Gas Turbine Heat Transfer Laboratory

Laboratory Coordinator: Dr. A. K. Saha

Associated Faculty Members (if any):

List of Major Equipment:

- IR Camera
- High Speed Blower
- High Speed Camera
- Shadowgraph/Schlieren Setup
- Multiple Cameras, Laser as light-source, Optical quality mirror.
- Laser Doppler Velocimetry (LDV)
- Laser Induced Fluorescence (LIF)
- Hot-wire Anemometry, Load-Cell
- Constant Temperature Water Bath
- Rotating Test Rig

Brief description of the laboratory:

Heat transfer laboratory caters for the research in gas turbine application, fundamentals of heat transfer and flow physics. The IR thermography and Schlieren systems are the two most important equipment that help in getting spatial distribution of heat transfer unlike the thermos-couple which provides point measurements. The rotating test rig is another facility that helps in getting the convective heat transfer co-efficient under rotating conditions.

Vayu, a parallel cluster machine used in our laboratory for high-fidelity simulations of flow and heat transfer over an array of bluff bodies.

Laboratory research keywords:

IR thermography; Schlieren system; Rotating test rig

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	• The enhancement of heat transfer from a rib-roughened surface under rotating conditions has been carried out at various Reb and Rotation numbers. The effect of rib geometry and duct aspect ratio is also studied. • Fluid flow measurement in a convectively cooled plate using a synthetic jet with the help PIV is being carried out. • Computation of heat transfer enhancement from an array of heated bodies mounted on a wall is carried out at high Reynolds number using the parallel cluster machine. • Three-dimensional simulation of head-on and off-center collision of two

	miscible liquid drops is performed to see the effect of drop inertia and impact parameters on flow characteristics, energy budget and mixing index using a parallel clustered machine.
2019-2020	• The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken at various Reynolds number and Rotation numbers. • Fluid flow measurement in a convectively cooled plate using a synthetic jet with the help PIV is being carried out. • Computation of heat transfer enhancement from an array of heated bodies mounted on a wall is carried out at high Reynolds number using the parallel cluster machine. • Computation of coalescence of two drops of different liquid properties is conducted to investigate the influence of surface tension gradients on partial coalescence process.
2018-2019	• The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken for various rib geometries and duct aspect ratio. • Computation of heat transfer enhancement from a heated body mounted on a wall is carried out at high Re using the parallel cluster machine. • Simulations are performed to examine the behavior of physical properties of surrounding liquid as well as the drop liquids in various pinch-off regimes during coalescence of two unequal-sized drops.
2017-2018	• The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken for various rib geometries and duct aspect ratio. • Computation of heat transfer enhancement from a heated body mounted on a wall is carried out at high Re using the parallel cluster machine. • The mechanism of heat transfer between solid and liquid surfaces has been analyzed using oblique high-speed cold micro-sized drop impact on a hot liquid film with variations in impact velocity, impact angle and liquid film thickness.
2016-2017	• The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken for various flow velocities. • Computation of heat transfer enhancement from a heated body mounted on a wall is carried out at high Re using the parallel cluster machine. • The mechanism of heat transfer between solid and liquid surfaces has been analyzed using normal high-speed cold micro-sized drop impact on a hot liquid film with variations in impact velocity and liquid film thickness.
2015-2016	• The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken for various rib geometries and duct aspect ratio. • Computation of heat transfer enhancement from a heated body mounted on a wall is carried out at high Re number using parallel cluster machine. • The mechanism of heat transfer between solid and liquid surfaces has been analyzed using normal high-speed cold micro-sized drop impact on a hot liquid film with variations in impact velocity and liquid film thickness.

