Open Experiment: Measurement Of Convective Heat Transfer Coefficient Over a Flat Surface

Group-2

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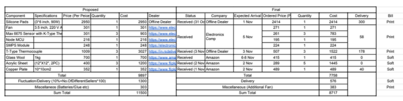
Bill Of Materials

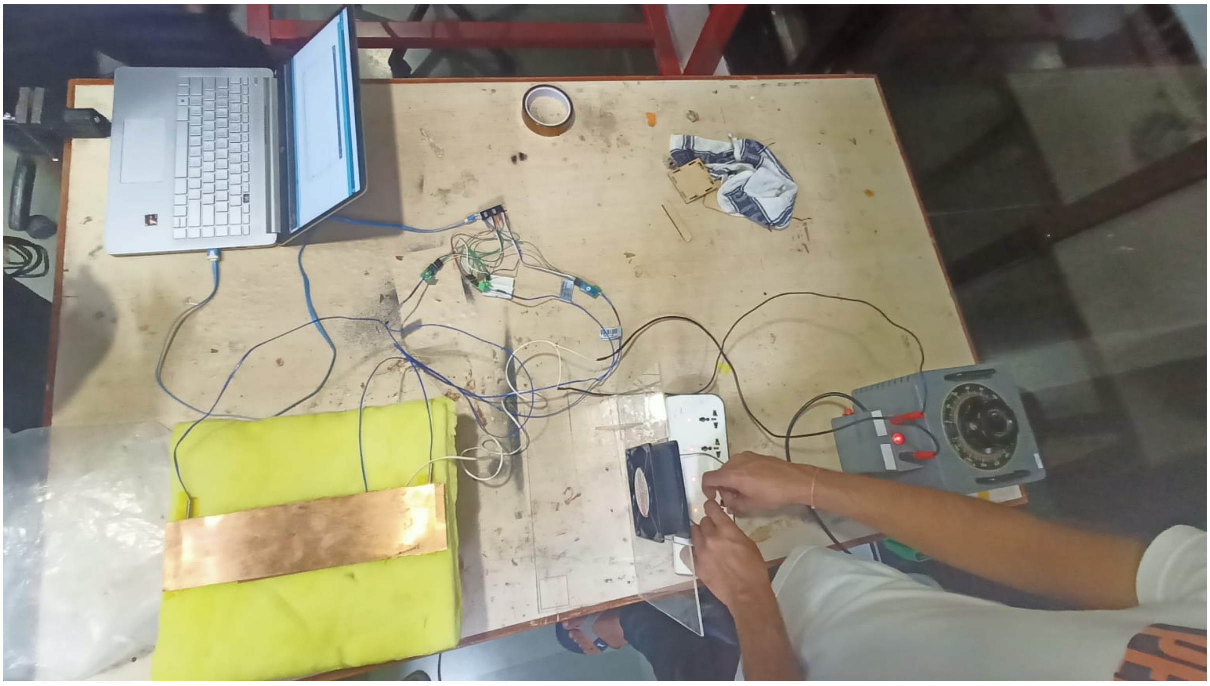
BOM| ME Lab Open Experiment| Final

Sheet1 Proposed,Final Component,Specifications,Price (Per Peice),Quantity,Cost,Dealer,Status,Company,Expected Arrival,Ordered Price (Per Piece),Quantity,Cost,Delivery Silicone

https://docs.google.com/spreadsheets/d/1lgM_1tlKLjqt6ZRaXVtyFMK4Sk5S2AIKURmWIy-mzow/edit?usp=sharing



Setup



Theoretical Approach

Theoretically, we can find the average heat transfer coefficient for a given flow rate using the relation between Nusselt Number, Reynold's Number, and Prandtl Number.

