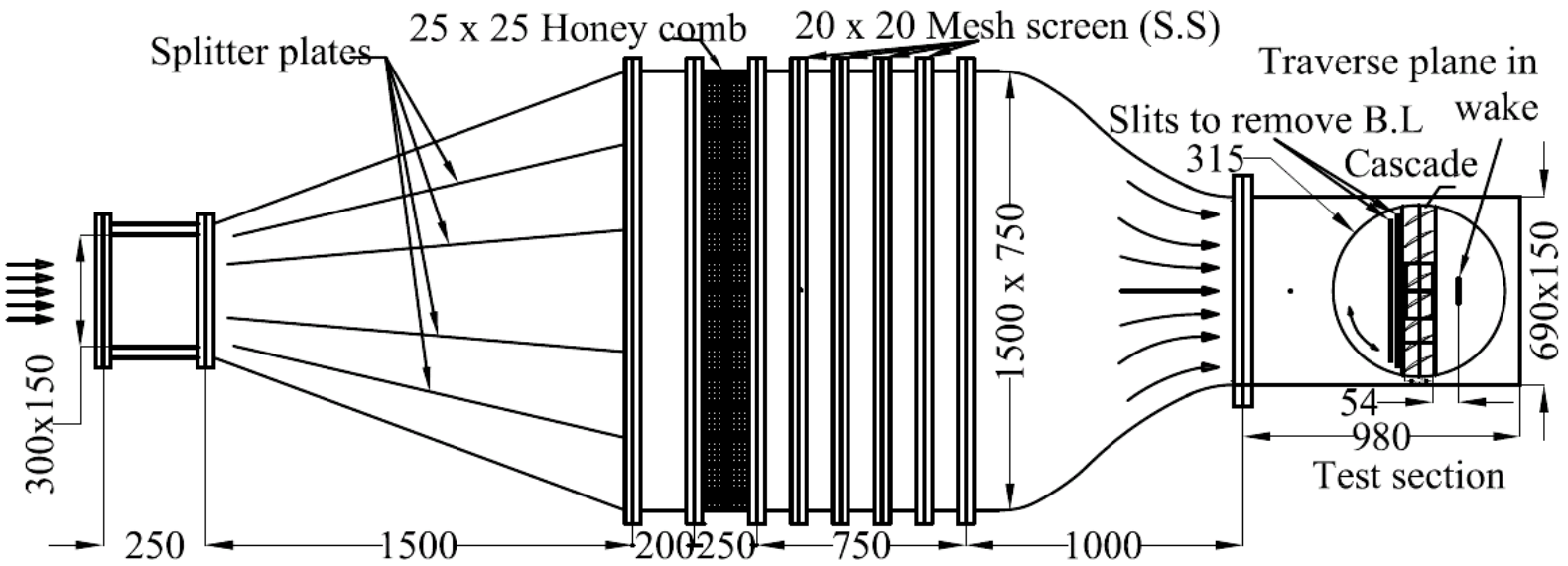
Turbomachinery Research Laboratory

Department of Aerospace Engineering
Indian Institute of Technology Bombay
Mumbai 400076, India

A M Pradeep and Bhaskar Roy
ampradeep@aero.iitb.ac.in, aeroyia@aero.iitb.ac.in

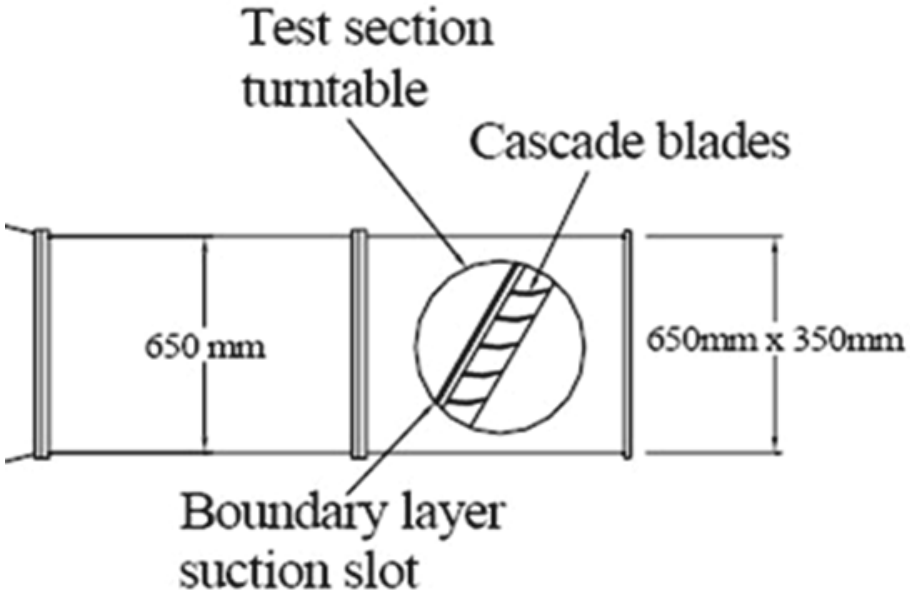
- Current research activities
  - Cascade studies
    - Highly loaded compressor blade aerodynamics
    - Tandem cascades
    - Swept and lean blades (compressor and turbines)
    - Endwall contouring in compressors
    - Secondary flow control (compressor and turbines)
  - Low speed axial compressor
    - Stall inception studies
    - Tip leakage flow physics
    - Rotor tip leakage-cantilevered stator leakage interaction
  - Contra-rotating axial flow fan studies
    - Stall inception studies
    - Tip leakage flow physics
    - Inflow distortion
  - Turbine exhaust diffuser analysis

Low Speed Cascade Wind Tunnel



Test conditions

- Flow Velocity = 40 m/s
- Mach Number = 0.1
- Blade Chord Re number = 1.3 x 10^5
- Test Section Mass Flow = 2.4 kg/s
- Angles of Incidence = - 17° to +13°
- Atmospheric Temperature = 300 K
- Compressor and turbine blades
- Moving end wall