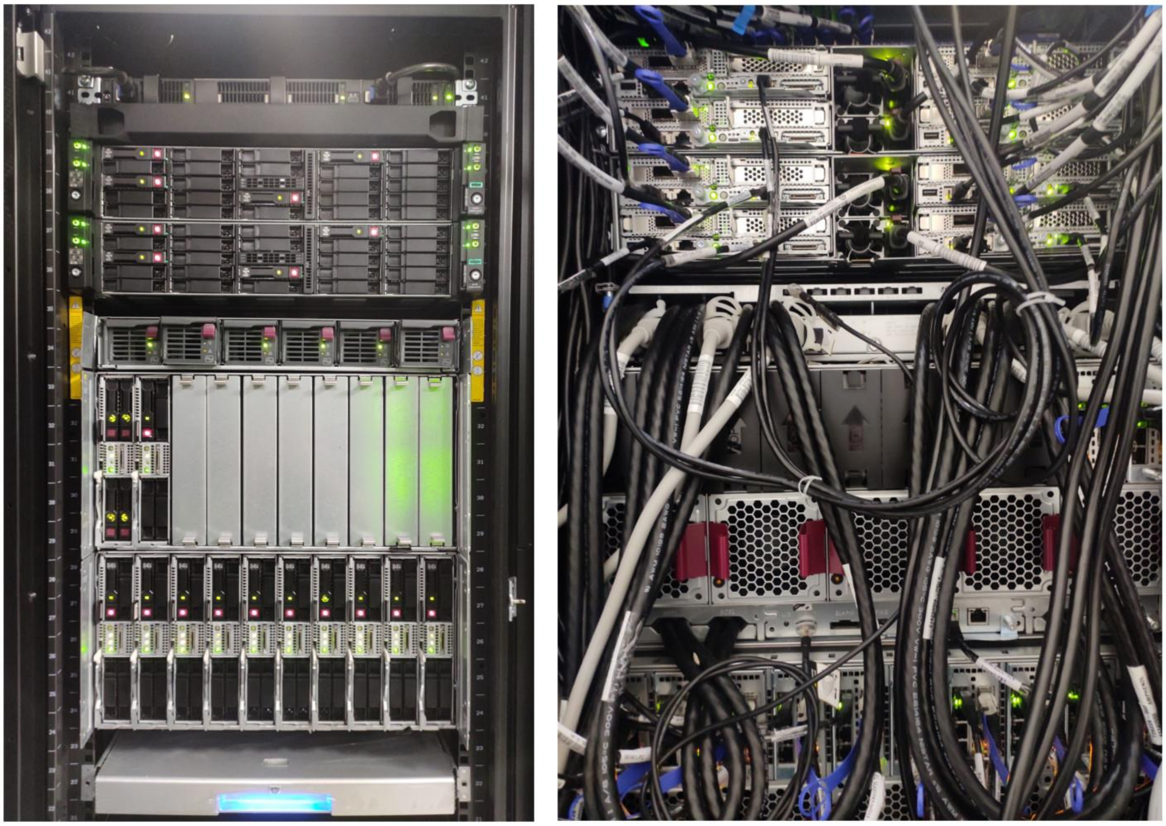


Figure #1: *Vayu*, a parallel cluster machine used for high-fidelity simulations.