Where,

$$Nu = \frac{h_l L}{k},$$
$$Re = \frac{\rho V L}{\mu}, \text{ and}$$
$$Pr = \frac{\mu C_p}{k}$$

For Laminar Flow

$$Nu = 0.664 (Re)^{0.5} (Pr)^{0.33}$$
$$\implies h_l = 0.664 \frac{k}{L} \left(\frac{\rho V L}{\mu}\right)^{0.5} \left(\frac{\mu C_p}{k}\right)^{0.33}$$
$$= 0.664 * \frac{(\rho * V)^{0.5} * C_p^{0.33} * k^{0.67}}{L^{0.5} * \mu^{0.17}}$$

For Turbulent Flow

$$Nu = 0.037 (Re)^{0.8} (Pr)^{0.33}$$

Practical Approach

From experimental readings, we can find average heat transfer coefficient using,

$$\dot{q} = hA(T_s - T_\infty) = V * I$$

where,

T_s → Temperature of surface

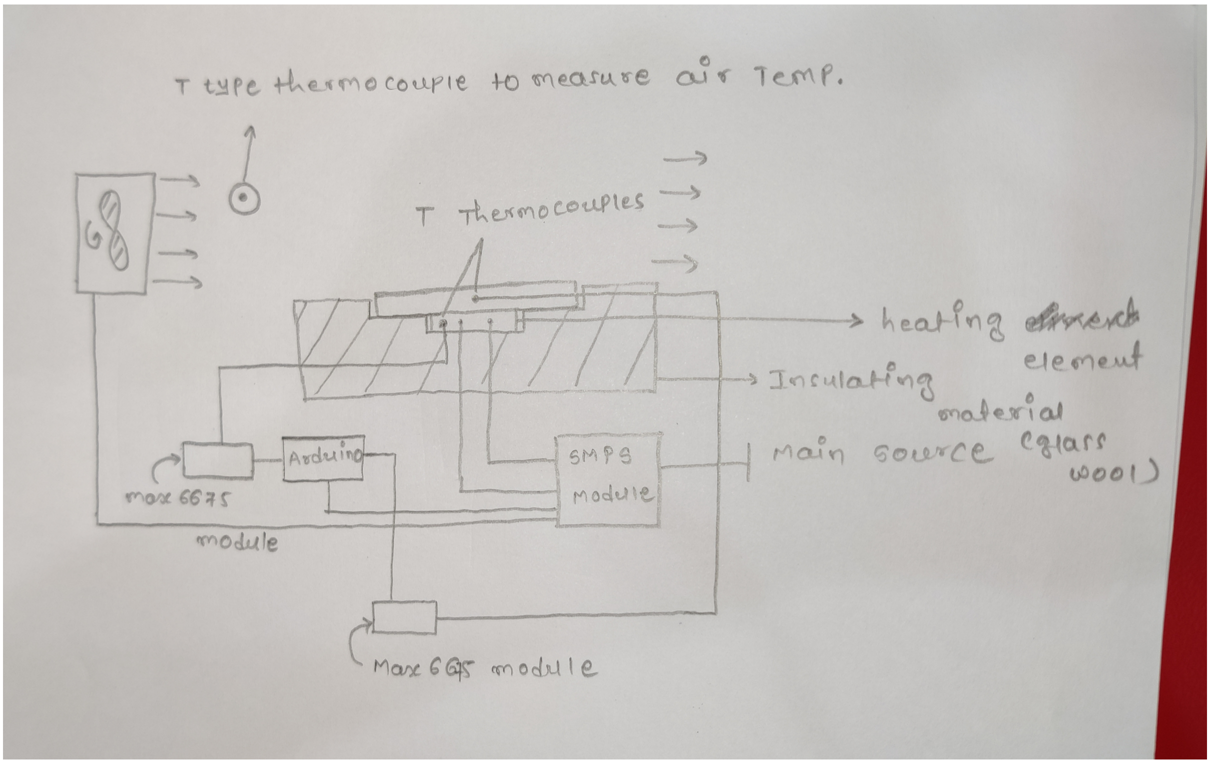
T_∞ → Temperature of Air

$$\text{Average surface temperature } (T_{as}) = \frac{\int T dA}{\int dA}$$

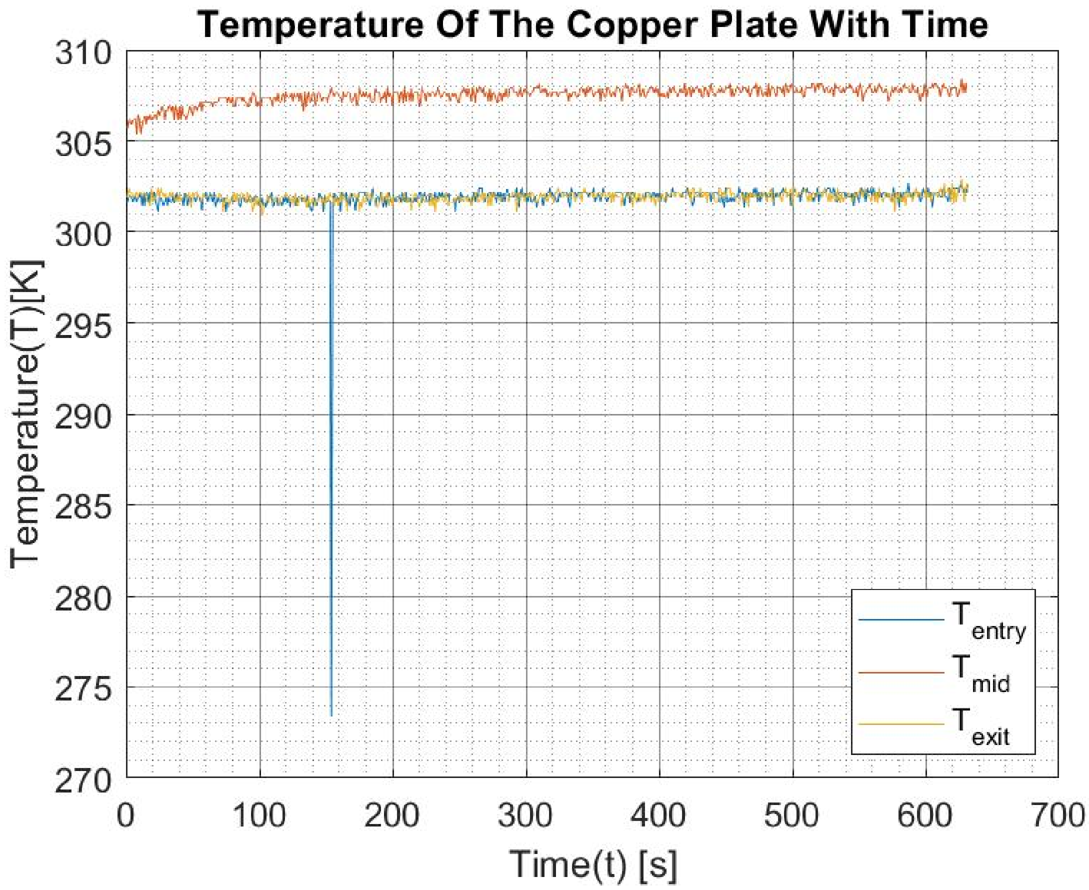
$$= \frac{b * \left(\int_0^{l_{in}} T_{in} e^{ln\left(\frac{T_{mid}}{T_{in}}\right)\frac{x}{l_{in}}} dx + l_{mid} * T_{mid} + \int_0^{l_{ex}} T_{ex} e^{ln\left(\frac{T_{mid}}{T_{ex}}\right)\frac{x}{l_{ex}}} dx \right)}{b * L}$$