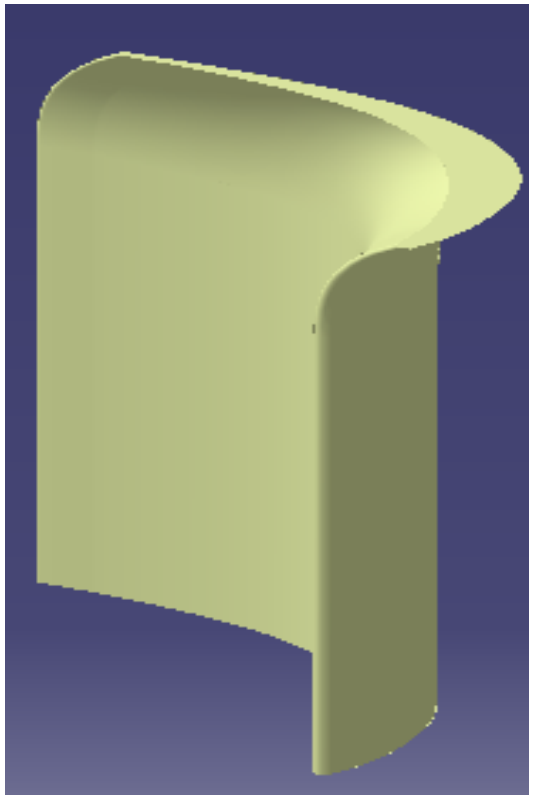
Moving endwall mechanism

Low speed cascade wind tunnel at IITB

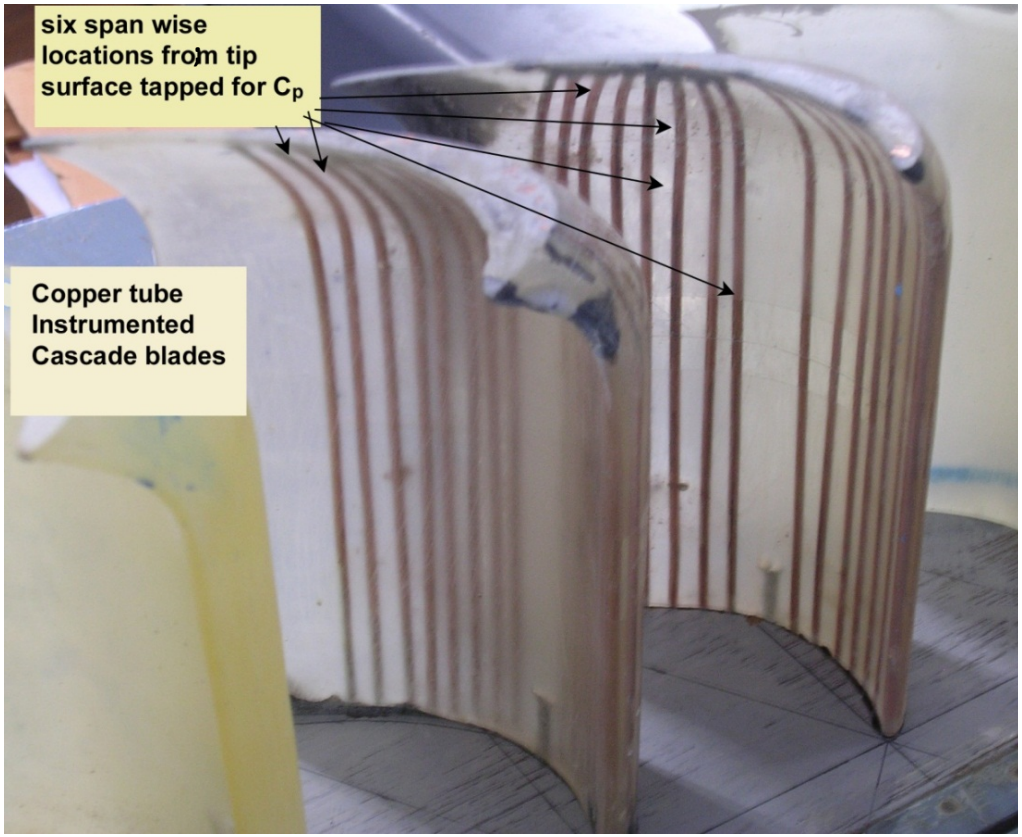
Cascade tunnel with the 2D auto traverse mechanism