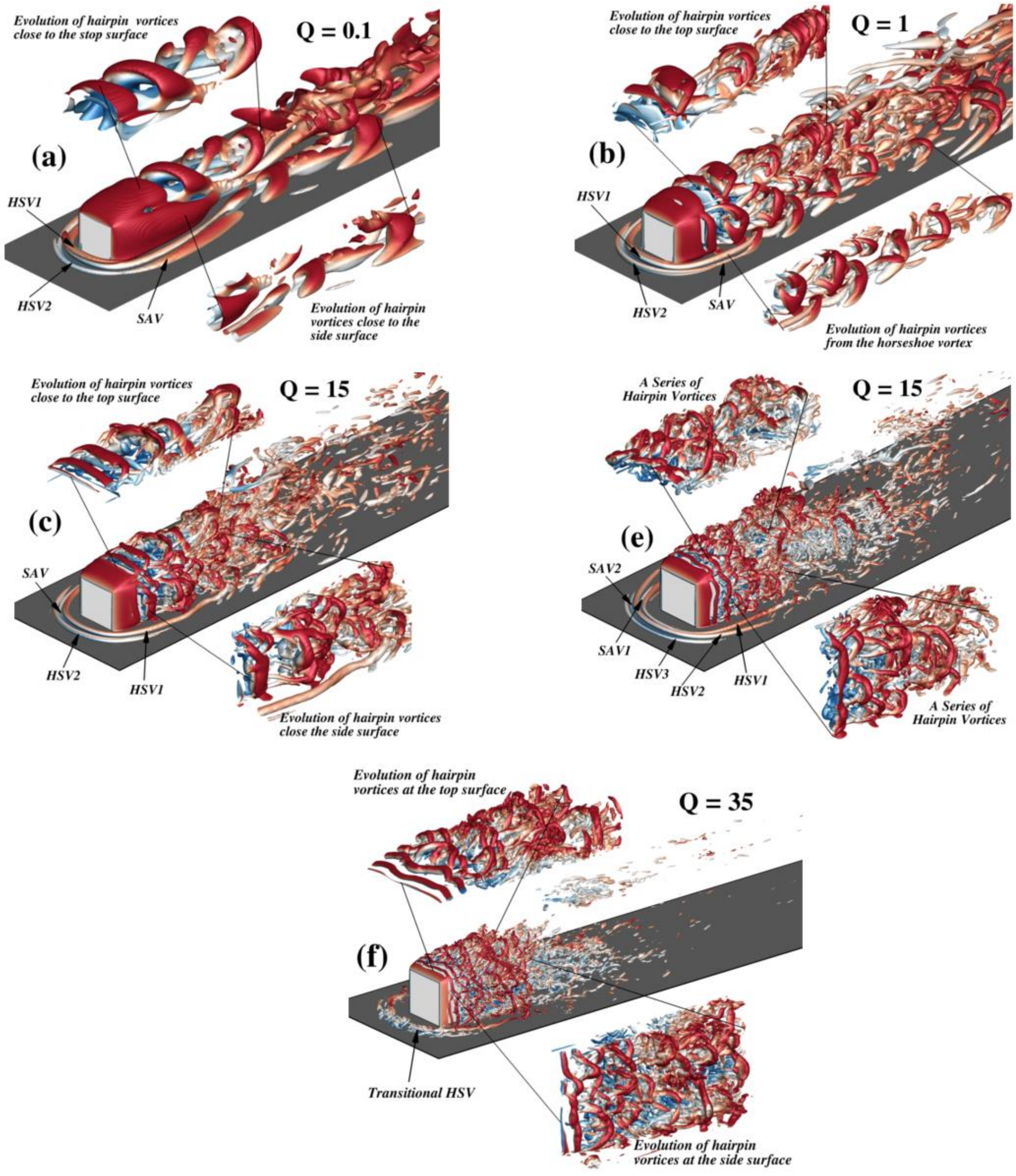


Figure #2: Iso-surface of instantaneous Q-criteria coloured by the streamwise velocity for the Reynolds numbers (a) 500 (b) 1000 (c) 2000 (d) 3500 and (e) 5000.

