The University of Jordan

School of Engineering

Chemical Engineering Department

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Experiment Number (9)

Free and Forced Convection

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Abstract

There are various methods of heat transfer, such as convection which involved the transfer of heat between a solid surface and a fluid. Convection heat transfer had two parts, free and forced convection. For free convection, hot air rises from the surface to the top of the duct by density differences resulting from (buoyancy forces) temperature gradient. For forced convection, fluid was forced over a surface by any mechanical means such as fans a variable speed fan pulls air through the duct and across the pinned. Thermocouples measure the air temperature upstream and downstream of the surface and the temperature at the heat transfer surface. The objective of the experiment was to study how heat transfer by convection of the flat and pinned surface both under free and forced convection and determined free and forced convection heat transfer coefficient for these surfaces.

main Results

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Tables

1)Free Convection:

Table1 : Raw data for free convection pinned surface

Heat Transfer pinned surface			
power(w)	T2(surface temp.) C	T1(duct inlet) C	T2-T1
0	21.1	19	2.1
5	27.2	19.6	7.6
10	37.6	20	17.6

2) Forced Convection:

Table2 : Raw data for forced convection p=20 watt

Heat Transfer surface (power P=20 watt)			
Air Velocity v(m/s)	T2(surface temp.) C	T1(duct inlet) C	t2-t1
1	39.6	19.7	19.9
2	37	19.7	17.3
3	34.6	19.9	14.7

3)Heat Transfer Coefficient:

Table3 : Raw data for heat transfer coefficent (p=20 watt , V=3 m/s)

Heat Transfer Coefficient hc at P=20 watt, V=3m/s					
Duct Position(mm)	T1 (Tin) C	T2 (Ts) C	Tp	Ts-Tin	Tp-Tin
0	19.6	32.5	21	12.9	1.4
1	19.6	32.5	20.8	12.9	1.2
2	19.7	32.4	20.8	12.7	1.1
3	19.6	32.4	20.4	12.8	0.8
4	19.9	32.5	20.2	12.6	0.3
5	19.6	32.6	20	13	0.4
6	19.7	32.5	19.9	12.8	0.2
7	19.5	32.4	19.8	12.9	0.3
8	19.5	32.4	20	12.9	0.5
T avg	19.63333333	32.46666667	20.32222222	12.83333	0.688889