Effect of Sweep and Lean on Aerodynamic Performance of Turbine Blades

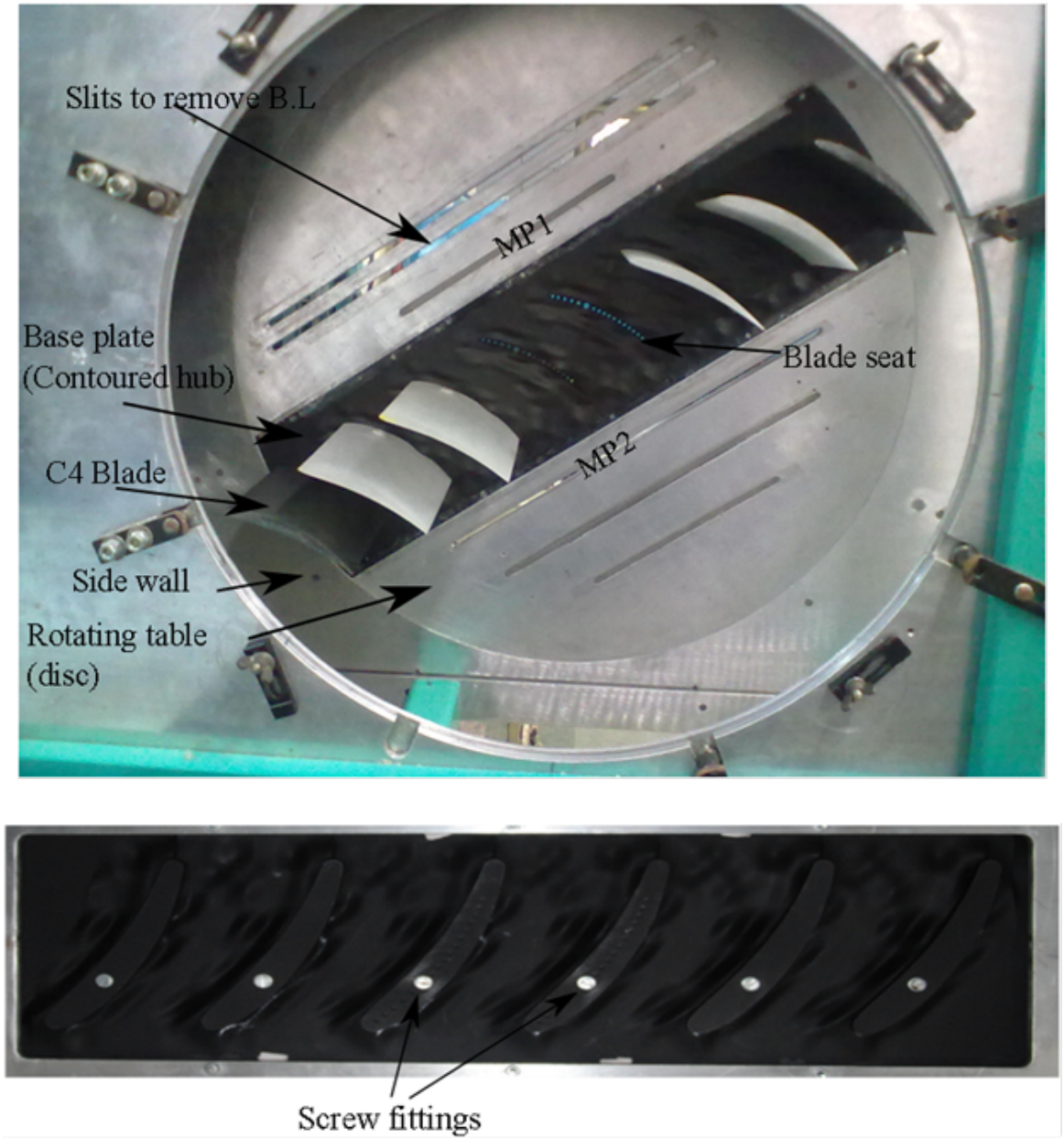
- Three cascades studies - straight, swept and leaned (in the 20% at tip)
- Pressure taps at 5 rows from the tip and one row at mid span