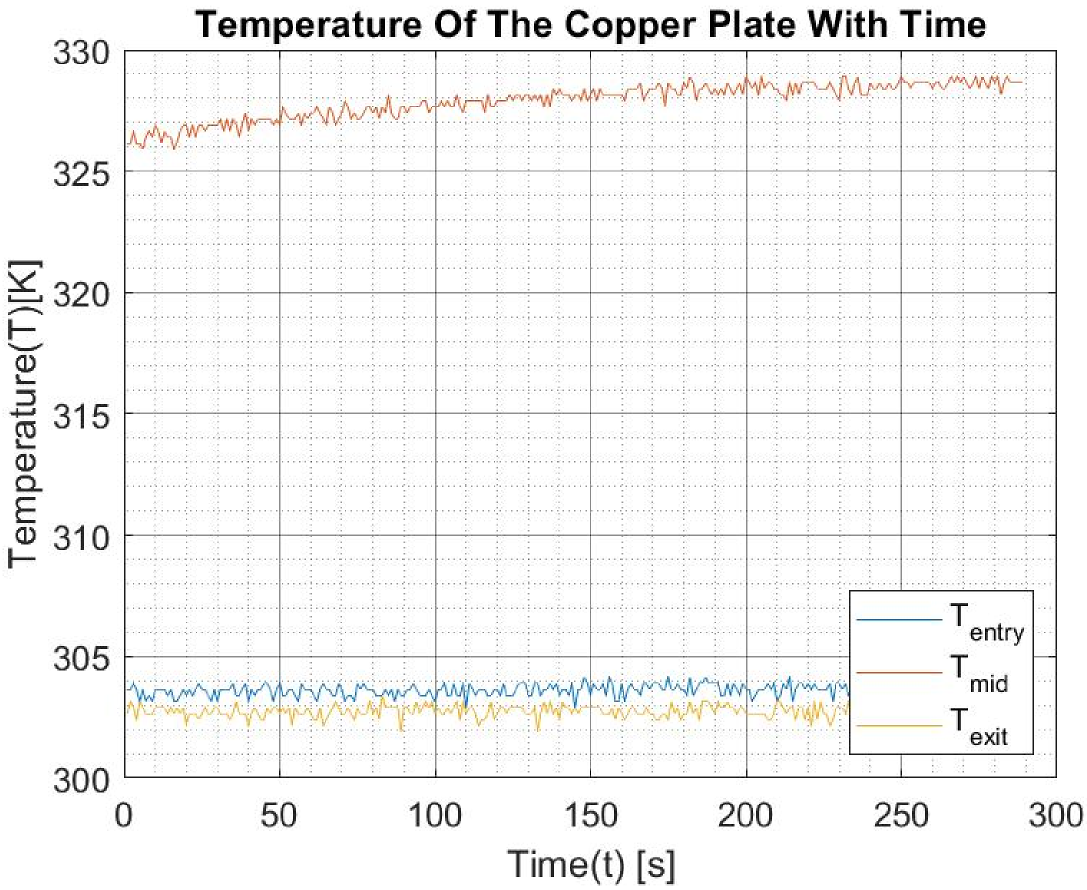
$$\implies T_{as} = \frac{l_{in} * \frac{T_{mid} - T_{in}}{ln(T_{mid}/T_{in})} + l_{mid} * T_{mid} + l_{ex} * \frac{T_{mid} - T_{ex}}{ln(T_{mid}/T_{ex})}}{L}$$

