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Development of the advanced high-enthalpy test facility for hypersonic vehicles

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The hypersonic technology is one of the key issues for future aerospace industries, and the hypersonic physics is a challenging topic in gas dynamics research area. The high-enthalpy test facility being capable of duplicating hypersonic flight conditions is one of the most important tools not only for developing hypersonic vehicles, but also for promoting the fundamental study on high temperature gas flows. Advanced high-enthalpy test facilities have been developed for more than 50 years, but there is still the lack of the facilities for generating high-enthalpy flows with a Mach number higher than 7 for hypersonic propulsion due to huge technological barriers in wind tunnel techniques, especially for facility damages due to severe heat transfer problems.

Development of a large detonation-driven shock tunnel for exploring hypersonic physics is reported in this paper. To produce hypervelocity test flows with properly long test-duration for the supersonic combustion and the aerodynamic force measurement, several new techniques were proposed and investigated to improve shock tunnel performance and extend its test duration, which include the backward-running detonation driver for strong incident shock generation, the tailored interface condition for detonation drivers, the shock/boundary interaction control at the end of the driven section, and the E-shaped configuration of the vacuum tank for damping wave reflections. With these techniques, the long-test-duration hypervelocity detonation-driven shock tunnel was built up. The shock tunnel, as shown in Fig. 1, is about 265 m in total length with a 2.5 m diameter nozzle. Its performance tests were carried out and some experimental results are presented to demonstrate its capability for duplicating hypersonic conditions.

Fig. 1 Photo of long-test-duration hypervelocity detonation-driven shock tunnel viewing from its vacuum system