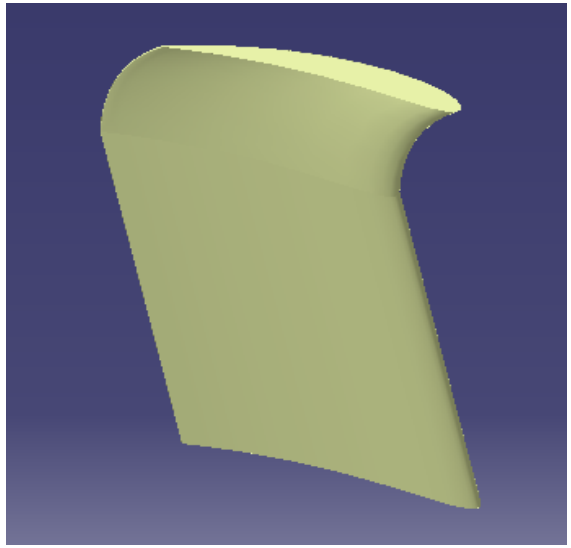
Swept turbine Blade



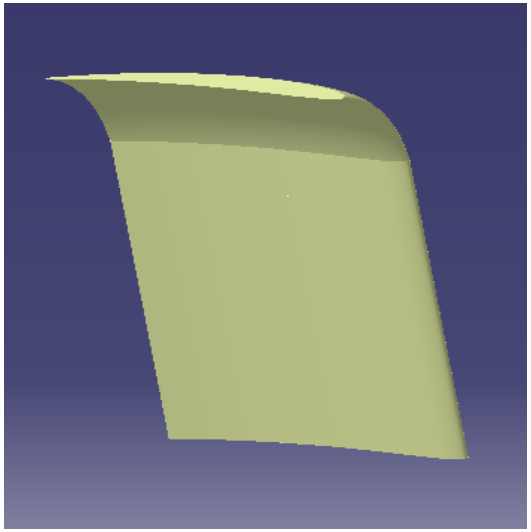
Leaned Turbine Cascade blades



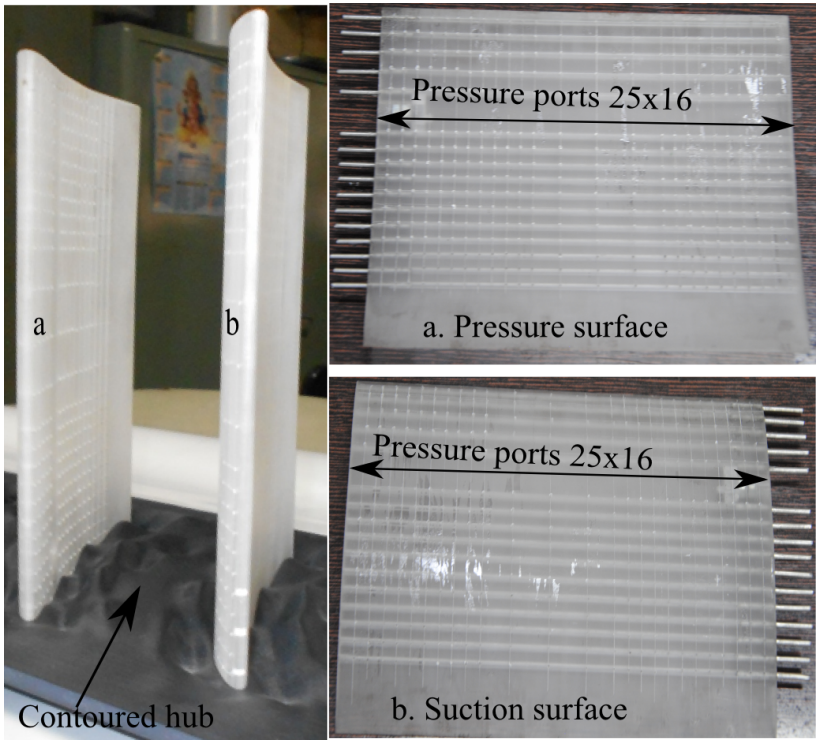
Cascade test section with contoured endwall and blade mountings



