

## Determination of Radiation Constant of Iron Cylinder

**Aim:** To determine the radiation constant of iron cylinder

**Requirements:** Iron cylinder, thermometer, wooden plank, stop clock, tongs & heating source

**Principle:** Heat is lost from hot cylinder surface to surrounding atmosphere by means of conduction and radiation. Heat transfer by radiation occurs, energy transfer through space by means of electromagnetic radiation (waves). Thus a body acts as an emitter, than energy being transmitted through the intervening spaces, and it is effective even in a perfect vacuum or inter-spacious space. The amount of thermal energy radiated by a surface is increased rapidly with increasing temperature, when a heat flows by actual mixing of warmer portions with cooler portions of the same material. This mechanism is known as **Convection**

### Procedure:

1. Select an iron cylinder whose surface is smooth & radiation constant is determined.
2. Note & record the room temperature, measure the weight, area and radius of the cylinder. Insert the thermometer into the cavity of the cylinder.
3. Place the cylinder on a tripod stand and heat it for about  $300^{\circ}\text{C}$
4. Now hold the cylinder with the tongs and place on a non-conducting surface (wooden), without touching any surface.
5. Note the temperature reading for every 5 min, by using stop clock.
6. Plot a graph between temperature on y-axis and time on x-axis.
7. Find out the slopes  $d\theta/dt$ , at various arbitrary temperatures.
8. Calculate the radiation constant by using equation.

### Precautions:

1. The cylinder must be transferred as fast as possible
2. Avoid parallax error while recording the temperature.

- (m) Wt. of cylinder = gm.  
 (H) Height of cylinder = cm.  
 (D) Diameter = cm.

$$\text{Area (A)} = 2\pi rh + \pi r^2 \text{ in Sq.cm}$$

$$^{\circ}\text{F} = 9/5 ^{\circ}\text{C} + 32 \text{ [For } T_1 \text{ \& } T_2]$$

$$^{\circ}\text{R} = ^{\circ}\text{F} + 459.4$$

$$Q = M \cdot C_p \cdot d\theta/dt \quad [d\theta/dt = (Y_2 - Y_1)/(X_2 - X_1)]$$

$C_p$  = Specific heat of Iron = 0.44 J/g. K.

$$Q_R = Q - Q_C \text{ (in Btu/hr)}$$

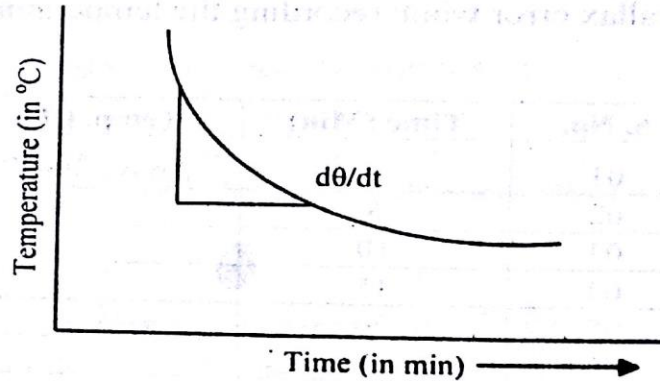
$$Q_C = \beta \left( \frac{T_1 - T_2}{D} \right)^{0.25}$$

$$\sigma = Q_R / A \cdot \epsilon (T_1^4 - T_2^4) \text{ (in Btu/hr. Sq.cm. } ^{\circ}\text{F)} \text{ for iron} - \epsilon = 0.65$$

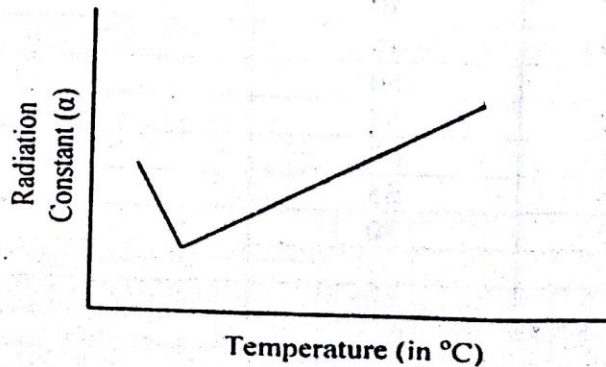
**Report :**

**Graphs :** Graphical representation

(a) Determination of slope



(b) Influence of temperature on radiation constant



The rate of heat transfer by a hot body equal to sum of heat transfer through conduction and radiation

$$Q = Q_C + Q_R \quad \dots(1)$$

Where,  $Q$  = Rate of heat loss/transfer in **Btu/hr**

$Q_C$  = Rate of heat transfer by conduction in **Btu/hr**

$Q_R$  = Rate of heat transfer by radiation in **Btu/hr**

The rate of heat transfer through a heat body to  $0^\circ\text{C}$  per time

$$Q = MC_P d\theta/dt \quad \dots(2)$$

Where,  $M$  = **Mass** of the cylinder in gm.

