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Experiment Number (7)

Heat Conduction

80/100

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Abstract

Thermal conduction is the method of heat transfer that takes place in a material and takes place when the molecules of matter vibrate then temperature difference is done, and heat energy is transferred from a higher temperature area to a lower one this process involve by Fourier's law or the law of thermal conductivity. Also, Heat conduction occurs in three dimensions, but in this experiment, it done by using a one-dimensional (linear conduction through a uniform bar) and steady flow of heat to measure the temperature distribution and determine the thermal conductivity of brass. The main result is increasing in voltage increases the heat input and leads to increase in thermal conductivity and moving from top to bottom leads to a decrease in heat from top to bottom and finally, the relationship between temperature and thermal conductivity is linear.

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Results

Table 1:Raw data for heat conduction at steady state (at 60 volt)

T_1 °C	T_2 °C	T_3 °C	T_4 °C	T_5 °C	T_6 °C	T_7 °C	T_8 °C	Input Volts	Input Ampere	Water flow
29.61	28.99	27.99	26.25	24.93	23.24	23.14	22.15	62.76	0.067	35.8663

Table 2:Raw data for heat conduction at steady state (at 100 volt)

T_1 °C	T_2 °C	T_3 °C	T_4 °C	T_5 °C	T_6 °C	T_7 °C	T_8 °C	Input Volts	Input Ampere	Water flow
42.24	40.55	38.24	33.88	31.37	27.45	25.98	24.12	93.36	0.105	35.8397

Table 3: Raw data for heat conduction at steady state (at 140 volt)

T_1 °C	T_2 °C	T_3 °C	T_4 °C	T_5 °C	T_6 °C	T_7 °C	T_8 °C	Input Volts	Input Ampere	Water flow
63.69	59.96	55.46	46.6	41.9	34.18	30.55	26.82	133.44	0.1455	35.6369

Table 4:Calculated data for heat conduction at three different voltages

➔ The length and diameter of the sample are 30 and 25 mm, respectively.

voltage (volt)	Current (A)	Area (m^2)	T_4 °C	T_5 °C	ΔT	Q (W)	K (W/m.K)
60	0.067	0.0004906	26.25	24.93	-1.32	4.0	186.219
100	0.101	0.0004906	33.88	31.37	-2.51	10.1	244.830
140	0.146	0.0004906	46.6	41.9	-4.7	20.4	265.012