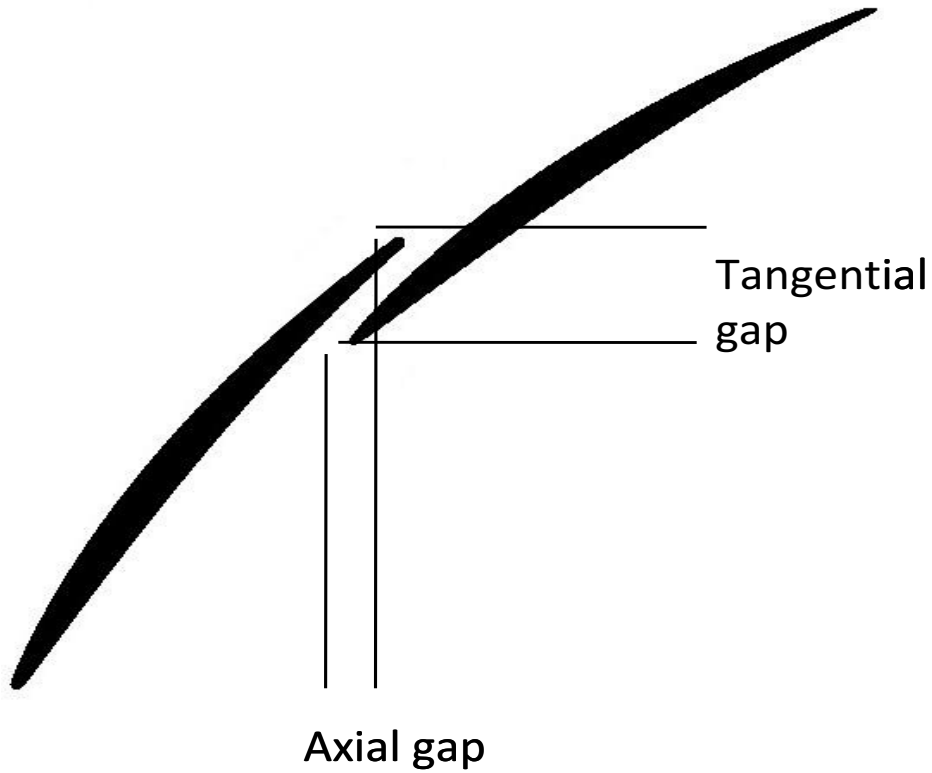
Swept Compressor Cascade blade



Leaned Compressor cascade blade

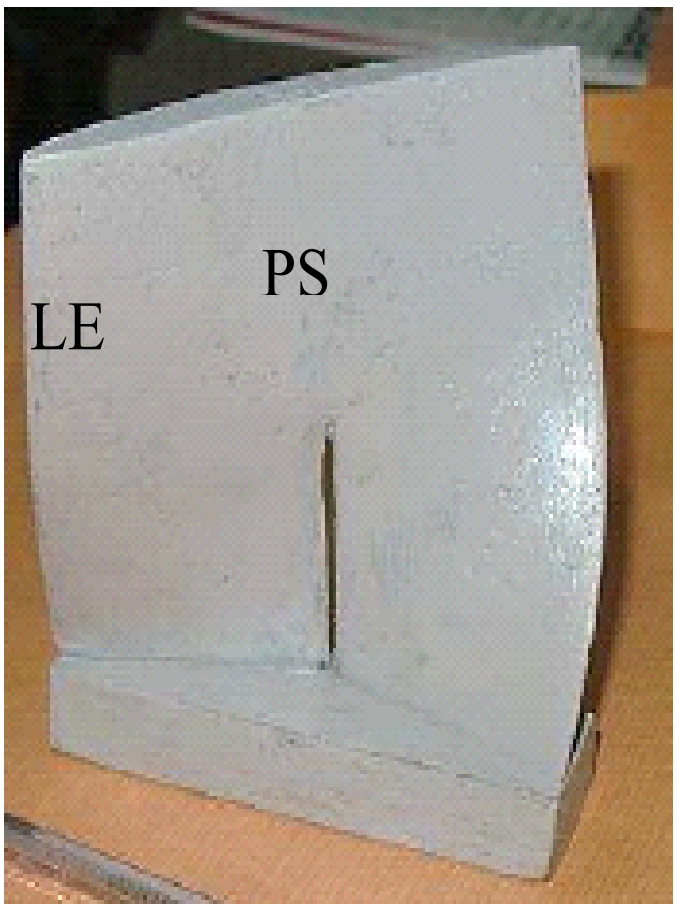


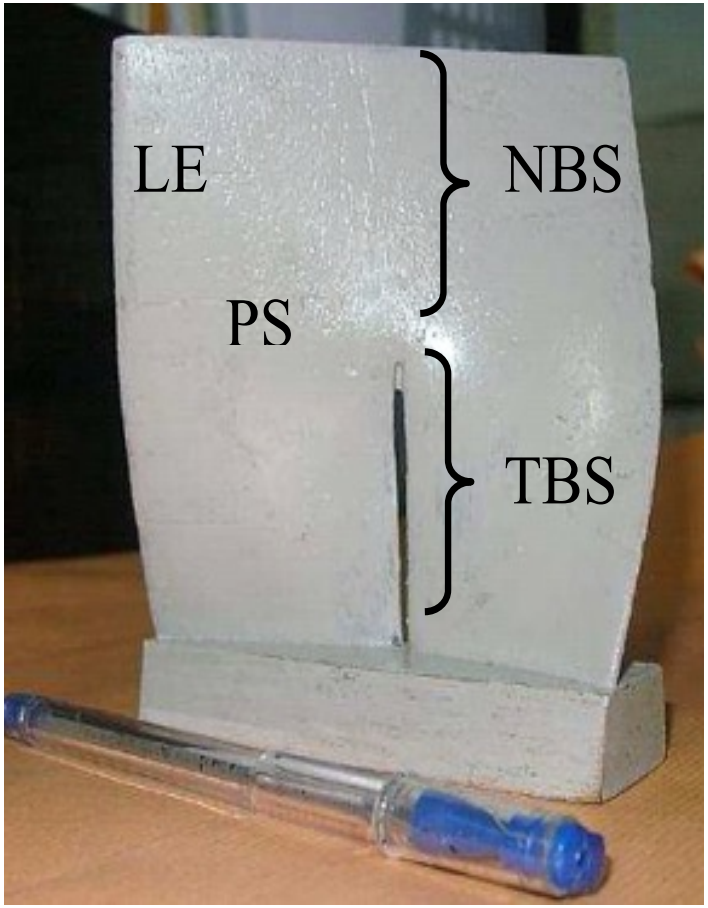
Cascade Blade tapping for Cp measurement



Tandem configuration: Axial and tangential gaps, individual tandem blade chords : cascade and rotor blade studies at low speed

Part Span Tandem Bladed Rotor at IITB





LE – Leading edge, PS – Pressure surface,
NBS – Normal blade section, TBS – Tandem blade section

Axial Fan Test Rig

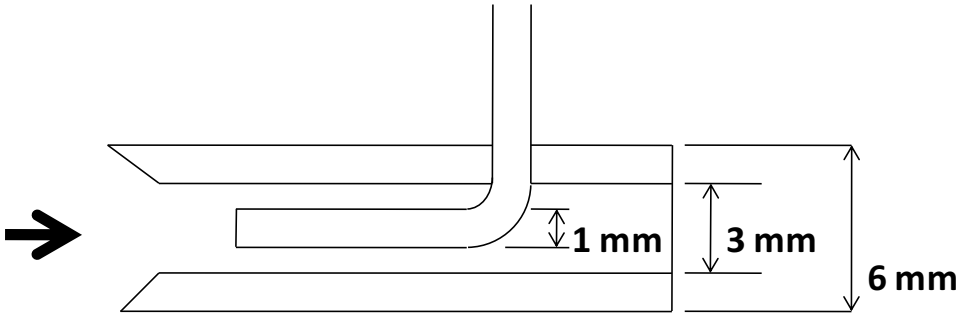