$C_p$  = **Specific heat** of material (Cylinder) in  $\text{Cal/gm}^\circ\text{C}$

$d\theta/dt$  = **Slope** of the graph plotted between time on X-axis and temperature on Y- Axis

$Q$  = Rate of heat transfer in **Btu/hr**

The rate of heat transfer through radiation is

$$Q_R = \epsilon A \sigma (T_1^4 - T_2^4) \quad \dots(3)$$

(*Stefan-Boltzmann's Law* gives the total amount of radiation emitted by a body)

Where,

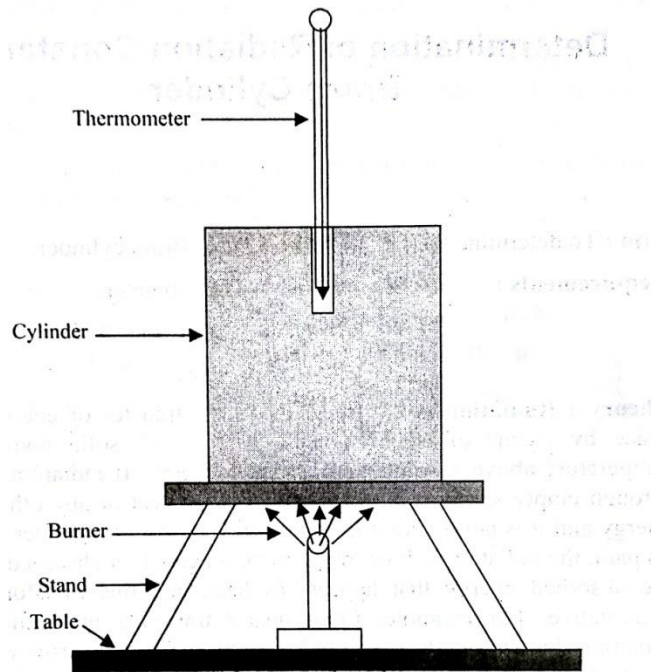
- $\epsilon$  = Emissivity of the cylinder (for black body  $\epsilon = 1$ )
- $A$  = Area of the cylinder [ $2\pi rh + \pi r^2$ ] in Sq.cm.
- $\sigma$  = Stefan- Boltzman constant (for black bodies  $b = 0.174 \times 10^{-8}$  Btu/hr. Sq. ft.  $^\circ\text{F}^4$  or  $5.67 \times 10^{-8}$   $\text{W/m}^2.\text{K}^4$ )
- $T_1$  &  $T_2$  are the absolute temperatures of initial & final in  $^\circ\text{C}$  respectively.

Heat loss through conducts :

$$Q_c = \beta \left[ \frac{T_1 - T_2}{D} \right]^{0.25} \quad \dots(4)$$

$\beta$  = Convection Constant (Iron = 0.28)

$D$  = Diameter of cylinder



Experimental setup for Determination of Radiation constant of Iron cylinder.

**Observation:**

S.No	Time(min)	Temp.(°c)
1	0	Above 300 <sup>0</sup> C
2	5	
<b>15</b>	<b>70</b>	

**Bibliography:**

1. Walter L.Badger and Juliust T.Banchero(page no.117 & 152-155)
2. K.Sambamurthy (page no 75-77)

## Determination of Radiation Constant of Brass Cylinder

**Aim:** To determine the radiation constant of Brass cylinder

**Requirements:** Brass cylinder, thermometer, wooden plank, stop clock, tongs & heating source

**Principle:** Heat is lost from hot cylinder surface to surrounding atmosphere by means of conduction and radiation. Heat transfer by radiation occurs, energy transfer through space by means of electromagnetic radiation (waves). Thus a body acts as an emitter, than energy being transmitted through the intervening spaces, and it is effective even in a perfect vacuum or inter-spacious space. The amount of thermal energy radiated by a surface is increased rapidly with increasing temperature, when a heat flows by actual mixing of warmer portions with cooler portions of the same material. This mechanism is known as **Convection**

### Procedure:

1. Select an brass cylinder whose surface is smooth & radiation constant is determined.
2. Note & record the room temperature, measure the weight, area and radius of the cylinder. Insert the thermometer into the cavity of the cylinder.
3. Place the cylinder on a tripod stand and heats it for about  $300^{\circ}\text{C}$
4. Now hold the cylinder with the tongs and place on a non-conducting surface (wooden), without touching any surface.
5. Note the temperature reading for every 5 min, by using stop clock.
6. Plot a graph between temperature on y-axis and time on x-axis.
7. Find out the slopes  $d\theta/dt$ , at various arbitrary temperatures.
8. Caliculate the radiation constant by using equation.

### Precautions:

1. The cylinder must be transferred as fast as possible
2. Avoid parallax error while recording the temperature.

The rate of heat transfer by a hot body equal to sum of heat transfer through conduction and radiation

$$Q = Q_C + Q_R \quad \dots(1)$$

Where,  $Q$  = Rate of heat loss/transfer in **Btu/hr**

$Q_C$  = Rate of heat transfer by conduction in **Btu/hr**

$Q_R$  = Rate of heat transfer by radiation in **Btu/hr**

The rate of heat transfer through a heat body to 0 °C per time

$$Q = MC_p \frac{d\theta}{dt} \quad \dots(2)$$

Where,  $M$  = Mass of the cylinder in gm.

