A new miniature shock tube for kinetic studies

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Conventional shock tubes have been widely used to carry out chemical kinetic studies using numerous complementary detection techniques[1-3]. Nevertheless, these shock tubes do not allow access to the most recent advanced techniques based on Synchrotron light due to physical and operational constrains. Recently, miniature shock tubes have been designed and constructed to overcome such limitations thanks to their small dimensions (around one meter in length) and high-repetition rates (up to 4 experiments per second)[4-5]. The coupling between miniature shock tubes and Synchrotron based techniques provides a powerful tool for performing complex kinetic studies at engine-like conditions with the potential to finally bring light on long-standing problematics.

In this work, we will discuss the design of a new miniature shock tube. The shock tube which has been developed at ICARE, based on the original design by Tranter and Lynch[1], has a driven section of 1.05 m length and an internal diameter of 8 mm. Five pneumatically operated valves are used to evacuate the exhaust gases from the driven section and fill the shock tube with fresh gas mixture before each experiment. The shock wave is generated by the sudden opening of a solenoid actuated valve and consequent displacement of a poppet which initially isolates the low-pressure from the high-pressure sections. The fully automated shock tube is expected to operate at 1 Hz. The ICARE miniature shock tube will be used in future studies with low signal-to-noise ratio, Synchrotron based detectors such as vacuum ultraviolet photoionization mass spectrometers. The details of the design and the results of preliminary tests will be presented.

References

1. The Shock Tube in High Temperature Chemical Physics; Gaydon, A.G.; Hurle, I.R.; Chapman and Hall, London, 1963.
2. Handbook of shock waves, vol 3. Chemical Reactions in Shock Waves and Detonations; Ben-Dor, G.; Igra, O.; Elperin, T., Ed.; Lifshitz, A., invited Ed.; Academic Press, San Diego, 2001.
3. Shock Waves in Chemistry; Lifshitz, A., Ed.; Marcel Dekker, New York, 1981.
4. Tranter, R.S., P.T. Lynch. "A miniature high repetition rate shock tube." Rev. Sci. Instrum. 2013, 84, 094102.
5. Lynch, P. T. Note: An improved solenoid driver valve for miniature shock tubes. Rev. Sci. Instrum. 2016, 87, 056110.