Republic of Iraq
Ministry of Higher Education
and Scientific
Al-Mustaqbal University College
Chemical Engineering and Petroleum Industries
Department

Subject: Heat Transfer Lab.

Third Class

Lecture three

Heat transfer from extended surface

3.1:Aim of This Experiment:

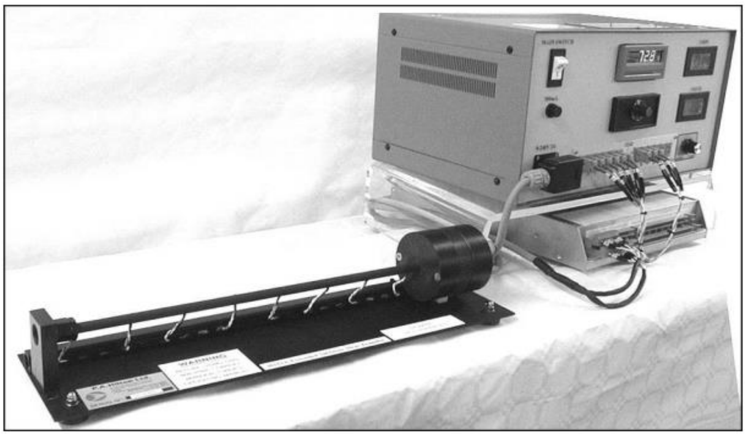
This experiment aims to measure the temperature distribution along an extended surface and compare the practical results with a theoretical analysis.

3.2: Theory:

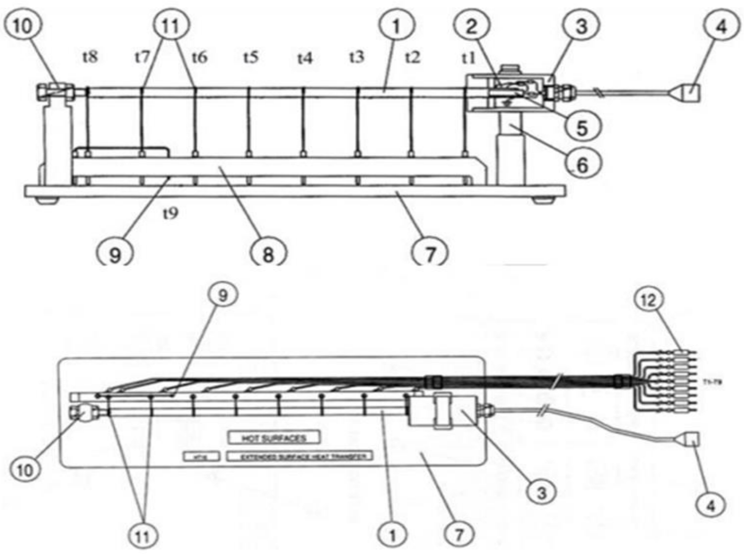
Extended surfaces have fins attached to the primary surface on one side of a two-fluid or a multi fluid heat exchanger. ... Pins are primarily used to increase the surface area (when the heat transfer coefficient on that fluid side is relatively low) and consequently to increase the total rate of heat transfer. Explanation: Fins are provided to a heat exchanger surface to augment the heat transfer by increasing the surface area exposed to the surroundings. When the temperature Ts and Ta are fixed by design considerations, there are only two ways to increase the heat transfer rate: i) To increase the convection coefficient h, ... Generally, the fins are used on the surfaces where the heat transfer coefficient is very low.

3.3:Experimental Set – up:

The Extended Surface Heat Transfer experiment allows investigation of one dimensional conduction from a fin. A small diameter metal rod is heated at one end and the remaining exposed length is allowed to cool by natural convection and radiation. This results in a diminishing temperature distribution along the bar that is measured by regularly spaced thermocouples. The accessory comprises a 10mm diameter brass rod (1) of approximately 350mm effective length mounted horizontally with a support (6) at the heated end and a mounting steady(10) at the opposite end. Inside an insulated housing (3) is a 240V electric heater E1(5) in direct contact with the brass rod. The heater has a nominal power rating of approximately 30 Watts at 240V AC. The power supplied to the heated cylinder is provided by the Heat Transfer Service Unit H111 through the power lead (4). The Heat Transfer Service Unit H111 also allows the operator to vary the power input to the heater by control of the voltage supply to the heater element. For safety purposes a thermostat (2) limits the maximum temperature of the heater to approximately 150°C. Eight thermocouples (11) are located at 50mm intervals along the rod to record the surface temperature. These connect to the Heat Transfer Service Unit H111 through the miniature plugs(12). The thermocouples are attached to the rod in order to minimize errors from conduction effects. An additional thermocouple (9) is mounted on the unit to record the ambient air temperature. In order to protect the thermocouples from damage all lead terminations are mounted firmly into trucking and conduit (8). The rod is coated with a heat resistant matt black paint in order to provide a constant radiant emissivity close to 1.



Schematic Representation of Linear Conduction Experiment Unit



3.4:Capabilities Of The Extended Surfaces Unit:

1. Measuring the temperature distribution along an extended surface and comparing the result with a theoretical analysis.

2. Calculating the heat transfer from an extended surface resulting from the combined modes of free convection and radiation heat transfer and comparing the result with a theoretical analysis.

3. Determining the constant of proportionality (the thermal conductivity k) of the rod material.

3.5:Operating Procedure Of Extended Surfaces Unit:

1. Ensure that the main switch is in the off position (the three digital displays should not be illuminated). Ensure that the residual current circuit breaker on the rear panel is in the ON position.

2. Turn the voltage controller fully anti-clockwise to set the AC voltage to minimum. Ensure the Extended Surface Heat Transfer accessory has been connected to the Heat Transfer Service Unit.

3. Ensure that the heated cylinder (7) is located inside its housing (10) before turning on power to the unit.

4. Turn on the main switch, digital displays should illuminate. Set the temperature selector to display T1.Rotate the voltage controller to increase the voltage to that specified in the procedure for each experiment.

5. After adjusting the heater voltage ensure that T1 (the thermocouple closest to the heater)varies in accordance with the sense of adjustment. i.e if the voltage has been increased the temperature T1 should also increase, if the voltage is reduced the temperature T 1 will reduce. Note that if T1

is close to 100°C and the current (Amps) displays Zero, it may be that the safety thermostat (2) has activated. Reduce the voltage and wait for the thermostat to reset.

6. Allow the system to reach stability, and take readings and make adjustments as instructed in the individual procedures for each experiment. Note that due to the process of conduction and the small differential temperatures involved for reasons of safety the time taken to achieve stability can be long.

7. When the experimental procedure is completed, it is good practice to turn off the power to the heater by reducing the voltage to zero and monitor T1 until the rod has cooled. Then turn off the main switch. Allow the components to cool completely to ambient before storing them away safely.

3.6:Calculation:

$Q_{fin} = H * A * (T_s - T_a)$ …………………(1)

Where:

$H = h_r + h_c$

$h_C = 1.32 * ((T_S - T_a)/D)$

$h_r = \varepsilon * \sigma * F * ((T_S^4 - T_a^4)/(T_S - T_a))$

$A_s = \pi * D * l$

T_a= from nine thermocouples (T9)

$T_s = (T1+T2+T3+T4+T5+T6+T7+T8) / 8$

$Q_{without\ fin} = V*I$……………….(2)

$ή = Q_{fin}/Q_{without\ fin}$……………..(3)

Appendix – I Symbolas and Units

SYMBOLS AND UNITS

Symbol		Units
A	Cross sectional area	m^2
A_s	Heat Transfer area (Surface Area)	m^2
D	Diameter of Extended Surface	m
F	Shape Factor	
h	Overall convection heat transfer coefficient	W/m^2K
I	Heater Current	A
k	Thermal conductivity	W/mK
L	Length of extended surface	m
Q	Heat loss to natural convection	W
t	Temperature	°C
T	Absolute temperature	K
V	Heater Voltage	V
x	Distance	m
σ	Stefan Boltzmann constant for radiation	
ξ	Emissivity of cylinder	
θ	$(T_x - T_a)$	°

Subscripts

9	Ambient condition	
1-8	Rod Surface Temperature	
a	Ambient Condition	
s	Surface Condition	
Mean	Mean Condition $\left(\frac{T1 + T2 + ... Tn}{n}\right)$	