INSTRUCTION MANUAL
FOR
THERMAL SCIENCE LABORATORY EXPERIMENTS

FREE AND FORCED CONVECTION

INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
DEPARTMENT OF MECHANICAL ENGINEERING
NORTH GUWAHATI, GUWAHATI-781039

GENERAL INSTRUCTIONS

1. The instructions in this manual provide only the outline. Come prepared with the back-up material i.e. go through the theory related to the experiments, know in advance the readings to be taken, the calculations to be performed and the results to be presented

2. The data sheets are to be countersigned by the instructor. The calculations are to be completed and checked by the instructor on the same day. The complete report should be submitted on the day of next lab class.

3. Each student has to submit his/her individual report and his/her individual comments and remarks.

4 The report should include
   - The aim of the experiment
   - A sketch/block diagram of the apparatus
   - A listing of the instruments used with details (type, range, accuracy etc.)
   - Transient/steady state readings in tabular form
   - Results in graphical form where required
   - Comments and natures of the results with standard/reference values.
   - Source of errors and error analysis.

5. The report need not include
   - A description of the Apparatus
   - A description of the experimental procedure

6 The following points should be attended before starting the experiment.
   - Take note of any precaution with regard to the experimental set-up
   - Check electrical connections before starting the experiment.
   - Clarify any doubt with regard to the experiment
   - Do not put on the computer attached to the set-up

DO NOT PUT ON THE SYSTEM UNTIL THE CONNECTION ARE CHECKED BY THE INSTRUCTOR

FREE AND FORCED CONVECTION

AIM: To determine the effectiveness and heat transfer coefficient in free and forced convection it for a flat heated surface.

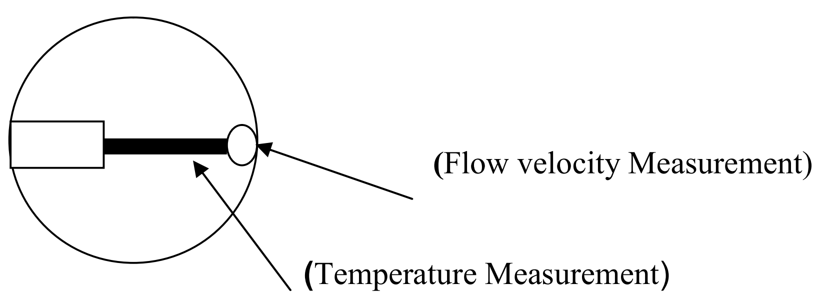
PRINCIPLE: In free convection, fluid motion is due to buoyancy forces within in the fluid, while in forced convection it is externally imposed. Buoyancy is due to the combined presence of a fluid density gradient and a body force that is proportional to density. In practice, the body force is usually gravitational, although it may be a centrifugal force in rotating fluid machinery or a coriolis force in atmospheric and oceanic rotational motional motions. The density of gases and liquids depends on temperature, generally decreasing (due to fluid expansion) with increasing temperature.

DESCRIPTION: The air duct used to guide the flow of air and is fitted with measuring glands which enable the temperature and flow rate to be measured at different positions using measuring probes .The duct has across section of 120 x120 mm^2 and is 1m long. Twelve measuring glands are arranged over the duct such that the temperature and flow rate can be measured at all relevant positions by inserting probes. A built –in fan with adjustable speed mounted at the top of the tank is used to suck the air for experiment on forced convection.

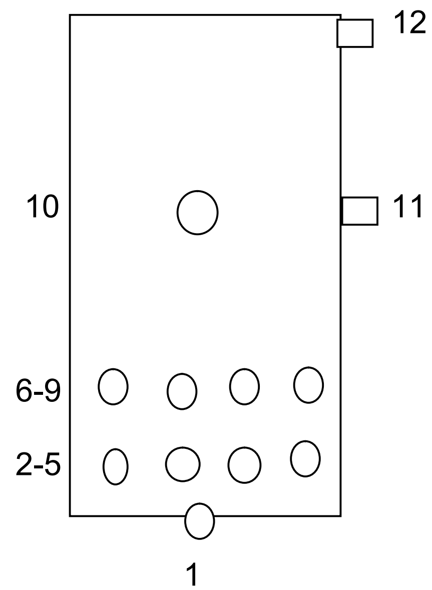
Heater inserts are used in ducts. These are mounted using simple toggle type fasteners. The different heated surfaces (flat plate, cylinder or fins) are heated by four resistive heaters with a maximum total power readout of approximately 170W .the applied voltage is adjustable by a variable heat output.

The control and display unit contains the power supply and regulators for the fan and heater inserts. In addition, this unit displays the electrical power supplied to the heater elements. A digital display provides a temperature read-out provided by a type K thermocouple.