$C_p$  = Specific heat of material (Cylinder) in Cal/gm/°C

$d\theta/dt$  = Slope of the graph plotted between time on X-axis and temperature on Y- Axis

$Q$  = Rate of heat transfer in **Btu/hr**

The rate of transfer through radiation is

$$Q_R = \epsilon A \sigma (T_1^4 - T_2^4) \quad \dots(3)$$

(Stefan-Boltzmann's Law gives the total amount of radiation emitted by a body)

Where,

- $\epsilon$  = Emissivity of the cylinder (for black body  $\epsilon = 1$ )
- $A$  = Area of the cylinder [ $2\pi rh + \pi r^2$ ] in Sq.cm.
- $\sigma$  = Stefan-Boltzmann constant (for black bodies  $\sigma = 0.174 \times 10^{-8}$  Btu/hr. Sq. ft. °F<sup>4</sup> or  $5.67 \times 10^{-8}$  W/m<sup>2</sup>.K<sup>4</sup>)
- $T_1$  &  $T_2$  are the absolute temperatures of initial & final in °C respectively.

Heat loss through conduction :

$$Q_c = \beta \left[ \frac{T_1 - T_2}{D} \right]^{0.25} \quad \dots(4)$$

$\beta$  = Convection Constant (Iron = 0.28)

$D$  = Diameter of cylinder

(m) Wt. of cylinder = gm.  
(H) Height of cylinder = cm.  
(D) Diameter = cm.

Area (A) =  $2\pi rh + \pi r^2$  in Sq.cm

°F =  $9/5$  °C + 32 [For  $T_1$  &  $T_2$ ]

°R = °F + 459.4

$Q = M \cdot C_p \cdot d\theta/dt$  [ $d\theta/dt = (Y_2 - Y_1)/(X_2 - X_1)$ ]

$C_p$  = Specific heat of Iron = 0.44 J/g. K.

$Q_R = Q - Q_C$  (in Btu/hr)

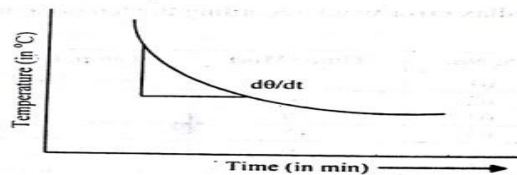
$Q_c = \beta \left( \frac{T_1 - T_2}{D} \right)^{0.25}$

$\sigma = Q_R / A \cdot \epsilon (T_1^4 - T_2^4)$  (in Btu/hr. Sq.cm. °F) for iron -  $\epsilon = 0.65$

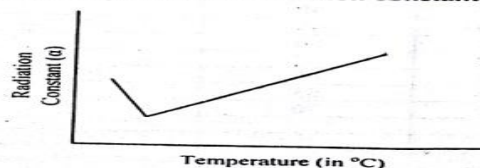
Report :

Graphs : Graphical representation

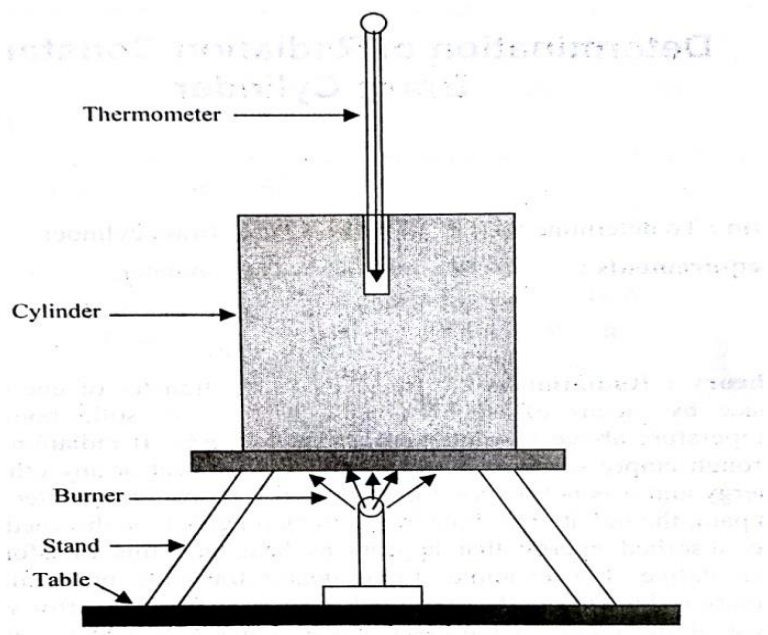
(a) Determination of slope



(b) Influence of temperature on radiation constant







Experimental setup for Determination of Radiation constant of Iron cylinder.

**Observation:**

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