SRUSHTI

HAND OPERATED SHOCK TUBE AND HYPERSONIC SHOCK TUNNEL

IISc Invention to Help Transition from Aeronautical to Aerospace Engineering

EXCELLENCE AND INNOVATION

BUILT INTO EVERY DESIGN

LHSR

ABOUT SRUSHTI

Srushti Education Systems Private Limited (SESPL) was founded by Prof. K. P. J Reddy and Prof. G. Jagadeesh, senior professors at the Department of Aerospace Engineering, Indian Institute of Science, (IISc), Bangalore to commercialize their own inventions. With decades of experience between them in the fields of gas dynamics, high speed aerodynamics and shock waves, they set out with the vision of introducing these otherwise almost exclusively Post Graduate and Doctoral level research fields, into the Bachelors level. With the growing knowledge that the power of shock waves can be harnessed constructively in almost all fields of science and engineering, SESPL has taken it upon itself to educate the budding scientists and engineers to better equip them to carve out a bright tomorrow for all mankind.

This company is a sister concern of Super-Wave Technology Private Limited (SWTPL), incubated within the IISc, which focuses on research and development of various products by employing shock waves. It is well known that except for a couple of medical applications the commercial potential of shock waves has not been exploited properly. Today, under the leadership of Prof. Reddy and Prof. Jagadeesh, the company has extended the scope of shock wave applications to various fields such as biology, electronics, civil engineering, nanoscience, genetic engineering, biomedical engineering, veterinary etc. SESPL stemmed from the desire of the directors to introduce this fascinating field of shock waves to engineering and science students at an early stage.

In order to achieve this both the founder directors have devoted substantial part of their research efforts towards developing incredibly simple systems to produce and study the shock waves in the laboratory without any risks associated with the existing large scale systems. Two such inventions, namely, Reddy Tube and Reddy Tunnel described in this brochure have been successfully launched as table top hand operated Shock Tube and Hypersonic Shock Tunnel specifically tailored to carry out laboratory experiments on shock waves and hypersonic flows by the undergraduate as well as graduate level students. These two equipments provide opportunity to students to carry out practical classes in the subjects of compressible flows, shock waves, supersonic and hypersonic flows including reentry aerodynamics. Thus Reddy tube and Reddy Shock Tunnel have formed basis for elevating the Aeronautical Engineering degree to Aerospace Engineering degree.

It is heartening to note the inclusion of Reddy Tube and tunnel in the syllabus of famous Universities in India including Visveswaraya Technological University of Karnataka, Periyar Maniammai University of Thanjavur and many other private universities and autonomous colleges. Many professors in foreign universities are also teaching Reddy tube in their classes and a famous professor working on medical applications of shock waves in Mexico is publishing an advanced book with one Chapter on Reddy tube. These facilities are also being used as research tools in prestigious institutions including IISc, National Institute of Mental Health and Neurosciences and Indian Space Research Organisation.

BASIC PRINCIPLES OF A SHOCK TUBE

Conventional high pressure driven shock tube shown schematically in the figure below consists of a constant area tube divided in to driver and driven sections separated by a diaphragm. On one side of the diaphragm, a gas is filled to a pressure high enough to rupture the metal diaphragm, and pressure in the other tube is reduced to a lower value than atmospheric pressure as required. The former is termed the driver side and the latter the driven side. When the diaphragm ruptures due to the high pressure gas in the driver tube, it generates a shock wave that moves along the length of the driven tube, thereby increasing the pressure, temperature and density of the driven gas. In a shock tube, the gas filled in the driven section is the test gas under consideration.