Air velocity measurement and temperature measurements are simultaneously carried out by a thermal probe as shown in fig below.



The flow velocity is measured using the sphere on the tip of the probe. This sphere is heated. The air flowing round the sphere cools it down. At the same time, the resistance of the NTC resister in the tip changes. In order to maintain the sphere at constant temperature, an electronic circuit increases the heater current. By this means the heater currents becomes a measure of airflow velocity. The thermocouple measures the temperature. This probe cover the flow velocity range of 0.2-10 m/s. the temperature range covered by this probe is –20-70^{0}C.



Measuring Points	Measurements	Measurement probe
1 &12	Inlet temperature and flow velocity	Air probe
2-5	Surface temperature of the heat source	Thermocouple
6-9	Temperature layering of the air after the heat source	Thermocouple
10 & 11	Flow velocity and temperature profile of the air	Air probe

PROCEDURE:

Free convection:

1) One of the heater inserts is mounted in the air duct .the potentiometer on the control unit set to approx.160w after the power supply has been given.
2) Once the steady state condition has been reached, that is not noticeable temperature change at the surface of the heater element, take the temperature an\d velocity at various measuring points as suggested by the above table and the surface temperature.

FORCED CONVECTION:

1) Immediately, after of the free convection experiment, the fan is put on and the flow velocity is set to around 2.0 - 2.8 m/s using the knob for the fan the control panel.
2) Once the steady state is reached, take the reading and velocity at various points as suggested by the above table.
3) Before the putting off the switch, set the potentiometer of the heater to zero.

WARNING:

1) Do not touch the heated surfaces at the end of the experiment or place them near the items sensitive to heat.
2) Use the right the sensors at each location as suggested by the above table. Note that the thermal probe is very sensitive. If the temperature is above 70^{0}C, it will damage the probe.
3) Do not connect the heater directly to mains.

4) Always switch off the control and display unit prior to changing the power supply or changing the heater inserts. Otherwise, the temperature sensors may get damaged. Before putting off the control unit, set the heater power and fan speed to zero.

DATA:

The amount of heat transferred by air = $\dot{Q} = \dot{m}\ C_p\ (T_{out} - T_{in})$

Effectiveness of the free/forced convection = $\eta = \dfrac{\dot{Q}}{P}$

P = power supplied

Heat transfer coefficient = $\dfrac{\dot{Q}}{A\Delta T_m}$

Logarithmic temperature difference $\Delta T_m = \dfrac{T_{10} - T_1}{\ln \dfrac{T_S - T_1}{T_S - T_{10}}}$

Where T_s is the surface temperature.

RESULTS:

Calculate the effectiveness and heat transfer coefficient in free convection and forced convection for heater inserts experimented.

TECHNICAL DATA

Dimensions of the air duct: Cross-Section area = 120X120 mm^2

Height = 1 meter

Heated Surface area: Flat Plate = 0.014 m^2

Cylinder = 0.098 m^2

Fins = 0.14 m^2

Guidelines for Report Preparation

The report should include

- Aim of the experiment
- Schematic/block diagram of the experimental set-up
- List of the instruments used with details (type, range, accuracy etc.)
- Data sheets of steady state readings
- Sample calculation of one reading (Each for linear and radial)
- Graphical results (Heat transfer co-efficient vs. Velocity for different inserts)
- Error/Uncertainty analysis
- Conclusion

The report need not include

- Description of the experimental set-up
- Description of the experimental procedure

Note: A single copy of lab report needs to be submitted per group on the same day.

Forced Convection

Insert: Rectangular fins A=0.14 m^2 Heat input: 115

Sl. No	Velocity	Insert temperature (°C)				TS	T1	T10	η	h
		T3	T5	T7	T9					
01	2	39	37	35	34	40	29	33		
	4	37	35	34	32	36	29	31		

Insert: Cylindrical Fins A=0.098 m^2 Heat input:86.8 W

Sl. No	Velocity	Insert temperature (°C)				TS	T1	T10	η	h
		T3	T5	T7	T9					
01	2	38	37	35	34	38	30	33		
	3	36	35	33	33	35	30	32		

Free Convection

Insert: Rectangular fins A=0.14 m^2 Heat input: 60.7 W

Sl. No	Velocity	Insert temperature (°C)				TS	T1	T10	η	h
		T3	T5	T7	T9					
01	0.6	70	58	42	40	70	32	39		

Insert: Cylinder A=0.098 m^2 Heat input:43 W

Sl. No	Velocity	Insert temperature (°C)				TS	T1	T10	η	h
		T3	T5	T7	T9					
01	**0.6**	**62**	**56**	**40**	**39**	**65**	**33**	**38**		

Conclusion: