EXPERIMENT NO. III

AIR ENTRAINMENT INTO AN IRS DEVICE

Objective

To investigate air entrainment into a **louvered infrared suppression (IRS) device** experimentally on a laboratory scale set up both with cold air and hot air.

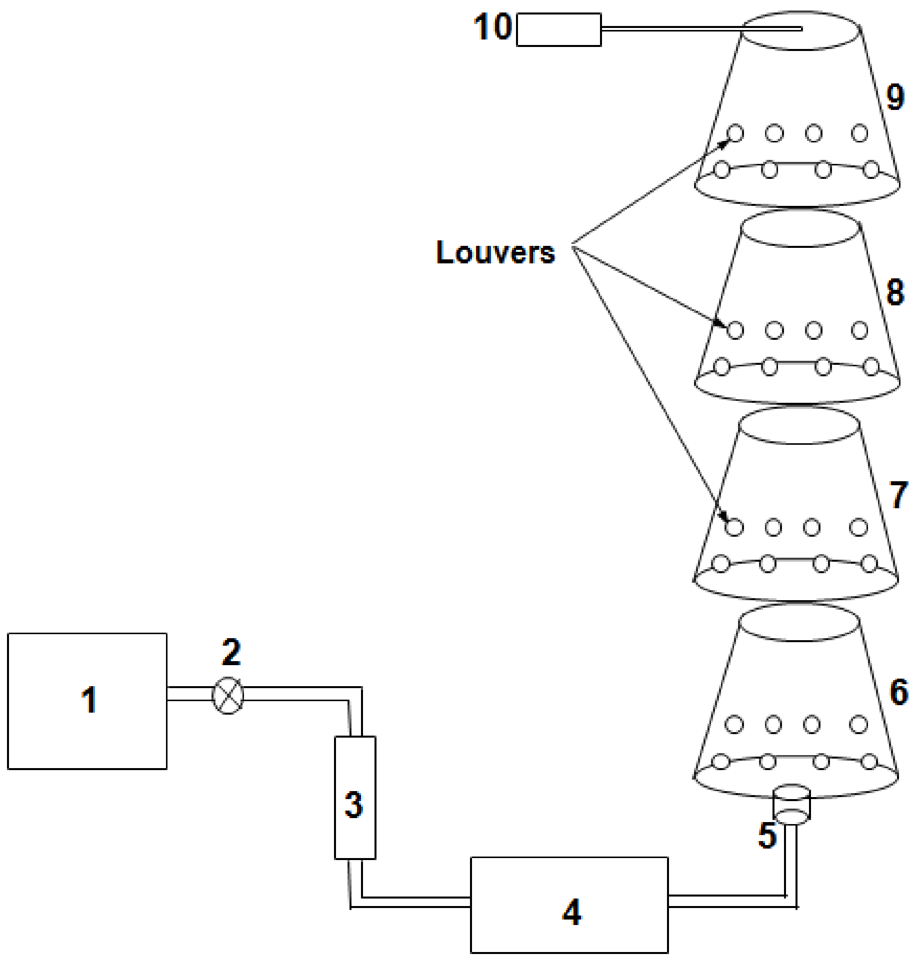
Experimental Set Up

Fig.1 shows the schematic diagram of experimental set up and sensor locations. From the experimental set up it is observed that the louvered IRS device may consist of two, three or four funnels, made up of thin mild steel sheet are stacked one up on another. The shape of each funnel is just like frustum of a cone. All the four funnels are similar in dimensions; each having a height of **20.7 cm**, top diameter of **14.4 cm** and bottom diameter of **20.4 cm**. Each funnel is having two rows of louvers located at a distance of about **5.15 cm** and **10.15 cm** respectively from the bottom of each funnel. Each funnel is having eight number of louvers per row each having diameter of **2.5 cm**, thus there are a total of **16 louvers** in each of the funnel as shown in the figure. These louvers are arranged in a circumferential manner around the surface of each funnel. This device is held vertically with the help of an iron stand. All the funnels and nozzle are attached to this iron stand by means of nuts and bolts. By sliding funnels through the groove provided in the iron stand the parameters like ***funnel overlap*** and ***nozzle protrusion*** can be varied easily. A nozzle diameter of **1.25 cm** is used for the present experiment. The nozzle receives high speed cold as well as hot air from the exit of the air heater through the connecting pipe. When heater is switched on the nozzle receives hot air; otherwise, it receives cold air. In house design and fabrication of air heater provides good temperature ranges (**60 ºC to 120 ºC**, approximately) for present experiment. A schematic view of the air heater as well as snap shots of the heater are shown in Fig. 2, 3 and 4 respectively.

The exit velocities at different locations on top-most surface of funnel and nozzle are measured by a hot wire anemometer. A hot wire anemometer is shown in the Fig.5.

Experimental Procedure

The air from the storage tank of a compressor (Fig.1) is allowed to enter the duct heater via a flow control valve, which can at the best monitor 150 l/min of flow by a rotameter. Experiments on hot air are carried out by heating air in a duct heater. The cold or the hot air is thrown vertically up into the IRS device from a metal **nozzle having a diameter of 1.25 cm and length of 7.5 cm.** In the present case, since the length to diameter ratio is very small, it is expected to have uniform velocity at the exit of the nozzle. The mass flow rate at the nozzle exit is varied using the flow control valve.



