COMBUSTION RESEARCH ACTIVITIES AT TDCE LABORATORY
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Overview

The Thermodynamics and Combustion Engineering (**TDCE)** Laboratory of Mechanical Engineering Department has the expertise in the areas of Combustion Kinetics, Premixed and Turbulent Jet Combustion, Low-NOx Burners, Spray Combustion, Supersonic Combustion and Computational Modeling of Reacting Flows. The Laboratory offers courses in Thermodynamics, Combustion and Propulsion at the undergraduate and Postgraduate levels.

One of the important facilities in the laboratory is a shock tube which has an internal diameter of 72 mm with 3m driver and 5m driven sections. A temperature of the order of 5000K can easily be reached with hydrogen as driver gas. The facility has been extensively used for the determination of rate coefficient data for various fuels and ignition temperature and minimum ignition energy for solid propellants.

Most industrial gas burners encounter turbulent flows. The complex interaction between the turbulent flow and Combustion has been studied on open and confined premixed flames at varied turbulence levels, flow Reynolds numbers and mixture equivalence ratios. The resulting flame image is analysed using Digital Image Processing (DIP) technique and a generalized DIP algorithm has been developed for flame structure analysis and evaluation of burning velocity of premixed turbulent flames.

Fossil-fuel Combustion is a strongly polluting process. Control of oxides of nitrogen, NOx, emanating from LPG burner flames employing combustion modification is actively being studied. The overall combustion process can be split into more than one stage, with fuel-rich combustion followed by addition of secondary air, or fuel-lean combustion followed by injection of extra fuel. The central theme is to avoid the high temperature window of 1800K by which formation of thermal NOx is suppressed.

Droplet combustion is a fundamental mechanism of heat release in gas turbines, diesel engines, liquid combustors and oil-fired furnaces. A porous sphere facility is available for experimentally simulating droplet combustion. This consists of porous alundum spheres, which are fed with liquid fuel using infusion pumps in a precisely controlled manner. Single and multiple droplets burning in various upward and downward airflow configurations have been simulated experimentally and computationally.

Supersonic Combustion research has assumed significance in light of the need to power hypersonic vehicles. The concept has been proposed in

SCRAMJET (Supersonic Combustion Ramjet) engines, wherein, combustion occurs at supersonic speeds to generate thrust required for hypersonic air breathing propulsion. A supersonic combustion facility for burning gaseous hydrogen in a supersonic stream of air is available in the laboratory. Compressed air from storage vessels is discharged in blow-down mode through a C-D nozzle. A hydrogen pilot burner system has been developed with the help of which burning of hydrogen issuing from the strut has been achieved successfully in the ducted air stream of Mach number range of M < 2.0.

Studies on Cavity Enhanced Mixing for Supersonic Combustion

Cavities are fluid dynamic configurations, which are characterized by self-sustaining pressure oscillations. A practical supersonic combustor could employ a system of cavities for mixing enhancement and flame holding. Therefore, prior to flame holding studies, there is a need to understand the underlying physics of flows over multiple cavity systems like in-line and opposed cavity configurations. Further, the stability characteristics of flame holding supersonics flows viz., the best location for establishing flame with regard to cavities producing acoustic resonating zone is to be established. Figure 1 shows the experimental setup being used in the Laboratory for the scramjet studies. Figure 2 shows the computed Mach number contours for an opposed cavity configuration.