Figures

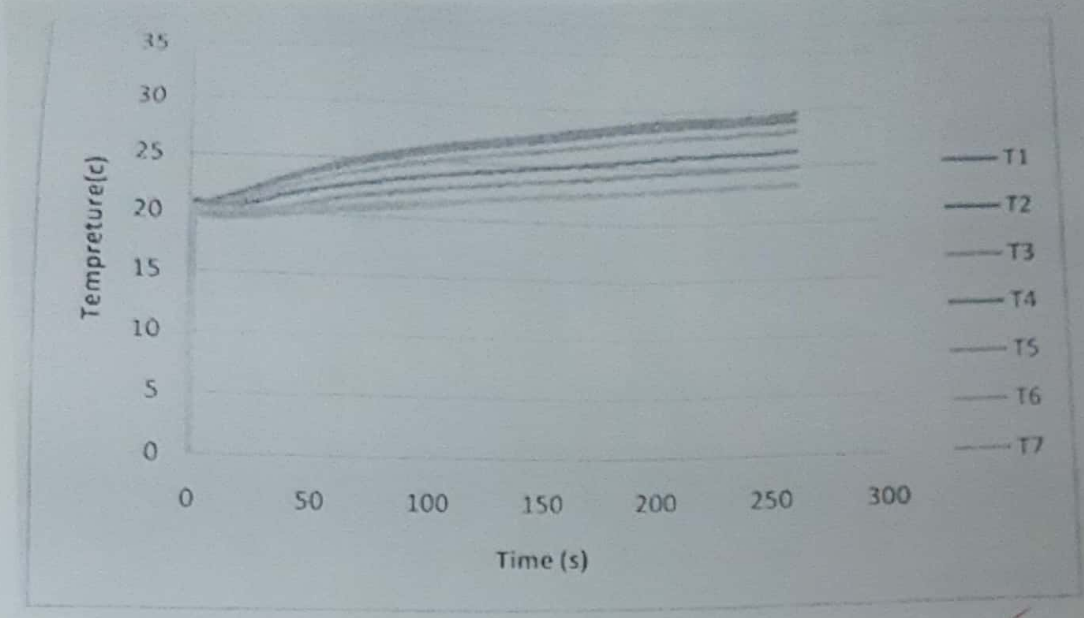

Figure 1 : Temperature vs. Time at voltage = 60 v

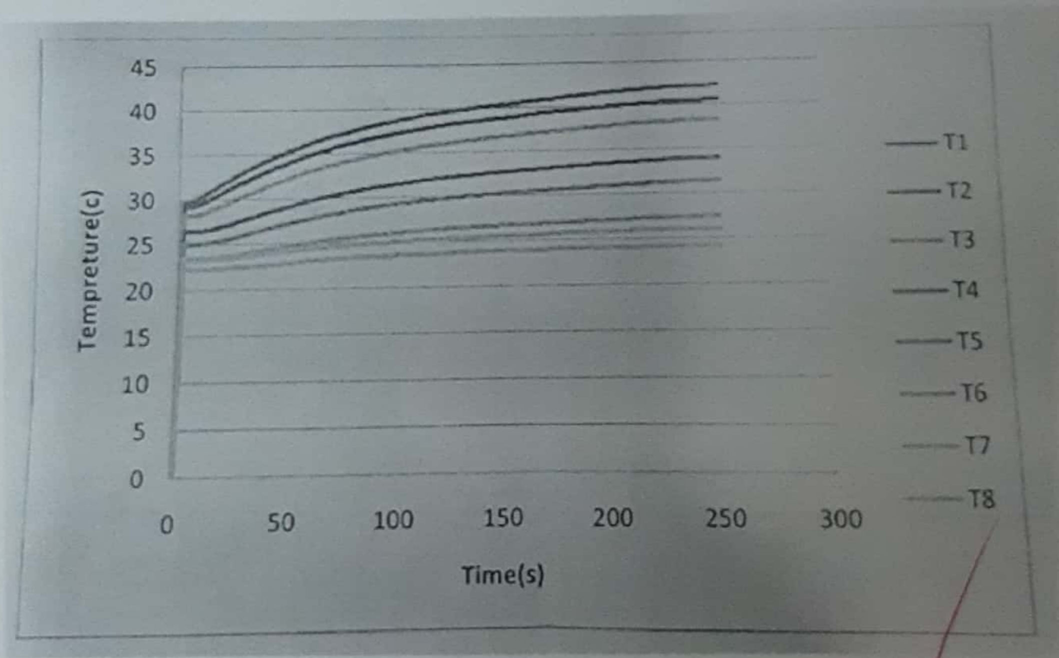

Figure 2 : Temperature vs. Time at voltage = 100 v

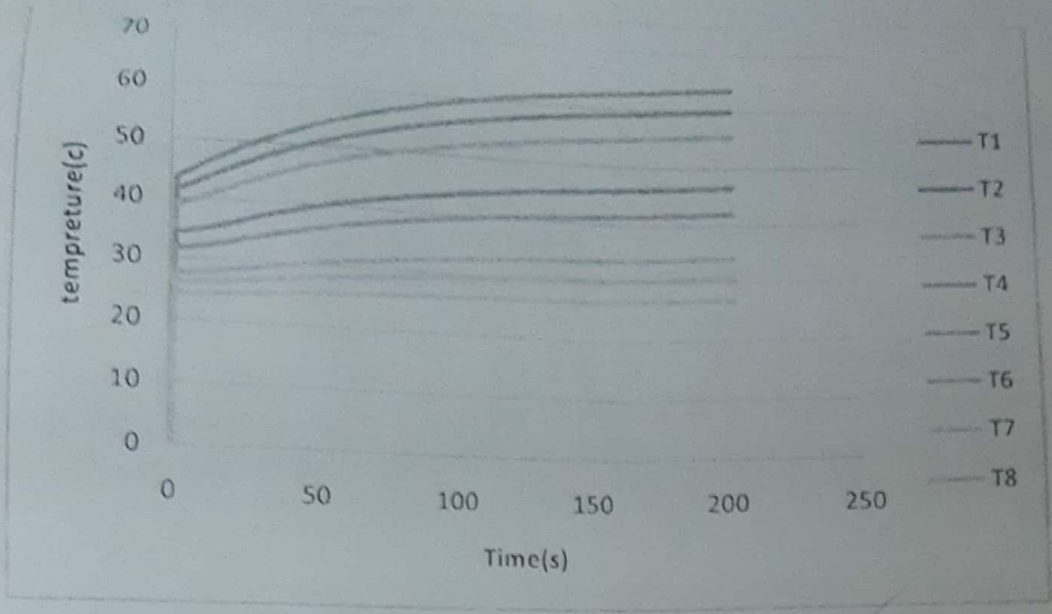

Figure 3 : Temperature vs. Time at voltage = 140

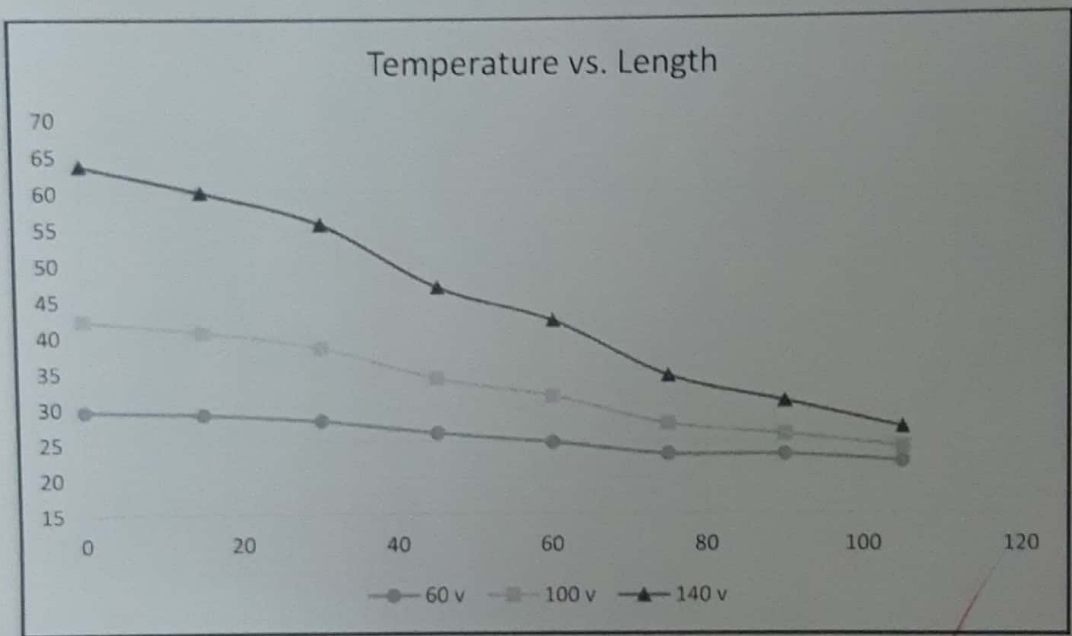

Figure 4 : Temperature vs. Length

Discussion

Based on the results, increasing in voltage increases the heat input and leads to increase in thermal conductivity and it depends on Fourier's law. Also, graphs 1,2 and 3 show that temperature increases with time. However, if a body is heated for a long time, all its parts can reach the same temperature, which would affect the experiment's accuracy. In graph 4, it shows that when moving from top to bottom of device, it moves away from the heating area, which leads to a decrease in heat from top to bottom. From data of the experiment, the average of thermal conductivity is 232 W/m.K and the theoretical value is around 150 W/m.K. There is an error that occurred because of losses in heat due to a defect in insulation. Also, brass is an alloy of copper but the percentage of copper and in the alloy isn't known, so the theoretical value is an approximation value.

Conclusion

By conducting the experiments on three different input voltage, we can conclude that:

- Increase in the voltage leads to increases the variation in temperature.
- Increase in the voltage lead to T_1 increase while T_8 nearly the same (different is smaller in T_8 than T_1).
- Increase in heat input leads to increase in temperature with the time until reaching the steady state.