***1**. Air compressor* ***2**. Flow control Valve* ***3**.Rotameter* ***4**.Rectangular duct heater* ***5**.Nozzle*
***6**,**7,8,9**.Louvered IRS Funnels* ***10**.Velocity probe of hot wire anemometer*

***Fig.1**. Schematic diagram of the experimental set up and sensor locations*

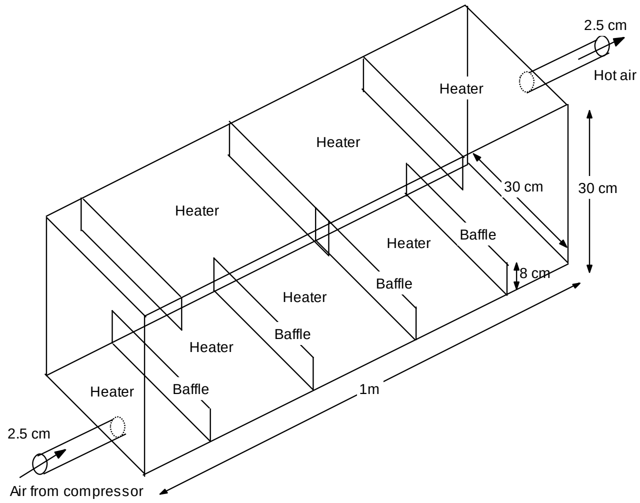


Fig.2. *Schematic view of the rectangular duct air heater*

Fig.3. *Snap shot of air heater*

Fig.4. *Snap shot of rectangular duct air heater*

Fig.5. *Snap shot of velocity meter based on hot wire anemometer principle*

The velocity is measured on the nozzle exit plane and at nine locations on the exit plane of the IRS device using **a single probe hot-wire anemometer** under isothermal conditions of ambient temperature. To ensure correct measurement of flow velocity, the probe of the hot-wire anemometer is kept perpendicular to the air flow as shown in the schematic diagram (refer Fig.1). If the hot air case is being done, temperature measurements are obtained using Resistance Temperature Detector (RTD) sensors mounted at approximately the same locations.

In order to get the mass flow rate at the nozzle inlet ($\dot{m}_{in}$), multiplication of the area of the nozzle, nozzle exit velocity and the density of the air has been done. While for evaluating the mass flow rate at the exit ($\dot{m}_{out}$) of the IRS device the numerical integration for the local mass flow rate has been performed as follows:

$$a_{nz} = \pi \times \frac{D_{nz}^{2}}{4}$$

$$\dot{q}_{in} = a_{nz} \times v_{nz}$$

$$\dot{m}_{in} = \dot{q}_{in} \times \rho$$

$$\dot{q}_{out} = 2 \times \pi \times \int (r \times v)\, dr$$

$$\dot{m}_{out} = \dot{q}_{out} \times \rho$$

$$\text{Entrainment Ratio} = \dot{m}_{out} / \dot{m}_{in}$$

Where,

a_{nz} = area of the nozzle, m^2

D_{nz} = diameter of the nozzle, m

v_{nz} = nozzle exit velocity, m/s

$\dot{q}_{in}$ = volume flow rate at the nozzle inlet, m^3/s

$\dot{m}_{in}$ = mass flow rate at the nozzle inlet, kg/s

ρ = density of working fluid, kg/m^3

$\dot{q}_{out}$ = volume flow rate at the nozzle outlet, m^3/s

$\dot{m}_{out}$ = mass flow rate at the nozzle outlet, kg/s

Observation:

A. For cold Study

No of funnels:.........

Funnel overlap:.........

Nozzle Protrusion:...........

Average Velocity of the jet coming out of the nozzle exit:.............m/s

Average temperature of air coming out of the nozzle: .... ^oC

Density of air at the above temperature:.............kg/m^3

Observation Table (cold study):

Sensor location/Point on thread	**Velocity (m/s)**	$\dot{m}_{in}$ **(kg/s)**	$\dot{m}_{out}$ **(kg/s)**	$\dot{m}_{suc}/\dot{m}_{in} = \dot{m}_{out} - \dot{m}_{in}/\dot{m}_{in}$
1				
2				
3				
4				
5				
6				
7				
8				
9				

B. For hot Study

No of funnels:.........

Funnel overlap:.........

Nozzle Protrusion:...........

Average Velocity of the jet coming out of the nozzle exit:.............m/s

Average temperature of air coming out of the nozzle: .... ^{o}C

Density of air at the above temperature:.............kg/m^3

Observation Table (hot study):

Sensor location/Point on thread	**Velocity (m/s)**	**Temperature (^{o}C)**	$\dot{m}_{in}$ **(kg/s)**	$\dot{m}_{out}$ **(kg/s)**	$\dot{m}_{suc}/\dot{m}_{in} = \dot{m}_{out} - \dot{m}_{in}/\dot{m}_{in}$
1					
2					
3					
4					
5					
6					
7					
8					
9					