- 1.5 stage (IGV+rotor+stator) axial compressor test facility
- Design mass flow 8 kg/s @ 2400 rpm
- Compressor tip diameter: 0.5 m
- Blades fabricated : ABS plastic moulding (Rapid prototyping)

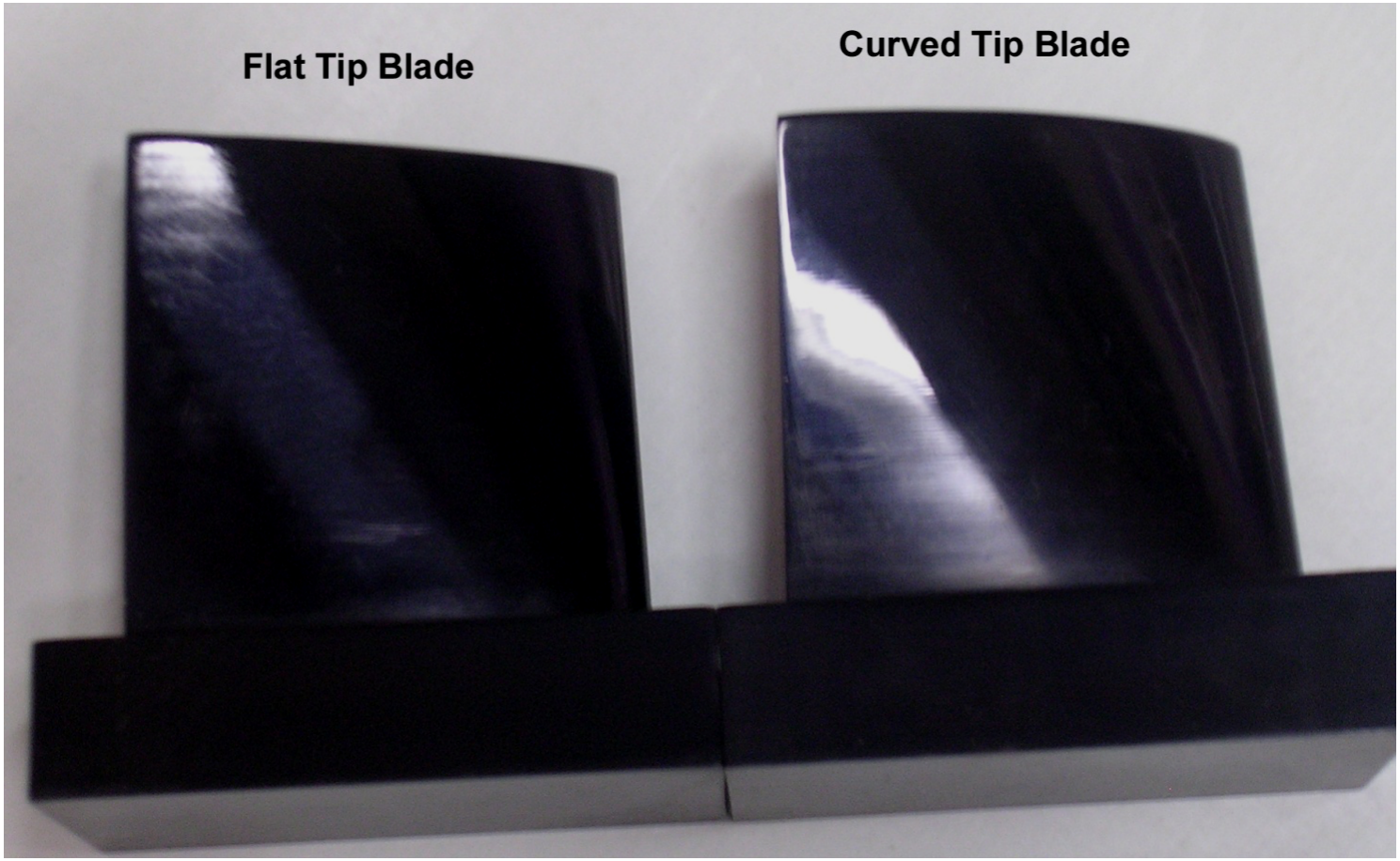
- Axial compressor rig: current tests
  - High hub-tip ratio rotor blades
  - Effect of varying tip clearance on performance at design and off-design conditions
  - Effect of varying tip geometries (and clearance) on performance and design and off-design conditions
  - Tip flow measurements using hot wire probes

Turbine Exhaust Diffuser Test Rig

Various probes on the set up

Kiel Probes traverse for Total pressure survey from hub to tip

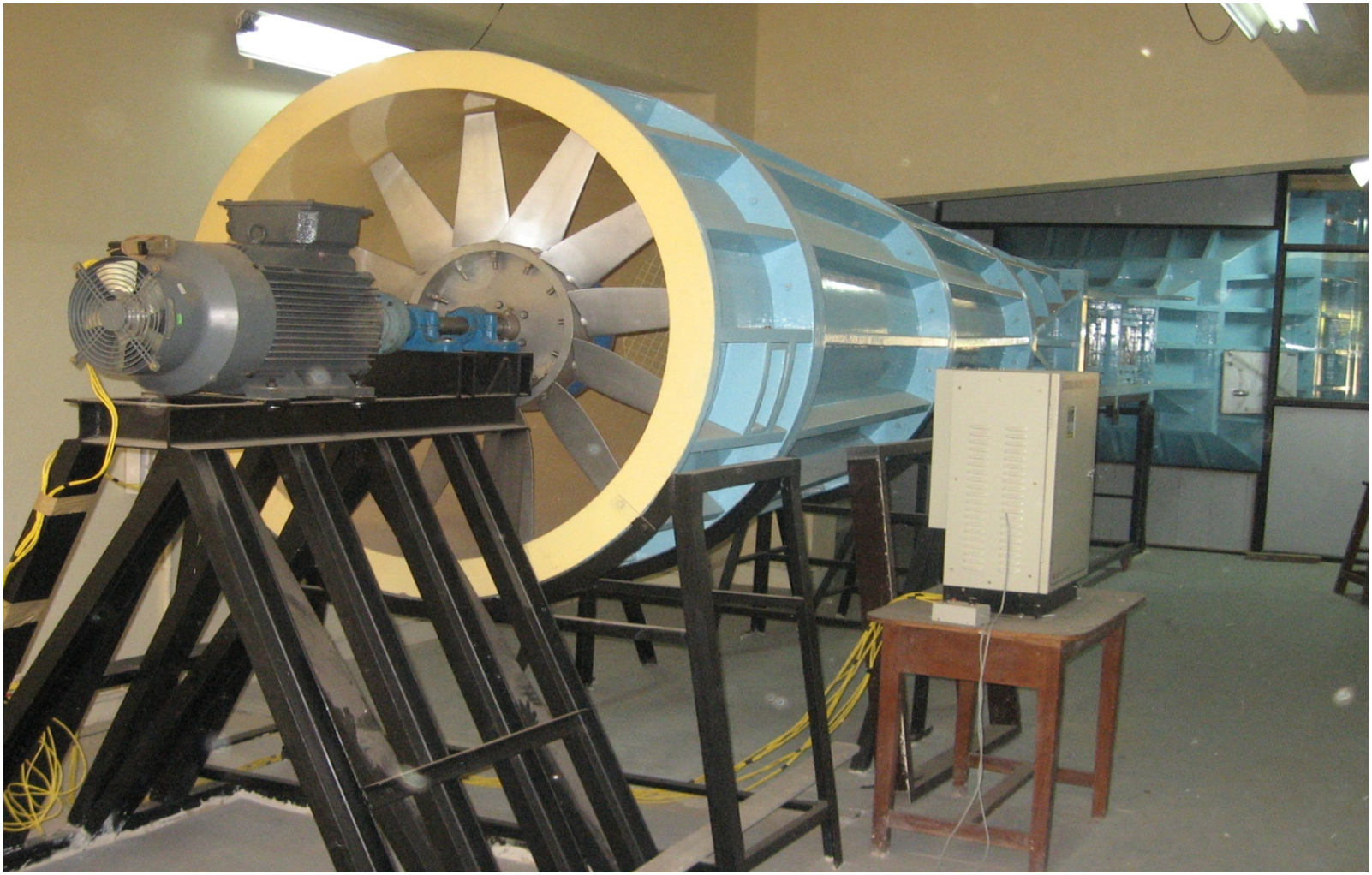




Blades fabricated by rapid prototyping

Low Speed Low Turbulence Wind Tunnel

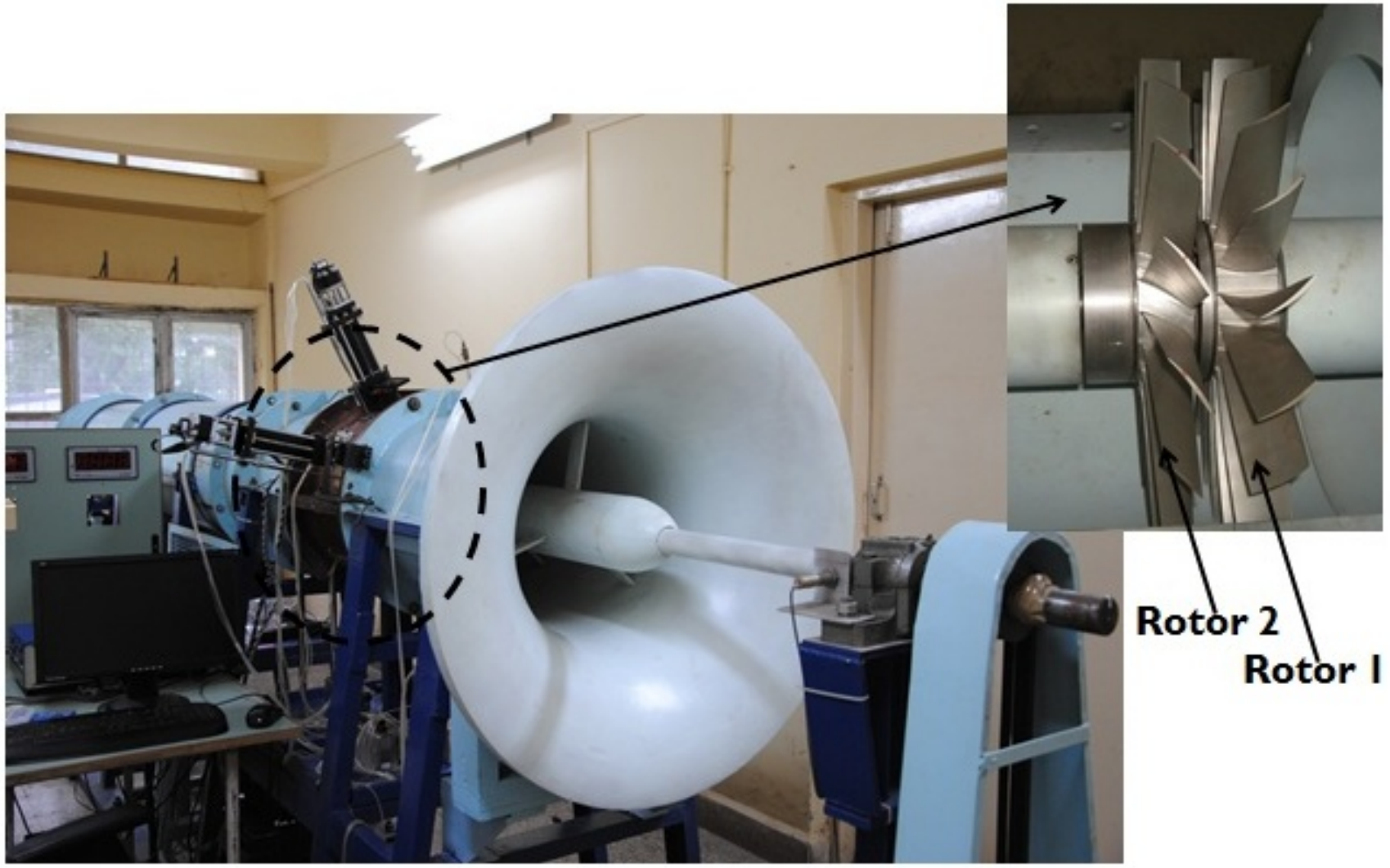
- Suction type open circuit wind tunnel
- Low subsonic: Max speed 40 m/s
- Test cross section: 2’x 2’
- Low turbulence levels: < 0.1 %
- Provision for flow visualization



Low speed, low turbulence wind tunnel at IITB

Contra-rotating Axial Flow Fan Test Rig

- Rotational speed: 2400 rpm
- Mass flow rate: 6 kg/s
- Aspect ratio: 3.0
- Hub-tip ratio: 0.35
- Casing diameter: 406 mm
- Reynolds number: 5×10^5
- Provision to vary the axial spacing, speed ratio etc.



Contra-rotating axial flow fan test rig

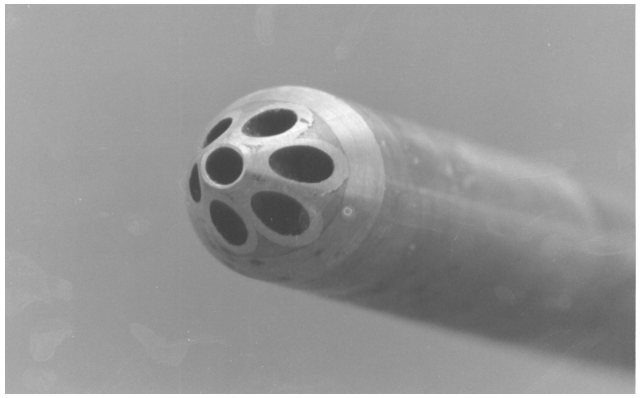
Instrumentation

- Pressure
  - Digital micromanometers
  - Scanivalves (48 channel)
  - Unsteady pressure transducers (Kulite)
- Pressure Probes
  - Kiel probes
  - 7-hole probes
  - 3-hole cobra probes
  - Boundary layer probes
  - Pitot static probes
  - Total pressure probe rakes