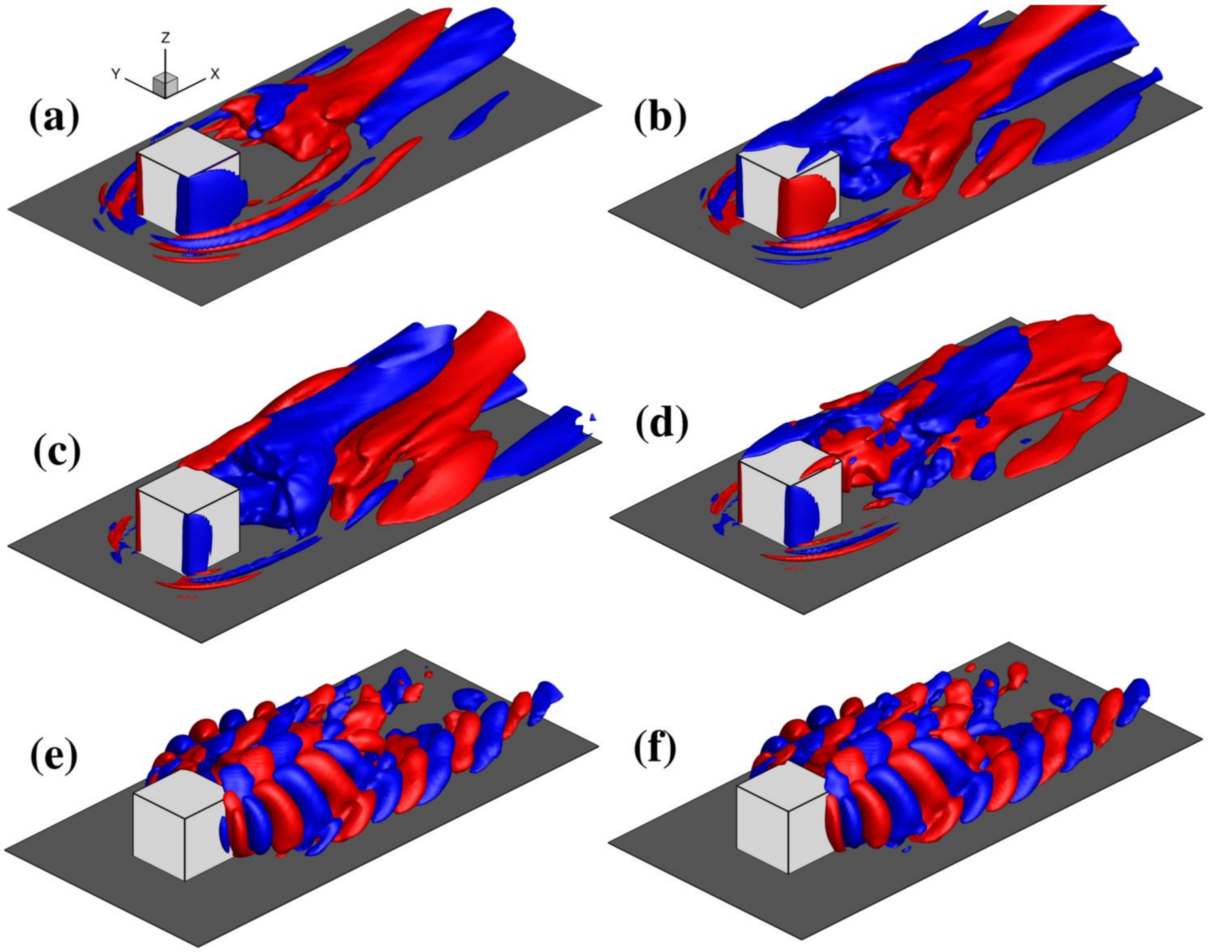


Figure #3: Iso-surface of fluctuating spanwise velocity (v') showing the three-dimensional POD modes: (a) mode 1 (b) mode 2 (c) mode 3 (d) mode 4 (e) mode 5 and (f) mode 6, for a Reynolds number of 1000