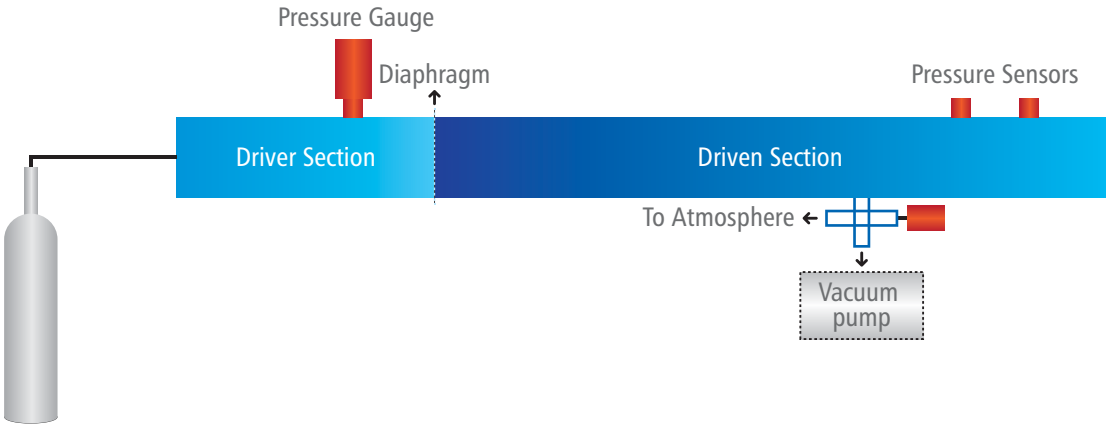

Fig: Shock Tube Schematic

REDDY TUBE

This is a revolutionary table top devise invented by Prof. K P J Reddy where the shock waves are produced by hand driven piston without any hazardous effects associated with the conventional shock tubes. The high pressure required for rupturing the diaphragm to produce a shock wave is generated inside the driver tube by pushing a piston akin to the plunger in a medical syringe. The importance of this devise is its versatility and ease of operation. In addition to being a good practical devise for teaching shock waves and compressible aerodynamics the Reddy Tube has been applied for artificial insemination of cattle, investigation of brain injuries in accidents, removal of brain tumor, water purification, oil extraction from medicinal plants and even for making tasty pickles by many researchers and students. Details of the Reddy tube with associated instrumentation suitable for carrying out many experiments in the laboratory are shown in the accompanying figure. Shock Mach numbers of up to 1.5 are easily produced with air as the driver gas while higher value shock Mach numbers (stronger shock waves) can be produced by using helium gas as the driver gas.

Technical Specifications

- Diameter: 29 mm
- Driver tube length: 400mm
- Driven tube length: 600mm
- Diaphragm material: paper

Instrumentation

- Diaphragm rupture pressure monitor.
- High speed pressure sensors for measurement of
  - Shock speed
  - Pressures behind primary shock wave
  - Pressure behind reflected shock wave
- Data acquisition oscilloscope.

Working Parameters

- Diaphragm rupture pressure : Up to 7 bar (manual).
- Initial driven side pressure : 200 – 760 mm of Hg.
- Primary shock Mach number range : 1.3 – 2.0

List of experiments

a) Calibration studies of shock tube
b) Bullet launcher
c) Basic material studies research
d) Dynamic calibration of pressure transducers
e) Investigation of traumatic brain injury.

Customizations Available

Table-top gas driven shock tube.

The physical dimensions of this instrument is similar to the Reddy tube. Working pressures of 100 atmospheres or even higher can be obtained. Shock Mach numbers up to 3.5 – 4 can be achieved. This instrument can be used as a full on research tool into shock waves.

Full scale shock tube

This instrument is at least 6 m in length. Working pressures can be up to 200 bar or higher. Shock Mach numbers up to 5 can be achieved. Experiments of shock wave visualization can be conducted.

The Reddy tube is capable of conducting research on any aspect of shock waves with the limitation of the upper limit of shock strength.