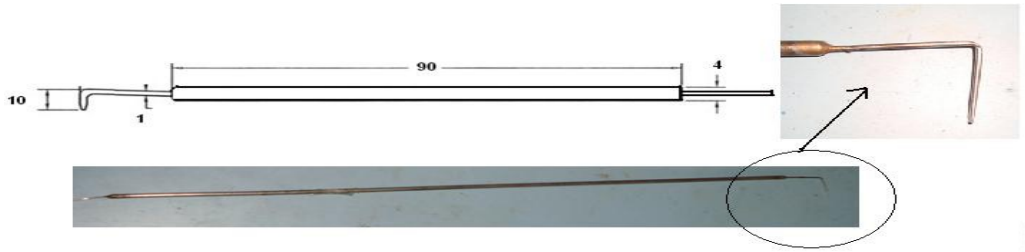
Instrumentation (cont...)

- 3-channel hot wire anemometer (Dantec)
  - Variety of 1-D, 2-D and 3-D probes, split fibre probes
- Digital mass flow controllers
- Torquemeters
- Auto and manual traverses for probe traverse
- Data acquisition systems
- PC interfaces
- Flow visualization: Smoke, tufts, oil

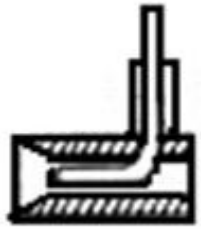
3-hole cobra probe

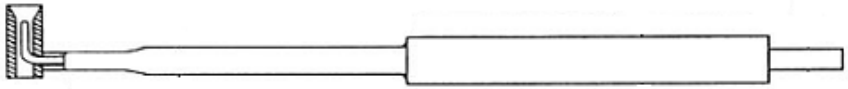


7-hole probe

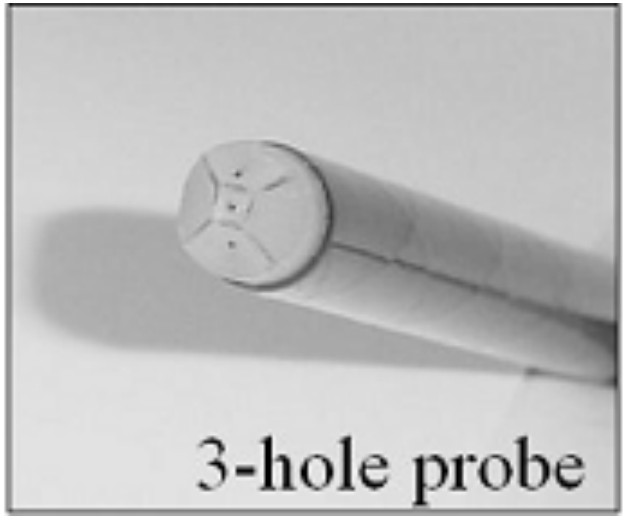


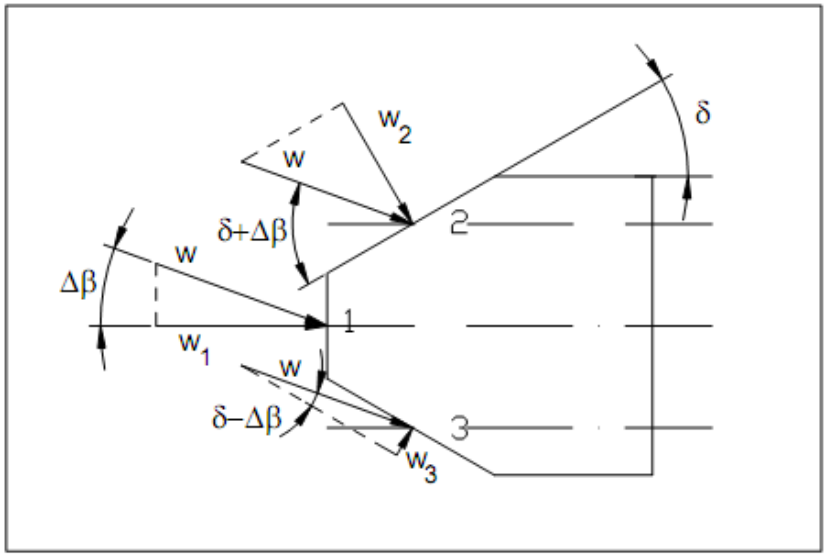
Boundary layer probe





Kiel probe





3-hole probe

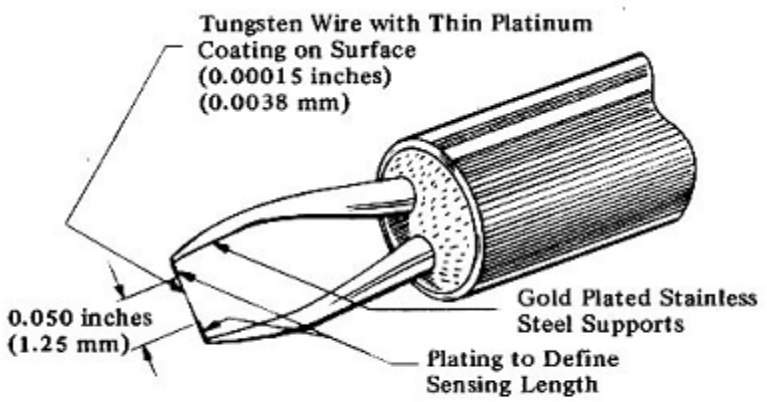


Figure 1: Tungsten Hot Wire Sensor and Support Needles-
0.00015" Dia. (0.0038 mm)

Hotwire probe

Total pressure rake