of Texas A&M University. The facility is modeled after prior experiences by the authors and recent developments from the literature. This shock tube has many of the same features in other facilities used by the authors, but it also has some additional features to enhance the utility of the present shock tube as compared to other versions. For the purposes of the current project, the shock-tube facility will be used to study combustion properties of long-chain hydrocarbon fuel components and mixtures at realistic engine conditions.

To this end, an aerosol generation and entrainment facility is utilized along with an enlarged driver section and double-diaphragm interface between the driver and driven sections. As is the practice with other shock-tube designs, this facility is equipped for use with modern methods of shock velocity measurement and optical diagnostics, among other diagnostic techniques. Experimental reflected-shock conditions achievable in this facility include reflected-shock pressures up to 100 atm and temperatures as high as 4000 K. Furthermore, the post-reflected-shock test time duration of this facility is expected to be on the order of 20 ms, far eclipsing test time durations previously achieved in the authors' other facilities. Along with the study of aerosolized liquids (fuels and non-fuels) related to combustion chemistry, reaction kinetics, evaporation studies, and particle-fluid interactions, the facility is capable of investigating traditional gas-phase mixtures similar to those typically undertaken in conventional shock tubes. Details on the setup and the methods of operation are discussed.

As interest in combustion behavior of heavy hydrocarbon fuels has grown, continued advancement of technology and methodologies for the study of such fuels has been vital to the accuracy of such investigations. Traditionally, the study of low-vapor pressure fuels in shock tubes has been conducted using the heated shock-tube method, such as in previous works [Rotavera and Petersen, 2012, 2013; Horning, 2002]. Due to the low vapor pressures of heavy hydrocarbons, they are unable to be mixed reliably as a gaseous component at standard atmospheric temperatures and pressures using traditional shock-tube mixing methods. Instead, such fuels must either be heated to be held in the gas phase, or physically suspended as an aerosol while being introduced into a shock-tube mixture. For the present shock tube, the heavy hydrocarbons will be suspended in an aerosolized mixture and constrained to a region near the endwall of the shock tube prior to shock passage. A diagram of the gate valve setup is shown in Fig. 1. Details of the new shock-tube design, set up, and characterization are presented in this paper.

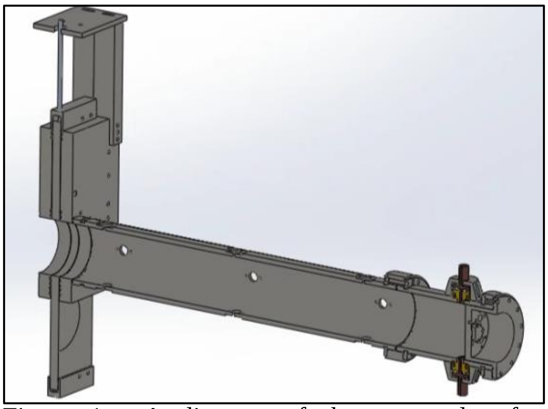

Figure 1. A diagram of the gate valve for constraining the aerosol near the endwall.

References

B. Rotavera, E.L. Petersen: Model predictions of higher-order normal alkane ignition from dilute shock-tube experiments. Shock Waves J. 23 (2013), p. 345-359.

B. Rotavera, E.L. Petersen. Shock-Wave Induced Ignition of Normal Undecane (n-C1 1H2 4) and Comparison to Other High-Molecular-Weight n-Alkanes. 28th International Symposium on Shock Waves. Springer, Berlin, Heidelberg (2012), p. 783-788

D.C. Horning, D.F. Davidson, R.K. Hanson: Study of the High-Temperature Autoignition of n-Alkane/O/Ar Mixtures. J. Propulsion and Power 18 (2002).