Experiment: 19

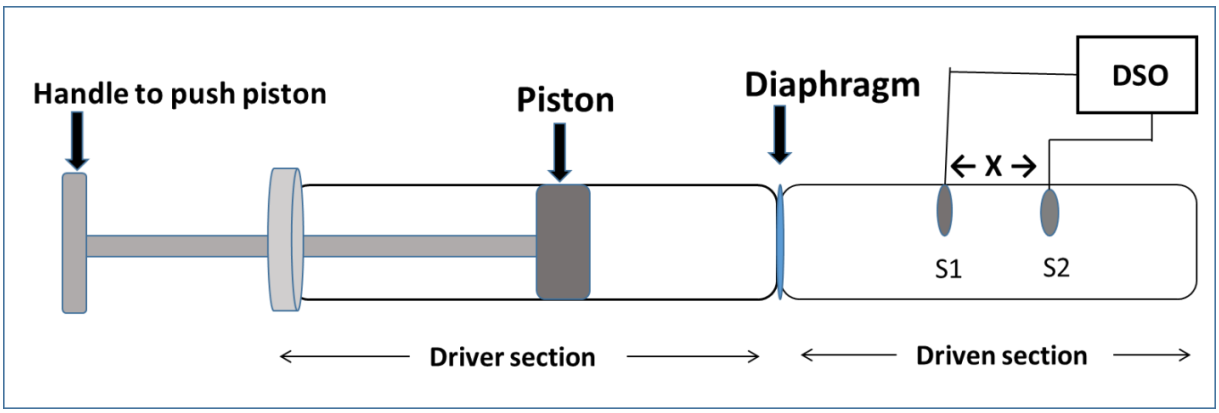
DEMONSTRATION EXPERIMENT

SHOCK WAVE GENERATION AND DETERMINATION OF MACH NUMBER USING HAND OPERATED SHOCK TUBE

AIM: To determine the Mach number of shock waves produced by rupturing cellophane (plastic) diaphragm in the shock tube.

APPARATUS: Shock tube, piezoelectric sensors and Digital storage Oscilloscope (DSO), Cellophane Tape

EXPERIMENTAL ARRANGEMENT DIAGRAM:

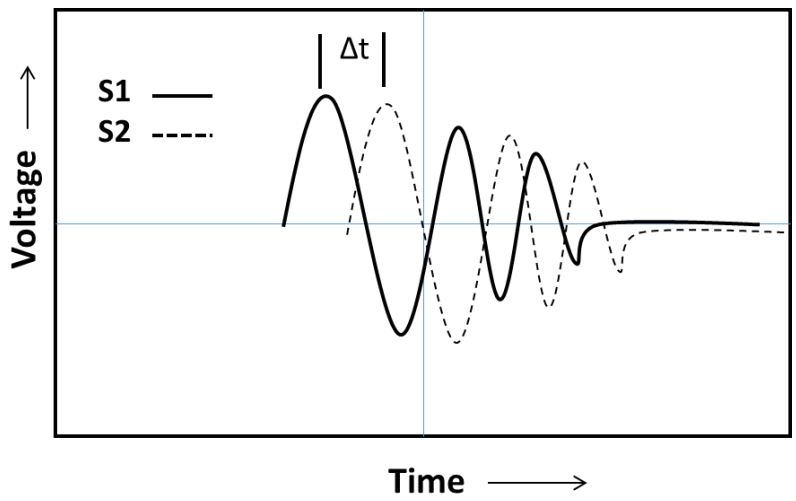


Apparatus consists of Air tight Stainless steel tube of length 0.75m fitted with Teflon piston at the one end and cellophane tape at the other end. This serves as driver section and the driven section consists of plastic tube of length 0.5 m fitted inside two piezoelectric sensorsseparated by a distance 'X' = 10 cm, connected to external channels of digital storage oscilloscope (DSO). One end of the driven section is connected to driver section end separated by the diaphragm (cellophane tape) and the other end left open to avoid reflection of the shock waves generated. Piezoelectric sensors (S1, S2) generate voltage when shock waves impinge on the sensors and will be recorded with the help of DSO.

PROCEDURE:

1. Fix the cellophane diaphragm tightly at the end of the driver section, and align the driven section with it.
2. Connect theS1 sensor cables to the chanel-1 and that of S2 to the chanel-2 of the DSO
3. Calibrate DSO (Ground both channels without connecting sensors and) and set time constant of the DSO to 1ms/unit and voltage gain of the channels to 5V/unit.
4. Push the piston in the driver section till pressure inside the tube enough to rupture the diaphragm. During the rupture of the diaphragm, fluid inside the tube in this case air is pushed out in the driver section with the speed greater than that of the sound speed, results in the generation of a shock wave.**This is the principle behind generation of shock waves in hand operated Reddy Shock Tube.** This shock wave generated, impinges the pressure sensors separated by some fixed distance (X cm) and correspondingly induces voltage signals. The time delay between these signals in the DSO is recorded immediately after the diaphragm ruptures.
5. Measure the time delay between the voltage signals in the recorded spectrum in the DSO. Let the time delay between the sensors signals be 'Δt' seconds.
6. Velocity (Vo) of the shock waves can be calculated using $Vo = X/\Delta t$ (m/s)
7. Mach Number for the shock waves generated is given by $M = Vo/Vs$
   where, Vo is the velocity of sound in air.

Nature of the sensor signals in the DSO



OBSERVATIONS:

1. Thickness of the given Cellophane diaphragm = 0.1 mm
2. Distance between the Sensors X =10 cm
3. Measured time delay between voltage signals Δt = …… s
4. Velocity of sound wave V_S = 330 m/s

CALCULATIONS:

1. Speed of the Shock waves generated = Vo = X/Δt (m/s)
   = ……. m/s
2. Mach number of the generated shock waves = Vo/ Vs = ……..

RESULT:

Velocity of the shock waves generated by the Cellophane diaphragm = ….. m/s and Mach number = …..