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MINISTERE DE L'ENSEIGNEMENT SUPERIEUR ET DE LA RECHERCHE SCIENTIFIQUE

UNIVERSITE MOHAMED BOUDIAF - M'SILA

جامعة محمد بوضياف - المسيلة
Université Mohamed Boudiaf - M'sila

FACULTE DES SCIENCES **DOMAINE : Sciences de la matière**

DEPARTEMENT DE PHYSIQUE **FILIERE : Physique**

OPTION : physique énergétique

3rd year license energy physics

TP 03 The Forced Convection

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Dr BOURAS Abdelkrim

Description

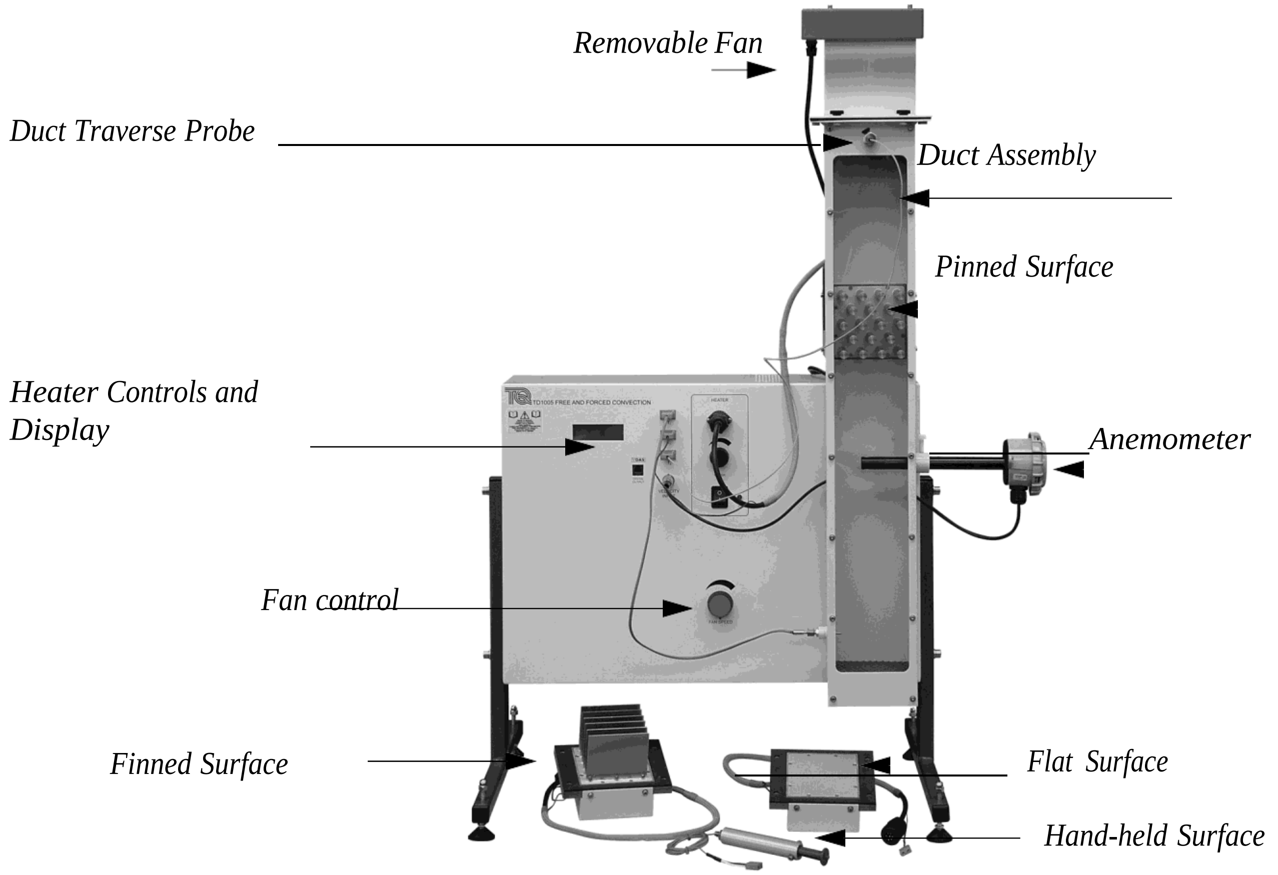

Figure 01 The Forced Convection

The Main Unit

The Main Unit is a compact bench-mounting frame that connects to a suitable electrical supply. It has a vertical duct assembly and a main 'Control Panel' with electrical controls and displays.

Each of the three heat transfer surfaces (supplied) fit into the back of the vertical duct, at just above half-way up the duct.
The vertical duct allows air to pass over the heat transfer surface, both by free convection, or by forced convection using a removable variable speed electric fan at the top of the duct. A fixed thermocouple probe measures the inlet (ambient) air temperature in the duct. A movable thermocouple probe in a traversing mechanism allows measurement of the temperature distribution across the duct at the outlet.This allows students to find the bulk outlet temperature for the more advanced calculations. An anemometer measures air velocity in the duct.

Each heat transfer surface includes a built-in thermocouple to measure its surface temperature. The equipment also includes a hand-held thermocouple probe for heat distribution measurement along the finned and pinned heat transfer surfaces. The user inserts the probe tip into a selection of six equally-spaced holes in the side of the duct (see Technical Details for distances). A magnetic cover allows you to cover the holes completely or so that you can only use one at a time, reducing stray convection caused by the other holes.