HYPERSONIC SHOCK TUNNEL

Hypersonic shock tunnel is essentially short duration hypersonic wind tunnel used for testing the hypersonic vehicles configuration like launch vehicles, missiles and space shuttles flying at Mach number higher than 5. Schematic diagram of a typical hypersonic shock tunnel is shown in the accompanying diagram. It consists of a shock tube connected to a convergent divergent hypersonic nozzle which is in turn connected to a test section and a dump tank. Driver and driven tubes of shock tube are separated by a metallic diaphragm and the nozzle and the shock tube are separated by a thin paper diaphragm. Test model is mounted in the test section which is evacuated to very high vacuum initially using vacuum pump. Operation of the hypersonic shock tunnel is very complex and the facility is more suitable to carry out research work and hence it is seldom used for teaching purpose at undergraduate level.

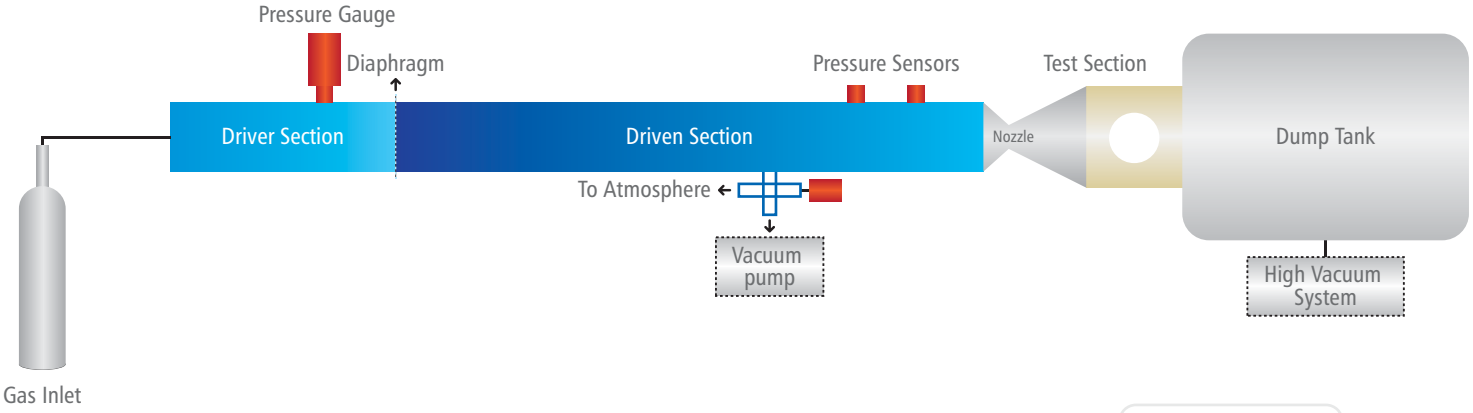

Fig: Shock Tunnel Schematic

REDDY TUNNEL

As stated above the conventional hypersonic shock tunnel is more a research facility and facility for producing the design data for practical flight vehicles. But teaching of hypersonic aerodynamics at undergraduate and postgraduate levels is incomplete unless students are allowed to conduct practical experiments in the laboratories. For this purpose Prof. K. P. J. Reddy invented hand operated table top hypersonic shock tunnel named Reddy Tunnel which is ideally designed for conducting practical classes in colleges offering Aerospace Engineering degree courses. This device serves as a stepping stone towards extending studies in aeronautics to the field of aerospace engineering.

Technical Specifications Shock Tube:

- Diameter : 29 mm
- Driver tube length : 400mm
- Driven tube length : 600mm
- Diaphragm material : paper

Wind Tunnel Section:

- Hypersonic Nozzle : Convergent divergent nozzle of 60 mm exit diameter.
- Test section : Rectangular test section with optical windows.
- Dump tank : Cylindrical dump tank with model mounting base and facility for data throughput.

Instrumentation:

- Diaphragm rupture pressure monitor.
- High speed pressure sensors for measurement of
  - Shock speed
  - Pressures behind primary shock wave
  - Pressure behind reflected shock wave
- Data acquisition oscilloscope.
- Vacuum pump to create vacuum in test section and dump tank.

Working Parameters:

- Maximum model dimension : 50 mm (crosswise)
- Flow Mach number : 6
- Maximum effective test time: 300 μs

Test gas : Typically air but can be changed as required.