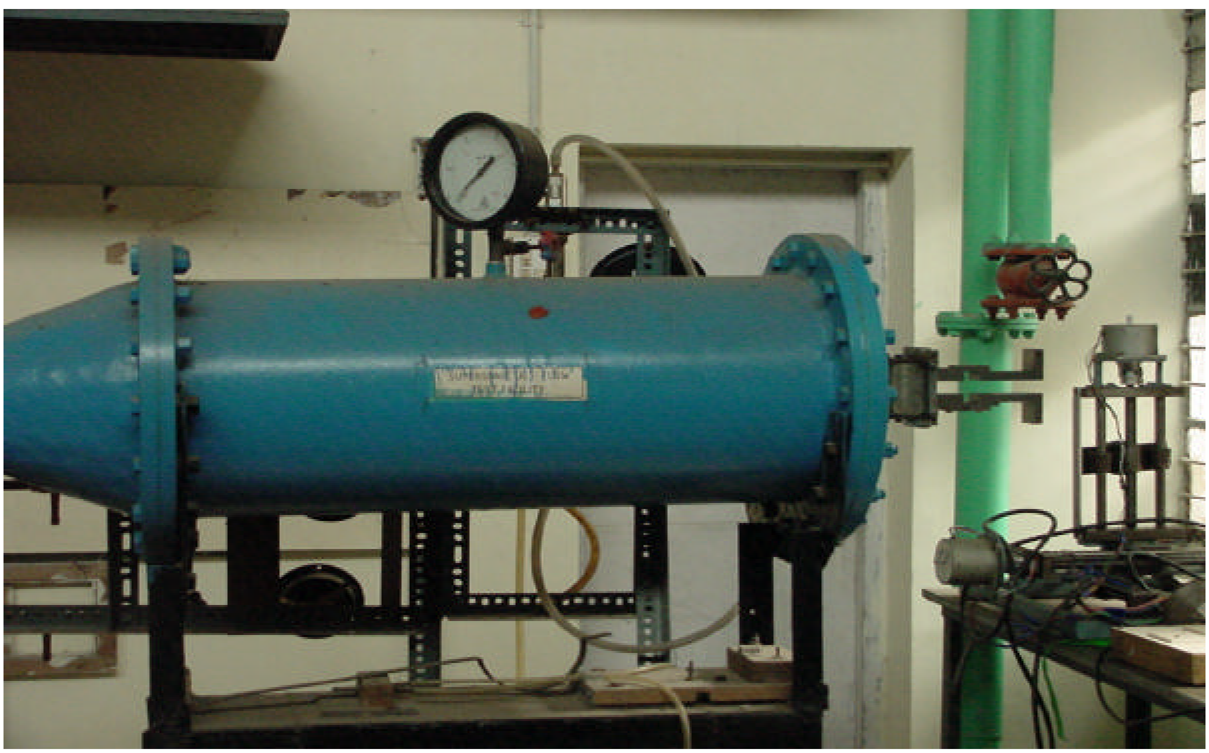

Fig.1. Test Facility for Cavity Enhanced Mixing for Supersonic Combustion

When placed directly opposed, the cavities interact destructively leading to substantial attenuation of pressure oscillations in the shear layer. The degree of attenuation reduces as the cavities are shifted outside their respective acoustic fields. There is an optimal offset distance for which the acoustic interaction is maximum, and the mixing between the reactants is substantially improved. Experimental and computational work is in progress to analyze the cavity assisted mixing and combustion in supersonic ducted flows.

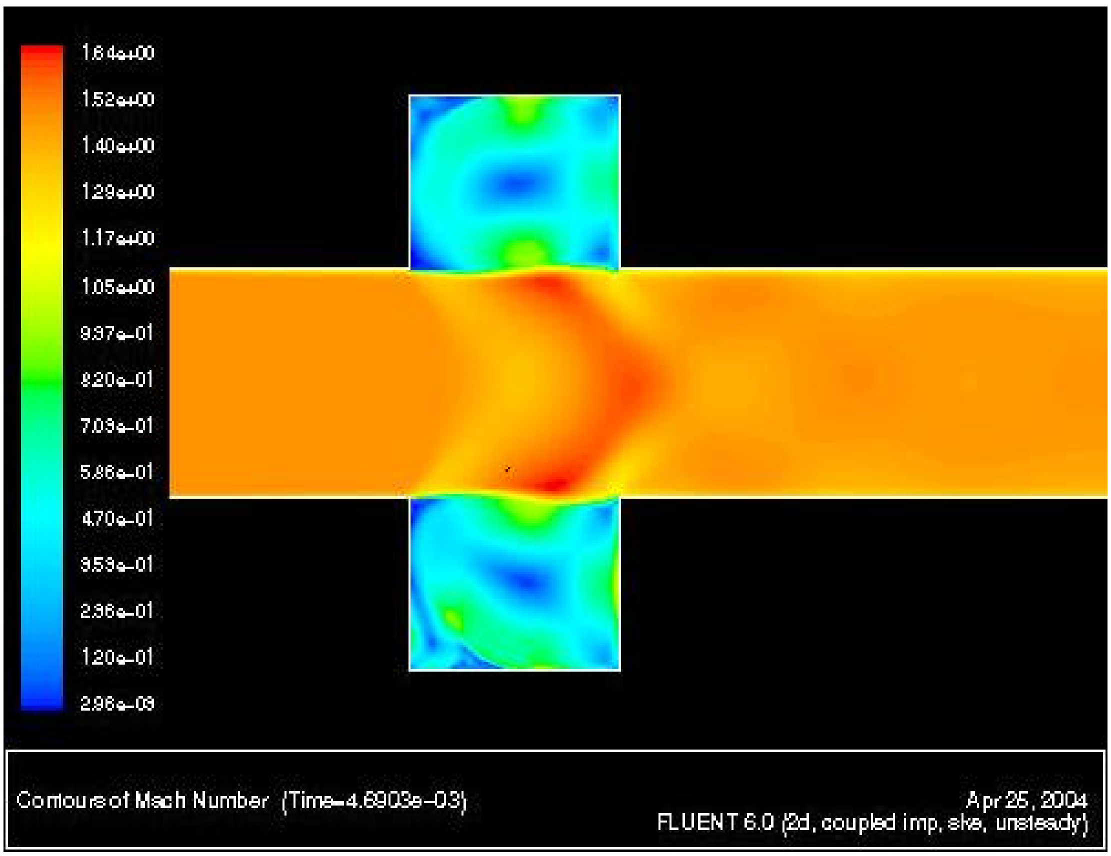

Fig 2: Computed Mach number contours for a directly opposed cavity configuration

Computational Modeling Work

Computational modeling expertise is available for the simulation of droplet combustion, jet flames, reacting flows in rocket combustors, ramjet combustion and internal and external compressible flows. Some of the on-going studies include: computational simulation of High Altitude Test facility operation, high speed combustion modeling, modeling of low-NOx staged burner systems and high-intensity low-NOx PCF cyclone combustors.