- The hot temperature distribution is in the top near to the heater (power source) and the cooled temperature distribution is in the top section near to the water flow.
- Thermal conductivity value is affected directly proportional with temperature and heat transfer, but inverse proportional with the length, as well as is affected by type of material.

References

1) Chemical engineering laboratory "1" (0915361); University of Jordan; faculty of engineering and Technology; Department of Chemical engineering.

2) Incropera, (2011), Fundamentals of Heat and Mass Transfer, John Wiley & Sons, Inc., seventh edition, (pp. 1003).

Appendix

- **Sample of calculation; for run 1:**

- $\text{Area}(\text{m}^2) = \frac{\pi \times D^2}{4} = \frac{3.14 \times 0.025^2}{4} = 0.00049\ \text{m}^2$

- $\Delta T = T4 - T5 = 24.93 - 2.95 = -1.32\ ^\circ\text{C}$

- $Q = V \times I = 60 \times 0.067 = 4\ volt.A = 4\ W$

- $k = \frac{-Q \times L}{A \times \Delta T} = \frac{-4 \times 0.03}{0.00049 \times -1.32} = 186.22\ \text{W/m.K}$

Heat Conduction Data Sheet

Run # 1: Voltage =60V

date	Time(s)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	INPUT VOLTS	INPUT AMPS	WATER FLOW
263	11/16/2022	29.61	28.99	27.99	26.25	24.93	23.24	23.14	22.15	62.76	0.067	35.86633

Run # 2: Voltage =100V

date	Time(s)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	INPUT VOLTS	INPUT AMPS	WATER FLOW
250	11/16/2022	42.24	40.55	38.24	33.88	31.37	27.45	25.98	24.12	93.35999	0.1005	35.83972

Run #3: Voltage =140V

date	Time(s)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	INPUT VOLTS	INPUT AMPS	WATER FLOW
202	11/16/2022	63.69	59.96	55.46	46.6	41.9	34.18	30.55	26.82	133.44	0.1455	35.63699

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