List of experiments

a) Calibration of test section core flow
b) Measurement of drag and lift co-efficient.
c) Measurement of surface pressures
d) Measurement of heat fluxes
e) Measurement of pitching and yawing moments.
f) Schileren flow visualization studies

Customizations

Gas driven table top hypersonic shock tunnel

The gas driven shock tube can be incorporated into a shock tunnel thereby increasing the maximum flow stagnation enthalpy to up to 3 MJ/kg.

Full scale hypersonic shock tunnel

This instrument will measure in excess of 10m. The test section area can be increased to suit any size of test model. Flow stagnation enthalpy of up to 5 MJ/kg can be achieved.

LIST OF CUSTOMERS

1. Department of Aerospace Engineering, Indian Institute of Science, Bangalore.
2. Center for Nano Science and Engineering, Indian Institute of Science, Bangalore.
3. Liquid Propulsion Systems Center (LPSC), Indian Space Research Organization (ISRO), Bangalore.
4. Physical Research Laboratory (PRL), Ahmedabad.
5. Defense Institute of Advanced Technology (DIAT), Pune.
6. Society for Integrated Circuit Technology and Applied Research (SITAR), Bangalore.
7. BMS College of Engineering, Bangalore.
8. BML Munjal University, Gurgaon.
9. Siddaganga Institute of Technology, Tumkur.
10. Amrita Vishwa Vidyapeetham (Amrita University), Bangalore.
11. College of Engineering, Trivandrum.
12. Sri Ramakrishna Engineering College, Coimbatore.

In a very short time since the invention many research papers have been published on Reddy tube. Partial list of these publications are given below:

1. Reddy K.P.J. and Sharath N, "Manually operated piston-driven shock tube", Current Science, 104 (2), pp 172-176, 2013.
2. Reddy K.P.J. and Babu R. "Reddy tube driven table top hypersonic shock tunnel", Proceedings of the International Symposium on Shock Waves 29, Wiscosin, USA, 2013.
3. Kumar, C. S, Takayama, K, Reddy, K. P. J, "Shock Waves Made Simple," Wiley Eastern Limited, New Delhi (2013).
4. Surana K.S., Reddy K.P.J., Joy A.D. and Reddy J.N., "Riemann shock tube: 1D normal shocks in air, simulations and experiments", International Journal of Computational Fluid Dynamics, DOI:10.1080/10618562.2014.927056, 2014.
5. Dhananjaya I. Bhat, Dhaval Shukla, Anita Mahadevan, N. Sharath, K.P.J. Reddy, "Validation of a blast induced neurotrauma model using modified Reddy tube in rats: A pilot study", The Indian Journal of Neurotrauma, 11, 91-96, 2014.
6. C S Kumar and Reddy K.P.J. "Experiments in hand operated, hypersonic shock tunnel facility", Shock Waves, DOI: 10.1007/s00193-015-0608-x, 2015.
7. Reddy K. P. J, Sharath N, Babu R and C S Kumar, "Experiments using Reddy Tube Driven Table Top Hypersonic Shock Tunnel", Proceedings of the International Symposium on Shock Waves 30, Tel Aviv, Israel, 2015.
8. Reddy KPJ, Sharath N, Babu R and C S Kumar, "Table top shock tube and hypersonic shock tunnel facilities", Proceedings of the 11th International Workshop on Shock Tube Technology, Gottingen, Germany, 2016.

Blast induced neurotrauma model

Flow studies using cone models and Schileren flow visualization studies of the induced shock

SRUSHTI EDUCATION SYSTEMS PVT. LTD.

Who we are

Srushti Education Systems is an initiative of Super-Wave Technology Pvt. Ltd. Our mission is to bring inventions to the classroom to encourage the future generations to enter the field of science and technology.

Areas of focus

- Reddy Shock Tube and Reddy Shock Tunnel
- Instrumentation for Hypersonic Flow Studies

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