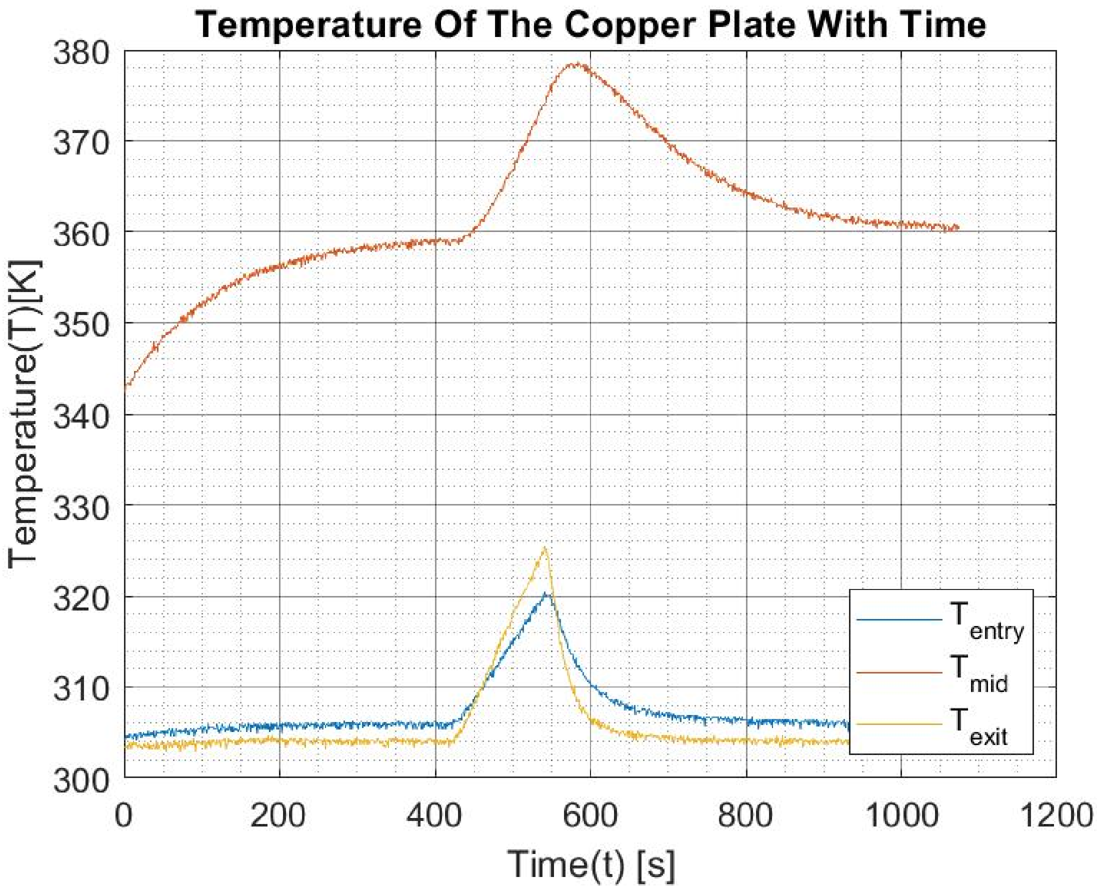
Schematic



Data


Temperature Of The Copper Plate With Time
310
305
300
295
290
285
280
275
270
Temperature(T)[K]
0
100
200
300
400
500
600
700
Time(t) [s]
T entry
T mid
T exit
40 Volt


Temperature Of The Copper Plate With Time
330
325
320
315
310
305
300
Temperature(T)[K]
0
50
100
150
200
250
300
Time(t) [s]
T entry
T mid
T exit
80 Volt



120 Volt

""	"Theory"	"Practical"
"40 Volt"	"17.544"	"16.3623"
"80 Volt"	"17.4876"	"20.2807"
"120 Volt"	"17.4053"	"21.6507"

The values of theoretical and practical heat transfer coefficients

Here please note that the small differences in values of theoretical heat transfer coefficients is because of difference in specific heat of air with temperature (among other properties). Properties of air were taken at,

$$T_{av} = \frac{T_{as} + T_{\infty}}{2}$$

Reasons for Error:

1. Heating pad was smaller than our flat plate. So apart from the middle portion of the plate other portions are being heated by heat transfer from middle to those portions.
2. Experiment showed that the far side of the plate had lower temperature than the near portion of plate to the fan, theoretically it should be the other way around. The reason behind that was that the plate has more width at the end than at the near portion which increases the area of the plate at the end which allows more convection to happen at the back. Which lowered its temperature than the front side.