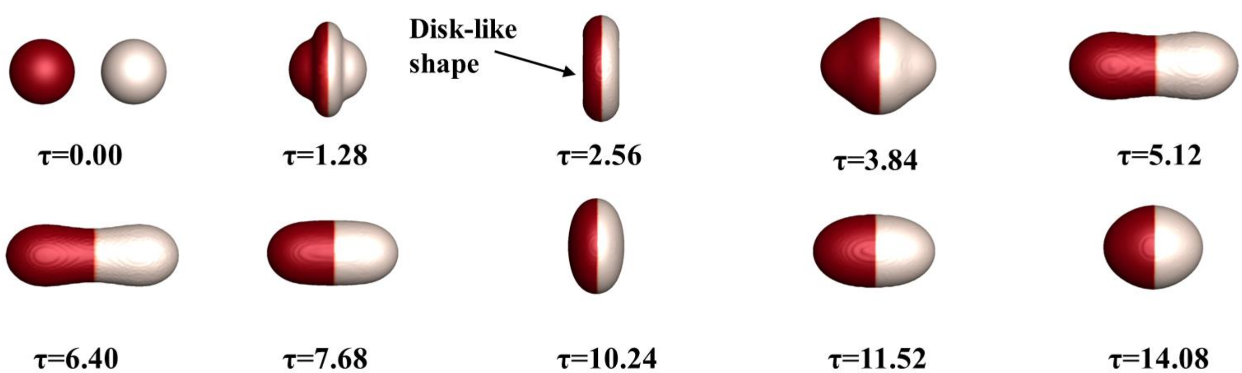


Figure #4: Head-on collision dynamics of ethanol (dark red) and water (white) drop resulting in coalescence at Reynolds Number=335 and Weber number=8.

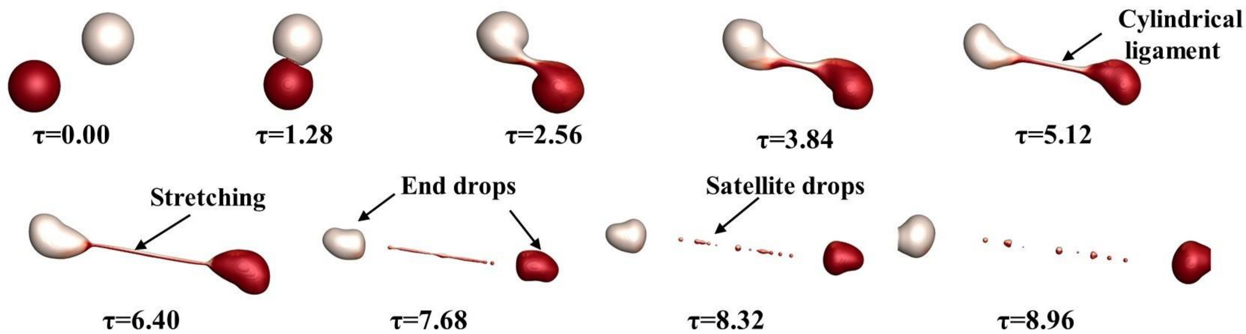
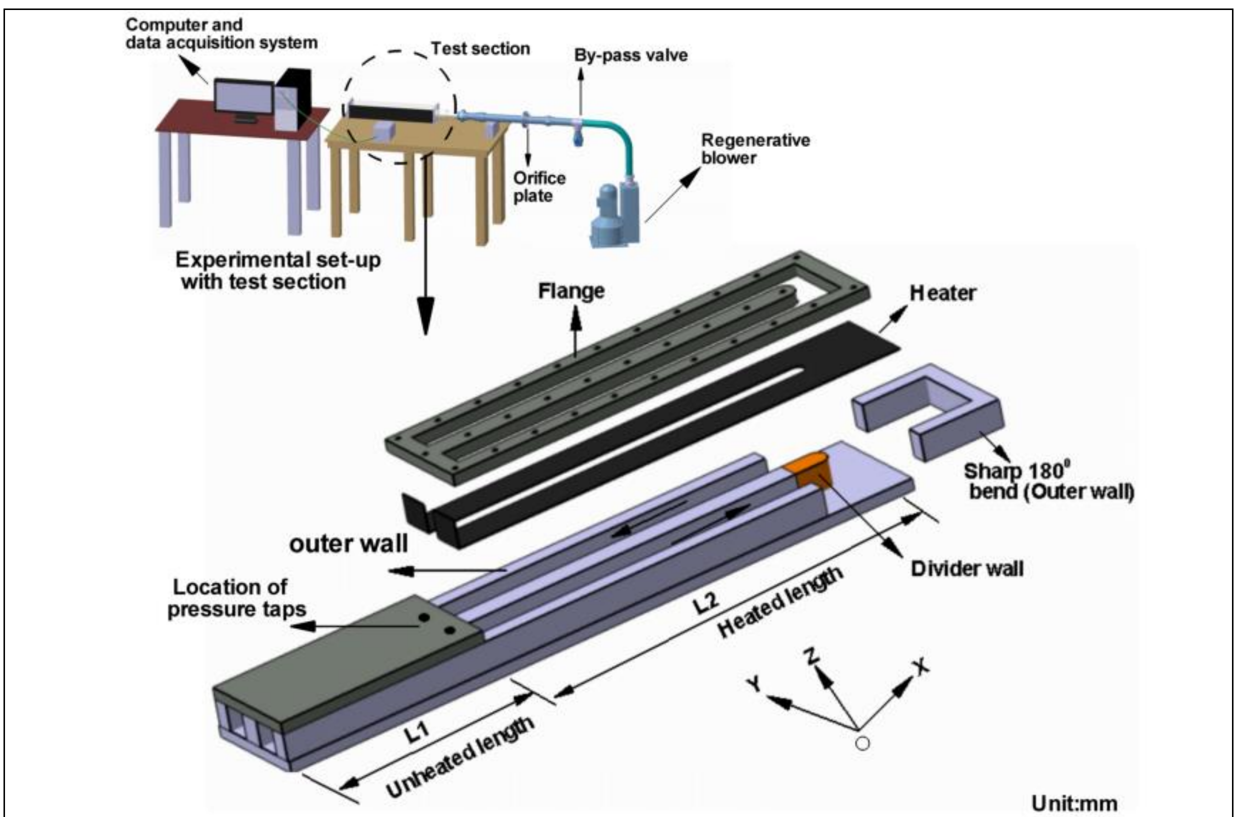