Tm=48.10871466 C

hc=15.39722576 $\frac{w}{m^2.k}$

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Figures

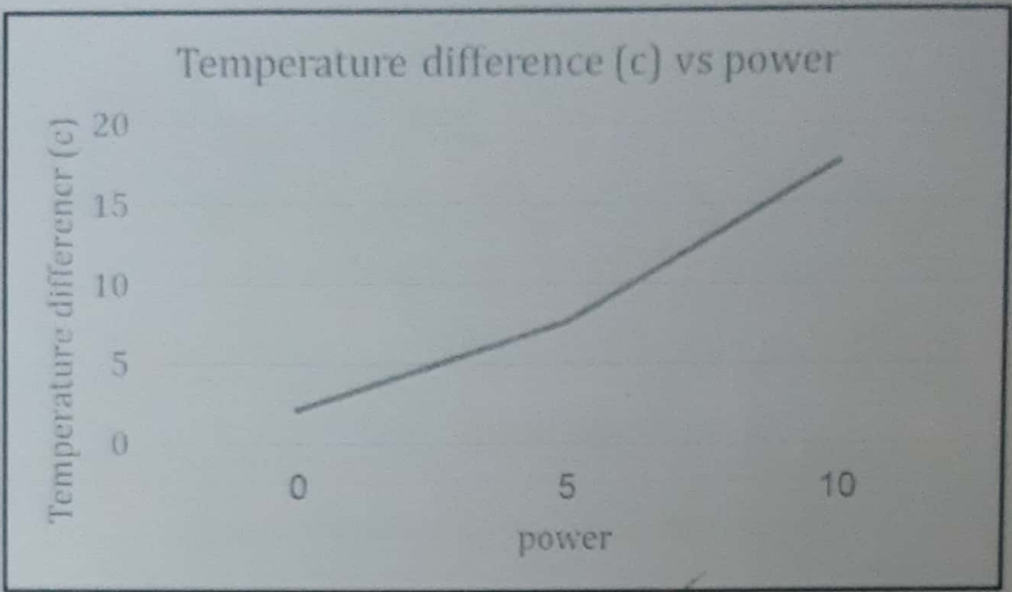

Figure 1: Temperature difference against the power

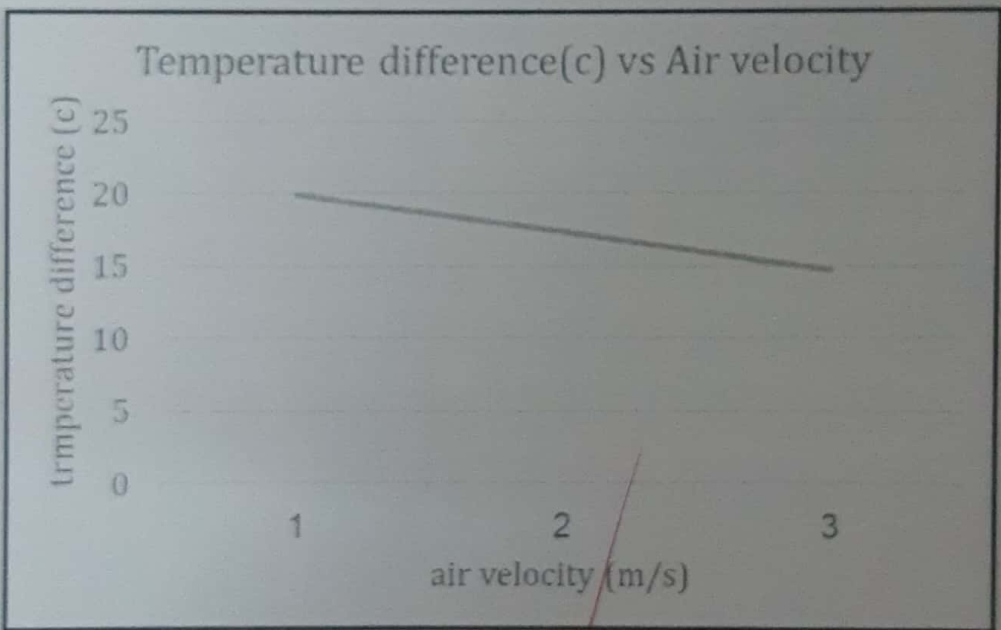

Figure 2:Temperature difference against air velocity

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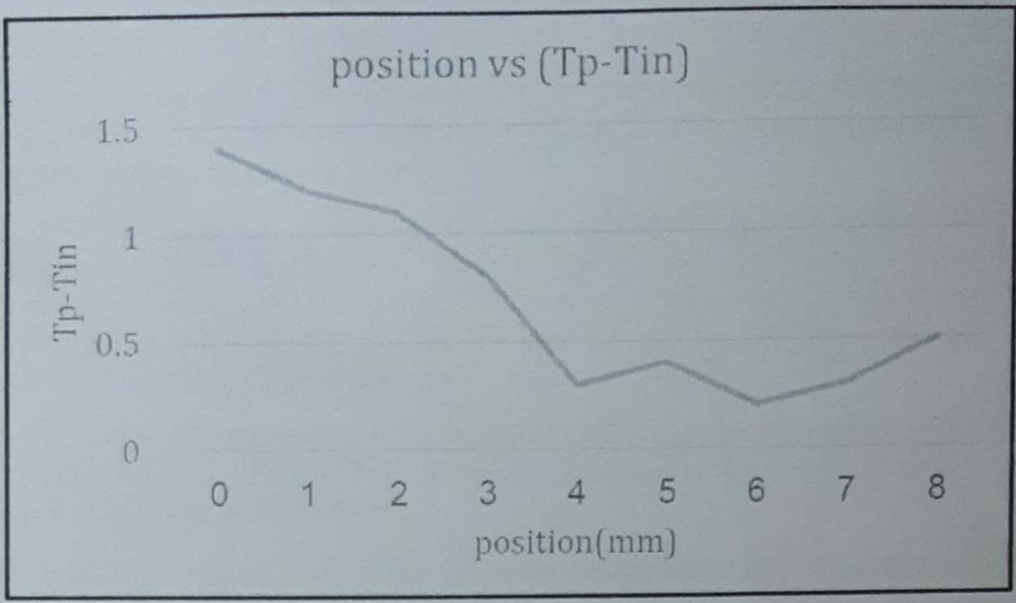

Figure 3:Duct position against Temperature differences

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Discussion

In this lab, free and forced convection heat transfer coefficient is determine and all calculations are based on data collected from 10 to 20 minutes of the experiment and used to compute experimental values.

In figure 1 that shows as expected the direct relationship (for pin surface) between temperature difference and power. While the figure 2 that shows inverse relationship between air velocity and temperature difference as a result of the air temperature not rising greatly while passing through the pins. And in the last figure we show the relationship of outlet temperature profile with respect to inlet.

Experimental analysis is found that the forced convection heat transfer coefficient is 15.4 W/ (m2.K), and this value is acceptable compared to the range values of forced convection (10 to 200 W/m2K).

If difference is found it will be due to either the experimental error or error in data collection.

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Conclusion

- Extended surfaces like pins and fins increase the rate of heat transfer, pinned surface shows higher heat transfer than other surfaces.
- The rate of heat transfer in forced convection is higher than it in free convection, heat transfer coefficient in forced convection is greater than it in free convection).
- Forced convection system has a higher overall heat transfer coefficient than free convection system.
- Temperature difference increase with power increased.
- Temperature difference decrease with air velocity increased. (The higher the air velocity the faster it transports heat away from the object).

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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.

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Appendices

Sample of calculations:

For free convection:

$\Delta T = T2 - T1$

=21.1-19

=2.1°C

For forced convection:

$\Delta T = T2 - T1$

=39.6-19.7

=19.9 °C

For heat transfer coefficient:

$\Delta T = Ts - Tin$

=32.5-19.6

=12.9 °C

$\Delta T = Tp - Tin$

=21-19.6

=1.4 °C

Tm: logarithmic mean temperature

$$Tm = \frac{Tout - Tin}{\log\left(\frac{Ts - Tin}{Ts - Tout}\right)}$$

$$= \frac{0.68889 - 19.633}{\log\left(\frac{32.4666 - 19.633}{32.4666 - 0.68889}\right)}$$

=48.10871466

$$hc = \frac{P}{A * Tm}$$

$$= \frac{20}{0.027 * 48.108}$$

=15.397

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