Forced Convection

This is when an external force moves air around or across the surface. The movement of air transports the heated air away from the object. The higher the air velocity, the faster it transports heat away from the object.

Heat Transfer Coefficient (Convective) (h_c)

Heat transfer coefficient is a material's ability to conduct heat to another material.
Convective heat transfer occurs between the surface of a material and a moving fluid. Liquid boiling and condensing are examples of convective heat transfer.

Typical values of heat transfer to air are:

10 to 200 W/m^2K in ***forced*** convection

Measuring Bulk Air Temperature Downstream (T_{out})

Due to the heat source on one side, the air temperature in the duct downstream of the heated surface may not be even across the duct, giving a temperature profile across the duct and a variation in T_{out} .

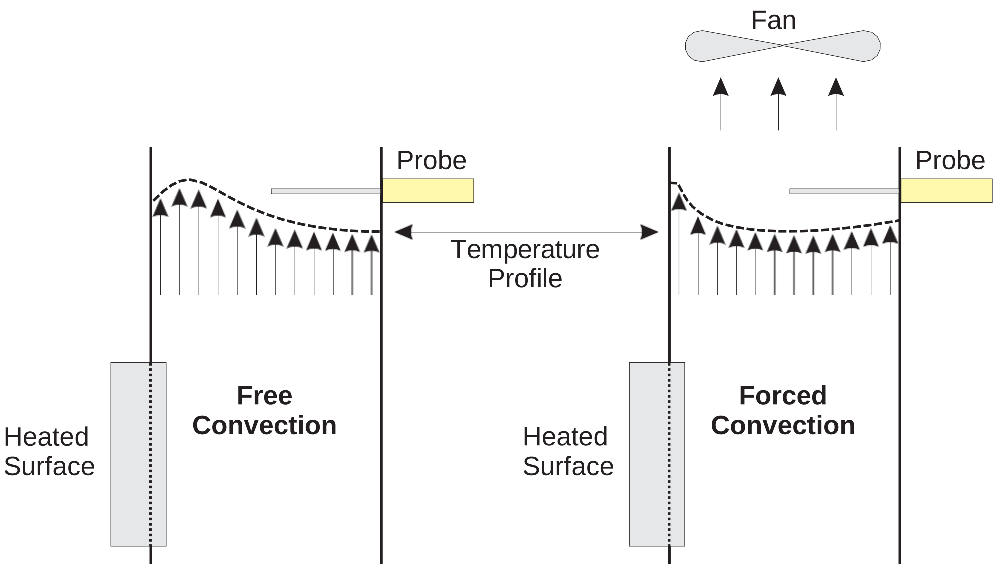

Figure 02 Temperature Profile

As with the velocity probe, a single point measurement of downstream temperature may not give anaccurate value for the bulk temperature of the air. The theory and experiments show that the extended surfaces give a thermal gradient along their length which you can see will transfer to the air passing over them and therefore up the duct. The geometry, thermal conduction of the extended surfaces and the air velocity all affect the temperature profile. However, the upper probe allows a traverse across the duct so you can use simple averaging or integration of the temperature values to give sensible values of T_{out}.

Tout by Simple Averaging

If you traverse across the duct in equal and very small steps (1 mm), your temperature profile becomes very precise and you can simply average your values by the number of steps to find Tout. fewer steps gives a less accurate profile and less accurate results.

Tout = sum of all temperatures/steps

However, this can take time.

Experiment 01: Forced Convection - Fixed Power

Power = 15 W Air Velocity = 2 m.s^{-1}			
Heat Transfer Surface	T_2	T_1	
	Surface Ts (˚C)	Duct Inlet (ambient) Tin (˚C)	Difference T_S - T_{IN} (˚C)
Flat Plate			
Pinned			
Finned			

Table 01 Blank Results Table

Results Analysis

For each table of results, subtract the inlet temperature from the heat transfer surface temperature to complete your results tables. The temperature difference gives a value with respect to ambient, helping to allow for changes in local conditions.

Compare your results with those from free convection. Which surface improves the least with forced convection and which improves the most. Can you explain this?

Experiment 02: Forced Convection - Flow Obstruction

Method

Heat Transfer Surface	Airflow ($m.s^{-1}$)
Flat	
Finned	
Pinned	

Table 02 Blank Results Table

Results Analysis

Note the difference in airflow. How would this affect your choice of heat transfer surface for any application.

Experiment 03: Forced Convection - Effect of Velocity

Heat transfer Surface: Power:			
	T_2	T_1	
Air velocity ($m.s^{-1}$)	Surface Ts (˚C)	Duct Inlet (ambient) Tin (˚C)	Difference T_S - T_{IN} (˚C)

Table 03 Blank Results Table

1. Set the fan to give an air velocity of 1 $m.s^{-1}$.
2. Set the heater power to 50 W.
3. **Wait for the temperatures to stabilise.**
4. Record the surface and inlet temperatures.
5. Repeat for increased air velocities of approximately 1.5, 2.0, 2.5 and 3.0 $m.s^{-1}$.
6. Repeat for the other surface.

Results Analysis

For each table of results, subtract the inlet temperature from the heat transfer surface temperature to complete your results tables. The temperature difference gives a value with respect to ambient, helping to allow for changes in local conditions.

For each surface, create a chart of Ts - Tin (vertical axis) against

velocity.What does the chart say about temperature and velocity?

Which surface has the coolest temperature for any given air velocity?