Figure #5: Off-center collision dynamics of ethanol (dark red) and water (white) drop resulting in stretching separation at Reynolds Number=710, Weber number=35 and impact parameter=0.9.

R&D facility



AR=(W/H)	1:2	1:1	2:1
W	18	24	36
H	36	24	18

Figure #1: Stationary experimental set-up with exploded view of the test section used in experiments.

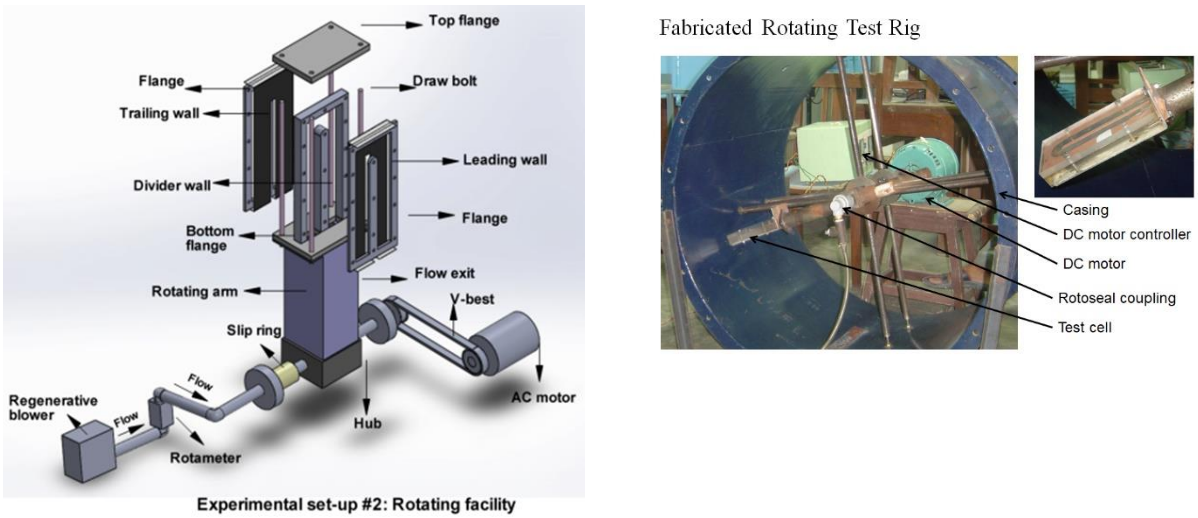


Figure #2: Rotating experimental set-up with exploded view of test section used in experiments

Figure #3: Infra-red camera.

PhD Students:
[1] Swati Singh
[2] Basheer Ahmad Khan

Post Doc:
[3] Dr. Gaurav Saxena