ME341A-HEAT AND MASS TRANSFER

Experiment - 4

Emissivity Measurement

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Group – G1(a)

Shikhar Shivraj Jaiswal – 150670
Anutosh Nimesh – 150125
Avinash Kumar - 150169

Objective:

To determine the emissivity of test plate surface made of aluminium oxide at various temperatures.

Procedure:

1. Give power supply to temperature indicator (230V single phase) and adjust the reading in it equal to room temperature by rotating the compensation knob (Normally this is pre- adjusted).
2. Select the proper range of voltage on wattmeter/voltmeter and Ammeter.
3. Gradually increase the power input to the heater of the black plate and adjust it to some value 30,50,75 watts and adjust the power input to the test plate to a slightly less value than the black plate 27,35,55 watts etc.
4. Check the temperatures of the two plates at minor intervals and adjust the power input of the test plate only by means of the dimmer stat such that the two plates are maintained at the same temperature.
5. This will require some trial and error and one has to wait sufficiently long (more than one hour or so) to obtain the steady state condition.
6. After attaining the steady state record the reading of W_1, W_2, T_S and T_D ;
   where $W_1 = V_1 I_1$ and $W_2 = V_2 I_2$.
7. The same procedure is repeated for various plate surface temperatures in increasing order.

Results:

By using the expression:

$$W_1 - W_2 = (\varepsilon_b - \varepsilon).A.\sigma.(T_s^4 - T_d^4)/0.86$$

and assuming that $\varepsilon_b = 1$ (for the black plate)

For both test plate and black plate:

$$A = \pi D^2/4$$

Here D = 160 mm

$$A = \pi\,(0.16)^2/4 = 0.02\ m^2$$

1. $W_1 = 34.5$ W, $W_2 = 26.7$ W, $T_1 = T_2 = T_S = 85°$ C, $T_D = 26°$ C

$$\varepsilon_b - \varepsilon = \frac{W_1 - W_2}{A.\sigma.(T_S^4 - T_D^4)/0.86}$$

$$\varepsilon_b - \varepsilon = \frac{(34.5-26.7)}{0.02*5.67*10^{-8}*\frac{(358^4-299^4)}{0.86}}$$

$$\varepsilon = 1 - 0.70$$

$$\varepsilon = 0.30$$

2. $W_1 = 36.2$ W, $W_2 = 27.2$ W, $T_1 = T_2 = T_S = 86°$ C, $T_D = 27°$ C (steady state was not achieved)

$$\varepsilon_b - \varepsilon = \frac{W_1 - W_2}{A.\sigma.(T_S^4 - T_D^4)/0.86}$$

$$\varepsilon_b - \varepsilon = \frac{(36.2-27.2)}{0.02*5.67*10^{-8}*\frac{(359^4-300^4)}{0.86}}$$

$$\varepsilon = 1 - 0.80$$

$$\varepsilon = 0.20$$

S.No.	Temp. of test plate(T_s)	Emissivity(ε)
1.	$85^\circ C$	0.30
2**.	$86^\circ C$	0.20

*Due to only two observations, exact nature of the graph cannot be obtained.

**Steady State was not achieved

<u>Uncertainty Analysis</u>:

From the literature, value of emissivity (ε) at 20^0 C is 0.2

For first reading, $T_s = 85^0$ C

$$\Delta = \frac{0.3-0.2}{0.2}$$

$$\Delta = 0.50$$

$$\Delta = 50\%$$

$$\varepsilon = 0.30 \pm 0.50$$

For second reading, $T_s = 86^0$ C

*(*although it is not the steady state reading)*

$$\Delta = \frac{0.2-0.2}{0.2}$$

$$\Delta = 0$$

$$\Delta = 0\ \%$$

$$\varepsilon = 0.20 \pm 0$$

<u>Discussions and Conclusions:</u>

Standard value of emissivity of aluminium oxide ranges from 0.2 to 0.33 for a temperature range of 90 - 540^0 C; while in our experiments the value of emissivity turns around to be 0.30 at 85^0 C, which is significantly high. This large error in value of emissivity may have come due to the following reasons:

1. Surface emissivity depends on the nature of the surface; a roughened, oxidised metal surface is bound to have a comparatively high emissivity. It could have happened that the test plate in our experiment might have had a higher roughness than standard aluminium oxide test plate. This will naturally lead to increase in emissivity.

2. The least count of the temperature scale was one, which is not exactly sufficient for accurate calculations of emissivity - especially given that it was subject to massive fluctuations. Similarly, more precise ammeters and voltmeters are needed if we are to give an accurate measurement.

3.The black plate emissivity is assumed to be 1, which is physically impossible to attain. When subtracted from 1, the emissivity will turn out to be higher than it would have if the black plate emissivity was given (which would have been less than 1).

4. The apparatus used in the experiment was also outdated which cannot ensure that the heat dissipation by conduction and convection is same for both the plates.

5. The steady state requires a lot of time to attain, although temperature were noted at steady state but it is hard to say whether the final state of the experiment really reached the steady state. In one case, it did not reach the steady state

With increase in temperature of the plates, the emissivity of the test plate is expected to increase theoretically, as the test surface becomes somewhat dull.
The nature of the graph obtained from the experiments can not be ascertained since there were only two observations, and it's impossible to construct a graph from 2 points - especially given the fact that the 2nd case did not achieve steady state.

Graph:
We were supposed to plot a graph with two data points i.e. from both the cases. But we were unable to get the steady state for the second case in the provided lab time, so we are unable to plot a graph.
*Due to only two observations, exact nature of the graph cannot be obtained.

Sample Calculations:

Area of both plates = 0.02 m^2

Ambient temperature (T_D) = 26° C

For black plate: W_1 = 34.5 W, $T_1 = T_S$ = 85° C,

For test plate: W_2 = 26.7 W, $T_2 = T_S$ = 85° C

$$\varepsilon_b - \varepsilon = \frac{W_1 - W_2}{A.\sigma.(T_S^4 - T_D^4)/0.86}$$

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$$\varepsilon_b - \varepsilon = \frac{(34.5-26.7)}{0.02*5.67*10^{-8}*\frac{(358^4-299^4)}{0.86}}$$

$$\varepsilon = 1 - 0.70$$

$$\varepsilon = 0.30$$

References:

1. A test book Heat Transfer by Dr . S. P. Sukhabmo.

2. Experimental methods for Engineering by J. P. Holman McGraw- Hill Company.